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Path dependence and path shaping:
unearthing institutional dynamics in large-scale project organizing

Ermal Hetemi

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Thesis Supervisors:

Prof. Joaquín Ordieres-Meré

Universidad Politécnica de Madrid

&

Assoc. Prof. Anna Jerbrant

KTH Royal Institute of Technology

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Path dependence and path shaping:

unearthing institutional dynamics in large-scale project organizing

AUTOR: *ERMAL HETEMI*

DIRECTORES: *PROF. JOAQUÍN ORDIERES-MERÉ Y ASSOC. PROF. ANNA JERBRANT*

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Author’s address:

1. Universidad Politécnica de Madrid, Department of Industrial Engineering, Business Administration and Statistics, C/ José Gutiérrez Abascal 2, E-28006, Madrid, Spain. E-mail: e.hetemi@upm.es
2. KTH Royal Institute of Technology, Department of Industrial Economics and Management, Lindstedtsvägen 30, SE-100 44 Stockholm, Sweden. E-mail: ermal.hetemi@indek.kth.se

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To my wife, Florentina.

Acknowledgements

Not different from the projects that I have studied, this thesis, although my own craft, has been profoundly influenced by many people, the related institutions, and the broader societal environment. In the spirit of the thesis, I will attempt to provide a diachronic storyline and explain how all started and how I and the thesis consequently evolved.

More than five years ago, in an afternoon, I was sitting on the porch in Ann Arbor, Michigan, with Marcia and Donald MacMullan, who entered my life in August 2013 as I interned for the latter's Architectural office. During spring 2014, I was looking to improve my housing situation near Eastern Michigan University (EMU) in Ypsilanti, where I was doing my master's degree in Construction Management. Both over the 70s, Don and Marcia lived close to EMU and had a spare bedroom, which they offered to me. Often, Don, Marcia, and I would have supper together. We shared a common interest in Engineering, Architecture with Don, and shared passions for novels and columns with Marcia. Don and Marcia were invaluable to me; they were very supportive; they even participated during my Master graduation ceremony. Indeed, they were my family during my time in the United States. Besides his architectural expertise, in his spare time, Don read and reviewed for several professional journals. At the same time, I was writing my term papers, and we would discuss and review my paper ideas and craft for hours. During this period, I was also in close contact with my elder brother Dardan, who was doing a PhD in Chemistry at the Paris Diderot University – Paris 7. The thorough discussions with Don, during that afternoon, and the inspiration he provided every day was immense. This and also Dardan's incredibly cool and somehow mysterious work nurtured the academic interest in me. So, at the end of my Master-level studies, I was seriously considering doing a PhD.

Eventually, in April 2015, I returned home in Kosova. I started to work as an Engineer for Henkel, and as a lecturer in Project Management at the University of Prishtina (the same university I did my bachelor's degree). Shortly after that, in May 2015, I was offered a four-year contract PhD position within European Doctorate in Industrial Management (EDIM). I was thrilled and felt so lucky, and instantly decided to join EDIM to conduct my doctoral dissertation on the following year.

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Naturally, being part of EDIM, I was to spend at least one year of my doctorate at KTH Royal Institute of Technology in Stockholm, Sweden. On September 1st, 2017, I continued my work at KTH. My time at KTH profoundly affected me, my research interests, and this thesis. It is visible already that my engineering background led me to conduct my PhD in industrial management. I charted my research path and engineering interest forward in project studies. Yet, during my time at KTH, I ended up taking a course on Classics in Industrial Management, given by Professor Mats Engwall. The course provided a historical knowledge, and perspective to the main discourses on Industrial Management (how the research evolved.) It gave an in-depth sociological understanding and explanations to the industrial engineering and economic phenomena at large. In hindsight, the course started with the industrial revolution, and the rise of mass production, Social Technical Systems, Contingency thinking, from manufacturing to operations, and innovation management, among others. In the end, it ended in a speculative finish about the future of industrial management. Throughout our weekly sessions, in a roundtable, we discussed these classical studies, and I learned that operations management and projects consequently could actually be understood empirically and by a social research approach instead of purely numbers logic. Given my engineering background, at that point, I was shocked, yet more and more curious about this way of understanding. Visible in this thesis, these classics deeply affected me, and this thesis argument. Hitherto, I envision my research in industrial/ project management heavily embedded in organization theory. My research path transition and adaptation from engineering to being a social scientist has been challenging, yet enjoyable, and so much rewarding.

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Summary

In the last decades, inter-organizational projects and other forms of temporary organizing have gained prominence. An organizing form variously defined as the megaproject, global project, or service-led project has proliferated and gained renown influence in recent years. These definitions apply to large-scale projects that typically deliver a substantial physical infrastructure or a complex product with a lifecycle that can extend for decades and across industries. Large-scale projects' grown popularity corresponds with the so-called 'infrastructure-gap' and the new pressing needs for infrastructure investment worldwide. Large-scale projects are an essential vehicle for developing sustainability-oriented infrastructure that helps to overcome many of today's societal issues, such as climate change, for achieving economic growth, managing welfare, health, and safety concerns. Accordingly, over the last two decades, large-scale project endeavors that involve massive capital infrastructure investments have become the norm for many utility sectors, such as transport, energy, water, or food. These projects may evolve, arising as inherently societal concerns, and then shift to technical problems and vice-versa. However, such projects are complex endeavors embedded in highly institutionalized social structures and technologies, including public and private actors with various rationalities, modes of collaboration, and project management competencies. Thus, large-scale projects pose enormous coordination challenges, creating wicked problems for their management. They entail technical and social elements that are deeply entwined and co-evolved over a long time, introducing inertia, organizational path-dependency, and lock-in. Besides, a significant policy perspective and the trend points to the new generation of large-scale projects, which in contrast to the Fordist era in the US and Europe, compels efforts that require management to minimize affecting the surrounding societal environment, hence achieving project legitimacy. Therefore, although most of the economic and engineering problems have been tackled, the (inter-) organizational context, the social misalignments of large-scale projects, and the widely diverse actors in them remain under-studied. Hence, the questions of how these large-scale projects as inter-organizational collaboration unfold, and how they can be successfully managed and organized despite these challenges have become crucial in academia and practice alike.

Scholars from different disciplines have picked up these questions of organizational, technological, and environmental issues in large-scale infrastructure project organizing and have put forth valuable insights into such endeavors. Nevertheless, hitherto the dominant perspective of studies in large-scale infrastructure projects continues emphasizing the economic aspects and, for that purpose, applies the behavioral psychology lens. Indeed, focusing on intra-organizational aspects explaining the overall performance of large-scale infrastructure projects by maintaining the logic of individualism, while considering the constitutive features in the setting as given, and deriving behavioral conclusions from them. Such a frame of reference holds to large-scale project performance – their relative efficiency and the importance of accountability – and points to different actors' vested interests and the value of cost-benefit analysis. It seems the dominant perspective has analyzed large-scale infrastructure projects

from a normative ideal. It has, for long, embraced an objectivist, static and ahistorical view. This thesis challenges these underlying assumptions.

The thesis is explorative, engaging with the empirical context as the point of departure. In line with the overall research aim and conceptual framework, the research design has a qualitative nature and relies on a multi-level process approach. In adopting a process approach, it builds in extensive case studies, and case elaboration method. The first study represents an in-depth “insider” case study of project-based processes in the division of Adif - the Spanish Administrator of Rail Infrastructure. Besides, the second and third case studies investigate both public and private infrastructure organizational actors, which were heavily involved in sustainable-oriented large-scale projects that required technology adoption. The thesis employs a combination of data collection methods, including semi-structured interviews, (participant) observations, database search, documents, and other secondary data following the intensive media discussions.

This thesis contributes to the debate on large-scale project organizing by advancing an institutional perspective. Further, it puts a socio-technical approach that accounts for the co-evolution of organizational and technology issues in large-scale infrastructure projects. It provides a rich empirical examination; it shows that to understand large-scale infrastructure project processes, there is a need to change the ontological priorities that underpin the dominant research on the behavioral studies in project management. The thesis develops nascent theorizing on how the temporary and (inter-) organizational nature of large-scale projects in the presence of institutions narrates the emergence of processes, e.g., path-dependence, and lock-in. A conceptualization of path-shaping and project actors’ agency that bridges the gap between the intra-organizational and institutional level efforts is promoted.

The managerial implications of this thesis are two-fold. First, the appended papers put forth among other frameworks and process models that are indeed useful to be utilized. They outline ideas relevant because they lay the groundwork for project managers to extend their efforts beyond the micro-managing of tasks. In particular, Paper I develops the lock-in process model that can be useful for project managers. Secondly, the thesis gives countless advice and managerial implications. The most important being the consideration of heterogeneity in large-scale project contexts in the multi-organizational setting and their interdependencies in broad project networks. They represent the sources of variation in the desired outcomes. Accordingly, Paper III suggests attention needs to be directed to the understanding of the institutional logics and (inter-) organizational elements in the context as an essential feature of project management practice. In other words, this thesis suggests that embeddedness in large-scale infrastructure projects is of crucial importance. To this end, Paper II proposes means for an active project owner organization, that are essential for effectively interacting with other actors, and for selecting and managing both contractual and trust-based mechanisms effectively. Conclusively, the thesis suggests that project managers’ institutional knowledge in large-scale project setting is equally important, if not more, than the economic or engineering expertise.

Resumen

En las últimas décadas, los proyectos con fuerte implicación de diferentes organizaciones, así como otras formas de organización temporal han ganado importancia. Una forma organizativa definida de manera diversa como megaproyecto, proyecto global o proyecto gestionado por medio de servicios profesionales especializados ha proliferado y ha ganado renombre en los últimos años. Estas definiciones se aplican a proyectos a gran escala que generalmente ofrecen una infraestructura física sustancial o un producto complejo con un ciclo de vida que puede extenderse por décadas. La creciente popularidad de los proyectos a gran escala corresponde a la llamada "brecha de infraestructura" y las nuevas necesidades apremiantes de inversión en infraestructura en todo el mundo. Los proyectos a gran escala son un vehículo esencial para el desarrollo de una infraestructura orientada a la sostenibilidad que ayuda a superar muchos de los problemas sociales de la actualidad, como el cambio climático, para lograr el crecimiento económico, gestionar las preocupaciones de bienestar, salud y seguridad. En consecuencia, en las últimas dos décadas, los esfuerzos de proyectos de infraestructuras a gran escala que involucran inversiones masivas de capital se han convertido en la norma para muchos sectores de servicios públicos, como el transporte, la energía, el agua o la alimentación. Estos proyectos pueden evolucionar, surgiendo como inquietudes inherentemente sociales, y luego cambiar a problemas técnicos y viceversa. Sin embargo, tales proyectos son esfuerzos complejos integrados en estructuras y tecnologías sociales altamente institucionalizadas, incluidos actores públicos y privados con diversas racionalidades, modos de colaboración y competencias de gestión de proyectos. Por lo tanto, los proyectos a gran escala plantean enormes desafíos de coordinación, creando problemas perversos para su gestión. Implican elementos técnicos y sociales que están profundamente entrelazados y evolucionados conjuntamente durante mucho tiempo, introduciendo inercia, dependencia de la ruta organizativa y bloqueo. Adicionalmente, las tendencias y la nueva perspectiva política apuntan a una nueva generación de proyectos a gran escala, que en contraste con "el fordismo" obliga a esfuerzos que requieren gestión para minimizar el impacto en el entorno social circundante, logrando así la legitimidad del proyecto. Por lo tanto, aunque se han abordado la mayoría de los problemas económicos y de ingeniería, el contexto (inter) organizacional, las desalineaciones sociales de los proyectos a gran escala y los actores muy diversos en ellos siguen estando poco estudiados. Por lo tanto, las preguntas sobre cómo se desarrollan la colaboración interorganizativa y los proyectos a gran escala, y cómo gestionar y organizar con éxito a pesar de estos desafíos se han vuelto cruciales en la academia y en la práctica por igual.

Los académicos de diferentes disciplinas han seleccionado estas cuestiones relacionadas con problemas tanto organizativos, como tecnológicos y ambientales entorno a la organización de grandes proyectos de infraestructuras y ambientales en la organización de proyectos de infraestructura a gran escala y han aportado valiosos conocimientos sobre tales esfuerzos. Sin embargo, hasta ahora la perspectiva dominante de los estudios en proyectos de infraestructura a gran escala continúa enfatizando

los aspectos económicos y, para ese propósito, aplica la perspectiva de la psicología del comportamiento. De hecho, enfocándose en los aspectos intraorganizacionales que explican el desempeño general de los proyectos de infraestructura a gran escala manteniendo la lógica del individualismo, mientras se consideran las características constitutivas en el entorno tal como se dan, y se derivan conclusiones conductuales de ellos. Tal marco de referencia es válido para el desempeño del proyecto a gran escala, su relativa eficiencia y la importancia de la rendición de cuentas, y apunta a los intereses creados de diferentes actores y al valor del análisis de costo-beneficio. Parece que la perspectiva dominante ha analizado proyectos de infraestructura a gran escala desde un ideal normativo. Durante mucho tiempo, abrazó una visión objetivista, estática y ahistórica. Esta tesis desafía estos supuestos subyacentes.

La tesis es exploratoria y se relaciona con el contexto empírico como punto de partida. En línea con el objetivo general de la investigación y el marco conceptual, el diseño de la investigación tiene una naturaleza cualitativa y se basa en un enfoque de proceso de niveles múltiples. Al adoptar un enfoque basado en procesos, se basa en amplios estudios y métodos de elaboración de casos. El primer estudio representa un caso "interno" de procesos basados en proyectos en la división de Adif, el administrador español de infraestructura ferroviaria. Además, los estudios de caso segundo y tercero investigan los actores organizacionales de infraestructura tanto públicos como privados, que estuvieron muy involucrados en proyectos a gran escala orientados a la sostenibilidad que requirieron la adopción de tecnología. La tesis emplea una combinación de métodos de recolección de datos, que incluyen entrevistas semiestructuradas, observaciones (participantes), búsqueda en bases de datos, documentos y otros datos secundarios luego de las intensas discusiones en los medios.

Esta tesis contribuye al debate sobre la organización de proyectos a gran escala mediante el avance de una perspectiva institucional. Además, pone un enfoque socio-técnico que explica la co-evolución de los problemas organizativos y tecnológicos en proyectos de infraestructura a gran escala. Proporciona un rico examen empírico; muestra que para comprender los procesos de proyectos de infraestructura a gran escala, es necesario cambiar las prioridades ontológicas que sustentan la investigación dominante sobre los estudios de comportamiento en la gestión de proyectos. La tesis desarrolla teorías incipientes sobre cómo la naturaleza temporal e (inter) organizacional de proyectos a gran escala en presencia de instituciones narra la aparición de procesos, por ejemplo, dependencia del camino y bloqueo. Se promueve una conceptualización de los agentes del proyecto y de la configuración de acciones que reduce la brecha entre los esfuerzos a nivel institucional e intraorganizacional.

Las implicaciones de gestión en esta tesis son dobles. Primero, los artículos adjuntados promocionan otros marcos y modelos de procesos que de hecho son útiles para su uso. Esbozan ideas relevantes porque sientan las bases para que los gerentes de proyecto extiendan sus esfuerzos más allá de la microgestión de tareas. En particular el artículo número 1 desarrolla el modelo de proceso de bloqueo que puede ser útil para los gerentes de proyecto. En segundo lugar, la tesis ofrece innumerables consejos e implicaciones de gestión. La más importante es la consideración de la heterogeneidad en

contextos de proyectos a gran escala en el entorno de múltiples organizaciones y sus interdependencias en redes de proyectos amplias. Representan las fuentes de variación en los resultados deseados. En consecuencia, el artículo número tres sugiere que la atención debe dirigirse a la comprensión de las lógicas institucionales y los elementos (inter) organizacionales en el contexto como una característica esencial de la práctica de gestión de proyectos. En otras palabras, esta tesis sugiere que la integración en proyectos de infraestructura a gran escala es de crucial importancia. Con este fin, el artículo número dos propone medios para una organización activa de propietarios de proyectos, que son esenciales para interactuar efectivamente con otros actores, y para seleccionar y administrar mecanismos contractuales y basados en la confianza de manera efectiva. En conclusión, la tesis sugiere que el conocimiento institucional de los gerentes de proyecto en la configuración de proyectos a gran escala es igualmente importante, si no más, que la experiencia económica o de ingeniería.

List of appended papers

This Doctoral Thesis is based on three academic papers that are enclosed at the end.

Paper I

Hetemi, E., Jerbrant, A., & Mere, J. O. (2020). Exploring the emergence of lock-in in large-scale projects: A process view. *International Journal of Project Management*, 38(1), 47-63.
<https://doi.org/10.1016/j.ijproman.2019.10.001>

An earlier version of this paper was presented at the Conference *International Research Network on Organizing by Projects (IRNOP)*, Melbourne, Australia, 9-12 December 2018.

PAPER II

Hetemi, E., Gemünden H. G., & Mere, J. O. (2020).

Embeddedness and actors' behaviors in large-scale project lifecycle: Lessons learned from a High-Speed Rail project in Spain. *Journal of Management in Engineering*.

[https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000849](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000849)

An earlier version of this paper was presented at the International Conference *European Academy of Management (EURAM)*, Lisbon, Portugal. 26-28 June 2019.

PAPER III

Hetemi, E., Mere, J. O., & Nuur, C. (2020). Hetemi, E., Ordieres-Meré, J., and Nuur, C. (2020).

An Institutional Approach to Digitalization in Sustainability-Oriented Infrastructure Projects: The Limits of the Building Information Model. *Sustainability*, 12(9), p.3893.

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An earlier version of this paper was presented at the International Conference *European Academy of Management (EURAM)*, Reykjavik, Iceland. 19-24 June 2018.

List of selected additional papers (not appended)

Hetemi, E., van Marrewijk, A. Jerbrant, A., & Bosch-Rekveldt (2020). The recursive interaction of institutional environment and managerial legitimation in large-scale projects. *International Journal of Project Management* (second round of review).

An earlier version of this paper was presented at the International Conference *European Academy of Management (EURAM)*, Lisbon, Portugal. 26-28 June 2019.

Hetemi, E., Mere, J. O., & Nuur, C. (2020). Inter-organizational collaboration and knowledge transfer in a coopetitive context: the perspective of the project owner organization. *Knowledge Management Research and Practice* (second round of review).

Hetemi, E. (2020). The adoption of project management certification: an empirical investigation in Sweden and Spain. *International Journal of Project Management* (working paper).

Hetemi, E., Mere, J.O., Nuur, C., and Engwall, M., 2017. Exploring mechanisms underlying lock-in in large infrastructure projects: A management perspective. *Procedia Computer Science*, 121, pp.681-691. <https://doi.org/10.1016/j.procs.2017.11.089>

An earlier version of this paper was presented at the International Conference *on Project MANagement (CENTERIS)*, Barcelona, Spain, 12-14 November 2017

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Chapter 1. Introduction

1.1. *Setting the scene*

Looking back at history, significant and historical endeavors have left a footprint: The Great Wall of China, the Egyptian Pyramids, the raids of the Vikings, and so on. Large-scale events were then, and arguably still are a symbol of power and status. Civilizations have ever since been fascinated with large-scale endeavors and the skills of managing them (Engwall, 2001; Lundin et al., 2015). Yet it was not until the 1950's that this phenomenon was categorized as 'projects' in the modern meaning (Engwall, 1998, 2001). Since the 1960s, project studies have discussed the challenges associated with the implementation of large-scale projects within the framework of infrastructure establishments. Historically, the significant problems in carrying out infrastructure endeavors were primarily technical and financial in nature. In the early project management literature, the underestimation of costs at the planning stage, the political sensitivity regarding costs and benefits, and the difficulty of halting unsuccessful projects were recognized as crucial challenges (Lenfle and Loch, 2010). Although not a recent phenomenon, *large-scale projects* are enjoying renewed popularity. A body of literature, mainly based on cases from Europe and North America, has argued for the emergence of the new generation of large-scale projects (Kennedy, 2015; Söderlund *et al.*, 2018). In contrast to the Fordist era in the US and Europe, this new generation compels efforts that require management to minimize affecting the surrounding societal environment, hence achieving project legitimacy (Scott, 2012). Large-scale projects are temporary inter-organizational contexts, i.e., a socio-technical setting in which multiple organizations collaborate temporarily with an ex-ante agreed termination (Jones and Lichtenstein, 2008).

In the past decades, *inter-organizational projects*, and other forms of *temporary organizing* have gained prominence (Powell, 1990; Lundin and Söderholm, 1995; Gulati *et al.*, 2012). Since the 1980s, there has been a dramatic increase in inter-organizational collaboration – as companies are blurring their established boundaries and are continuously relying on various forms of external collaboration (Lundin et al., 2015; Berends and Sydow, 2020). This emergence of inter-organizational collaboration

is driven mainly by technological changes and development paths (Rosenberg, 1963; Dosi, 1982) and is underpinned by the regulatory, normative, and dynamic cultural-cognitive forces (DiMaggio and Powell, 1983; Scott, 1987, 2013). Inter-organizational collaboration has a project-based character embedded in more or less permanent organizations, longer-term relationships or networks (Manning and Sydow, 2011; Manning, 2017), and the institutional context (Scott *et al.*, 2011; Scott, 2012). To this end, leading scholars in project management and organization theory argue that we are witnessing the phenomenon of “projectification,” which points to the new era of “Project Society” (Lundin *et al.*, 2015; (Lundin and Söderholm, 1995; Packendorff, 1995). In other words, one major research trend points to the increased organizing of industrial action in inter-organizational projects and temporary systems of work organization, rather than large permanent organizations (Bakker *et al.*, 2011, 2016).

Inter-organizational projects, therefore, have been receiving growing attention due to their distinctive challenges, i.e., there are no comprehensive standard models for how to manage and organize them. Their ascendance in practice has grown in parallel with the research interest in organization studies. Particularly their organizing and the network dynamics have been the foci (Powell *et al.*, 1996). Research on projects in particular and on temporary forms of organization, however, has in sharp contrast to organizational studies, not yet adequately considered the inter-organizational project’s temporal and historical embeddedness (Sydow and Braun, 2018). It appears, in most project studies, that while the world of practice has been changing dramatically in a direction that sets ever greater importance on coordination beyond the project boundaries of the organization. Our theorizing of organizational project management continues with their strong intra-organizational bias (cf. Lundin *et al.*, 2015; Sydow and Braun, 2018). Specifically, in large-scale project studies as inter-organizational contexts, the dominant perspective of which continuously emphasizes at most the dyadic relationship of principal and agents. It remains embodied in governance structures, controllability, and contractual sphericities (cf. Sanderson, 2012; Steen *et al.*, 2017). Besides, the increased cooperation – extending organizational boundaries – poses an emphasis on project governing process, trust development, and the management of opportunism (Bakker *et al.*, 2011; Sanderson, 2012). Such an emphasis requires a shift in focus from the intra-organizational view of the single projects to long-term relations embedding

the project in multiple-contexts (Sydow and Staber, 2002; Manning, 2008). There is a need to match the processes in large-scale projects to the long-term relations in the inter-organizational context (Grabher and Thiel, 2015; Dille *et al.*, 2018).

Nevertheless, the dominant perspective of studies in large-scale projects has emphasized economic aspects and applied behavioral, psychological lenses (e.g., Flyvbjerg, 2013; Flyvbjerg *et al.*, 2018). In this view, potential deviations from the ‘rationally’ right decision are classified as biases and errors, and their root causes are analyzed through mostly quantitative methods (cf. Stingl and Geraldi, 2017). Yet, the issue is not the level of analysis of the dominant perspective *per se*. It is the atomic conception of individuals, and at the same time, their capability attempts to mislead stakeholders in large-scale project organizations. Thus, although the cognitive bias and strategic misinterpretation flagged by the dominant perspective of studies in large-scale projects might exist, in a large-scale project context, there are a milieu of complex (inter-)organizational processes that are at work (cf. DeFillippi and Sydow, 2016; Steen *et al.*, 2017).

Large-scale projects are referred to as dynamic constellations (Jones and Lichtenstein, 2008). At first sight, large-scale projects are arguably the most flexible and dynamic form of temporary organizing. However, they rely strongly on experience and future expectations (Grabher and Thiel, 2015), which enables and also constrains the coordination across organizational boundaries. As indicated earlier, infrastructures are heavily influenced by technological and institutional constructs. Thus large-scale infrastructure projects are very much likely to develop inter-organizational path dependencies (Hellström *et al.*, 2013; Ligthart *et al.*, 2016). Concerning large-scale projects as inter-organizational settings, Aaltonen *et al.* (2017) queries the (inter-) organizational inertial dynamics and suggests that project actors can be even locked-in into a path that is affected by shared history. Given the multi-actor project setting, the main challenge relates to "whether the project should be tightly knit around the initial ideas or whether various unique interests should be given room to influence the project's evolution" (Lundin *et al.*, 2015, p. 128). The organizing of large-scale infrastructure projects, thus, is complex and must be adapted not only to the multiple contexts but also to each phase of the project lifecycle. In consequence, the project studies should become sensitive and construct better

connectivity among these projects and contexts (Manning, 2008). Hence, it makes limited sense to speculate further if escalation in cost & time, and benefit shortfalls could be attributed to an error in estimation or lies by project sponsors and estimators as the dominant perspective of studies in large-scale projects perpetuates, without having investigated how these projects are actually organized.

Large-scale projects as inter-organizational settings, therefore, pose challenges as they span across the organizational field, underpinning different institutional framing, differing norms, and exhibiting diverse actors' interests (Scott, 2012). Hence, the development of large-scale infrastructure projects is related to numerous salient institutional ingredients such as the social footprint (i.e., the size, composition, and the populations affected), and the institutional project environment, which demands particular attention (Scott *et al.*, 2011). Moreover, infrastructures are heavily influenced by technical and social constructs that, throughout a period, are highly intertwined and co-evolved, which introduce inertia, path-dependency, and organizational lock-in (Bassanini and Dosi, 2001; Walker *et al.*, 2008; Sydow *et al.*, 2009). Thus, there is a need for exploring path related processes, revealing the contextual conditions that give rise to or underline the organizational or institutional path-dependence, and lock-in (Aaltonen *et al.*, 2017; Sydow and Koll, 2017). Consequently, if the studies of scholars such as Scott (2012), concerning the institutional environment of large-scale infrastructure projects are even closely correct with regards to the inter-organizational relationships and the dynamic institutional forces they introduce. It appears we have indeed been playing Hamlet without the Prince!

Given this backdrop, it is more relevant and enlightening to study large-scale infrastructure projects and their (inter-) organizational contextual detail, the interactions and actors' behaviors: 1) in the context of the institutional environment that is orchestrating them; and 2) through time, considering the project lifecycle and the dramatic changes that the project phases pose in terms of influence activities and actors' flexibility. Thus, the extensive reliance on inter-organizational projects, particularly in the infrastructure industry (Manning, 2017; Scott and Levitt, 2017), demands careful theoretical reflection and plentiful empirical evidence by organization and project scholars.

This Ph.D. thesis, in response, tackles both the theoretical and contextual research fields of large-scale infrastructure projects. In the theoretical field, it focuses on the dual dynamics – the impact of the

institutional environment on the project and vice-versa – stressing the importance of the field restructuration due to the development of these large-scale infrastructure projects. In doing so, it builds on the foundations provided by the (neo) institutional theory (Meyer and Rowan, 1977; DiMaggio and Powell, 1983; Scott, 1987, 2013). A neo-institutional lens enables one to deconstruct the dynamic and multifaceted relation among the institutional environment and the (inter-) organizational project context. In particular, it allows the investigation of how large-scale projects as temporary (inter-)organizational settings are permeable organizational units in an institutional environment, which does not only constrain them but also provides resources for and empowers the actors in the project (Scott *et al.*, 2011).

In the contextual field, it addresses the implications of the institutional and (inter-) organizational context in the large-scale infrastructure project processes and activities. Empirically, it is based on data from large-scale infrastructure projects, including diverse actor – organizations such as public agencies, private and non-governmental bodies from the European project contexts. The thesis focus is on large-scale project organizing – privileging processes and activities, and not just related organizational structures (Lundin and Söderholm, 1995; Bakker *et al.*, 2016). The explicit focus on processes and activities is because of the emergent and temporary nature of large-scale projects. Their structures demand an understanding of the significance of (inter-) organizational processes and events over the impact of the cause-and-effects in the more traditional terms (Bakker *et al.*, 2016; Berends and Sydow, 2020). Hence, the thesis intends to go beneath the surface to understand “how’s” and explain “whys” – to unveil part of the constitutional features in the context that shape the discernible regularities.

1.2. Research objective and question(s)

This thesis – in contrast to other contemporary project studies – employs a multi-layer lens (Mathieu and Chen, 2011). It shifts from an examination of the large-scale projects through a dyadic view, and the focus on traditional contractual arrangements. Instead, it considers the peculiarities of the: 1) project organizational practice (the micro-level); 2) the (inter-)organizational context (the meso level); 3) and the overall implications of the institutional environment (the macro level), taking the context and history

of the project organizing into account. Conceptually, the thesis considers the linkages between the different processes and actor organizations in a large-scale project context, that provide avenues for exploring relevant issues to develop theoretical understanding. Large-scale projects and their (inter-) organizational contexts are thus recursively constituted in time and space. In this regard, the thesis employs a multi-level process approach (Langley, 1999; Langley et al., 2013), benefiting from “process pluralism,” thus, complementing former more moderate cross-case analysis in the field of project studies as a whole (Bakker et al., 2016; Geraldi and Söderlund, 2016). Employing the multi-level process approach, this thesis builds on Seidl and Whittington (2014) term ‘large,’ enabling both for ‘tall’ ontologies in which micro-level practices are embedded on larger macrostructures, and for ‘flat’ ontologies in which the large is what stretches out sideways in a network of relationships.

More specifically, this thesis aims to explore how the institutional, and the temporary (inter-) organizational context shapes the processes and activities in large-scale infrastructure projects. It examines the constitutional features in the background that shape processes and activities in the setting by discussing three particular aspects: 1) the contextual conditions that give rise or support project processes and activities; 2) the dynamics of institutional forces that affect the arrangement and organizing of these projects, and 3) the adoption and implementation of digitalization tools at the (inter-) organizational level. It addresses the following overarching research question in the context of project owners, operators, and suppliers as established entities, which are exploring innovative ways to manage these endeavors:

How can a dynamic process view of large-scale infrastructure project organizing be conceptualized and empirically analyzed?

To tackle this research question, three specific sub-questions are considered:

- 1) How and why does lock-in emerge in large-scale projects?
- 2) How does the institutional environment influence the arrangement and organizing of large-scale projects and their governing, and how can project owners deal with the opportunistic behavior of some of their providers?

- 3) What is the role of institutional actors interpretive framing or rationale for BIM technology adoption?

This endeavor seems relevant, timely, and necessary when considering the recent calls for more empirical research into examining the institutional dynamics and path related processes in the temporary inter-organizational context such as large-scale projects (Söderlund and Sydow, 2019; Berends and Sydow, 2020).

1.3. Structure of the Thesis

This thesis consists of a cover essay and three appended papers, see the thesis process structure in Fig. 1. Following this introduction, the cover essay is structured as follows. Chapter 2 discusses the theoretical background, where state-of-the-art research on large-scale infrastructure projects is critically reviewed. In this chapter, I embrace a Neo-Institutional theory as a theoretical lens to examine the organizing in large-scale infrastructure projects, explaining its fundamental assumptions and how it provides a more dynamic and substantive account of the context detail. Chapter 3 presents the thesis research design, the empirical setting, and methodological approach, while Chapter 4 summarizes the three appended papers and describes the author's contribution to each article. Chapter 5 discusses the findings – synthesizing the results of the appended papers to answer the theses research question. Chapter 6 summarizes the conclusions of this thesis and provides the theoretical and managerial implications of the findings. Lastly, the appendices comprise the appended papers, which are a fundamental part of this thesis compilation.

Fig. 1. The thesis process structure

Chapter 2. Theoretical foundations

This section describes the current debate in large-scale project studies. It scrutinizes the literature in large-scale project studies, and temporary organizing using the neo-institutional theory as a promissory avenue to theorize the large-scale project organizing. It emphasizes the need for a more dynamic contextualized approach to examining the organization of large-scale projects.

2.1. Theoretical points of departure

The following summary of the literature in large-scale projects, and temporary organizations using the neo-institutional lens, illustrates both the promises and the hurdles of institutional analysis and project studies. To the date the field of project studies has been built upon the following primary approaches:

1) traditional and normative approach on project scheduling and control, the efficiency of project management, which has its origins in optimization literature and applied sciences (Kerzner, 2009; Meredith and Mantel, 2013); and

2) the empirically driven and context-sensitive approach underscores the temporary organizing, which originates from the mid-1990s under the contours of the Scandinavian approach to project management (Kreiner, 1995; Lundin and Söderholm, 1995; Packendorff, 1995). Project studies were then, and arguably still are, concerned with the former logic, i.e., the rational planning of operations, which speaks to the logic of humankind (Hallgren *et al.*, 2012; Söderlund and Sydow, 2019).

By traditional and normative approach, infrastructure projects represent large and complex initiatives, with long span and typically underestimated costs, (see, e.g., Love *et al.*, 2016; Flyvbjerg *et al.*, 2018). This normative approach has a common denominator – the technically based roots, i.e., linear, quantitative technicalities of the project management aspect, are favored. It is centered on the application of a rational and trustworthy model to limit overspendings and benefit shortfalls. Nevertheless, the empirical focus in project studies has evolved from examining traditional project setting to investigating many diverse processes of temporary organizing (Söderlund and Sydow, 2019). Theoretically, two key areas lie behind the latter's reasoning. In a sense, these two have led to the rise

of the Scandinavian approach to project management (Engwall *et al.*, 2003): (1) the influence of the neo-institutional theory (Meyer and Rowan, 1978, among others), (2) and the uncertainty as an organizational actuality (Thompson, 1967).

The Scandinavian approach to project studies has influenced - made a turn and opened up the field for alternative theoretical viewpoints and a wider variety of empirical research. The generic point is that the project is not an isolated event, and large-scale projects are not the different “animal” that project literature often portrays it to be, but that projects are situated on a broader project institutional context. At this end of the spectrum, the rising and expanding number of descriptive studies focuses on the organizing of large-scale infrastructure projects, blending institutional challenges as one of the backdrops (Scott, 2012; Brunet, 2018; van den Ende and van Marrewijk, 2018). Within this stream, an infrastructure project is defined as a complex undertaking. Yet, its complexities refer less to the technicalities and cost-related issues. Instead, the focus is on the substantiation features of large-scale projects as temporary organizations, e.g., large-scale project ‘governing’ (Sanderson, 2012). Besides, this stream defines infrastructure projects not merely as “magnified versions of smaller projects” (Flyvbjerg, 2014, p. 3) instead it claims for particular consideration on power dynamics (Clegg *et al.*, 2016), actors desires (Artto *et al.*, 2016), and the inter-relations with the institutional environment (Scott, 2012; Scott and Levitt, 2017). To this end, it is essential that the institutional perspective, is currently gaining traction in project studies (cf. Bresnen, 2016; Söderlund and Sydow, 2019). However, despite this cultivating research interest and the increasing societal significance and complexity of projects, the progressions towards the comprehension of the embeddedness of projects into (inter-) organizational, or even broader institutional contexts are still quite limited (Biesenthal *et al.*, 2018; Söderlund and Sydow, 2019). According to Söderlund and Sydow (2019, p. 260), projects, for the most part, are still “viewed as separated islands with little interaction with their environment, and if the context is addressed, then projects are oftentimes treated as black boxes.”

From a neo-institutional lens, projects are analyzed as a consequence of how they are situated in time and space (Scott, 2012). For example, the conflicts in projects are seen as an integral part of project contexts, and institutions are understood to shape the conditions for projects and particular actors explained based on institutional diffusion and recognition. Contemporary research on large-scale

projects applying neo-institutional includes for example “Projects, institutional logics and institutional work practices” where Uriarte et al. (2019) argues that multiple tensions reside concurrently due to competing institutional logics in projects and that institutional work practices help for understanding the institutional maintenance in recurring temporary organizations.

In a recently published article, Biesenthal et al. (2018) call for the application of the institutional analysis in projects, with an emphasis on large-scale projects as sociotechnical undertakings where institutional work, the authors argue, must precede technical work. As opposed to traditional and normative approaches, van den Ende and van Marrewijk (2019), in their longitudinal study, explore how project actors that plan and implement large-scale infrastructure projects legitimized their projects and embed these projects in their environment. Brunet (2019) provides both the individual practices when analyzing large-scale project endeavors and the more contextualized practices in their project governing. She argues that the large-scale project governing is a continuum to which practices are enacted at different levels: the project and institutional level, respectively.

In summary, existing research, has recently (re)directed the focus to the institutional environment of the project, but the application of the neo-institutional theory at large is nascent (Bresnen, 2016; Biesenthal et al., 2018; Söderlund and Sydow, 2019).

2.2. Organizing Large-scale Infrastructure Projects

From a socio-technical point of view, large-scale infrastructure projects involve a complex process of developing and hardware platforms, such as the case of high-speed rail systems (Walker et al., 2008). They typically start with a somewhat specific request from the project owner, which later involves diverse and specialized actors in its customized implementation (Manning, 2017). The project owners are often highly involved in both the front-end and the development processes and at times in the operation (Morris, 2013). These projects are highly complex, including public and private actors with various rationalities, modes of collaboration, and project management competencies (DeFillippi and Sydow, 2016; Steen *et al.*, 2018; Braun and Sydow, 2019). Indeed, they are a set of 'multiple rationalities' (Pitsis *et al.*, 2018, p. 11). Similar to Cohen *et al.* 's., (1972), garbage can model, large-scale project setting underline random alignment of actions and decisions of multiple rationalities. They

require expansion and upgrading following technology lifecycles (Geyer and Davies, 2000; Manning, 2017). Thus, large-scale projects have fuzzy limits; their lifecycle is extended by continuous servicing and maintenance. They ‘extend’ into multiple service relationships beyond the typical time-limit of projects (Manning, 2017, p. 1406). Because of this, relational embeddedness tends to be high among the specialized actors (i.e., integrators, suppliers), yet it remains low with the project owner even though it develops through repeated interaction over several years (cf. Jones and Lichtenstein, 2008).

There is a misguided belief, however, that large-scale projects are inherently unique and that there is a little commonality among them (cf. Cooper et al., 2002). The project’s end-product itself is unique, but the model of the processes involved shares patterns and commonalities with other projects. Thus, large-scale projects include high degrees of customization and tend to be unique while relying on some standardized elements (Gemünden, 2015; Scott and Levitt, 2017). These projects involve functional activities, e.g., design and planning, engineering, integration and supply, construction craft per se, and component and material installations with increasingly complex technologies (Lundin et al., 2015). The processes include organizations from a range of sectors around the design, implementation, maintenance, and adaptation (Gann and Salter, 2000). So, the collaboration is crucial since the organizing, and the overall project performance relies on the efficient operation of the whole network rather than one single organization (Lundin et al., 2015; DeFillippi and Sydow, 2016). Besides, many studies show a tendency in the field for the organizations to repeatedly collaborate in different projects, forming repeated or recursive ties (Sydow and Windeler, 1998; Manning and Sydow, 2011). Therefore, much like project networks, large-scale projects as inter-organizational settings do not rely on hierarchy but mobilize other aspects such as cooperation, trust, and reciprocity (Powell, 1990; Sydow and Braun, 2018). Conclusively, large-scale projects are open systems, and they exceed professional and organizational boundaries. They can be influenced by various peripheral actors and events, i.e., actors that are outside the scope of the formal project arrangements (Scott and Davis, 2007).

2.3. The (inter-)organizational context in the current discourse of large-scale project studies

Major research themes within large-scale projects topic discuss these endeavors as arenas for innovations development and project operational capabilities (e.g., Davies and Mackenzie, 2014;

Lehtinen *et al.*, 2019), for organizational learning and knowledge management (e.g., Grabher and Thiel, 2015), streamlining supply chains (e.g., Caldwell *et al.*, 2009), for restructuring metropolitan cities on a global scale (Kennedy, 2015; van Marrewijk, 2017), or for responding to emergencies (e.g., Walker *et al.*, 2017). Meanwhile, the dominant stream of large-scale project studies has an excessive focus on project accountability – with the sole objective of evaluating such projects (e.g., Flyvbjerg *et al.*, 2018). Yet it is overlooking, in particular, the (inter-)organizational context, the projects' temporary organizational nature at large, including the benefits as a source of learning, reflexivity, and adaptive governance (cf. Sanderson, 2012; Lehtonen, 2014; Brunet, 2018). For few exceptions, see (Davies and Mackenzie, 2014; Braun and Sydow, 2019), which have begun to unpack and identify what goes inside the black box of large-scale infrastructure projects – recognizing that successful performance also depends on developing new routines, practices, and collaborative behavior.

The current debate in the engineering and project management literature concerns the causes of cost and time overruns and benefit shortfalls of large-scale infrastructure projects, particularly in the transportation sector. On the one hand, Flyvbjerg *et al.*, (2018) stress optimism bias as a root cause leading to cost and time overruns and shortfalls of benefits. The four sublimates reinforce this essential behavioral trait researched first by Kahnemann and Tversky (1979a, b) and followers: technological, political, economic, and aesthetic that drive a winning coalition of project promoters from different fields engaging for an ambitious project (Flyvbjerg, 2014). Flyvbjerg and colleagues state in several articles that these promoters use strategic misrepresentation and deception to reach their goals, i.e., the implementation of the large-scale infrastructure project (Flyvbjerg *et al.*, 2002, 2009, 2018). On the other hand, Love and Ahiaga-Dagbui (2018) question the validity of these claims and the quality of the gathered data. They also challenge the relevance of the hypotheses and argue for a more complex, systemic, and evolutionary framework: many events and actions that are not accounted for in initial estimates tend to drive up cost (see also Love *et al.*, 2012). The rejoinder from Flyvbjerg *et al.* (2018) clarifies several points but sticks to the assumptions that delusion and deception are the root cause of the observed failures. While there is widespread consensus that cost overruns are a pervasive problem, their origins remain matters of contention. It seems scholars' have adopted more of a positivist view, and they have analyzed large-scale projects from a normative ideal. Hence, the process of governing

and project processes in large-scale projects has been mainly examined concerning the quality and effects of inter-personal relations and individual attributes, primarily captured through survey-questionnaires and desk research (e.g., Flyvbjerg, 2013; Shi *et al.*, 2018; Liu *et al.*, 2019). Although useful, such view presents a project from a snapshot view without giving details of its (inter-)organizational context and the project lifecycle (cf. Söderlund, 2011).

Three primary assumptions underline the dominant perspective of large-scale project studies and its underlying rational kernel. Firstly, that large-scale projects are motivated by vested interests (van Marrewijk *et al.*, 2008; Steen *et al.*, 2017; Pitsis *et al.*, 2018). Secondly, that large-scale projects are initiated with unclear specifications revolving project goals that change during the project implementation; the key reason why such a condition occurs is attributed to governance mechanisms incompleteness and deficient contracts (cf. Engwall, 2002; Sanderson, 2012). Thirdly, plentiful choice options are available to the project actors (cf. Sydow *et al.*, 2009; Aaltonen *et al.*, 2017). Yet neither of the assumptions appears to be well justified. At this point, Davis's seminal insights (1971), that challenging assumption is what makes theory interesting, has been an essential source of inspiration for this thesis. This thesis, however, is crafted and scrutinized, arguably so that it will not be refuted spontaneously since provocative reasonings must carry some of the reader's source understanding to prevail and be interesting (Davis, 1971). With such a belief in mind, in the following, the thesis contrasts the implicit assumptions and opens to new and more promising paths.

Regarding the first assumption, van Marrewijk *et al.*, (2008, p. 597) argue that large-scale projects are not premised on widespread conspiracies but are “managed to the best of their abilities, by professionals and civil servants in the context of very complex operations, paradoxes, uncertainties, influences and ambiguities which surround these projects.” Hitherto, few empirical studies address the (inter-) organizational dynamics of large-scale projects. The organizational literature, however, is more sanguine, with regards to recognizing the heterogeneity of large-scale project context in the multi-organizational setting and their interdependencies in broad project networks, which represent the sources of variation in the desired outcomes (Bakker *et al.*, 2016; Ligthart *et al.*, 2016).

With regards to the second assumption, according to the descriptive stream on project studies, it has been placed that a project's goals, design options, and scope will change over time (Artto *et al.*, 2016;

Aaltonen *et al.*, 2017). Moreover, the understanding that large-scale projects can have clear goals and controlled objectives, beginning in the early phase of the project's lifecycle, has been questioned (cf. Engwall, 2002). Lastly, regarding the third assumption, in large-scale project context processes are emergent, and they comprise the actors' process interdependencies, they demand reflection on the project's (inter-)organizational context (Sydow and Braun, 2018). Thus, processes in large-scale project contexts cannot be controlled by the individual or any single project actor organization (Aaltonen *et al.*, 2017). The choices made by project actors are possibly partial, i.e., the actors and their interests are institutionally constructed (Scott *et al.*, 2011; Scott, 2012).

2.4. Large-scale infrastructure projects: a multi-level process perspective

During the past decades, two different views of large-scale projects have emerged. The first by Jones and Lichtenstein (2008, p. 20) refers to large-scale projects as "constellations" of organizations that collaborate at a certain point in time on a particular project. Similar understanding, i.e., that large-scale projects are confined to a one-time collaboration is also provided by Hellgren and Stjernberg (1995). The second view, although not directly related to large-scale projects, by contrast, brings a network mapping on large-scale projects, among others (cf. Lundin *et al.*, 2015). The latter provides a more contextualized view. It pays attention to the issues of time and mechanisms that enable the coordination among organizations: it sees a connection between the past and future expectations, which allows and at the same time constraints the organizing of large-scale projects (Sydow and Windeler, 1998; Manning and Sydow, 2011; Ligthart *et al.*, 2016; Sydow and Koll, 2017).

According to the latter approach, repeated collaboration exists as, in some cases, the same organization plays different roles in large-scale projects, e.g., as a contractor, and at times as a supplier of specific elements of the project (Lundin *et al.*, 2015). The repeated collaboration, therefore, helps the management to enact shared formal rules developing a cooperative mode that dominates this context as compared to the hierarchical one (Powell, 1990; Powell *et al.*, 1996). Alongside history and the broader institutional context has substantial effects on large-scale project processes and activities (Engwall, 2003; Scott *et al.*, 2011; Scott, 2012). Thus, large-scale projects are not an "island" and cannot be conceived without taking into account their temporal and relational embeddedness (Engwall, 2003;

Grabher and Thiel, 2015). This understanding implies three consequences in terms of how to theorize the organizing of large-scale projects. First, the interaction of actors, the social embeddedness shapes the project processes and activities. Second, the temporal embeddedness gives rise to particular (inter-)organizational mechanisms for managing the uncertainty inherent in this context. Third, large-scale projects are embedded into (inter-)organization project networks and institutional environments. The investigation of multilevel relations is a promissory avenue proposed by Mathieu and Chen (2011) to develop further the multilevel paradigm in management research.

At the macro level: large-scale projects are embedded in a landscape at a transitional or global level (Scott *et al.*, 2011). Actors in this landscape involve relevant governmental bodies, developers, contractors, consultants, suppliers, banks, law firms, social movement organizations, and their participants share similar educational and professional training institutions (Scott, 2012). The private sector organizations have developed in parallel with the changes in the public and non-profit sectors, as they are engaged in the creation of governance systems for the field (Harvey *et al.*, 2010; Scott, 2012). Large-scale projects salient feature is the *dual nature* of these projects – since they apart from other types of temporary organizations operate in both global and local institutional environment (Ainamo *et al.*, 2010; Scott, 2012). These projects have to be built and operated in culturally diverse regional settings, so the institutional expertise is essential, if not more than technical, financial or engineering knowledge (Javernick-Will and Scott, 2010; Scott, 2012; van Marrewijk *et al.*, 2016).

At the meso level: managing large-scale projects as an inter-organizational setting requires a different approach as compared to managing project-based-organizations due to the distinct governance mode (Lundin *et al.*, 2015). To this end, there is a consensus in the literature regarding project networks and clusters – and in consequence on large- scale projects – that hierarchical model of governance fails in this context (Powell, 1990; Sydow and Windeler, 1998; Lundin *et al.*, 2015). Yet the type of governing mechanisms continue to be debated (e.g., Williamson, 1989; Powell, 1990). Without going further in-depth with this debate, large-scale projects are characterized by more or less inter-organizational cooperation and rely on trust and reciprocity (Kadefors, 2004; Lundin *et al.*, 2015). Hence, both cooperation and competition define the management of these organizational forms (Cao and Lumineau, 2015; Verschoore and Adami, 2020).

In the case of large-scale projects, when it comes to coordinating activities in the setting, project managers cannot rely on authority purely as within project-based-organization; they have to continuously (re)negotiate social order in a path-shaping fashion (Aaltonen *et al.*, 2017). The subtle interplay between cooperation and competition in the context creates challenges for project managers (cf. Lundin *et al.*, 2015). That is, apart from the daily tasks they have to engage with new managerial tasks: selecting delivery partners (Braun and Sydow, 2019), developing guiding rules (Davies *et al.*, 2016), securing finances and allocating project resources (Steen *et al.*, 2018), etc.

At the micro-level: the trajectory of large-scale projects has been studied as a specific social setting concerning professionals' knowledge (Grabher and Thiel, 2015). The practice turn in social science (Tsoukas and Chia, 2002; Nicolini, 2012), has gained prominence among scholars in large-scale project studies. Recent studies are emphasizing the practice and processual view of organizational work in large-scale projects set to tackle project governing (Brunet, 2018). Still, research at the micro-level form, as regards to what actually project managers do, remains quite silent in large-scale project studies (Sanderson, 2012; van den Ende and van Marrewijk, 2018). In a recent book published on project society, Lundin *et al.* (2015) commend neo-institutional theory for being applied to temporary organizations, including large-scale projects. Based on the work of 'structuration' (see Giddens, 1984) and the relationship between structure and agency, Neo-institutionalism, Lundin *et al.* (2015, p. 225-230) argues is better prepared than ever to inform research on projects and other forms of temporary organization. Besides, Bakker *et al.*, (2016) and Berends and Sydow, (2020, in press) explicitly call for the process perspective needed in studying temporary organizations, to capture the (inter-) organizational dynamics and stress the temporariness. Accordingly, the thesis investigates how dynamic institutional forces, the (inter-) organizational relations, and the temporary project nature influence the project processes and activities in space and time.

Chapter 3. Research methodology

This section describes the methods employed to answer the thesis research question(s), it discusses the overall research design and the methods related to data gathering, analysis, and interpretations and lastly the methodological considerations without delving into particular issues of data collection.

3.1. Overall research design

As indicated in addition to the cover essay, this thesis consists of three appended papers. Although the thesis compilation opens opportunities to address the whole research question in a sequence, i.e., through research papers, it also brings methodological issues. I return to this point and explain the challenges in the following.

The thesis is explorative in nature, engaging with the empirical context as the point of departure while with more latitude and serendipity, i.e., building on case research as theory ‘elaboration’ (Ketokivi and Choi, 2014). Serendipity in case study research as theory elaboration entails researchers’ openness to unanticipated findings while understanding the possibility that with time also theories need reconstruction and reconsideration (Lundin and Soderholm, 2013). In this view, empirical data are used not just to understand it but to challenge the general and taking-for-granted or already known ‘truths’ and understandings. The case research, as theory elaboration – in conceptual terms resonates with abductive reasoning. That is, the researcher in case elaboration prescribes a process of iteration between the empirical data and ‘general’ theory in this thesis research context – the institutional approach. Hence, the researcher seeks to modify the logic of the ‘general’ argument and reconcile it with idiosyncrasies of the context (cf. Ketokivi & Choi 2014). Therefore, although there is a significant inductive integral part, the thesis is not purely inductive. During the research process, I have brought various preconceptions based on my prior experience, and from the literature readings (Alvesson and Kärreman, 2011).

The thesis primarily relies on a qualitative case-based research method, Social Network Analysis (SNA) method, and employs quantitative means, for example, database search. It is argued that the explorative case study, which was mainly used in the thesis, allows the researcher to engage with the

context and produce context-dependent knowledge. According to (Flyvbjerg, 2006, p. 223), a case study offers a closeness to a real-life situation, and it is essential for the development of nuanced view, including the belief that human behavior cannot be meaningfully understood as merely the rule-governed act. That is, qualitative case study approach enabled me to uncover the contextual conditions, which are highly pertinent to the organizing of large-scale projects - helping to reveal project insides and (inter-) organizational dynamics instead of reporting from an inclusive perspective (Eisenhardt and Graebner, 2007; Eisenhardt *et al.*, 2016). Moreover, case-based research enabled the multi-level interactions within the study setting, which is most needed in project studies (Mathieu and Chen, 2011).

Given the multitude of actors in a large-scale project setting, the thesis empirically includes diverse actors' perspectives. For that purpose, I selected the three organizations:

1. Case I, 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. Case II, the main organization studied, was created in 1991 as a state company that manages and operates Spanish airports and heliports of public interest.

3. Case III, the consultancy organization studied, was established 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.

In line with the overall research aim and theoretical framework, the research design has a qualitative nature and relies on a multi-level process approach (Langley, 1999). In adopting a process approach, it relies on an extensive 'insider/ outsider' case study (Case I), in the Adif organization (Louis and Bartunek, 1992) seeking to explain how phenomena emerge, develop, grow, or terminate over time (Langley, 1999; Langley *et al.*, 2013). As indicated earlier, the thesis builds on three case studies. The first study represents an in-depth "insider" case study, where project-based processes in the division of Adif – the Spanish Administrator of Rail Infrastructure – have been examined longitudinally. The second and the third also qualitative case studies of project-based processes in the division of Organization B and C. The thesis employs a combination of data collection methods, including semi-structured interviews, (participant) observations, document analysis, and secondary data following the

intensive media discussion. As outlined in Table 1, Paper I and Paper II primarily rely on the first case study – the Adif case. Whereas Paper-III comprises the three cases – the Adif and Organization B, and C from case II and IIIrd, respectively. Apart from paper II, generalization in a statistical sense was not used. All the papers rely upon case-elaboration and theory building (Ketokivi and Choi, 2014), except for paper II, which also involves quantitative means. Paper II combines both qualitative and quantitative means; it relies on a theoretically-driven approach and a case study using SNA and Bayes inference. The process of data analysis and categorization is distinct for each paper, depending on the analysis framing and the specific literature interaction. I return to this point in section 3.4

Table 1. Details of the appended paper's

	Paper I	Paper II	Paper III
Topic	Exploring the emergence of lock-in in large-scale projects: a process view	Embeddedness and actors' behaviors in large-scale project lifecycle: Lessons learned from a High-Speed Rail project in Spain	An institutional approach to digitalization: The Limits of Building Information Modeling
Time Factor	2016-2019	2018-2020	2019-2020
Unit of analysis	Parent organization and the project context and network	Parent organizations and the project inter-organizational setting	Parent organizations and the project inter-organizational setting
Methodology	Process perspective; In-depth case study involving 19 interviews, 3 months observation, and more than 20 documents analyses	Project lifecycle perspective; Social Network Analysis, a case study involving 40+ interviews, 3 months observation, and more than 20 documents analyses	Three Case studies; 12 interviews, 3 months observation, and more than 20 documents analyses
Theoretical perspective	Path Dependence/Creation and Neo-Institutional Theory	Neo-Institutional Theory	Neo-Institutional Theory

3.2. Empirical setting

3.2.1. Case I

The Madrid–Barcelona HSL (Case I) that ran from the early 1990s to 2017 was ambitiously planned and designed to reach speeds of 350 km/h, connecting the Spanish capital of Madrid with the city of Barcelona (649 kilometers) to replace the existing air traffic route substantially. The project definition phase started in the mid-1980s. On 8 December 1988, the Spanish Council of Ministers approved to proceed with the project. The project was co-funded by the EU and the Spanish government and was considered to be a prestigious project since it connected Spain to the European high-speed rail network. As the owner responsible for the management of infrastructure, Adif developed the project scope as

three major construction phases. Throughout different stages, the track used different versions of the ERTMS security system. The first phase/ segment relies on ERTMS 1.0, while the other two rely on ERTMS 2.0. The major construction works within the project lasted for two decades (1990-2008). However, due to problems with contracts and suspensions during the period 2009-2017, the project's network organization continuously rearranged the project's design and plans, redefining its scope. The project faced uncertainties as the three phases progressed. For example, the 649 kilometers were contracted at a 9% decrease from the tendered amount but ended up costing 31% more than the amount contracted: the bid amount of €7.55 billion. The project was initially contracted for €6.80 billion, but ultimately cost a little under €9.00 billion. Table 2 below summarizes the Madrid–Barcelona HSL characteristics.

Table 2. Summary of the Madrid-Barcelona HSL project, up to 2010

<i>HSL Project</i>	<i>(Case I) HSL Madrid-Barcelona</i>
<i>Principal Client</i>	Ministry of Transport, Adif
<i>Main Contractor</i>	n/a –multiple consortiums, at least seven important
<i>Operator</i>	RENFE
<i>Length/ Project scale</i>	621 km
<i>Design speed</i>	350 km/h
<i>Operational speed</i>	300 km/h
<i>Approval date</i>	February 1988
<i>Construction start date</i>	The year 1999
<i>Inauguration of full service</i>	The year 2009

3.2.2. Case II and III

On March 9, 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 sector (Fomento Group and Ineco, 2018, p. 9). The goal was to facilitate the integration of information and

communication technologies (ICTs) in the management of infrastructures and transport, prompting users and public actors to use open data providing relevant information.

The new Directive 2014/24/EU mandates BIM adoption in infrastructure projects financed by EU public funds resulting in its application in several different countries. 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 had been made up of five different task groups that focus on distinct themes: strategy, people, processes, technology, and International Liaison (Fomento Group and Ineco, 2018). The BIM Committees' goal was to set a roadmap for the implementation of BIM in Spain. To fulfill this goal, the Committee has 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 Cases studied here, make part of the BIM committee. The Organization B, and C are situated in the infrastructure sector context in which they seek to deliver as per requirements set by the state agreement and the new BIM directive and policy agenda. That is, each of the organizations under study is represented in the BIM committee and actively participated in the series of the meeting – every six months. The organizational representative - these leaders considered the BIM initiative would ultimately be worth it, so they forced to implement it in their respective organizations.

The Ministry of Infrastructure complemented the above actions by establishing the Innovation Plan for Infrastructure and Transport 2018-2020, which help analyze the use of BIM in rail infrastructure, airports, harbors, and other linear infrastructures (Fomento Group and Ineco, 2018). 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, 2019). As mentioned earlier, the action plans were established by the organization

representatives. However, the longer-term goals, each of the representative's and organizations' visions for 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 long-term goals to pursue.

3.2.3. Case selections strategy

The three cases examined here illustrate organizing and practices driven both by organizational agents and by adaptation to the institutional and technological project environment. As Stake (2006) highlights, case study research is concerned with the complexity and particular nature of the phenomenon under observation; its adoption overcomes the pitfall for researcher biases. According to Stake, 2006, (p. 28), in case-study, "the researcher has certain possible influences in mind, - but sweeping widely, the researcher lets his or her mind and eye scan many happenings, variables, and contexts. He or she examines different activities in different settings, looking for 'correspondence' and patterns of covariation." To this end, the three cases were considered symbolic in terms of infrastructure investment and engagement, and there was considerable documentary evidence of them in newspapers, audits, and official reports, particularly in Case I (Report, 2012, 2017; Omega Team Report, 2014). These three cases were selected following several criteria: (1) the core business and operations involved infrastructure and technology management, (2) the organizations had central positions in infrastructure projects, and were heavily involved in the digital transformation recently (Fomento Group and Ineco, 2018), and (3) during the data collection, the organizations were continuously collaborating in BIM technology adoption and implementation.

One primary reason for selecting these three cases, particular the multi-actor Madrid-Barcelona within Adif is the consideration for it as both critical and representative case (Yin, 2013, p. 43). Besides, I selected the other two cases through theoretical sampling because I consider them to be suitable and revelatory in the light of institutional constructs and process theories (Eisenhardt and Graebner, 2007). Firstly, the institutional context for the three cases shares similar regulative and, normative demands under the European umbrella and Spanish context (cf. Eriksson et al., 2017). The railway sector in

Europe has undergone considerable (de)centralization variation over time as a sector (Geyer and Davies, 2000). Although the institutional reform of the rail sector took place in different years, late 2002 in Case I, and in 2004 on the other two cases, the three cases resemble the same institutional context (i.e., Spanish regulatory system). The Spanish state remains the principal stockholder, the infrastructure manager Adif (Spain), and Organization B operates under the direct authority of the Ministry of Public works. At the same time, the concession of the leading railway network has been assigned to the former state railway operator Renfe Operadora for a limited period (Duijnhoven, 2010, p. 204).

3.3. Data collection

The primary source of information consisted of interviews with respondents from the management division, involving more than 50 interviews tracking the Madrid-Barcelona HSL projects over more than 4 years of situated study, which included informal conversations with the managers, designers, and engineers. Interviews were semi-structured, lasted approximately one and two and a half hours each, and were digitally recorded and transcribed. Members of Adif and the other two organizations B, C, and project managers (PMs) from large contractors involved in the projects were interviewed repeatedly over more than 4 years. Also, informal contact was maintained between formal interviews via e-mail and telephone. Participants included the head of infrastructure projects, the head of systems integration projects both at Adif and ProRail; Project Manager(s), the construction manager (CM), civil, and environmental engineers, including the PMs of organizations A & B (both large contractors to the particular project) and organization B and C. In addition, document analysis, and observations were made. In the following section, the data collection for the three cases is explained in greater detail. Concurrently with the interviews, I studied the project documentation made available, both as a continuous data validation effort and to increase the understanding of the interviews. More than 45 documents were reviewed, including programme documents (internal financial and audit reports, overview presentations, internal organization and escalation matrices, lessons learned, and programme tools).

3.3.1. The Case I: Interviews and observations

In addition to the document analysis, for the HSL Madrid-Barcelona, data was collected during two periods, which enabled a longitudinal view of the project over the entire project lifecycle, see details in appendix A (Paper I). Accordingly, I visited the Adif project offices and site to conduct the data collection in person. This round of data collection also involved interviews held in Spanish and direct observations this time. The main period of data collection took place between 2016 and 2019, and about 52 interviews were held during this period. Given that the institutional influence cannot be measured objectively (Scott, 2012), and when considering the difficulties to empirically distinguish among the institutional and technical rules and procedures (Scott and Meyer, 1991). I consciously attempted to discover interviewees' points of view (Gioia et al., 2013). In conveying this research on the institutional influence on the HSL project arrangement, I asked questions regarding project goals, project design, and potential impacts in the project decision-making.

The methodological triangulation used included biographical interviews, observation, participant observation, group interviews, and desk research. The interviews were semi-structured and lasted 60–90 min. Each interview was digitally recorded and then transcribed. Within this period of data collection, I also conducted direct observations at the Adif management division during three months between August and November 2016. I spent two to three days per week at the Adif offices in Madrid and conducted seven direct observations of management meetings. Recording meetings was not permitted. Instead, observations relied on extensive notetaking and, to ensure reliability, observations were discussed with Adif team members during the interviews. Besides, to overcome the potential subjective interpretation, the interviews were triangulated with the findings from the document analysis and the overall interviews collected throughout both periods.

3.3.2. The Case II and III: Interviews and observations

Data for the case II and IIIrd was collected between 2018-2019, during the adoption and implementation of BIM in procurement projects. For the most part interviews were conducted by my supervisor and me—one taking notes and the other doing the interview, which is called researcher triangulation. In total, we conducted 11 interviews with respondents from the three organizations.

Interviews were held in Spanish and typically lasted between one and a half hours. All interviews were transcribed after they had taken place. Finally, data triangulation was applied in terms of the sources consulted, including interviews, websites, public reports, management reports, internal reports, and public hearings. Thus, I have collected information from multiple levels and different actor viewpoints, including Adif and Organization B and C management division, major contractors, and suppliers. Table 3 below, describes the criteria used to select the interviewees, which was based on their profiles, organizational background, and involvement during the project's lifecycle. However, due to practical considerations, I did not recruit interviewees such as local government employees, other local subcontractors.

Table 3. Interviewee representativeness, their profile and organization background concerning the project life cycle

<i>Design Consultant</i>	☐	☐		
	☐	☐		
<i>Contractor</i>		☐		
		☐		
<i>Supplier</i>				☐
				☐
<i>Project owner</i>	☐	☐	☐	☐
	☐	☐	☐	☐
	<i>Project Definition</i>	<i>Plan</i>	<i>Execute & Control</i>	<i>Closeout/ Operations</i>
Organization background	Project life cycle involvement			
Case I - Adif	>50 interviews			
Case II and III - Organization B & C	>10 interviews			

Apart from qualitative data, quantitative data were collected. Quantitative data involved, for example, information regarding the tendered amount, the granted amount, changes to time and economic intelligence, delivery times, initially measured span, term contracted, contract winner, etc. Data formatting was required, so the data was imported into an SQL platform, which allowed querying and reviewing of the contractual progress, description of relationships from the commencement of the investigation, and their progression throughout the project implementation. The dataset underpinning the quantitative inquiry comprised more than 5,000 contracts narrating to over 4,000 sub-segments of the HSL. It is worth remarking that a particular agreement could apply to several sub-segments. The

typology for these agreements treated eight distinctive topics in varying stages, from plan to development and maintenance. When contemplating the entire portfolio, the timespan reached from September 1996 till December 2016 and included more than 1,700 diverse contractors. Data regarding the awarded delivery dates and budget was also provided at the contract level, in such a way that variations in both schedule and cost could be analyzed by contract level, period, section, or contractor.

In the following, I summarize the research data collected in the three cases, see Table 4.

Table 4. Summary of data collection

Data collection method		Data collected
<i>The case I: Madrid-Barcelona HSL project</i>		
Semi-structured interviews	Period (1996-2010)	several interviews with the HSL PM, Adif Quality Controller, Head of Infrastructure Projects, Engineer at Organization B, project proponent, and other relevant actors. The average duration was slightly over one hour.
	Period (2016-2019)	52 interviews with the program managers and other relevant actors (project managers, construction manager at Adif, Organization 'A' Contractor PM, Organization B Supplier, Organization C Contractor PM). The average duration was slightly over one hour.
(Participant) Observations	Period (1996-2010)	<ul style="list-style-type: none"> ○ participant observations, ○ group interviews, ○ Extensive informal communication
	Second period (2015-2010)	The insider spent 2–3 days per week at the organization's offices and conducted observations: <ul style="list-style-type: none"> ○ Seven management meetings; ○ Extensive informal communication; ○ Field notes for each of the days spent on-site;
<i>Case II and III: Organization B & C</i>		
Semi-structured interviews	Period (2018-2019)	More than 10 interviews with two public-private organizations in the field involved: a state company that manages and operates Spanish airports and heliports of public interest; and the consultancy organization, which provides technical consultancy to the public-private project in the context of Spain. The average duration was slightly over one hour. Interviews with relevant stakeholders in the BIM adoption and implementation projects (project managers, construction managers and other BIM Engineers, Architect IT Coordinator, Program Coordinator) involving also: <ul style="list-style-type: none"> ○ group interviews, ○ desk research, and ○ Extensive informal communication
Document analysis	In total more than 30 documents: <ul style="list-style-type: none"> ➤ Internal program documents (internal financial and audit reports, overview presentations, internal organization and escalation matrices, lessons learned, and program tools, e.g., risk logs). ➤ Multiple audit inquiries related to the HSL South project: the investigation of the HSL tender process (Survey-Committee-Construction, 2002), and of the tendering of the high-speed trains (Report, 2003, 2010, 2013, 2017). ➤ Organization-wide guidelines and frameworks for project and program risk management. ➤ Three hundred pages of public material drawn from the press coverage of the project. 	

3.4. Data analysis

After the data collection, co-authors and I performed an in-depth analysis of the data collected. By taking an outsider perspective, the co-authors helped to make sense of the data, scrutinizing and challenging my interpretations. Apart from paying attention to the multiple voices of different interviewees (Gioia *et al.*, 2013), in the three cases, I searched to identify competitive alternatives.

Following the guidelines for qualitative inquiry (Denzin & Lincoln, 2011), within all three appended papers, I used both first- and second-order analyses. In the first empirical study (paper I), I employed a strong process view (Langley *et al.*, 2013), and scrutinized the subject of the research, relying on observations. Besides, using part of the data collected – the interviews helped to explore further how the PMs coped with different issues. In line with the purpose of process studies, I used the concept of 'temporal bracketing' (Langley, 1999), decomposing three distinct periods T1 (1990-1998), T2 (1999-2008), T3 (2009-2017) to sequence the processes and events chronologically for analytic purpose. I explain this process in detail in the appended study – appendix A. Similarly, in papers II, and III, I analyzed the data qualitatively based on the respective analytical framing. That is, each paper has its process of data analyses, which is explained in a very detailed level in the individual articles.

Overall throughout the thesis, I have aimed at applying a multi-layer lens to analyze the empirical data on the influence of institutional environment in the HSL project from a contextual, (inter-) organizational and practice level, see Table 5. The multi-scalar method approach was exploited through different papers. In paper II, I aimed to understand how the project's institutional environment influenced the process of project arrangements and actor behaviors. Similarly, in the paper, I, the institutional environment influence in project processes and activities, was tackled by following an unowned process approach (Langley *et al.*, 2013; Mackay and Chia, 2013). Within the first paper, I, however, zoomed-in closer to the subject of study. This close perspective helped to understand – the practice – how the management team organizes their activities and how they relate to different issues. At the other end, certain choices required the bird's view – zooming out to detect the effects of institutional setting its history and context. According to Langley *et al.*, (1995), in adopting a process perspective, researchers need to zoom outwards also to consider the histories of the project organization over long periods, as in the research of Engwall (2003). In paper II, I employed a project lifecycle view

and directed the attention to the course of shared history - in the phenomena that I describe. To this end, in all of the appended papers, I applied event structure analysis and process tracing (Langley *et al.*, 2013) identifying the main cross-case patterns of importance: including the institutional environment, its structure, the legal boundaries influencing the project processes, etc. Given the observations, which enabled a closer view – to the practice level. In the paper I, while tracing choices through time, I paid particular attention to both the intended and unintended consequences: 'the peripheral events seemingly remote' from the project—in creating the storyline of events (Mackay & Chia, 2013, p.211). Apart from qualitative analysis, including interviews and observations, paper II relied on quantitative analysis (Morgan, 1998). The quantitative approach first involved the use of social network analysis (SNA), measured the structural attributes of the multiple contract packages of the HSL project, tracing change patterns, and several contract flows. Second, the Bayesian approach was used, employing the quantitative data to exploit the fields of uncertainty stemming from actors' behavior in the project setting. Its application enabled the owner's response capacity to be assessed, vis-à-vis the selected actor/contractor.

Table 5. The influence of institutional environment at different levels of analysis in the case studies

Level	Empirical findings	Analysis of the institutional influence	Papers covering this information
Contextual	The problematic history of HSL project, most European railway systems were organized in the form of state-owned and vertically integrated monopolies, during 90's the railway systems have been restructured and deregulated in both cases. The evolution of the field –restructuring the institutional environment. The institutional structure, in the case I, was restructured. Adif was created during the project implementation representing a new actor in the organizational field.	The influence of the institutional environment, the dynamic forces become increasingly critical over time. Rule guided behavior, the HSL project has adopted a hierarchical governance structure to control and monitor the project. This also implied a mode for justification of internal investment decisions and help contractor's engagement	Paper I, II, and III
	Social and political resistance among the Spanish community; on 1994/96 the ministry of Transport and the Ministry of Spatial Planning competed for the preferred route	The influence of the institutional environment is not unidirectional, and it varies in terms of the management responses.	
		In such a context, the three cases had to be constructed in harmony with the time requirements, thus breaking	

<i>(Inter-) organizational</i>	<p>The adoption of joint rules in the ADIF organization, the model continued to replicate in similar projects, and it became fixed. Even though project members recognized challenges with time in the governance structure, they failed to change the practices</p>	<p>the monopolistic positions, i.e., separating the ownership and the operations of the infrastructure based on the Council of EU Directives. This turned out to be, as our interviewees interpreted, a very "complex" and challenging endeavor.</p>	
	<p>It is critical to highlight the new project collaborative practices, the emergence of PPP as a new form of collaboration in project contexts. Besides, BIM platform emergence as a new form of collaboration in their project-based organizational contexts.</p>	<p>The management in Case I and other project actors involved in the project aimed to institutionalize the new project delivery model and the new underlying practices.</p>	Paper I, II, III
	<p>Formalizing contracts - the plan of actions to follow the BIM guidelines.</p>	<p>The influence from the institutional environment was unpredictable and varied at times. Thus, the project organization became loosely coupled with its behavior structure. That is, project actors struggled to control and anticipate the drifting environment and engaged in improvisational actions.</p>	
	<p>The industry and regulatory regime influence the management activities, as the transportation sector and the rail industry has been increasingly based on contractual relationships (Case I).</p>		
	<p>Actors were likely to adhere to the industry guidelines (e.g., ERTMS standard) defining the construction and operational practices. Industrial norms governed project processes in the situation when the permanent becomes a temporary condition in social systems.</p>	<p>Building embedded relationships with institutions in the environment. Formalizing and professionalizing operations and organizational structures to follow the BIM mandate.</p>	
<i>Practice</i>	<p>A strong emphasis on control framed management decisions in the project. Such a tendency was reinforced by further industrial specialization: e.g., the development of ERTMS.</p>	<p>Multiple actors serve to engage in joint objectives. The more efficient the interaction among the actors in the project, the more efficient the choices they made. To some extent, their choices became anticipated. For them, it is more attractive to adapt to the rules.</p>	
	<p>In the three cases, the PMs and their teams turned to symbolic actions, and these actions emerged out of interaction with the institutional environment in their tendency to communicate with their "central stakeholders."</p>	<p>The symbolic performance of project management into coping with the drifting environment; different legitimacy approaches during the HSL project(s) processes.</p>	Paper I, and III
	<p>Lack of motivation to improve everyday choices in the project and at the organization level. Instead, the behavior to stick to the same choices was likely to gain more legitimacy and triggered more acceptance</p>	<p>Actors' focus is underlined by simplicity in interaction, exploiting the strength through gaining learning effects while losing the opportunities. Thus, choices became more natural and narrowly focused.</p>	

<p>The interviewees generally interpreted the necessity for their projects to be aligned with the "macro-level," for example, with central stakeholders: the funding sources, the regulatory regime, and the government managerial units. The interpretation from the Adif management revolving the management model choice because of the social, cultural, and political issues regarding the HSL project and history process.</p>	<p>Forces of public operators have been significant – driving decisions in the project.</p>
<p>In the project context, members were willing to adopt the best PM practices in choice selection. Since members were uncertain for the choice selection, they felt safe in following the preferred choice. Thus, a dominant solution emerged.</p>	<p>Building embedded relationships with institutions in the environment. Formalizing and professionalizing operations and organizational structures to follow the BIM mandate.</p>
<p>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.</p>	<p>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.</p>

3.5. Criteria for judging the trustworthiness of the research design

According to Yin (2013, p.34), a case study research design should follow a "logical set," that can be judged based on the quality criteria – developing specific logical tests. However, I draw on broader principles from the social science research approach (Denzin and Lincoln, 2011; Yin, 2013). Thus, eight trustworthiness criteria were employed to ensure the rigor of the research study design: reliability, external validity, dependability, confirmability, and integrity, taken from interpretive view (Thomas et al., 2007; Yin, 2013). Fit, understanding, and generality are made from grounded analysis, respectively (Gioia et al., 2013). Table 6 shows the criteria and steps to address the requirements for both case I, II, and III.

Table 6. The rigor of the study: Criteria and actions to address the requirements

Criteria and explanation	Steps to address the requirements
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<i>Reliability (the extent to which the findings appear to be representations of the data)</i>	<p>The interviewees were asked to verify the interpretations of data obtained from the interviews and reports;</p> <p>The use of the case study protocol and the development of the case study report. The case study report(s) were sent both to ADIF and Organizations B and C, respectively, for their consent to publish. Also, the final workshops discussing findings were held;</p> <p>Triangulation/ corroboration of data sources between interviews and reports. No contradictory evidence was identified via triangulation of data sources</p>
<i>External validity (the extent to which the findings from a study in one context will apply to other settings)</i>	<p>It is ensured using the strong theoretical foundation as the neo-institutional lens (Meyer and Rowan, 1977; DiMaggio and Powell, 1983; Scott, 1987) and the use of the replication logic and comparisons between the three cases enabling generalizations.</p> <p>Transparency of the study analysis, enabling the replication of the findings, details in appended papers (Yin, 2013, p. 37)</p>
<i>Dependability (the extent to which the results are unique to time and place; the stability or consistency of explanations)</i>	<p>All interviewees are experienced project managers that have expertise and knowledge regarding decision practice and their work with project management in LIPs setting;</p> <p>Consistent comparisons between the three cases, in the III paper;</p> <p>Interviewees reflected as far back as >10 years;</p> <p>Secondary data, including internal reports, was reviewed as far back 15-20 years.</p>
<i>Confirmability (the extent to which interpretations are the result of the participants and the phenomenon as opposed to research bias)</i>	<p>Triangulation and pattern matching among the data;</p> <p>The interviewees were asked to verify the interpretations of data obtained from the interviews and reports;</p> <p>By taking an outsider perspective, the third and fourth authors helped to make sense of the data, scrutinizing and challenging the interpretations of the first and second author</p>
<i>Integrity (the extent to which misinformation or evasions by participants influence interpretations)</i>	<p>No contradictory evidence was identified via triangulation of data sources;</p> <p>Confidentiality of obtained data was assured to all interviewees through the signed confidentiality agreement both in the case of Adif and Organizations B and C at the initial of the study.</p>
<i>Fit (the extent to which findings fit the substantive area under investigation)</i>	<p>It is ensured by reliability, external validity (in comparison with the existing theory), and confirmability of the study.</p>
<i>Understanding (the extent to which the interviewees and other participants accept the results as possible representations of their world)</i>	<p>The interviewees were asked to verify the interpretations of data obtained from direct observations, interviews, and reports.</p> <p>The case study report(s) were sent to ADIF and Organizations B & C for their consent to publish.</p>
<i>Generality (the extent to which findings cover multiple aspects of the phenomenon)</i>	<p>The interviews last between one and a half hours each enabled in-depth insight to the project practice and allowed for flexibility in the discussion;</p> <p>Within the three cases I searched to identify competitive alternatives. Thus, I have collected information from multiple levels and different actor</p>

viewpoints including Adif management division, principal contractors and suppliers involved in the project(s); Organization B and C.

Particularly case I, was considered symbolic in terms of infrastructure investment (van Marrewijk, 2017), and there was considerable documentary evidence revolving them in newspapers, audits, and official reports (Report, 2012, 2017).

Chapter 4. Summary of the appended papers

This section briefly presents the three appended papers. The author's contribution, the workload designated for each research article, is shown in Table 7.

Paper	Paper status and outlet	Order of authors	Author's contribution
I	Published 28/10/2019 - <i>International Journal of Project Management</i>	Hetemi, Jerbrant, Ordieres	The study design was carried out by Hetemi and Ordieres. Both Ordieres and Hetemi collected the data. Hetemi analyzed the data, while Jerbrant and Ordieres helped to make sense of the data by taking an outsider perspective, criticizing and scrutinizing the interpretations. The paper was mainly co-written by Hetemi and Jerbrant, with Hetemi as the primary contributor.
II	Published 03/06/2020 - <i>Journal of Management in Engineering</i>	Hetemi, Gemünden, Ordieres	The study design was carried out by Hetemi and Ordieres, based on an idea proposed by Hetemi. Both Ordieres and Hetemi collected the data. Hetemi and Ordieres analyzed the data, while Gemünden helped to make sense of the data by taking an outsider perspective, criticizing and scrutinizing the interpretations. Both Gemünden and Ordieres contributed valuable ideas during the discussions. Hetemi wrote the paper.
III	Published 08/05/2020 - <i>Sustainability</i>	Hetemi, Ordieres, Nuur	The study design was carried out by Hetemi and Ordieres, based on an idea proposed by Hetemi. Both Ordieres and Hetemi collected the data. Hetemi analyzed the data, while Nuur helped to make sense of the data by taking an outsider perspective, criticizing and scrutinizing the interpretations. The paper was mainly written by Hetemi and Nuur, with Hetemi as the primary contributor.

4.1. Paper I

Purpose – The purpose of this paper is to investigate the emergence of *lock-in* in large-scale infrastructure projects. Its particular aim is to understand the emergence of lock-in, to shed some light on the contextual conditions that give rise or support the emergence of lock-in concerning the institutional influences, pre- and post-project effects and management practices at the project level.

Methodology – This paper builds in a qualitative, longitudinal case study (Rowley, 2002). The research setting is the multi-actor Madrid–Barcelona High-Speed rail Line (HSL) project in Spain. The data was collected at two periods, which were carried out under the supervision of the third

author, which enabled an in-depth contextual analysis. The first period of data collection was from 1996-2010, during which the third author provided privileged access to data due to his role as research advisor to Adif on several project portfolio issues. Over 40 interviews were held during the first period of data collection. The second period of data collection took place between 2015-2018. Similar to the first period, 12 interviews and this time, observations involving seven management meetings were carried. In total, 17 interviews were useful for this study. The data analysis included a second-order analysis (Denzin & Lincoln, 2011).

In the first order, the case history was written – creating a thick description of managerial choices and processes (Langley, 1999). In the second-order, Sydow et al. 's., (2009), self-reinforcing mechanisms grounded the categorization of the data. In line with the abductive approach, we continually reviewed the literature on project studies, path dependence/ creation, and organizational processes. To this end, following a robust process approach (Langley, 1999; Langley *et al.*, 2013), we applied 'temporal bracketing' decomposing three distinct periods T1 (1990-1998), T2 (1999-2008), T3 (2009-2017) to sequence the processes and events chronologically for analytic purpose. We employed concepts relating to the organizational mechanisms, to understand how the project's (inter-) organizational setting influenced the emergence of lock-in. We identified additional effects by which the project's (inter-)organizational context influenced the choices and the emergence of a 'soft' lock-in (Sydow et al., 2012, p. 170). After the coding and the emergence of the first-order themes (Gioia et al. 2013), we engaged in axial coding to identify the second-order themes (Gioia et al., 2013). From this detailed case analysis, five other effects emerged, which complemented the data structure.

Findings – Lock-in has been contemplated either as a starting point or an outcome, but the process logic that gives rise or supports it remains underexplored. In our aim to complement the reductionist view, we contend that the emergence of lock-in in large-scale projects is a behavioral pattern grounded in prior ties and the interactions of the actors involved. The process perspective that we used, however, served to enrich the understanding of lock-in. Through our qualitative inquiry, the findings demonstrated the influence of several mechanisms and effects not only on the project but also from the project network on the emergence of lock-in in the large-scale Madrid-Barcelona HSL project. Also, the implications of its inter-organizational and temporary nature. Our findings indicate

that to understand decision-making in large-scale projects, there is a need to change the ontological priorities that underpin the existing research on the behavioral decision in project management. We develop a conceptual process framework to explain the emergence of lock-in in large-scale projects through the influence of different (inter-) organizational mechanisms and effects.

Research implications – employing a robust process approach, the paper suggests that lock-in emergence and process in projects, in general, requires the recognition of the long-term (inter-) organizational context. A view concerning mechanisms and effects rather than confining decisions to the individual single actor control in the front end of projects. The managerial implication of this paper is that a numbers-logic oriented tradition of cost/benefit analysis is unable to suggest how lock-in emerges and has a potential influence on project performance. Alternatively, attention should be directed to the understanding of the (inter-) organizational elements in the context as an essential feature of project management practice.

Originality/ value – The paper provides nascent theorizing on how the temporary and (inter-) organizational nature of large-scale projects affects the emergence of lock-ins. Rather than taking the view that confines decisions to the individual or single actor control in front-end of projects, the paper through a rich longitudinal case study examined the development of the decision process throughout the evolution of the project – considering its (inter-) organizational context. The conceptualization of lock-in emergence through mechanisms and effects as non-purposive revealed another side compared to the reductionist view (e.g., Cantarelli et al., 2010; Flyvbjerg, 2013).

Contribution to the thesis – The paper contributed to the understanding of path dependence/ creation logic at the project inter-organizational level.

4.2. Paper II

Purpose – This paper focuses on the structural and relational governance mechanisms in large-scale infrastructure projects, to examine the behavioral patterns of project actors as contracting parties.

Methodology – The paper employs a project lifecycle view, building on a theoretical analysis it puts forth a set of propositions, relevant for the study of the inter-organizational actors' behavior

during the project lifecycle in the context of large-scale infrastructure projects. Through the examination of an empirical case, the multi-actor Madrid-Barcelona high-speed rail line (HSL) project (1990-2017), it illustrates how the propositions can be used to explore the behavior of actors' in the inter-organizational setting. Methodologically the paper is based on a longitudinal case study (Yin, 2013), combining both quantitative and qualitative data (Morgan, 1998), which was gathered from an inter-organizational delivery project from the construction and information systems of Adif - the Spanish administrator of rail infrastructure. First, we approached the data through a quantitative approach, which informed the future qualitative inquiry.

Findings – findings point to the significance of project lifecycle and project phases that are dramatically different, indicating that project actors engage in a diverse set of influence activities, where project actor's flexibility and project owner response is crucial. Besides, the findings suggest an influence of the institutional environment in the contracting form and the governing process, and consequently to the actor's behaviors and their governing activities. It advances the concept idea that an active owner is vital to effectively cope with the high transaction costs, uncertainty, and opportunism in large-scale infrastructure projects.

Research implications – by employing a project lifecycle view, the paper enhances the comprehension of project actor's behavioral patterns in the context of large-scale infrastructure projects. While existing literature presents all-embracing and timeless propositions, this paper presents specific propositions and explains the project actors' behavioral patterns during the project lifecycle. Extant research states the importance of contract design and argues for the need for sophisticated contract design in mitigating cost and time escalation (Turner and Simister, 2001; Winch, 2010; Gao *et al.*, 2018). However, a much-sophisticated contract design only partially addresses the dynamics of driving escalation and other issues identified here – some of them are internal to the project owner organization and closely linked to the public project context. Besides, while few quality and effects of inter-personal relations and behavior attributes may explain the potential governing activities and actors' behavioral patterns; the adoption of a lifecycle perspective in our case analysis brings a view that has been missing from much of the existing literature (cf. Söderlund, 2011). Project urgency, contractual loopholes (public contract tolerance and the latitude

for speculation) together with contractor's opportunism, and the passive project owner trapped with the inertia of prior contractual commitments and the escalation dynamics were identified to influence both governance salience, i.e., the public project context reliance on formal governing mechanisms and safeguards, as well as the project actor's behavioral patterns during different stages of the project lifecycle.

Originality/ value – to the best of my knowledge, this is the first attempt to provide a lifecycle perspective and discuss actors' behaviors in terms of patterns in the project setting. Besides, it is one of the recent tendencies to link the institution environment influences in the project and the governing activities. Conclusively it affirms that each lifecycle phase is distinctive and characterized by different constituents that affect both the governing actions and the project actor's behaviors and their strategizing.

Contribution to the thesis –the paper adds an institutional explanation to the conditions shaping project actor's behavior in large-scale infrastructure projects.

4.3. Paper III

Purpose – This paper adopts an institutional analysis and puts the BIM technology in the (inter-) organizational context in infrastructure delivery. It takes into account the agency – as organizations are 'inhabited institutions' at the end, and the institutional norms, practices, and logics in them are significant.

Methodology – The research design for this study is based on three qualitative case studies of evolving digital transformation, involving BIM technology. Drawing on empirical data from three organizations in infrastructure delivery in Spain, the paper analyses the tensions among actors during BIM adoption and implementation. The four-stage process model by (Swanson and Ramiller, 2004) of firms involved with an IT innovation serves the analytical purpose. Given the effect of the BIM mandate in the (inter-) organizational context, I 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.

Findings – The findings reveal three main logics competing throughout BIM adoption across organizations: the state, corporate, and the professional. The empirical analysis findings show that the management teams’ practices were strongly influenced by the government or industrial norms and corporate logic. The flow of influence remains notoriously lopsided. That is, during the comprehension process phase, the institutional structures, have had more impact on the actor organizations in the field than the reverse. Besides, the most critical distinguishing logic during the technology adoption process phase is professionalism. Because the material aspect of the technology requires the active engagement of professionals, triggering the mindful technology comprehension processes. The professional logic can be crucial, especially when it becomes “direct,” and aligned within their rationale (the case of organization C). That is, corresponding internal or external institutional work by professionals for BIM comprehension and adoption across organizations results in more successful BIM implementation in projects.

Research implications – The point of departure is the institutional project framework and its potential for complementarity in explaining the adoption and implementation BIM technology. While existing studies have excessively focused on the economic aspects undermining the social effects. This paper presents the actor organizations and project individuals embedded in the institutional context, which in turn influences the adoption and implementation of latest technology.

Originality/ value – Although the current debates in the BIM literature correctly argue that BIM technology has made coordination and inter-organizational collaboration open and almost free-flowing, the actual practice entails an institutional logic. The current debate in BIM literature is, for the most 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. This paper, therefore, suggest that the current normative view be complemented with an evolutionary ecosystem approach in line with Singh and colleagues, and through the Industrial Marketing and Purchasing (IMP) approach that views technology as context-dependent and through organizational relationships of various actors being individual professionals or organizations.

Contribution to the thesis –the paper adds an institutional explanation, framing BIM technology as digital transformation in the infrastructure sector. Such a view simultaneously reveals the

integration and standardization and how this relates to the local (inter-) organizational configuration context, including the practice, in time and space.

Chapter 5. Discussions

This section discusses the findings of the thesis. The thesis aim is to enhance our understanding of large-scale infrastructure project organizing by contextualizing them and empirically providing a more dynamic process view. Following the thesis groundings, the discussion is brought on a multi-scalar view, offering insights into the organizing of large-scale infrastructure projects. First, the contextual influence at the macro-level is presented; then following a relational (inter-)organizational context, the multifaceted elements are tackled at the meso-level. Finally, the project practice and micro-level actor's activities of path shaping are shown.

5.1. The multi-level perspective on large-scale infrastructure projects: path-dependent or flexible.

5.1.1. The macro- and meso-level

The institutional (logics) analysis, coupled with the processual character emphasis for a sociotechnical understanding of the large-scale projects as (inter-) organizational setting that are applied in this thesis, outreaches the existing normative dominant perspective and the technological determinism in project studies (Orlikowski and Barley, 2001; Greenwood *et al.*, 2008, 2011; Scott, 2012, 2013). Hence, it looks beyond the functional discourse of large-scale project organizing, the digital veil, and thoughtfully considers the (inter-) organizational dimension and institutional actors' interpretive framing. At the macro- and meso-level, paper, I, II, and III of this thesis offer a multi-dimensional answer as to how the institutional environment influences the processes and activities of large-scale infrastructure projects. The papers shed light to the (inter-) organizational dynamics and (multiple) actors' behaviors in infrastructure framework. They show that large-scale projects are embedded in complex institutional and technological frames, which in turn heavily influence the project processes and activities. To this end, the project actors' (organizations and individuals alike) are viewed as embedded when they set relations in such a way that are affected and affect other's behaviors and context.

For instance, the paper I shows that the institutional setting grounded the design choice path and orchestrated the effects at the permanent organizational level that shaped the choices made during the

HSL projects. Also, paper II shows that the institutional influence on the large-scale project process is recursive and that it is not unidirectional. The paper illustrates that the large-scale project arrangement is predominantly challenged by the impact of institutional elements of the project environment. Therefore, the institutional issues in large-scale infrastructure projects are beyond the technical ones. This means that project embeddedness in the case of large-scale infrastructure projects is of crucial importance. Thus, the institutional expertise is equally important if not more than the economic or engineering expertise (cf. Scott, 2012). Particularly because large-scale infrastructure projects extend across sectors, requiring adaptation to numerous salient institutional elements, e.g., regulative, normative, cultural-cognitive dynamics. Therefore, the attention needs to be directed to the institutional environment and the inter-organizational context, which frame the interest and desires of the project actors' in the field.

Paper I stresses that the understanding of project processes and their emergence in large-scale infrastructure projects, demands a view of the properties of the aggregate structure of the interactions among project actors and the industrial regime. To this end, the path of choice formation is a process involving (inter-) organizational interests and desires – it is not under the control of the single actors, for example, by project estimators and promoters, as the dominant perspective in large-scale project studies implies (Cantarelli *et al.*, 2010; Flyvbjerg, 2013). Paper I clearly demonstrates that the relational interdependencies among events at different levels influence the decision-making process and finds that the lock-in emergence is both subject to external and internal events. Important external events involve, for example, the procurement method, the industrial features – the ERTMS system requirements, and the uncertainty as a function of the environmental definition arising because of the diverse project actors. On the other hand, the internal events involve the embedded work practice (experience and modes of collaboration), the causal ambiguity of the work organization, the level of specialization, and the technology involved.

Given the entanglement of technical and social constructs in the inter-organizational setting, the paper I find the constituents introducing path dependency. It reveals particular conditions supporting inertia – the antecedents of path dependence. The findings illustrate that Adif management and the project actors, were less likely to alter their decisions or their grounded practices if the following

occurred: 1) due to coordination effects – if established patterns or routines were dominant among the actors privileging efficiency; 2) due to the complementarity effects – if previous collaboration among the actors existed, i.e., already a set of practices and synergies existed that made it less likely the choices alteration; 3) due to the learning effects – the lack of motivation to introduce new or improve the project practices as a consequence of preferences for more repetitive choices; and 4) due to the adaptive expectation affects – the actors in the project have previously collaborated and expected each another to follow certain behaviors and the engagement with project management best practice. Specifically, these findings advance the recent discussion by Aaltonen *et al.* (2017) and show the contextual conditions that give rise to or support the emergence of lock-in. Therefore, large-scale projects develop inter-organizational path dependencies. Yet, at the same time, since they involve project actors' interdependencies, they cannot lock the choices deterministically, i.e., into a deterministic trajectory. To this end, Paper I argues for a soft lock-in, it empirically defines the choices in a large-scale infrastructure project, as partly restricted at the beginning of the process (as a consequence of the project actors' shared history), and the continuously influenced by various changes, in the institutional and industrial setting and internal dynamics at the project level. In this view, lock-in provides the necessary ongoing social construction during the project arrangement and the negotiated mission throughout the project implementation. I will return to the latter when discussing the micro-level – the project practice.

Paper II offers a more dynamic and substantive account of the institutional environment and the project network detail. Examining the process of project arrangements develops a deeper understanding of large-scale project embeddedness and governance inseparability. The fundamental idea that paper II puts forth is that the governance choice in large-scale projects are actually more particularistic than the current discourse portrays. Hence, focusing on the characteristics of isolated transactions seems insufficient to explain the large-scale project performance. Following Argyres and Liebeskind (1999, p. 49), contractual commitments play a crucial role, and they should be discussed in context. Hence, the regulatory environment and prior contractual obligations made by an organization can limit its ability to differentiate or change its governance mechanisms in the future. Building on this reasoning and other argumentative discussions underpinning institutional and transactions cost economics, Paper II proceeds to consider the context influence, in turn. Therefore, paper II extended the existing

perspectives by exploring the inter-organizational interactions and actors' behavior: 1) in the context of the regulatory environment in Spain, which determines such interaction; and 2) sequentially, by discussing actors' behaviors throughout the project lifecycle. Importantly, paper II advances a small and suggestive set of propositions throughout the large-scale project lifecycle with which to seed future theorizing. Besides, while existing research disregards the likelihood of temporary settlements to the institutional environment, suggesting that project organizations enact single and substantial responses (e.g., Nguyen et al., 2019). Paper II found that the impact of institutional environments on large-scale projects is recursive. In consequence, the management responses vary in terms of how subject they are to the institutional elements' salience and actors' interactions. In additions, a closer examination of the data found two factors that drive the escalation dynamics in large-scale projects: (1) the timing mismatches—a ubiquitous feature of public sector project owners' organization—leading to the incapacity to influence governance during the project front-end and (2) owners' passive behavior during implementation. Concerning the latter, Paper II suggests that an active project owner organization with high project response capability is essential for effectively interacting with contractors and effectively selecting and managing both contractual and trust-based governance mechanisms. This paper suggests managerial actions, which are discussed in greater detail under section 6.2. These suggestions mainly help promoting the effectiveness of owner-contractor collaboration in large-scale infrastructure projects.

As indicate earlier, Paper II finds an interesting – paradox effect concerning the optimal timing for coping with the uncertainty in the large-scale project setting. Almost all existing studies, if not at least the dominant perspective, in engineering and project management literature argue and reduce uncertainty management to the project front-end (Williams *et al.*, 2009; Williams and Samset, 2010; Oh *et al.*, 2016). Paper II found that in practice, as a consequence of the institutional environment, i.e., the regulatory regime – the stringent public rules, and the project owners' bureaucratic organization *per se*, apart from others, the management is not able to take effective action in the front-end. This timing mismatch – a ubiquitous feature of the large-scale infrastructure projects has escalation dynamics as a consequence during the project implementation stage. Besides, paper II concludes that although the existing research has recently sought knowledge of inter-organizational relations and governance issues

in large-scale infrastructure projects, the researchers developed non-time-related propositional statements. Such framing failed to explain project actors' behavioral patterns during the project lifecycle. Besides, the existing literature, for the most part, has provided a first-order view of dyadic project owner-contractor relationships, seeking to explain the effects of interpersonal relations and behavioral attributes for the potential governing activities and actors' behavior. By employing a project lifecycle perspective and examining the actor's interdependencies from a network analysis perspective, paper II contributes a viewpoint that has mostly been missing from the existing literature (cf. Söderlund 2011).

The findings from paper III indicate that organizations technology adoption and implementation depend on the institutional context, and particularly the extent to which the organizations are centered on the delivery of projects. Drawing on empirical data from three organizations in infrastructure delivery in Spain, the paper analyses the tensions among actors during BIM adoption and implementation. To this point, it argues that the management teams' practices were strongly influenced by the government or industrial norms and corporate logic, and that the flow of influence remains notoriously lopsided. That is, during the comprehension process phase, the institutional structures, have 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 is professionalism. Because the material aspect of the technology requires the active engagement of professionals, triggering the mindful technology comprehension processes (Swanson and Ramiller, 2004). The professional logic can be crucial, especially when it becomes "direct," and aligned within their rationale (the case of organization C). That is, corresponding internal or external institutional work by professionals for BIM comprehension and adoption across organizations results in more successful BIM implementation in projects.

Furthermore, Paper III found three main logics competing throughout BIM adoption across organizations: the state, corporate, and professional. The BIM mandate, as 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). Second, corporate-based requirements were rather short-term but predominant and usually related to client demand for BIM

adoption (particularly in organization A and B). The three logics' presence made the frame institutionally complex (Greenwood *et al.*, 2011; Besharov and Smith, 2014), and underlined technology adoption and the change of organizational practices. Also, Paper III 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.

To summarize the findings, show how, when considering the project's institutional environment and their context, the efficiency is not the primary driver, nor strategic utility determines inter-organizational collaboration. As a result, while few quality and effects within the project and behavior attributes may explain the potential process and activities. The adoption of a robust process perspective (Langley, 1999) and a lifecycle consideration in our analysis brings a view that has been missing from much of the existing literature. It scrutinizes actors' behavioral patterns, considering the mechanisms and effects that reside not only in the project but also in the project's network and institutional field.

5.1.2. At the micro-level

At the micro-level, the thesis findings elaborate and conceptualize path-shaping and project actors' agency that bridges the gap between the intra-organizational and institutional level efforts in large-scale project organizing (particularly Paper I and IIIrd). The findings show that project managers and other actors engage and create the action space through the shielding effects, and the temporary fix effects (Paper I). Accordingly, project managers and actors, indeed engage in path shaping (Bassanini and Dosi, 2001; Aaltonen *et al.*, 2017), underscoring the importance of agency at the project implementation level. Under certain conditions, they were capable of shaping their paths. Hence, managers tended to distance themselves from tight structures, including the rules and norm-like guides. For example, Paper I found that the managers engaged in improvisational actions relating to social rentability and less to 'project cores' – project efficiency and key performance indicators. Instead, they referred to the soft objectives and demands of the project.

On the other hand, other actors in projects, e.g., the contractors, created their action spaces by ignoring the details of the project plan, thus, sending a vague plan to the Adif controller – for

confirmation. All these improvisation actions illustrate the actor's intention to safeguard choices from external disturbances (Paper I, and II). Such examples show that institutional pressure through rules and norms did not directly affect management behavior. The management embraced elements that are weakly connected to norms – thus capable of 'autonomous actions' (Scott and Davis 2007, p. 96).

At the project implementation level, certain constitutional conditions were significant for management behaviors. First, sticking to routines – their repetitive choices enhanced efficiency but made them less able to consider alternatives. In such a context, the management lacked motivation for other options – repetitive choices gained legitimacy and triggered greater acceptance in the inter-organizational project setting. Thus, these practices were facilitated by the learned routines, and the legitimacy gained in performing them. Although the Adif adopted guidelines and ideas from PM bodies of knowledge, which prescribed a linear decision mode, several events and issues prevented the management from making a 'rational choice.' Due to high uncertainty, the administration ignored the process guidelines or at least did not consider them thoroughly. The interviewees described situations where they did not follow process guidelines, and the way they ran the project had little to do with those guidelines.

Furthermore, paper II found that project management's interpretation of problems and their preferred solutions and justifications of actions manifested in shared beliefs and to some extent cultural assumptions. For instance, the tendency of mimicking standards and formalizations of operations through the use of complementary management systems occurred. At the project implementation level where the technical environment is dominant, the management and their teams turned to symbolic activities – they were committed to co perform and communicate effectively with their "central stakeholders." To this end, they conformed to project institutional demands. The symbolism stands because they adapted by merely brushing aside the hard costs and benefit analyses. Hence, in practice, project managers look beyond rational choice, and consider social approval and not only economic goals.

To summarize, an essential point that all of the appended papers in this thesis ought to make clear is that what defines pertinent institutional features for an organization varies depending on the project context and the position that the organization has in the delivery lifecycle. The appended papers

identified a multi-layered context for management actions in practice and shown their engagement in the project setting. Firstly, project managers and other actors in the field are capable of creating action spaces at the project implementation level. Secondly, management coped with the institutional pressure in employing diverse legitimacy acquisition approaches. At the project front-end, the management performance can be defined as loosely coupled – their activities were weakly connected to the guiding rules and norms. Their actions were symbolic, however inter-organizational dynamics and the tendency for repetitive choices were the norm. At the project implementation level, there was a tendency to perform – mimicking standards, yet again the management engaged in symbolic activities. Taken together with the institutional environment and inter-organizational interdependencies have had a substantial impact on the way that the case projects were conveyed, particularly Case I. But also, project managers have, with time, shaped these projects in a certain direction.

5.2. Contrasting views on large-scale project studies

The findings suggest that large-scale projects are a dynamic set of institutional forces and that project actors' activities and choices made are possibly partial. In particular, Paper I revealed that the process of lock-in emergence is substantially more than a control-oriented final purposive outcome. As indicated earlier, these findings contrast previous literature on project processes and their technical environment (e.g., Cantarelli *et al.*, 2010). Paper, I concluded that initial contingencies are not 'givens' and that mechanisms and effects are emergent contexts of action. Therefore, the decision-making process in large-scale projects is not always under the control of the single actors; more often than not, the opposite holds. Based on the findings of the HSL project, it could be argued that the emergence of a lock-in needs to be considered in the context of processes that are peculiar to the (inter-)organizational project and its institutional setting. In turn, paper II found that the institutional context and several actors influenced the project governance structures and other process processes and activities. Besides, the paper I and II found that project management in the HSL case ensued guidelines without recognizing their peculiar influences or develop them further. This indicates that their efforts were not framed strategically, as the current literature highlights (Aaltonen, 2013; Derakhshan *et al.*, 2019). In other words, the management was not implementing practices because their utility was directly recognized.

Paper II, indicates that the institutional context, particularly the regulatory system, is crucial when considering the arrangement of large-scale projects. Furthermore, paper II finds that the institutional influence increasingly stems from the international level, for example, through the European industrial regulations, for example, the ERTMS system.

So, what do the findings from this thesis tell us compared to the dominant perspective in large-scale project research (e.g., Flyvbjerg et al., 2003; Flyvbjerg, 2014) that analyzes them from the normative ideal and classifies potential deviations from the rationally right decision as biases and errors? Findings from papers I, II, and III clearly show that such views draw attention to the technical features of the environment but neglected the importance of institutional elements (cf. Scott et al., 2011; Tukiainen and Granqvist, 2016; van den Ende and van Marrewijk, 2018). While the focus on the technical environment as a source of explanation is not wrong, it is incomplete. Although the cognitive bias might exist, in a large-scale project context, there is a milieu of complex (inter-)organizational processes that are at work (cf. Steen et al., 2017).

To summarize, in practice, project managers reflect beyond the rational choice and consider social approval and not only economic goals. In this regard, the paper I and II show that large-scale project arrangement and their organizing relies on management shifting approaches of institutionalization with time, between the institutional and technical environment, in their struggle to accomplish them. In this framing, institutional contexts are similar to technical ones (see Scott and Meyer 1991), in the sense that they are multifaceted and enormously diverse and variable over time. Thus, to neglect their influence on large-scale project organizing is to ignore considerable underlying conditions shaping the project performance.

Chapter 6. Conclusions

This section concludes the cover essay streamlining the main argument of the thesis, presenting the theoretical contribution, the managerial, or practical implications.

The overarching research question asked: How can a dynamic process view of large-scale infrastructure project organizing be conceptualized and empirically analyzed?

In response, at the conceptual level, the thesis set forth the operationalization and empirical understanding of the large-scale projects engaging in an active process view with a particular focus on the (inter-) organizational facet. The empirical study of the transformative infrastructure sector and the Madrid-Barcelona HSL project, in particular, illuminated how processes and activities can be identified in a certain project network using qualitative methods. The analysis painted a detailed depiction of which mechanisms and effects, including institutional field logics, are dominant and influential in the management of large-scale projects. Therefore, it rendered the aspects of a large-scale projects as a socio-technical setting, which is heterogeneous and ‘hybrid.’

More precisely, the thesis aimed at exploring how dynamic institutional forces, the (inter-) organizational relations, and the temporary project nature influence large-scale infrastructure project processes and activities in space and time. It started by discussing the implicit assumptions of the dominant perspective of research in large-scale projects. Large-scale infrastructure projects have been excessively approached from the iron-triangle in search of accountability – with the sole objective of evaluating such projects. The thesis, in turn, argues for the need to contextualize the organizing of large-scale infrastructure projects. It questioned the view of the dominant perspective – defining it as reductionist, by engaging in problematization, unpacking and identifying what goes inside the black box — recognizing the institutional influence, the (inter-) organizational dynamics of large-scale projects, and the temporary project nature (Paper I and Paper II). Alongside this, the thesis established a step to enhance the understanding of the process of technology adoption and implementation (Paper III). Taken together, the conducted research offers a contextualized or situational approach, building on neo-institutional theory (Scott, 2013), and other argumentative discussions that view the organizing of large-scale projects as a process embedded in (inter-) organizational practice.

Building on an extensive insider/outsider case study (Case I), and the more moderate comparative cases (Case II and Case III), the thesis findings, convincingly argued and questioned the taken-for-granted assumptions (Davis, 1971), which underly the dominant perspective to the date. To this end, the thesis employed a multilayered institutional lens tackling large-scale projects organizing at the:

1. project organizational practice (the micro-level);
2. the (inter-)organizational context (the meso level);
3. and the overall implications of the institutional environment (the macro level), seriously considering the context and history of the project organizing.

The findings elaborate and conceptualize path-shaping and project actors' agency that bridges the gap between the intra-organizational and institutional level efforts in large-scale project organizing. By drawing from the organizational and institutional theory, this thesis's main contribution is to enrich our understanding of the emergency nature of processes (interdependencies) and activities in large-scale projects. Hence, this thesis's argument infers that individual actors or any vested interests cannot control large-scale projects, but it highlights at the same time that they are not passive pawns. To this end, the thesis puts forth novel conceptualizing of processes emergencies, through the management interplay with the dynamic institutional forces. It introduces the *soft lock-in processes, path-shaping* (Paper I), *embeddedness, governance inseparability* (Paper II), and portrays a deeper and more nuanced insight of the *institutional frames (logics)* and the *tensions* among actors during technology adoption and implementation (Paper III). After synthesizing the findings from the appended papers in answering the research questions, the present section discusses the critical contributions to the theory and management practice.

6.1. Theoretical contributions

Grounded on institutional theory in specific and within organization studies more broadly, the thesis's primary contribution is the explorative inquiry enriching the understanding of the large-scale infrastructure project organizing using process theories. First, the thesis introduces the concept of soft lock-in, and governance inseparability to the critical theme of bounded rationality in the organizing of large-scale infrastructure projects. Throughout a qualitative inquiry, it illustrates the evolution of the

project(s), considering the (inter-) organizational context (Sydow and Braun, 2018). To this end, it paints a detailed picture of how prior ties and multi-actor interdependencies in the project, the network, and the institutional environment influence the project processes and activities. It provides a ‘reflexive’ view addressing the interplay between the institutions and projects and adds to the recent growing interests in institutional theory with project scholars (Bresnen, 2016; Söderlund and Sydow, 2019).

The thesis contributes to the debate on large-scale infrastructure project organizing by further developing an institutional perspective.

Firstly, the thesis entails nascent theorizing on how the temporary and (inter-) organizational nature of large-scale projects in the presence of institutions narrates the emergence of processes, e.g., lock-in. Employing a strong process perspective (Langley, 1999), it affirms that the management of large-scale projects entails multiple ties with past and future that are necessary to get to grips with when facing the challenges this specific form of temporary organizing poses (Grabher and Thiel, 2015; DeFillippi and Sydow, 2016). It provides a rich empirical examination of the emergence of lock-in in the project (inter-) organizational network. To this end, it indicates that to understand large-scale infrastructure project processes and activities, and there is a need to change the ontological priorities that underpin the existing research on the behavioral decision in project management (cf. Stingl and Geraldi, 2017). The reductionist view and its focus on the input variables and the outcomes of the lock-in process lead us to cost-related issues. It takes us down paths designated by the owned process perspective, directions from which we must veer (Mackay and Chia, 2013). Thus, it recognized the heterogeneity of large-scale project contexts in the multi-organizational setting and their interdependencies in broad project networks. They represent the sources of variation in the desired outcomes (Artto et al., 2016).

Secondly, by linking the findings to the relevant theory, it shows that the conceptual stance adopted and operationalized through the process perspective differed as well as the implications of this difference, see Table 5, in Appendix A (Paper 1). These differences are a valuable contribution to the literature because they enable project management scholars to position their research more effectively. Relevant since the socio-technical complexities involved in the development of large-scale projects entail phenomenon-based research, which has gained and will continue to gain the interest of diverse scholars, thereby bridging conceptual and disciplinary divides (von Krogh et al., 2012).

Thirdly, it develops the institutional perspective – most needed in large-scale projects (Scott, 2012; Biesenthal *et al.*, 2018). It adds to the literature concerning technology and institutions by revealing the dual dynamics among the institutional structures and organizational actors, see particularly paper III. The article sets a step in the right direction to unpack the institutional complexity (actor's rationalities) and their strategic efforts that created the challenges during the BIM technology adoption and implementation. Hence, this finding differs from many others in how it reports the BIM mandate, the process of BIM technology adoption & implementation, and the ambiguity around 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 protocol adoption. It unfolds unexpectedly, and actor's agency or conscious managerial decisions and actions are crucial (Hinings *et al.*, 2018)

Fourthly, it introduces the conceptualization of path-shaping specifying the conditions for project managers' influences on the organizing of large-scale projects. The findings show the importance of agency and how project managers under such circumstances are capable of shaping their paths (Aaltonen *et al.*, 2017).

Fifth, it re-affirms the concept of the governance inseparability, and argues that large-scale infrastructure projects, are temporally-limited and goal-oriented contexts, that are characterized by two focal stages: 1) the project front-end and 2) project implementation, offering a unique setting for the study of inter-organizational relations and actors' behavioral patterns. Each lifecycle stage is delineated by distinctive constituents that affect both the governing activities and the project actors' behavior and strategizing. Hence, in contrast to the existing literature, it argues for the dynamic, time-dependent propositional statements. Besides, by employing a project lifecycle viewpoint and examining the actor's interdependencies from network analysis, the thesis contributes a viewpoint that has largely been missing from the existing literature.

Sixth, drawing from the rich neo-institutional theory, the thesis contributes to the literature showing that management cops with the project influence in a different way depending on the institutional pressure salience, and the project phase (e.g., front-end or implementation stage). It contrasts the most empirical studies that imply or assume that the project organizations enact single and sustainable

responses (e.g., Nguyen et al., 2019). Ultimately, it suggests for the project owners to match of the appropriate knowledge sharing mechanisms and adequate learning process with each phase through the project lifecycle.

Finally, it develops and institutionalized based perspective on the adoption and implementation of technology in the (inter-)organizations setting. It identifies the importance of institutionalized work and proposes that organizations involved in technology adoption and implementation in large-scale project need to understand that they are caught in an institutional bind (Burton-Jones *et al.*, 2019).

6.2. Managerial implications

The managerial implications of this thesis are two-fold. First, the appended papers put forth among other frameworks and process models that are indeed useful to be utilized. They outline ideas that are relevant because they lay the groundwork for PMs to extend their efforts beyond the micro-managing of tasks. In particular, the paper I develops the lock-in process model that can be useful for project managers in the field. Secondly, the thesis gives countless advice and managerial implications. The first being that a numbers-logic oriented tradition of cost/benefit analysis is unable to suggest how processes and activities emerge and have a potential influence on project performance. Alternatively, attention should be directed to the understanding of the (inter-) organizational elements in the context as an essential feature of project management practice.

It is not possible to impose any rule-of-thumb that delineates precisely the extent of the PM's enactment. Langley et al. (1995) have argued that too narrowly focused prescriptions derived from conventional organizational decision-making literature are simplistic, isolationism, and inapt for turbulent environments. With such criticism in mind, this thesis posits that in organizing the large-scale projects, PMs should carefully consider the following:

- Recognize and address the requirements of the institutional environment, including the pre- and post-project effects.
- This thesis frames the institutional environments similarly to technical settings (see Scott and Meyer 1991), in the sense that they are multifaceted and enormously diverse and variable over time. Thus, they require critical attention as the underlying conditions shape the project

organizing. In other words, institutional elements need to be worked alongside instrumental concerns (Ainamo *et al.*, 2010; Scott, 2012).

- Given path-dependence, analyze how the multiple mechanisms and effects may shape their decisions, reinforcing them to continue in specific directions. Thus all actors whose contractual position is considered potentially crucial should be involved in the early negotiations (cf. Lamberg *et al.*, 2008).
- Project managers should taper the gap between what the project owner organization needs to learn and what it has learned to do throughout the project lifecycle. In this context, the effectiveness of project owners' management in coping with uncertainty vis a vis the functionalities to be delivered, and their contractor's behavior has to be addressed proactively and with time. As the project makes progress through detailed design and into the execution, an active owner role remains vital.
- The need to continuously develop goal alignment and relational mechanisms (including contracts) for dealing with project changes, thus mitigating opportunism.
- The multi-organizational setting inherent during the decision process and the potential escalation of commitment should be treated accordingly, i.e., considering for each their mode of collaboration, experience, the cultural differences, and all alignment issues.
- The organization leaders, who are representing the organizations and promoting the technology (e.g., BIM), suggesting (how) to adopt it, 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, the institutional forces will still affect them. If actors realize this, they can be more mindful of the pressures and the choice they have.
- When implementing BIM and sharing the platform with third parties in sustainable-oriented infrastructure projects, organizations need to realize that the platform set-up is a complex process and the screening of inter-dependencies among collaborators, people's activities and within processes is crucial. So, the management needs to identify how BIM is essential to their plan and asset maintenance and realize that it coevolves with the project development. From this perspective, following Virtual Design and Construction (VDC) guidelines among

collaborators should be agreed upon and key terminologies updated (Kunz and Fischer, 2020), and recognize that it has to serve all the actors involved in the project.

Conclusively, the thesis suggests that PMs should work actively to align the actors' desired outcomes by organizing learning events, such as frequent thematic workshops, particularly in the early stages of the project. Such events would enable collective sense-making, which is critical in creating new ideas and generating commitments within the project network. Because of the inter-organizational and temporal nature of projects, PMs must consider and maintain a balance between controllability and unpredictability in delimiting their choices in large-scale project settings (Kreiner, 1995; Engwall, 2002). 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 organizations support across programme of projects (Kunz and Fischer, 2020).

6.3. Limitations and recommendations for future research

The limitations of this thesis include the reliance on it in case studies only. Such limitation is particular for papers, which findings are based on a single-case study (Paper I, II). The contribution and criticality of single-case study findings are well-argued by Flyvbjerg (2006) and Siggelkow (2007), among others. The above authors and several others have pointed out that the purpose of the case study is not to develop statistical generalizations, but analytical instead (Flyvbjerg, 2006).

Consequently, it could be argued that the case studied here, the HSL project, may thus be used to advance theory, through the heuristic nature of the case study, which widens the readers' understanding of the issue at hand – the organizing of large-scale infrastructure projects. Another limitation of this thesis includes some reinterpretation of the data sets, which were created over the course of more than 15 years. I tried to address this issue by going back and forth between the original data sets and the analysis (Rowley, 2002). Besides, to help tackle this challenge, apart from concentrating on the focal organization, in this case, the public organizations (Adif), I dugged into the network level (as much as possible) and underlined the essence of the view by other actors in projects. So, while the focus was intentionally placed on the project-owner organization (Adif), contractors and supplier's perspectives

have also been examined to have an informed view of the owner's response capability, see appendix B (Paper II). Also, in the application of the single case method, I used only qualitative data (Paper). Therefore, the lack of quantitative data within the paper I analysis may be considered a limitation since I was not able to compare the findings with other quantitative discourses, for example, in the paper I on the discussion of the lock-in emergence (Koch et al., 2009). In the paper I, Table 5 shows the differences in the conceptual stance needed to understand the emergence of lock-in. Undoubtedly, significant methodological challenges are associated with these differences (Smyth and Morris, 2007). Nevertheless, but a discussion of how these differences might be addressed is beyond the scope of this thesis.

Despite these limitations, the generic process framework, see Appendix A (Paper I) could guide future research on decision-making processes in a large-scale project context. The process framework could be adopted to explore different empirical settings, possibly through a longitudinal ethnographic study, which could lead to a deep empirical understanding of the role of contextual mechanisms and effects arising in the emergence of lock-ins. This understanding would enable researchers to empirically investigate and enhance the generalizability of the findings to other project contexts. Conclusively, I affirm that project scholars will benefit from taking a process approach in exploring lock-in and other path-related processes in large-scale project settings (Mackay & Chia, 2013). Future research should consider the mechanisms and effects revealed in this thesis and acknowledge that they reside not only in the project but also in the project's network, and the institutional field. Furthermore, future research should consider the subtle relationships among path dependencies and path creations in continuing to explore the contexts and conditions of project shaping and de-locking mechanisms.

Lastly, to further test and build theory in this domain, I encourage future research to use ethnographic and process approaches. To continue recognizing the multilayered (inter-) organizational settings that help study the influence of the institutional environment in projects over time and in practice. To adopt the new institutional lens and apply it from the macro- to the micro-levels and perspectives. I believe this will help fill the current gap between theory and practice concerning large-scale project organizing.

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Appendix A

Paper I

**Exploring the emergence of Lock-in in Large Scale
Projects: A Process view**

Ermal Hetemi, Anna Jerbrant, Joaquin Ordieres-Meré

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Exploring the emergence of lock-in in large scale projects: a process view

Ermal Hetemi^{a,b,1}, Anna Jerbrant^a, Joaquin Ordieres-Meré^b

^a Department of Industrial Economics and Management, KTH Royal Institute of Technology, Lindstedtsvägen 30, 100 44 Stockholm, Sweden

^b Departamento de Ingeniería de Organización, Administración de Empresas y Estadística, UPM Universidad Politécnica de Madrid, C/ José Gutiérrez Abascal 2, E-28006, Madrid, Spain

Abstract

The purpose of this paper is to investigate the emergence of *lock-in* in large-scale projects. Although large-scale projects have been studied for decades, most studies have applied economic or psychological perspectives to emphasize decision-making processes at the project front-end. Of those studies, some have focused on poor decision-making due to lock-in and the escalating commitments of decision-makers to ineffective courses of action. However, little is known about the way that project decisions are affected by organizational and inter-organizational contexts and the actors involved. Understanding decisions from a process viewpoint with a long-term (*inter-*) *organizational* perspective will lead to a better understanding of lock-in and the overall performance of large-scale projects. This qualitative research is based on a case study. The research setting is the multi-actor Madrid–Barcelona High-Speed rail Line (HSL) project in Spain. Through observations, interviews, several project documents, and report analysis, we explore the processual nature of the choices made during the course of the project. We consider the contextual conditions that give rise or support the emergence of lock-in in relation to pre- and post-project effects, institutional influences, and management practices that create *action spaces* at the project level. Our findings suggest that lock-in emergence requires the recognition of the long-term (*inter-*) *organizational* perspective regarding mechanisms and effects rather than confining decisions to the individual or single actor control in the front-end of projects. Based on organizational theory, the main contribution of this paper is to enrich our understanding of the emergence of lock-in using process theories.

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Keywords: Lock-in; Path dependence and creation; Decision-making process; Large-scale projects; Temporary inter-organizational setting; Process theory.

1. Introduction

Large-scale projects are multi-organizational settings involving diverse public and private actors whose interactions shape the scope of the project, locking it into a path that is influenced by the project actors' shared history (DeFillippi and Sydow, 2016; Aaltonen *et al.*, 2017). Mainly because of their long timespan, which is often decades (Flyvbjerg, 2014); this type of project is developed through a series of decisions that involve interdependencies between strategic and complex tasks at multiple points in time among disparate actors, whose visions for the project sometimes conflict (Scott and Levitt, 2017; Pitsis *et al.*, 2018). Consequently, the diverse contractual actors have different risk perceptions (Davies and Brady, 2016; Arashpour *et al.*, 2017) and value creation approaches (Morris, 2013; Samset and Volden, 2016). On the one hand, owners focus on the long-term project's lifecycle. On the other hand, (sub)contractors and other suppliers have a somewhat short-term perspective. Large-scale projects thus entail dynamic boundaries and contexts since the scope of their work is continuously negotiated, and the number of project participants is in constant flux throughout the project's lifecycle (Artto *et al.*, 2016).

Because of the clear understanding of the current state but the limited foresight regarding the (*inter-*) organizational context and the changing environment that characterizes large-scale projects (Sanderson, 2012; Artto *et al.*, 2016), management choices may become locked into a particular path that in the long-term may cause underperformance. In this regard, there are challenges involved in achieving consensus among the diverse actors, who have divergent modes of collaboration and differing project experience regarding the project's

* Corresponding author. Tel.: +46 8 790 76 58;
E-mail address: ermal.hetemi@indek.kth.se

vision and their contributions. There is abundant evidence of governance failure in coordinating decision processes in large-scale projects (Flyvbjerg, 2014; van Marrewijk et al., 2016). In most cases, however, these failures have been attributed to the poor decision-making due to self-reinforcing processes particularly the *lock-in* (Miller and Lessard, 2000; Cantarelli et al., 2010) and the escalating commitments of decision-makers to ineffective courses of action (Jani, 2011; Winch, 2013). The notion of lock-in refers to the decision-making process phase among multiple actors in the project setting, the dynamic of which is generally influenced by existing contractual commitments and other self-reinforcing effects, e.g., coordination, learning effects, etc. (Argyres and Liebeskind, 1999; Sydow et al., 2009). Hence the inertia of prior contractual commitments influences the overall project scope, the pace, and the sequencing of the decision process (Lamberg et al., 2008). Lock-in can, for example, occur when the project owners are stuck with inferior providers or contractors whose costs of services are higher than the average total costs of a new potential provider, implying that project owner decision makers err on the safe side and are bound by convention.

Nevertheless, in extant literature lock-in has been contemplated either as a starting point or an outcome (e.g., Cantarelli et al., 2010), but the process logic that gives rise or supports the lock-in emergence remains underexplored (Aaltonen et al., 2017; Sydow and Koll, 2017). Hence, the process of decision-making and lock-in in large-scale projects has been mainly examined concerning front-end decisions made by a single actor and the effects of the latter's poor performance (e.g., Cantarelli et al., 2010; Flyvbjerg, 2013). Researchers have examined the techniques and models designed to identify, assess, and optimize management choices at the project's front-end (Williams and Samset, 2010; Flyvbjerg, 2013). Consequently, in previous research, the perspective has been predominantly reductionist (cf. Stingl and Gerdali, 2017). That is, scholars have adopted more of a positivist/ objectivist view, and they have analyzed the decision-making process from a normative ideal. Thus, potential deviations from the rationally right decision have been classified as biases and errors and analyzed their root causes through mostly quantitative methods (e.g., Cantarelli et al., 2010; Flyvbjerg, 2013). Moreover, extant literature has taken a somewhat ahistorical view. It has made little attempt to examine the emergence of lock-in in large-scale projects when considering that project choices are affected by the (inter-) organizational context.

This paper's point of departure is the criticism of the 'reductionist view' and its underlying rationale kernel, which is grounded upon the following implicit three-fold assumption. Firstly, decisions cause action, an assumption that also seems to be underlying the normative project management (cf. Cohen et al., 1972; Engwall, 2003; Steen et al., 2017). Secondly, many large-scale projects are initiated with unclear specifications revolving project goals that change during the project implementation, the key reason why such condition occurs is attributed to governance mechanisms incompleteness and deficient contracts (cf. Engwall, 2002; Sanderson, 2012). Thirdly – and mainly that, plentiful choice options are available to the project actors (cf. Sydow et al., 2009; Aaltonen et al., 2017).

The central argument in this paper is that the lock-in emergence in large-scale projects requires a reflection on the nature of projects, and their environment as dynamic and ever-changing, which is partly recreated by the actors involved in a consecutive project pattern. We regard the concept of organizational *path dependence* (Sydow et al., 2009) as a promising starting point for developing an understanding of the lock-in emergence. The fundamental idea from path dependency to lock-in rejects the notion that regardless of the starting point and the actors involved, the process will gravitate to the same equilibrium (Grabher, 2005). Recently, there is a growing interest in considering the subtle relation among path dependencies and path creations into the dynamics of self-reinforcing processes (Aaltonen et al., 2017; Sydow and Koll, 2017). In this context, there is an attempt to consider the concept of path dependence in a thorough and rigor way beyond the metaphorical usage of 'history matters' (Bassanini and Dosi, 2001, p. 41). Building on them, we proceed to disentangle some of the contextual conditions that give rise to or support the emergence of lock-in. This endeavor seems relevant, timely, and necessary in considering the recent calls for more empirical research that examines path-related processes in the temporary inter-organizational context such as large-scale projects (Hellström et al., 2013; Levering et al., 2013; Aaltonen et al., 2017). Therefore, we pose the following research questions:

RQ1: How and why does lock-in emerge in large-scale projects?

RQ2: What are the underlying mechanisms and effects that affect lock-in in these settings?

The purpose of this paper is to explore the emergence of lock-in in a large-scale project context by empirically investigating the multi-actor Madrid–Barcelona High-Speed rail Line (abbreviated as HSL) project. The major construction works in the project lasted for two decades (1990-2008). However and due to immense withdrawn contracts and suspensions during which time (2009-2017), the project's network organization continuously rearranged the design and plans of the project, redefining its scope. We develop a conceptual process framework to explain the emergence of lock-in in large-scale projects through the influence of different (inter-) organizational mechanisms and effects. Besides, we discuss the importance of expanding the scope of previous research through the process view by including the nature of the project—its temporality and the (inter-) organizational context—to enable a fine-grained understanding of the emergence of lock-in. Apart from this introduction, our paper consists of five sections. Section 2 provides the theoretical framework, followed by the research design and methods in section 3. In section 4, we present an empirical account, discussing the contextual conditions that give rise to or support the lock-in emergence. Section 5 discusses the findings, and Section 6 concludes the paper by establishing contributions, the limitations of the study, and suggestions for future research.

2. Theoretical Framework

Historically, the significant challenges in carrying out infrastructure endeavors were primarily technical and financial in nature (Morris, 2013). Although most of these economic and engineering problems have been tackled (Samset and Volden, 2016), the complex (inter-) organizational and social misalignments of projects and actors in them remain under-studied (Pitsis *et al.*, 2018).

2.1. Lock-in and self-reinforcing processes revisited

Path dependence is the type of self-reinforcing process that is discussed the most in management studies (Sydow and Schreyögg, 2013). The fundamental point in the intuitive notion of path dependence is that history matters (Bassanini and Dosi, 2001). In organizational research, understanding how and why historical mechanisms take place in organizational life has become of critical interest (Sydow *et al.*, 2009). In particular, the concept of path dependence and lock-in (Arthur, 1989), which originates in evolutionary economics, has gained prominence. In this regard, although lock-in often entails technological lock-in (Arthur, 1989), we are concerned with its organizational, institutional, or behavioral form (Sydow *et al.*, 2009).

Nevertheless, in addition to appealing to both social and natural sciences, the concept of path dependence has been criticized for its ambiguity (Garud and Karnøe, 2001) and its disregard of human agency in the creation of new paths (Bassanini and Dosi, 2001; Garud and Karnøe, 2001). To address these criticisms, Garud and Karnøe (2001) proposed the perspective of path creation. These authors suggest that actors (*i.e.*, individuals, organizations, and fields) affect social phenomena and may alter or deviate from their expected paths. To this end, Sydow *et al.* (2009) developed a dynamic model that categorized the path dependence process into three phases: 1) pre-formation, 2) formation, and 3) the lock-in phase. In essence, these authors suggested that the process of path dependence starts with a singular historical event, which under certain conditions may become a self-reinforcing dynamic and possibly end in an organizational lock-in (Sydow *et al.*, 2009). Hence, lock-in is understood as the end-phase process of organizational path dependence, and the theory of organizational path dependence stresses the lack of any realistic alternative in the lock-in phase (Sydow *et al.*, 2009; Sydow and Koll, 2017). In management studies, the notion of path dependence has been used to describe decision-making as not only a point in time but as a process. Indeed, a behavioral pattern that, over time, renders a corridor of a limited scope of action that is “at least potentially” strategically inefficient for management (Sydow *et al.*, 2009, p. 704).

The path dependence process can be conceptualized as one or a combination of several mechanisms, such as coordination effects and learning effects (Sydow *et al.*, 2009). Hence, this self-reinforcing process is particularly interesting, as path dependencies do not concern only one type of self-reinforcing effect. According to Sydow and Schreyögg (2013), self-reinforcing effects are jointly related to the origin of the concept. Indeed, the combination of self-reinforcing effects (*i.e.*, irreversibility) and non-linearities are inherent in path dependence (Bassanini and Dosi, 2001). In addition to path dependence, the escalation of commitment is another self-reinforcing process that has received attention in behavioral decision-making studies (Stingl and Geraldi, 2017).

The escalation of commitment refers to a course of action that occurs when an initial investment decision has negative results, but the decision-making body continues to invest further funds supporting the same course of action to justify the costs in the hope of recouping the initial investment (Staw, 1981; Sydow and Schreyögg, 2013).

It is noteworthy that the concept of path creation builds on theorizing path dependence (Garud and Karnøe, 2001). Particularly the increasing convergence between the two concepts in organizational and regional studies (Sydow and Koll, 2017) as well as project studies (Aaltonen *et al.*, 2017). This concept may also be applied to large-scale project settings. In such contexts, mechanisms and effects are suitable ways to tackle the complex nature of decision processes compared to conventional approaches characterized by the focus on a single actor (cf. Pajunen, 2008; Sydow and Schreyögg, 2013). The reason is that the emergence of lock-in entails a process that is triggered by a combination of constituents rather than single activities (Sydow *et al.*, 2012). The focus on mechanisms and effects reveals the interdependencies of processes that generate outcomes, and provides a compelling explanation, contextualizing the emergence of lock-in (Pajunen, 2008). Hence, mechanisms and effects are powerful contextual conditions in the process of lock-in emergence compared to statistical cost-benefit analysis based on an outsider's perspective (Flyvbjerg, 2013). Within the latter, lock-in is explained by focussing on the input variable and outcomes but disregarding the process and the contextual conditions. The reductionist view (e.g., Flyvbjerg, 2013; Cantarelli *et al.*, 2010) seems concerned with the determinants of project failure and success more than with the actor's interactions that actually shape the decision process.

2.2. The reductionist view and the futile dream of the perfect goal for large-scale projects

Both lock-in (Cantarelli *et al.*, 2010; Levering *et al.*, 2013) and the escalation of commitment (Jani, 2011; Winch, 2013) have been discussed in project studies that focused on behavioral decision-making. In the extant literature that considers lock-in control-oriented by single actors (e.g., Flyvbjerg, 2006b; Flyvbjerg, 2013), reference class forecasting has been proposed based on the view that it is a form of de-bias emerging from behavioral economics studies (Lovallo and Kahneman, 2003). However, to understand what influences decision-making processes and lock-in emergence, reference class forecasting offers possible cures (e.g., Flyvbjerg, 2013). Therefore, efforts are still grounded in the reductionist view, in which correct decisions are made in an objective manner (Stingl and Gerdli, 2017). Thus, in the reductionist view, the issue of lock-in involves, at best, the dyadic relationships between the actors involved. Which downplays the project's nature, its temporality, and the inter-organizational context (Artto *et al.*, 2016; DeFillippi and Sydow, 2016). More importantly, the reductionist view (e.g., Cantarelli *et al.*, 2010; Flyvbjerg, 2013) is supported by the owned process perspective (cf. Mackay & Chia, 2013). This leads to the privileging of decision-making as ahistorical, occurring at points in time at which strategic misinterpretations or incompetence rather than choices, chance, and project circumstances are considered to shape the emergence of lock-in. Thus, the reductionist view establishes a decontextualized and static approach that focuses on cost-related issues and emphasizes performance as the ultimate independent variable.

Although many organizational project management scholars (e.g., Andersen, 2008; Lundin and Söderholm, 1995) have referred to the concept of limited rationality (Simon, 1955, p. 113), the reductionist view considers that action is the consequence of decision-making. Nevertheless, many studies have shown that an action is not always a consequence of decision and that more often than not, the opposite occurs (Cohen *et al.*, 1972; Langley *et al.*, 1995). Thus, because of the nature of processes and the unpredictable antecedents of actions, the decision-making processes in large-scale project contexts cannot be controlled by the individual project manager (PM) or any single project actor (Aaltonen *et al.*, 2017). Hence, processes are emergent, and because they comprise the actors' process interdependencies, they demand reflection on the project's inter-organizational context (Sydow and Braun, 2018). Mainly because of the latter, according to the descriptive stream on project studies, it has been established that a project's goals, design options, and scope will change over time (Artto *et al.*, 2016; Aaltonen *et al.*, 2017). Moreover, it is a myth that large-scale projects can have clear goals and controlled objectives, beginning in the early phase of the project's lifecycle (cf. Engwall, 2002).

As indicated earlier in this paper, the reductionist view focuses on the input variable and the outcome of the lock-in process rather than the process itself. Relatively little attention has been paid to the potential for decision-making to be understood from the analytical perspective of process studies (Langley *et al.*, 2013). Thus, the vital distinction made by process scholars between owned and unowned processes has been

overlooked (Mackay and Chia, 2013). Aaltonen et al., and Matinheikki et al. are notable exceptions in this context (see Aaltonen et al., 2017; Matinheikki et al., 2018). From the 'owned' perspective, according to Mackay and Chia (2013), chance, nonlinearity, and unintended consequences (i.e., effects not intended by managers coping with a chaotic and messy reality) are diminished. By contrast, according to Langley et al. (2013, p.5), in the unowned process perspective, 'context is not a constant and outside the changes being analyzed. But is itself continually reconstituted with and by process of interaction over time, generating unexpected and largely uncontrollable chains of activity' in which actors, environments, and organizations are all constantly and mutually interacting.

In the project's context (Engwall, 2003) and networks (Manning and Sydow, 2011; DeFillippi and Sydow, 2016), therefore, various actions combine to influence project choices and chance matters (Mackay and Chia, 2013). Consequently, there is a need for a social understanding that complements the psychological orientation of the reductionist view. There is a need for a process view in exploring decision-making processes by tracing wide-ranging effects in the long-term (inter-) organizational context (Lundin et al., 2015). This latter point will be explored in this paper. As we will show, if the research scope is expanded beyond the individual decision-maker and the single actor to account for the project's nature, its temporariness and the (inter-) organizational context, a fine-grained understanding of the emergence of the lock-in could be derived.

3. Research design and methods

In the following section, we present the analysis of the data collected from the in-depth qualitative case study (Rowley, 2002) on the processual nature of choices made in the HSL project. In this study, we aim to understand the emergence of lock-in through the dynamics of the large-scale project lifecycle as temporary yet embedded in a network (DeFillippi and Sydow, 2016). Thus, privileging processes over causes in contemporary project management theory. We, therefore, adopted the 'unowned process perspective' (Langley *et al.*, 2013, p. 5), which resonates with path dependence theory's recognition that context and manifold peripheral processes influence choices (Sydow et al., 2012). Through the unowned process perspective, we refrain from allocating heroism or expertise and incompetence to leaders (e.g., Eweje et al., 2012; Flyvbjerg, 2014). Instead, we favor eventualities of the unexpected and the (inter-) organizational project context, which influence the processes in the project and organization. This research, therefore, is abductive in nature because the starting point is the empirical context. It builds on the case research in the process of 'theory elaboration' (Ketokivi and Choi, 2014, p. 236). Thus, we engage in an iterative process that considers both empirical data and theory. We explain this approach in detail in sub-section 3.4.

We chose a qualitative, single case study method (Rowley, 2002), first to gain insights into the processual nature of the decision-making process by seeking empirical richness (Flyvbjerg, 2006a) and internal consistency (Gioia et al., 2013). Second, an explorative inquiry and qualitative case study enable the investigation of lock-in emergence (Sydow et al., 2012). Third, the case study involving observations, semi-structured interviews, and the secondary data allowed us to understand how actors make choices at different levels and how these choices are related (Mathieu and Chen, 2011).

3.1. Case selection and description

The unit of analysis in this empirical study was the multi-actor Madrid-Barcelona HSL project (1990-2017). The organizing of the project was a nexus activity that allowed multiple organizations to collaborate. Therefore, we considered the Adif organization and other actors (e.g., project proponents, contractors, and other suppliers) important in scrutinizing the inter-organizational facet to understand the emergence of lock-in and make sense of the actors' project choices (Sydow and Braun, 2018). We selected this specific case through theoretical sampling (Eisenhardt and Graebner, 2007) because we considered it particularly suitable and revelatory in the light of path dependence and creation constructs. The HSL case, which had an investment budget of around €9 billion, is still considered iconic in terms of infrastructure investment. It was extensively reported, and a considerable amount of documentary evidence is available in newspapers, audits, and official reports (Report, 2003, 2010, 2013, 2017). Thus, we used two main criteria to select this specific case. (1) It

provided access to potentially rich critical data (Flyvbjerg, 2006a). It involved multiple actors and interrelated network-level processes, thus providing a fruitful context for observing the process of lock-in emergence. (2) Mainly because the project under study had undergone considerable centralization and decentralization over-time within the European umbrella (Geyer and Davies, 2000). The case study we examine here illustrates choice formation that is driven by both inter-organizational actors and project management practice adaptation to the project's institutional norms.

The ambitious Madrid–Barcelona HSL project was conducted from the early 1990s to 2017. It was planned and designed to reach speeds of 350 km/h in connecting the Spanish capital of Madrid with the city of Barcelona (649 kilometers). On 17 November 2003, during the HSL project, the reorganization of the railway sector occurred, laying down the bases so that there could be a progressive entry of new players in this market. Adif² was created, which is a public governmental agency that acted as the project owner. First, GIF³ and then Adif as the HSL project owner responsible for the management of infrastructure developed the project scope in three major phases. The first phase was Madrid–Lleida (443 kilometers), which was carried out from 1995 and completed on 11 October 2003; during this period, GIF was responsible for the project work and the operation of the first line segment. The second phase was Lleida–Tarragona (108 kilometers), which was completed in December 2006; the third phase was Tarragona–Barcelona (98 kilometers), which was completed in February 2008. The project investment was co-financed by the EU and the Spanish government; the European Investment Bank was a crucial collaborator in the funding of this project, where the necessary public contribution was between 30% and 42% of the total investment.

The HSL project involved multiple contractors and suppliers. The procurement occurred at different points in time, considering that the line was segmented in three major phases, and the project involved multiple contract packages. Design Bid Build (DBB) was mainly used, and Design-Build (DB) was used only for constructing heavy civil infrastructures, such as tunnels and bridges. It is worth noting that at the time of the project's implementation, the Spanish contractors and suppliers were among the largest worldwide, and they employed in-house engineers (Belmonte, 2016; Report, 2017). However, the Spanish public administration tended to protect the consulting and design engineering companies in the country. Thus, using DBB and an external PM, which is similar to the construction manager agency in the US. The purpose of the adoption of DB mode to heavy civil infrastructure occurred since Adif expected the contractors or specialist suppliers to provide innovative technologies in such complex endeavor (Internal document; cooperation agreement, 2006). DB mode involved four main contracts, no. 10, 14, 23 and 24; two for the 28.7 km Guadarrama tunnel, which was completed on 22 October 2007, and the other two to connect different nodes to the existing rail networks (Internal document; financial report, 2009). Each contract was given to an independent consortium.

The HSL project faced uncertainties as the three phases progressed. Although the rail infrastructure was already completed in 2009, it came into operation, facing many issues (Report, 2010, 2013). That is, the initial tender contracts occurred between 1995 and 1996 after the concept was finalized. However, the term commencement of the works was delayed in 70% of the contracts, being the average delay of the beginning of the works of 7 months from the signing of the contract. In some cases, as in the contract of execution of works of the platform construction project of the first segment line Madrid–Lleida, section: “Santa Coloma - Sant Joan Despí” the delay was 30 months. On many occasions, these delays were due to the start of the bidding of the contracts without having begun the procedures of forced expropriation of the affected lands, leading to the suspension of the beginning of the works. Also, there were several problems involving withdrawn contracts and suspensions. For example, the one concerning the building of the central station “Madrid Puerta de Atocha” in Madrid, which failed to obtain local approval at initial. First, because of technicalities and then because of multiple contract-related issues, thus requiring re-tendering (Elpais, 2015; Report, 2017). Therefore, the completion of the first segment on 11 October 2003 included only part of the major construction works, and work was ongoing on this segment until the end of 2017. In Table 1, we provide a historical view of the entire HSL project, showing main events and the decision-making points along a timeline.

²Law 39/2003, of November 17, establishes that the RENFE public business entity is renamed Administrator of Railway Infrastructures (Adif) and assumes the functions assigned to the Railway Infrastructure administrator in the Law. To this end, Adif replaces the GIF, subrogating the public entity Adif in all its rights and obligations.

³ The “Gestor de Infraestructuras Ferroviarias” (GIF) [Rail Infrastructure Manager] was created by article 160 of Law 13/1996, of December 30, on Fiscal, Administrative and Social order measures, having as its object the construction and, if applicable, the administration of the railway infrastructures

Design Consultant	1	2		
Contractor			2	
Supplier				1
Project owner	3	2	3	2
Project Proponent	1			
	Project Definition	Plan	Execute & Control	Close out/ Operations
Organization background	Project life cycle involvement			
HSL Mad-Barcelona project	17 interviews			

Fig. 1. Interviewee representatives, their profile and organization background in relation to the project lifecycle. Note: the project lifecycle is outlined based on Morris (2013)

Events	Date
Policy analysis framing the concept of the HSL in the transportation sector	1985
The HSL project declared priority by the council of ministers	1987
Termination of the Madrid-Seville HSL project	1992
Agreement on the HSL network among Spain and France	1995
At the European Union Summit in Essen, the HSL project is included within the Director Scheme of the Trans-European High-Speed Network, being one of the 14 priority projects	1995
The first tenders and contracts were awarded by the Ministry of Public Works	1995-96
The Council of Ministers, attributed to the GIF the construction and administration of the HSL	1997
GIF started its activity through the formalization of several design and consultancy contracts	1997
The HSL project was declared priority by the Council of Ministers	1998
The Director of GIF approved an Internal Circular that regulated in detail the internal procedures for contracting the Public Entity	1999
Start of the construction phase: the shovel goes in the ground and the first steel was bent	1999
UIC (1,435 mm) track gauge implementation	2001
Addendum agreement signed by the parties involved, the Ministry of Development, Government of Catalunya, Madrid and Barcelona city council, GIF/ Adif and Renfe-Operator	2002
The Law 39/2003 established a complete reorganization of the rail sector, Adif was created	2003
Cost overrun reported by the Plenary of the Court of Auditors	2003
Start of construction works in problematic Tunnels de 'Guadarrama' (28,7 km)	2004
Adif adopted measures ensuring that the basic project design has enough details for implementation – approved guidelines for decision-making following phased-review model	2005
Delivery of rail foundation, bridges and tunnels	2007
Delivery of rail infrastructure, and problems with contracts suspensions and the ERTMS	2008
Start of operations partially, including a segment line	2009
The setup of the Monitoring Committee	2009
Adif implemented behavioral guides that regulated in detail the processes	2010
The first expansion phase, involving the separation of the departure and arrival areas in Atocha	2010
Sants- La Sagrera section was subject of contentious appeals, revolving the temple of the Sagrada	2012
Problematic start of Atocha-Chamartin tunnel in Madrid	2013
Final report by the Plenary of the Court of Auditors	2016

Table 1. A timeline of main events of Madrid-Barcelona HSL project

3.2. Data collection

We collected data through semi-structured interviews, observations, and secondary data sources (e.g., internal project folder and audit reports). The data was collected at two intervals, which were carried out under the supervision of the third author, which enabled an in-depth contextual analysis. The first interval of data collection was from 1996-2010, during which the third author provided privileged access to data due to his role as research advisor first to GIF and later Adif on several portfolio issues. He performed group interviews, participant observation, and in-depth analysis of the first and second implementation phase of the HSL project. During this interval, over 40 interviews were held. After the first interval of data collection, we felt we had not reached theoretical saturation (Eisenhardt and Graebner, 2007). The first author visited the Adif project offices and site to conduct a second interval of data collection in person, also involving interviews and observation. The data collected in the second interval, which took place between 2015-2018, were codified using the same procedure. The interviewees remained anonymous to ensure confidentiality, but the data reveal the interviewees' project affiliation. In total, including both intervals, we carried out 17 interviews. All interviews were audio-recorded with the participants' consent, which resulted in 19 hours and 25 minutes of audio-recorded material upon which we draw in this study. We discuss the second interval of data collection in detail in the following section.

3.2.1. Interviews

The primary sources: the 17 interviewees were the most important actors involved in the HSL project and the Adif organization. The interviews in both intervals were semi-structured and lasted 60–90 minutes. Each interview was digitally recorded and then transcribed. Members of Adif, PM, and large contractors involved in the project were interviewed several times over the second three-year data collection interval. Besides, between the formal interviews, informal contact was maintained with the participants via e-mail and telephone. The participants included the head of infrastructure projects and the head of systems integration projects at Adif; the PM at Adif, the construction manager (CM), and civil and environmental engineers, including the PMs of organizations A, B, and C (large contractors/ suppliers in the project). Fig. 1 shows the criteria used to select the interviewees, which were based on their profiles, organizational background, and their involvement throughout the project's lifecycle. We provide both a summary of the data collection and the interview design in Table 2.

Data collection method		Data collected
Semi-structured interviews	First interval (1996-2010)	5 interviews with the HSL PM, Adif Quality Controller, Head of Infrastructure Projects, Engineer at Organization B, project proponent and other relevant actors. Average duration was slightly over one hour.
	second interval (2015-2018)	12 interviews with the program managers and other relevant actors (project managers, construction manager at Adif, Organization 'A' Contractor PM, Organization B Supplier, Organization C Contractor PM). Average duration was slightly over one hour.
(Participant) Observations	First interval (1996-2018)	<ul style="list-style-type: none"> ○ participant observations, ○ group interviews, ○ Extensive informal communication
	second interval (2015-2018)	The insider spent 2–3 days per week at the organization's offices and conducted observations: <ul style="list-style-type: none"> ○ 7 management meetings; ○ Extensive informal communication; ○ Field notes for each of the days spent on site;
Document analysis	In total more than 20 documents: <ul style="list-style-type: none"> ➤ Internal program documents (internal financial and audit reports, overview presentations, internal organization and escalation matrices, lessons learned, and program tools, e.g., risk logs). ➤ Organization-wide guidelines and frameworks for project and program risk management. ➤ 90 pages of public material drawn from the press coverage of the project. 	

High-level interview design first interval (1996-2010)	Low-level interview design second interval (2015-2018)
<ol style="list-style-type: none"> Describe the role that governmental mechanisms play in your project. What are the specific events with regard to your project's life implications in decision-making? Describe specific events and processes influencing the formal decision. What do you think about project changes? Who, if anyone, disagrees with you on this? What are the main factors and processes influencing technical decisions and methods? What did the decision lead to? What are the main factors and processes influencing schedule overrun? Describe an example of possibly changing an inefficient decision involving the design of the project. Who have been the most influential actors involved in the process? Describe the process of estimation, prior to the decision-making level? Are there incentives promoting 'estimate accuracy' or reference class forecasting? 	<p><u>Interview warm-up</u></p> <ol style="list-style-type: none"> What is your job role and where are you located? Which project(s) have you been involved with? Can you elaborate on the history of this project? You mentioned project 'A' – why was this project started? <p><u>Exploratory</u></p> <ol style="list-style-type: none"> What difficulties did you face in this project? You mentioned the influence of project 'A' in your project. What is the connection of that project to your project? You mentioned this particular issue in the project; what drivers brought to this issue? Who would disagree with you about this, if anyone? Please elaborate. <p><u>Refine</u></p> <ol style="list-style-type: none"> My research looks at decision-making action and uncertainty management in a large project context, unfolding under schedule pressure in a multi-project environment. What does schedule pressure mean to you? How are resources allocated in your project? Describe an example of changing resource demands — who are the most influential actors involved in the process? You mentioned that decision 'X' increased the schedule pressure in your project; please describe the process influencing decision 'X' your project. From my observations, I found that decision 'Y' causes 'Z'. But what do you think causes 'Y' to happen? <p><u>Wrap-up</u></p> <ol style="list-style-type: none"> Do you think that the long project execution timescale explains the reasons for the problem you mentioned? Some interviewees told me that 'X' causes 'Y.' Do you agree? If not, please describe the process.

Table 2. Summary of data collection

3.2.2. Observations

In addition to the interviews, the embedded case study concerning the second data collection interval was focused on the project management division (Rowley, 2002) for three months between late August and November 2016. The empirical data collection involved an insider/outsider approach (Louis and Bartunek, 1992). That is, one of the authors acted as an insider while performing interviews and observations within the management environment, and the second author acted like an outsider, thereby integrating diverse perspectives on the empirical setting. During this interval, the insider spent two to three days per week at the Adif offices in Madrid and conducted seven direct observations of meetings at the management level. Recording the meetings was not permitted. Instead, observations were recorded in extensive note-taking, which, to ensure their reliability, were discussed with the Adif team members during the following interviews. The third member of the research team participated in all stages of the research. While the others performed in-depth analyses concerning the qualitative data that were collected. The outsider perspective helped the second author, mainly, to make sense of the data as well as to scrutinize and challenge the interpretations of the insider. It is worth noting that when the observations took place, some work was performed within the first segment of the project. As indicated earlier, the issues related to the Madrid central station in Atocha involved multiple actors and ongoing work. Which provided rich insights into the decision-making process and the project implementation practice.

3.3. Data analysis

3.3.1. Identification of the mechanisms underlying lock-in

Following the guidelines for qualitative inquiry (Denzin & Lincoln, 2011), we used both first- and second-order analyses. In the first-order analysis, we wrote the case history (Langley, 1999), which created a thick description (Rowley, 2002) of the managerial choices and emergent processes of the strategic decisions made at the HSL project. We then discussed the detailed description to make sense of the inter-organizational processes, particularly regarding how choices at the industry level influenced the project's organization. We then aimed to understand the influential mechanisms in the context of the Madrid–Barcelona HSL. As indicated earlier, we applied an abductive approach, and our analysis followed Gioia et al. (2013). We reviewed the literature on project studies, path dependence/creation, and organizational processes. As our analytical framework, we employed the four self-reinforcing effects on a permanent organizational setting identified by Sydow et al. (2009): coordination, complementary, organizational learning, and adaptive expectation. In our view, these four effects could be readily transferred to our analysis. We analyzed our interviewees' descriptions and the secondary data (i.e., industry regulations and the entire project folder) to describe how the project issues were dealt with and how the decisions were made. We focused on choices that were considered essential and could be traced back to several years. Two to five retrospective interviews per decision were deemed adequate to capture the key attributes of the process (Langley et al., 1995). In this phase of the analysis, we adopted an iterative method of constant comparison, moving between the data and the processual theory developed by process scholars (Langley et al., 2013). We followed their approach to analyzing our qualitative data to determine the emergence of lock-in. We discuss the findings of this analysis in sub-section 4.1.

Concurrently with the interviews, we studied the project documentation that was available to us to continuously valid the data and to inform the interviews. We were granted access to the main project design and the project management folder. At that time, when the first author (i.e., the insider) stayed at the Adif offices, the project documentation comprised over 1,850 pages. We thoroughly studied the various documents, particularly 20 documents that included internal financial and audit reports, HSL intranet, the overview presentations, internal organization charts, and escalation matrices.

3.3.2. Exploring the influence of effects related to the project and the (inter-) organizational context

In the second-order analysis, we aimed to understand the peculiarities of the (inter-) organizational project context and the implications of the temporary dimension on the emergence of lock-in; thus, we applied an inductive approach (Gioia et al., 2013). In tracing choices through time, we paid particular attention to both the intended and unintended consequences—the peripheral events seemingly remote from the project—in creating a storyline of the events (Mackay and Chia, 2013). We are convinced that the recall bias was minimal because all the respondents in our study were still active in the organization in some way. For example, one of our interviewees participated in all stages of the project, first as Engineer (2002–2007), then as PM and technical coordinator (2008–2016) and more recently (post-2016) as part of the senior management involved in finalizing the work issues related to the first line segment.

Following the process approach (Langley et al., 2013), we scrutinized the subject of our study, relying on observations. This close perspective throughout both data collection intervals helped us to understand how the management team organized its activities. Moreover, the interviews helped us to explore further how the PMs coped with different issues. However, other choices required a more general view, stepping back to detect the effects of the (inter-)organizational context. Scrutinizing other processes and the interdependencies among actors over a long period, as in the research of Sydow and Koll (2017) and Aaltonen et al., (2017). In line with the purpose of process studies, we used the concept of 'temporal bracketing' (Langley, 1999), decomposing three distinct periods T1 (1990–1998), T2 (1999–2008), T3 (2009–2017) to sequence the processes and events chronologically for analytic purpose. To this end, we frame these periods as follows: T1) the period of project front-end decisions and the institutional setting influencing the design choice path; T2) the period of prior ties as antecedents of path dependence; T3) the period of creation of action spaces at the project level. We build our analysis and reasoning for the preceding periods T1 & T2 while relying mostly upon the first interval (1996–

2010) of data collection sources. While we rely upon the second interval of data collection sources (2015-2018) for the latter period T3.

We employed concepts relating to the organizational mechanisms, to understand how the project's (inter-) organizational setting influenced the emergence of lock-in. Through which choices were shaped in initiating and performing the Madrid-Barcelona HSL project. We then grouped the findings into categories. Following the suggestions of earlier researchers that adopted a path-dependent approach (Sydow and Schreyögg, 2013). We employed process tracing (Langley *et al.*, 2013) and event structure analysis to identify significant patterns. Including the processes at the project entry stage, the prospective views of actors, and their implications for the overall project performance. Thus, we identified additional effects by which the project's (inter-)organizational setting influenced the choices and the emergence of a 'soft' lock-in (Sydow *et al.*, 2012, p. 170). After the coding and the emergence of the first-order themes (Gioia *et al.* 2013), we engaged in axial coding to identify the second-order themes (Gioia *et al.*, 2013). From this detailed case analysis, five other effects emerged, which complemented the data structure displayed in Fig. 2. For space reasons, as supplementary material, we provide an overview of the empirical findings and the data showing how the themes emerged, which enhances the transparency of our analysis.

3.4. Reliability and validity

We drew broad criteria from social science research (Denzin and Lincoln, 2011; Yin, 2013) to ensure the high validity and reliability of our findings. Thus, eight criteria for trustworthiness were employed to ensure the rigor of the study. Reliability, external validity, dependability, confirmability, and integrity were drawn from the interpretive view (Denzin and Lincoln, 2011). Fit, understanding, and generality were taken from grounded analysis (Gioia *et al.*, 2013). We list the criteria used in the method we adopted in our study in Table 3.

Figure 2. Data structure

Criteria and explanation	Steps to address the criteria
<i>Reliability (the extent to which the findings appear to be representations of the data)</i>	<p>The use of the case study protocol and the development of the case study report. The case study report was sent to ADIF for their consent;</p> <p>Data were collected from diverse informants, including key actors of the project network who viewed the processes from different perspectives;</p> <p>The interviewees were asked to verify the interpretations of data obtained from direct observations and the interviews;</p> <p>All interviews and result workshops were conducted by several researchers, one led the interview(s), and other complemented the interviews and took notes while alternating between them in the process;</p> <p>Corroboration of data sources between interviews, field notes, and reports. In-depth discussion of the analysis to ensure consistency and agreement among researchers.</p>
<i>External validity (the extent to which the findings from a study in one context will apply to other contexts)</i>	<p>The use of strong theoretical foundation, from the process literature and path dependence/ creation literature (Langley <i>et al.</i>, 1995, 2013; Garud and Karnøe, 2001; Sydow <i>et al.</i>, 2009) and other reliable studies in the field to compare the findings (Hellström <i>et al.</i>, 2013; Levering <i>et al.</i>, 2013; Aaltonen <i>et al.</i>, 2017) and enabling analytical generalizations;</p> <p>Transparency of the study analysis, allowing the replication of our findings (Yin, 2013, p. 37)</p>
<i>Dependability (the extent to which the findings are unique to time and place; the stability or consistency of explanations)</i>	<p>All interviewees are experienced project managers or engineers that have expertise and knowledge regarding decision practice and management practice in large-scale projects;</p> <p>Interviewees reflected as far back as >10 years;</p> <p>Secondary data, internal reports were reviewed as far back as 20 years;</p> <p>Detailed and rich description of the research context and the HSL project and events over time, establishing the boundaries for analytical generalization and transferability of the theoretical ideas;</p>
<i>Confirmability (the extent to which interpretations are the result of the participants and the phenomenon as opposed to research bias)</i>	<p>Data were collected from diverse informants, including key actors of the project network who viewed the processes from different perspectives;</p> <p>Triangulation and pattern matching among the data including observations, interviews and other reports;</p>
<i>Integrity (the extent to which interpretations are influenced)</i>	<p>No contradictory evidence was identified via triangulation of data;</p> <p>Confidentiality of obtained data, agreement signed with ADIF;</p>
<i>Fit (the extent to which findings fit the substantive under investigation)</i>	<p>Ensured by reliability, external validity (in comparison with the extant theory) and confirmability of the study;</p>
<i>Understanding (the extent to which the interviewees and other participants accept the results as possible representations of their world)</i>	<p>The interviewees were asked to verify the interpretations of data obtained from direct observations, the interviews, and reports;</p> <p>The case study report was sent to ADIF for their consent to publish;</p>
<i>Generality (the extent to which findings cover multiple aspects of the phenomenon)</i>	<p>Observations through the insider-outsider approach (Louis and Bartunek, 1992) over three month period, together with the first interval of data collection, interviews lasting between 60-90 and the review of reports each enabled in-depth insights to the project practice; both allowed for flexibility in the discussion;</p>

Table 3. Rigor of the study: criteria and steps to address the criteria

4. Findings

4.1. The emergence of soft lock-in in the Madrid–Barcelona HSL project

In this section, we begin by highlighting how the institutional setting created a design choice path. We also explain how the effects at the permanent organizational level occurred and how they shaped the choices made during the HSL project and how the actors created their action spaces in decision-making. Finally, by accounting for decision interactions relating to the temporal relationship between the second-order themes, we propose a conceptual process framework of lock-in emergence (Fig. 3).

Fig. 3. The lock-in emergence in large-scale project: a process framework

4.2. Period T1: The institutional setting influencing the design choice path (1990-1998)

4.2.1. Pre-project effects

The HSL originally appeared as one of the alternatives to address the challenges of the old rail capacity, its technical problems, and the loss of passengers and freight due to the quality of the services. Therefore, on 9 December 1987, the Council of Ministers decided that the new infrastructure should be built using high-speed parameters and with the gauge that predominated in other European countries, i.e., 1,435 mm. (the gauge of conventional Spanish lines is 1,668 mm.) Thus, high-speed trains began to be developed in Spain, first with the Madrid-Seville HSL (471 km) that went into operation in April 1992. Then the next point was the Madrid-Barcelona HSL project.

The Council of Ministers, at its meeting of May 23, 1997, attributed to the GIF the construction and administration of the Madrid-Barcelona HSL. In Spain, the formal authorization of project initiation is given by the Ministry of Infrastructure Development, which instructs the Sub-directorate of Railway Planning to prepare an informative study (i.e., a detailed planning document). This formal letter of approval, in Spanish 'the encargo,' was the formal order for GIF to start the construction of the line, including the search for funds to

finance the new HSL, including European funds, which depended on the degree of indebtedness and inclusion of financing in the general state budget. In order for GIF to start the HSL project, the detailed planning document had to be approved. In the Spanish model, however, the detailed planning document is not the responsibility of the line's management (Internal document; Project report, 2002). Instead, it is the strategic input of the system through which GIF received the order to execute a specific HSL project. The planning document then affects the project management's choices.

The effects of strategic planning on initializing a project are that any element that is not sufficiently defined in the informative study or that emerges during the execution of the line must be subject to a new complementary informative study and submitted to the full process of public information and environmental impact assessment. However, in this case, it was common for GIF to be entrusted with the execution of a line while the information study was still in process and had not yet been approved (Report, 2003). The formulation of the environmental impact statement by the Ministry of Environment was beyond the control of the Ministry of Infrastructure Development, which had already entrusted the execution of the line to GIF. The delays that this process caused in the rest of the project entailed important adjustments that affected its implementation and management. The PM at GIF outlined the implications of the above regulations as follows: 'There is no time to carry out a feasibility study properly or to evaluate infrastructure needs. There is no time to lose because the elections are in four years.' (Interview with former HSL PM, December 1997)

4.2.2. Institutional effects: The legal boundaries of decision-making

At GIF, a model was established in which the project owner's engineer directs and manages the works, and the engineering company executes it accordingly. In order to contract this type of service, the Ministry of Infrastructure Development must sign a report of insufficient means, a requirement that was imposed when the outsourcing of such works began and continues today. This functional position within GIF projects is the facultative director; this position has been continuously enacted throughout the project lifecycle. This position is responsible for the work and the quality approval, which directly influences the incomes of the project contractors, as one of our interviewees described:

'I was responsible for selecting suppliers, initiating project modifications, and developing the new components needed. As you know, GIF has a strict hierarchy: huge work packages are delivered to me, and I'm accountable for work approval and pricing for our contractors and suppliers, who I do not actually contract and, at times, do not supervise.' (Interview with facultative director, March 1998)

Our observation of this functional position indicated that it involves the contractual maintenance of a specific pattern that is an indicator of the path determined, which leads to a potentially inefficient lock-in. In other words, this function creates lock-in effects because of the lack of support or external oversight. More often than not, the size of the HSL project meant that it was simply impossible for the work approval process to be implemented at every stage. The remedies were simple: other internal personnel from the functional office were sent to observe the work performed and approve it. The problem was that the internal staff did not have the authority or the required competence to carry out such tasks. The point is that the person holding the functional position of facultative director seeks project controllability, indeed illustrative yet a cautionary tale. However, except for the legal boundaries of decision-making and the law of public procurement, other components were important and influenced management decision-making regarding the following:

- Projects for which the client is the GIF/ Adif organization itself, simultaneous events
- Multidisciplinary projects with different technological applications
- The influence of the traditional model on different areas of the project design and the execution of civil works

Because it was under government regulation, the GIF management established a phased review-based model, seeking legitimacy for their project choices. Such a strategy was followed throughout the project later by Adif. This model provided guidelines for decision-making in the project while considering the project's tendency to adopt best PM practices. That is, first, the GIF and later Adif guidelines included ideas taken from PM bodies of knowledge, following a linear model. However, and in contrast to their choice guidelines, which prescribed linear decisions based on the logic of consequences and rational decision-making (e.g., PMBOK guide, 2013, p. 516). Several events and issues prevented the Adif PM from making a 'rational' decision. In the project context, many modifications indicated the PM's motives. They sometimes ignored the process

guidelines or did not consider them thoroughly because they were uncertain. For example, this issue was described during an interview with the construction manager at Adif:

‘We were very task-oriented and not behavior-focused. We needed a giant step to becoming better organized. There were process guidelines, which described how to run things, but the way we lived life, the project had little to do with them.’ (Interview with the construction manager, October 2016)

Because many work packages at the project level lacked external observation. We concluded that the Adif management’s actions took directions and adopted patterns other than those prescribed and that their environment influenced them.

4.2.3. Post-project effects

The post-project effects occurred at both the project front-end and the project level. In the HSL case, project proponents gave meaning to the decision to build by advertising the image of modern transportation and the connection to the European rail network (Ministry of Infrastructure, 2012). Other actions by the project’s proponents included advertising the project as being environmentally friendly, but there were situations in which cost/benefit analysis and their influence were brushed aside. These actions illustrate behavior that has long been recognized in organizational studies (Cohen et al., 1972). Meaning for the project proposal to pass the selection process, it must be overly optimistic, and the cost-benefit analysis not fully considered. A project team member described this behavior during an interview:

‘It is the higher pressure we have—the schedule—due to political influence: they want to start the project. For them (the politicians and proponents involved), it is important to start the project, but not necessarily to get it done. At least, this is the Spanish way.’ (Transcript of the notes collected by one of the researchers during a research related-meeting with GIF management, April 1998)

At the project level, as indicated earlier, the management of GIF/ Adif used a phased review-based model in making their project choices. At the selection stage, which, in the case of the HSL project, often involved a high degree of uncertainty, to gain support for choices, compromises between actors reached through informal interaction were usually necessary. This situation set the scene for negotiated decisions, which included project choices in the form of negotiated agreements, even though these choices sometimes undermined efficiency. Some project members blamed the contractors:

‘There are also changes when the design is not done properly. When this happens, contractors and suppliers try to make money. In that respect, they are opportunistic if they have the chance. I believe it is a problem because, when you have a problem, and you change the approach from the one agreed, you have to ‘negotiate’ the changes and, foremost, agree on the pricing. When we are over schedule, we usually end up agreeing.’ (Transcript of the notes collected by one of the researchers during a research related-meeting with GIF management, July 1998)

In these conditions, the decision-making process was dominated by negotiations and compromises. Because of the fragmented set of actors in the HSL project setting that presented diverse conflicting interests and business objectives that were difficult to align.

4.3. Period T2: Prior ties enabling fixed choices (1999-2008)

The most productive period 1999-2008 saw some changes in the form of organizing both internally at the organizational project level and externally at the sector level. In November 1999, the Director of GIF approved an internal guideline that regulated in detail the internal procedures for contracting the Public Entity. In addition, the Law 39/2003 established a complete reorganization of the rail sector, and Adif was created, strengthening the management position within the HSL setting. During this period, we found patterns of underlying mechanisms and effects in the HSL project, several of which suggested that a soft lock-in had already occurred. We describe them in detail in the following section. Following the archetypical and interpretative categories provided by Sydow et al. (2012). We clarified some of the contextual conditions in different time scales and different levels of description (i.e., the temporary organization and the project network) that gave rise to the emergence of lock-in. We summarize the findings of our analysis in Table 4. We outline the fundamental indicators of each effect on the inter-organizational context and influence of the actors throughout the decision

process. The X-axis was taken from Sydow et al. (2009, 2012), and the Y-axis shows our interpretation of the empirical constitutive features at work.

4.3.1. Coordination effects

Our interviewees described situations in which the process guidelines in the project were almost impossible to change, even though they had discovered that the existing rules and guidelines did not provide optimal choices. However, from the perspective of Adif and the private organizations and other actors involved, it was essential to have standardized project management models and to comply with them. Specialist suppliers offered their expertise to complete interdependent complex tasks (e.g., Siemens and Thales). Here the coordination mechanisms were important. Hence, the coordination mechanisms within the project were also affected by industry practices. In the Madrid–Barcelona HSL project, these practices were implemented through the European Rail Traffic Management System (ERTMS 1/2) to ensure compliance with the signaling and safety requirements (Report, 2012). In particular, the Madrid–Lleida section was equipped with ERTMS level 1, whereas the Lleida–Tarragona and the Tarragona–Barcelona sections (the second and third sections, respectively) used the level 2 signaling system in their networks. As we explain below, our interviewees viewed the work as being highly controlled by a hierarchical structure that influenced their activities and choices; as the head of infrastructure projects put it:

[T]ake the ERTMS system, for example, it has been established for years, and there was a clear understanding of the work to be performed. In my view, it has improved production and maintenance costs while simplifying approval processes in the project by reducing the certification costs. Moreover, the ERTMS system remains the same from project to project, which enables easier installation and manufacturing. (Interview with the Head of Infrastructure Projects at ADIF, June 2008)

When the adoption of standardized industry practices spread from project to project, the actors involved developed a shared understanding, which helped them to coordinate their objectives and accomplish their work.

4.3.2. Complementary effects

As indicated earlier, the tender contracts occurred between 1995 and 1996 after the concept was finalized, but there were several withdrawn contracts and suspensions, which created the need for re-tendering. The use of complementary management systems (e.g., the use of management standards and national construction regulations in conformity with the national law (in Spain, Ley del Contratos del Sector Publico [Ley 30/2007]) explicitly guided the procurement methods, thus restricting the actors' choices. Similarly, the ERTMS system and its corresponding products were supporting tools that reinforced certain choices over others. The management practices at the project level were influenced by both the regulatory framework and the industry practices in the public sector. The public procurement law, Ley del Contratos del Sector Publico (Ley 30/2007), shaped the management's choices by reinforcing work divisions based on cost limitations. Thus, the project was divided into multiple packages, and the project management had to make regular choices about individual work packages that simultaneously influenced each other. In this context, the management at Adif and the private actors (contractors and suppliers) performed their work through repeated interactions in several work packages. The actors' organizational activity patterns became dominant because they developed through a long-term relationship during the project by sharing (at times) common objectives, interests, and products. The regulated public procurement and the industry standards had corresponding effects on the contractors, who were focused on becoming more functional, proposing multiple solutions that would require similar choices. By continuously combining and repeating the practices by two or more project actors generated added-value for their operations but not for the owner or the project in general. According to our informants, the actors in the project pursued joint objectives, which helped them complete the work instead of choosing the best available options:

'We were, in the project, pursuing joint objectives with our partners: we adhered to the usage of complementary management systems set by the owner, even though we were more advanced in some ways—in technology adoption, for instance.' (Interview with the Engineer at Organization B, June 2008)

4.3.3. Learning effects

The focus of Adif's management is characterized by repetitive interactions, which benefit the learning effect but loses many opportunities. Another aspect of the learning effect is the actors' competence in large-scale infrastructure delivery. For example, the major contractors had proven competence in infrastructure projects, having taken part in many similar projects worldwide. In such conditions, they gained the expertise needed (e.g., the Ferrovial organization's in projects in London and Hong Kong). These contractors already had a network in place, including many contacts that resembled the connections among providers and suppliers, which increasingly pervaded the HSL project environment. In the case of Adif, the organization was also engaged internationally in the design and project management of the Lima underground railway project, among others (Report, 2014).

The cooperation of the actors in similar projects and their specialization and strengths in infrastructure delivery included the training of technical personnel, which resulted in learning effects. Our project informants highlighted the importance of continuous improvement through learning:

'My job is to run the development and construction program: to put in place arrangements for developing and implementing projects that enable continuous performance improvement. A very clear objective is to make Adif a modern owner by improving our working routines while learning from projects in the international market, including our projects.' (Transcript of the notes collected by one of the researchers during a research related-meeting with ADIF management, May 2008)

The Adif managers were aware that repetitive choices enhanced efficiency but made them less able to consider alternatives such as technical options. In this context, we observed a lack of motivation in Adif's management to make different choices regarding the project. Instead, the behavior that reinforced repetitive choices gained legitimacy and gained greater acceptance by the project members. The head of infrastructure projects described the importance of continuous learning in the project:

'Nowadays, it is a different system; knowing the latest technology affects the bridge length, for example, has a big influence. In that sense, it is important to have a strong relationship with the contractor for the smooth delivery of infrastructure and for the purpose of learning. We need to learn more about the capabilities and the behavior of our contractors. Usually, this means more expense for Adif at the beginning, but we learn for future projects.' (Interview with the Head of Infrastructure Projects at ADIF, June 2008)

4.3.4. Adaptive expectation effects.

Adif management was willing to adopt certain practices and expected others to do the same. That includes project members who were focused on adopting best PM practices in delimiting their choices during the decision-making process. Because they experienced uncertainty in the selection, they felt confident following the preferred methods; thus, a dominant solution emerged. In this context, the project members followed similar processes because the legitimation of their choices was crucial for the implementation of the project. They had to relate to and make sense of different actors' opinions and processes. The Adif PM described how the management was affected:

'It was challenging to deliver our work chunk in the project. I had to relate to and analyze the work repeatedly and intensively, not only for the task at hand but at the same time at more macro levels of analysis.' (Interview with ADIF PM, October 2016)

Therefore, the preferences of the Adif management were not individually determined; instead, individuals fitted themselves to the activities and the expectations of others while responding at different levels.

Lock-in mechanisms	Level of interrelatedness	Triggering event	Multiple actors
Coordination effects	Rule guided behavior, the HSL project has adopted a hierarchical governance structure to control and monitor the project. This also implied a mode for	The adoption of joint rules in the ADIF organization, the model continued to replicate in similar projects, and it became fixed. Even though project members	Multiple actors serve to engage in joint objectives. The more efficient the interaction among the actors in the project, the more efficient the choices they made.

	justification of internal investment decisions and help contractor's engagement	recognized challenges with time in the governance structure, they failed to change the practices	To some extent, their choices became anticipated. For them, it is more attractive to adapt to the rules.
Complementary effects	The HSL project as an inter-organizational setting - the actors (including the operators and suppliers) involved in the project have been working together recurrently in the European market. There are indeed strategic choices, commitments among them.	The design and the use of the same complementarily technologies, e.g., the use of management standards concerning organizational arrangement. The possibility to use the same operations – drawing upon joint resources; e.g., the use of BIM modeling among the actors to facilitate their work.	Actors in the project relate to synergies from drawing on multiple resources concurrently rather than making use of them in isolation.
Organization learning effects	Self-reinforcing learning effects could be detected at various levels at Adif. A noticeable tendency or preference for repetitive choices. In a field context, a wide range of private actors – suppliers build knowledge on infrastructure operation.	Lack of motivation to improve everyday choices in the project and at the organization level. Instead, the behavior to stick to the same choices was likely to gain more legitimacy and triggered more acceptance.	Actors' focus is underlined by simplicity in interaction, exploiting the strength through gaining learning effects while losing the opportunities. Thus, choices became more natural and narrowly focused. Forces of public operators have been significant – driving choices in the project.
Adaptive expectation effects	In the project context, members were willing to adopt the best PM practices in choice selection. Since members were uncertain for the choice selection, they felt safe in following the preferred choice. Thus, a dominant solution emerged.	A strong emphasis on control framed management decisions in the project. Such a tendency was reinforced by further industrial specialization: e.g., the development of ERTMS.	Actors were likely to adhere to the industry guidelines (e.g., ERTMS standard) defining the construction and operational practices. Industrial norms governed project processes in the situation when the permanent becomes a temporary condition in social systems.

Table 4. Summary of mechanisms and effects identified in the context of Madrid – Barcelona HSL project

4.4. Period T3: Actors creating action spaces (2009-2017)

4.4.1. Shielding effects

During the period 2009-2017, considerable changes in the project's plans and scope occurred. The project was expanded, with the first line expansion phase involving the Atocha station in Madrid. Besides, the third line segment in the Sants-La Sagrera section was subject to expansion, and the project plan altered significantly. Throughout this period, the actors searched for ways to safeguard these drastic changes in the scope of the project. Hence, managers tended to distance themselves from tight structures, including regulatory mechanisms that control their choices. For example, distance from key performance indicators (KPI) and detailed contracts, gravitating instead to loose structures. These shielding effects manifested as an improvisational action, performed both by PMs at Adif and their contractors. We observed this action mainly during the later phases in the project implementation level. The PMs engaged in improvisational actions relating to social rentability. They referred to

the soft objectives and demands of the project, rather than the hard cost-benefit analysis. An interview with the head of infrastructure projects illustrated the issue:

‘We have a factor called social rentability that is valuable! For instance, if you give reasons for a specific part of the project not performing and having problems due to communication, this argument is considered prior to financial rentability.... So, the rentability of the line can rarely be managed as a whole.’ (Transcript of the notes collected by one of the researchers during a research related-meeting with ADIF management, April 2017)

The contractors, in contrast, created action spaces by ignoring the details of the project plan and sending a vague plan to the Adif project controller—the facultative director—for confirmation. The above illustrates their intention to safeguard choices from external interference. Regarding this situation, the Adif construction manager drew special attention to the contractors’ behavior: ‘It seems to be a well-known behavior: contractors tend to be very crafty and disclose information or reveal problems only when they have to, and it is good for their business.’ (Interview with construction manager at Adif, March 2018)

4.4.2. The ‘temporary fix’ effects

The Adif management frequently, and often unconsciously, preferred short-term solutions to their problems entangled in the decision trap. Our data analysis showed that Adif management generally was not responsive to changes to or deviations from the plan (Report, 2013, 2017). However, in some cases, they responded, but the choices they made were usually ineffective in the long run. As indicated earlier, the Adif management based their project choices on a phased review-based model. Following PM best practices, Adif divided the project into smaller components, and these components challenged the project’s management by further complicating the scope of work and the interactions between the actors involved. A member of the Adif project highlighted the following:

‘Lots of unforeseen issues occur. We experience pressure, and we have to fulfill the work responsibilities promptly. The problem is that the line is segmented, and each segment is subdivided. We provide the platform, and then other actors come along. We are engaged in civil work—not in telecommunications, electrification, or signaling, each of which influences the work differently.’ (Interview with a project team member at ADIF, March 2017)

One of the main issues in this approach was that in making decisions during the phases, the management needed to play separate roles. That required expertise in constant monitoring, the need for quality controllers (i.e., facultative director in Adif). However, Adif was usually understaffed, which was highlighted during the interview with the facultative director:

I lack support and human resources to carry out my work with colleagues. We have only three engineers, and it is difficult to cover the whole project—it’s actually ridiculous! It’s impossible to cover the work. I had to cope with five contracts at once, and we needed, like, five or six people to take care of the workload in the field. (Interview with the Quality controller at ADIF, April 2017)

Given the simultaneity of the various works, the multiple changes in the project, and the fact that Adif was understaffed into monitoring the work performed, then a Monitoring Committee was created. The Ministry of Infrastructure Development, Government of Catalunya, Madrid, and Barcelona city councils, Adif and Renfe-Operator, formed part of the Monitoring Committee (Report, 2017). The Follow-up Commissions were unified in common sessions in which the subjects of all the works in execution were dispatched. All sessions were held at the ADIF offices of Madrid and at times in La Sagrera in Barcelona. Those held were the following: session 1: December 17, 2009; 2nd: January 28, 2010; ...; 8th: March 1, 2012; 9th: July 12, 2012; 10th: November 15, 2012; 11th: March 14, 2013; 12th: November 7, 2013; 13th: February 20, 2014. All the minutes are available except for the last one (Report, 2010, 2013, 2017). The minutes corresponding to the 2nd, 7th, and 12th sessions are unsigned. As can be observed, the Monitoring Committee has not respected the quarterly periodicity; it has been pre-established and has not carried out a rigorous follow-up to prevent or minimize the numerous irregularities in the execution of the works in the HSL project. In such circumstances, the Adif management, as a solution to their problem, postponed the decisions they had to make in each phase. Thus, because of changes and the postponement of decisions, the project schedule began to lag, which placed an additional burden on the project management and negatively affected the project’s budget. Combined with contextual influences, the schedule slippage became disastrous for the project. The project member at Adif recalled such circumstances: ‘Trying to do things faster means exactly the opposite. I don’t know.... I guess it is just that, due to political

pressure, the management initiates the work packages too soon'. (Interview with a project team member at ADIF, March 2017)

At the project level in this context, other actors (e.g., contractors and suppliers) often influenced the decisions by detecting problems and deciding solutions for the project. During the interview, the contractor expressed the following:

'In my view.... I've seen cases where construction companies go and speak with the local administration with responsibility for that region and ask for changes based on the regulatory territory; so, when changes occur, it is because of the construction organization's maneuvers.' (Interview with the Engineer at Organization C, June 2017)

Decisions made in the early phases of the project involved concrete actions, agreements (e.g., contracts signed), and design plans. However, during the project and at the project level. The actors' actions affected the decisions made at the initiation phase, thus shaping the direction of the project.

5. Discussion

5.1. Project actors' shared history

The findings of the empirical analysis indicated that Adif management was less likely to alter their decisions or their grounded project practices if the following occurred:

- a) Certain patterns or routines were dominant among the actors, influencing the efficiency of the collaboration (i.e., the coordination effect).
- b) A set of practices and synergies existed, so it was less likely that they would alter choices based on established practice (i.e., the complementarity effect).
- c) The preference for more repetitive choices was accompanied by a lack of motivation to improve the project practices (i.e., the learning effect).
- d) The collaborating actors expected each another to follow PM best practices (i.e., the adaptive expectation effect).

In addition, our observations indicated other effects that influenced the decision process — effects concerning the nature of the project, its temporality, and the (inter-) organizational context. Mainly due to the shielding, the temporary fix, and the pre- and post-project institutional effects respectively, the choices were grounded in the initial stages, and they were continuously shaped in certain directions during the project implementation. Hence, the decision-making process involved some irreversible situations related to prior ties (i.e., patterns of permanent organizations) that introduced various forms of lock-ins to the project's trajectory. Thus, the understanding of project choices and lock-ins in such settings makes sense if the properties of the aggregate structure of interactions among project actors are considered. Visibility in following a path of choice formation that requires a long-term (inter-)organizational perspective instead of a short-term goal-setting relies focussing on the process outcome. Accordingly, the decision-making process in large-scale projects is not always under the control of the single actors; more often than not, the opposite holds. Based on the findings of our case study, it could be argued that the emergence of a lock-in needs to be considered in the context of processes that are peculiar to the (inter-)organizational project and its institutional setting.

Regarding links between events at different levels, the findings of our analysis confirmed that the decision-making process is subject to both internal and external events and other issues. Influential external events include industrial features (e.g., the ERTMS system requirement and the procurement method), uncertainty as a function of the environmental definition arising because of diverse project actors. Here the contentious interdependencies among the actors have consequences for managing large-scale projects and affect the emergence of a lock-in. Internal events involve mainly task complexity, the level of specialization, the embedded work practice, the causal-ambiguity of the work organization, and the technology used. The conceptual process framework we put forth in this paper examines in-depth the issue of lock-in, see Fig. 3. Structuring such links in a process fashion, the mechanisms and effects, thus contextualizing the phenomenon.

5.2. Toward a generic process framework for lock-in emergence in large-scale project

The development of this conceptual process framework is an outcome of our empirical analysis of the Madrid-Barcelona HSL project. It is important because it accounts comprehensively for the decision process in a temporary organizational setting while considering the multi-level interactions within the HSL project (Mathieu and Chen, 2011). As shown in Fig.3, the conceptual process framework parses the emergence of lock-in, and it's shaping into three temporal phases (T1, T2, and T3). It enables a better understanding of the importance of more institutional and permanent organization level structure and the interaction between priorities in the processes of inter-organizational setting. The first temporal phase emphasizes the emergence of lock-in and the importance of the institutional patterns influencing the design-choice path. In brief, the first temporal phase highlights that the choices are embedded in institutions and that they reflect the institutional framing. The second temporal phase of the framework shows the priorities (i.e., the antecedent of path dependence) and the dynamics of the self-reinforcing effects. The increasing denser backgrounds in fig.3 signifies the structuring of choices, which eventually lead to a dominant decision pattern during the second temporal phase. The third temporal phase of the framework regarding the actors and their action spaces introduces the idea of path-shaping we observed in continuity when actors faced with changes in the project. In specific the path-shaping activities, namely, the shielding effects and the temporary fixed effects, see Fig. 3. They illustrate an improvisation on the part of the actors. The two-sided arrow linking the lock-in and the third stage model phase signifies the duality of the process. It means the already established soft lock-in influences the actors in the inter-organizational setting. Yet, the actors also part take in the co-creation and further shape the decisions through their action at the project level. The creation of these 'action spaces,' we observed, builds both in improvised and somehow new practices but also involves existing ones. Therefore, the understanding of lock-in requires the recognition of the contextual conditions that give rise to or support the lock-in through mechanisms and effects resulting from choice paths. Hence, we need to query not only the estimations at the project front-end or the cost-benefit analysis, as the reductionist literature suggests (e.g., Cantarelli et al., 2010; Flyvbjerg, 2013). But also, analyze the previous cooperation of the project actors and how (if it exists) it affects their current choices.

5.3. Lock-in emergence: An ontological divide

The findings of our case study extend the significance of Winch's (2013) organizational perspective and support the input variables identified by Cantarelli et al. (2010). The process perspective that we used in the present research, however, served to enrich the understanding of lock-in. Through our qualitative inquiry, the findings demonstrated the influence of several mechanisms and effects not only in the project but also from the project network on the emergence of lock-in in the large-scale Madrid-Barcelona HSL project as well as the implications of its inter-organizational and temporary nature (Aaltonen *et al.*, 2017; Sydow and Braun, 2018).

Our findings indicate that to understand decision-making in large-scale projects, there is a need to change the ontological priorities that underpin the existing research on the behavioral decision in project management (cf. Stingl and Gherardi, 2017). The reductionist view and its focus on the input variables and the outcomes of the lock-in process lead us to cost-related issues. It takes us down paths designated by the owned process perspective, directions from which we must veer (Mackay and Chia, 2013; Pitsis *et al.*, 2018). The lock-in is thus substantially more than a control-oriented final purposive outcome, and the questioning of lock-in emergence should move from 'what is wrong' to 'how' and 'why' it emerges. There is a need to recognize the heterogeneity of large-scale project contexts in the multi-organizational setting and their interdependencies in broad project networks. They represent the sources of variation in the desired outcomes (Artto *et al.*, 2016).

Moreover, they could never completely lock the choices into a deterministic trajectory. In this regard, we need to consider new and promising theoretical groundings. We suggest the view that recognizes the reality of processes (Langley et al., 2013) in the inter-organizational context. Table 5 shows the implications of our perspective for conceptualizing the lock-in as compared with past research. It highlights the differences and their implications, which may be compared with Cantarelli et al. (2010) and Winch (2013). The fourth column in table 5 shows how this research study conceptualizes lock-in.

Constitutive feature	Self-reinforcing process		
	Lock-in as conceptualized by Cantarelli et al., (2010)	Escalating Commitment as conceptualized by Winch (2013)	Lock-in as conceptualized in this study
Initial Conditions	Given	Decision based	Constructed, important trigger, but with inconclusive affects to the outcome
Contingencies	Not so important, form basically shaped through external process	Exogenous and non-purposive	Emergent and non-purposive
Governance of process	Reproduction, primarily exogenous	Holding on to former decision, endogenous	Self-reinforcing mechanisms, endogenous effects, in the presence of exogenous forces
Mechanisms and effects	Given, and non-elaborated	Project embedded in organization	Shaped from experience, project embedded into (inter-) organization network and at times strategically manipulated by actors
Predictability	Given	Given after establishing a successful pattern	Not given, becomes clearer with path formation
Level of Analysis	Industry level	(Project) Organization	(Inter-) Organization, sometimes field level
Outcome of process	Persistence and absolute in-efficiency	Persistence and in-efficiency	Path dependence/ creation, potentially in-efficient lock-in

Table 5. Comparing the conceptual stance of self-reinforcing processes with past research

In our aim to complement the reductionist view, we contend that the emergence of lock-in in large-scale projects is a behavioral pattern grounded in prior ties and the interactions of the actors involved. We empirically define the choices in a large-scale project setting, as partly restricted at the beginning of the process and then continuously influenced by various changes, in the industrial level and other processes at the project level. We argue that lock-in provides the necessary ongoing social construction during the project arrangement and the negotiated mission throughout the project implementation. Our view does not undermine the significance of value-adding elements in the project's front-end (Artto et al., 2016; Liu et al., 2019). Nor does it intend to portray the arrangements in the early stage of the project as inept or lacking in purposive action. But we do recognize that the choices made by project actors are possibly partial. Based on the findings of our study, in which we applied the process view and built on the prior research on path dependence and creation (Sydow *et al.*, 2009, 2012), we conclude that initial conditions are not 'givens' and that contingencies, mechanisms, and effects are emergent contexts of action, see Table 5. In this paper, we have discussed these points using a narrative approach.

6. Conclusions

6.1. Theoretical contribution

We posed the following research questions: How and why does lock-in emerge within large-scale projects? What are the underlying mechanisms and effects that affect lock-in in these settings? Our study makes an important threefold contribution to the scholarly knowledge about project management as well as the path dependence and creation research that explores path-related processes and lock-in. First, our study relates the concept of lock-in to the critical theme of bounded rationality in the decision-making processes in large-scale

projects (Flyvbjerg, 2014; van Marrewijk *et al.*, 2016). Rather than taking the view that confines decisions to the individual or single actor control in front-end of projects. We followed the development of the decision process throughout the evolution of the project – considering its (inter-) organizational context (Sydow & Braun, 2018). The conceptualization of lock-in emergence through mechanisms and effects as non-purposive revealed another side compared to the reductionist view. Painting a detailed picture of how prior ties and multi-actor interdependencies in the project and network environment influence the decision-making process in a large-scale project setting.

We provide nascent theorizing on how the temporary and (inter-) organizational nature of large-scale projects affects the emergence of lock-ins. To this end, we showed how the organizing and decision process is continuously shaped in a specific direction by project actors over time, thus contextualizing the phenomena. We empirically examined how the contextual conditions that give rise to or support lock-in emergence affected the project's multi-actor overall scoping process and goals — thus adding to the limited knowledge about path-related processes in projects (Levering *et al.*, 2013; Aaltonen *et al.*, 2017). Based on these findings, we affirm that the management of large-scale projects entails multiple ties with past and future that are necessary to get to grips with when facing the challenges this specific form of temporary organizing poses (Grabher and Thiel, 2015; DeFillippi and Sydow, 2016). Researchers have already explored the underlying mechanisms that enable the conditions for the emergence of lock-in in permanent organizations (Sydow, 2009; Koch, 2011; Sydow *et al.*, 2012). We complement this previous work by providing a detailed empirical examination of the emergence of lock-in in the project (inter-) organizational network.

Second, by relying on Sydow's (2009) concept of organizational path dependence. We anchored our study in the process literature and the path dependence and creation perspective to focus on the decision process. By linking our findings to the relevant theory, we showed that the conceptual stance we adopted in the process perspective differed as well as the implications of this difference, see Table 5. We consider these differences a valuable contribution to the literature because they could enable project management scholars to position their research more effectively. Relevant since the issue of lock-in entails phenomenon-based research, which has gained and will continue to gain the interest of diverse scholars, thereby bridging conceptual and disciplinary divides (von Krogh *et al.*, 2012).

Third, our findings extend the recent research on projects by integrating studies on path dependence and creation (Garud and Karnøe, 2001; Sydow *et al.*, 2012). Specifically, we have advanced the recent discussion by Aaltonen *et al.* (2017) on the contextual conditions that give rise to or underline the emergence of lock-in. By taking a process perspective, our findings revealed that empirical patterns reflected prior ties that were the antecedents of path dependence, the front-end decisions made in the project, and the formation and continuous shaping of choices. Thus, informing the debate on the decision process in large-scale projects: in other words, between the organizational and the operational management perspectives. In particular, the latter effects where actors created the action space (i.e., the shielding effect and the temporary fix effect) supported previous findings on path creation (Bassanini and Dosi, 2001; Aaltonen *et al.*, 2017).

6.2. Managerial implications

The managerial implication of this paper is that a numbers-logic oriented tradition of cost/benefit analysis is unable to suggest how lock-in emerges and has a potential influence on project performance. Alternatively, attention should be directed to the understanding of the (inter-) organizational elements in the context as an essential feature of project management practice. It is not possible to impose any rule-of-thumb that delineates precisely the extent of the PM's enactment. On the one hand, this seems unsustainable because, in a large-scale project setting, the choice path is a non-ergodic process that is shaped over time. The soft lock-in is not necessarily purposive (Sanderson, 2012; Aaltonen *et al.*, 2017). On the other hand, as Langley *et al.* (1995) has argued that too narrowly focused prescriptions derived from conventional organizational decision-making literature are simplistic, isolationism, and inapt for turbulent environments. With such criticism in mind, we posit that in making choices in large-scale project settings, PMs should carefully consider the following:

- Recognize and address the requirements of the institutional environment, including the pre- and post-project effects.

- Given path-dependence, analyze how the multiple mechanisms and effects may shape their decisions, reinforcing them to continue in specific directions. Thus all actors whose contractual position is considered potentially crucial should be involved in the early negotiations (cf. Lamberg et al., 2008).
- The need to continuously develop goal alignment and clear contracts for dealing with project changes, thus mitigating opportunism (cf. Turner and Simister, 2001).
- The multi-organizational setting inherent during the decision process and the potential escalation of commitment should be treated accordingly, i.e., considering for each their mode of collaboration, experience, the cultural differences, and all alignment issues.

Furthermore, we suggest that PMs should work actively to align the actors' desired outcomes by organizing learning events, such as frequent thematic workshops, particularly in the early stages of the project. Such events would enable collective sense-making, which is critical in creating new ideas and generating commitments within the project network. Our observations of how the HSL project actors created action spaces at the project level revealed the importance of agency, helping PMs understand that under certain conditions, they are capable of shaping their own paths. Lastly, due to the inter-organizational and temporal nature of projects, PMs must consider and maintain a balance between controllability and unpredictability in delimiting their choices in large-scale project settings (Kreiner, 1995; Engwall, 2002). Table 4 and Fig. 3 provide PMs with ideas regarding how multiple processes at different levels may influence their project decisions. These ideas are relevant because they lay the groundwork for PMs to extend their efforts beyond the micro-managing of tasks.

6.3. Limitations and recommendations for future research

The limitations of our study include the reinterpretation of the data sets, which were created over 20 years. We tried to address this issue by interviewing multiple actors who viewed the decision process from different perspectives and who had participated at different levels in the HSL project and by reiterating between the original data sets and the analysis (Rowley, 2002). Although our single case study on the HSL project was based on semi-structured interviews, observations, and several documents and reports, our findings should be generalized with caution (Rowley, 2002).

In addition, in our application of the single case method, we used only qualitative data. Therefore, the lack of quantitative data in our analysis may be considered a limitation since we were not able to compare the findings with other quantitative discourses on lock-in emergence (Koch et al., 2009). Table 5 shows the differences in the conceptual stance needed to understand the emergence of lock-in. Undoubtedly, significant methodological challenges are associated with these differences (Smyth and Morris, 2007). Nevertheless, but a discussion of how these differences might be addressed is beyond the scope of this paper. Finally, our case study and findings lie within a constructivist mode and in general, do not show deterministically if a lock-in is always inefficient. In our view, this is a minor limitation because it was not included in the aims of our study. At this point in our research in this area, we have determined that the conceptualization of lock-in cannot be considered in isolation by confining decisions to the front-end of projects controlled by individuals or single actors. Instead, it must consider the prior ties and interdependencies among the multi-organizations in the setting.

Despite these limitations, our conceptual process framework could guide future research on decision-making processes in a large-scale project context. The process framework could be adopted to explore different empirical settings, possibly through a longitudinal ethnographic study, which could lead to a deep empirical understanding of the role of contextual mechanisms and effects arising in the emergence of lock-ins. This understanding would enable researchers to empirically investigate and enhance the generalizability of the findings to other project contexts. Conclusively, we affirm that project scholars will benefit from taking a process approach in exploring lock-in and other path-related processes in large-scale project settings (Mackay & Chia, 2013). In particular, future research should consider the mechanisms and effects revealed in our study and acknowledge that they reside not only in the project but also in the project's network. Furthermore, future research should consider the subtle relationships among path dependencies and path creations in continuing to explore the contexts and conditions of project shaping and de-locking mechanisms.

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Supplemental material

Appendix A. Overview of empirical evidence, illustrative data supporting interpretation

Identified theme	Illustrative interview data	Sources of evidence / respondents’ project affiliation and year
Institutional setting influencing the choice path trajectory		
Pre-project effects	<i>“When the project design was handed to Adif for further development and delivery, and we stepped in: “the train” was running in full speed and there was no way it could be stopped.”</i>	Transcript of the notes collected by one of the researchers during a Research related-meeting (approx. 45 min.) April 2006
	<i>“The Politicians, they want the work for tomorrow and they rush to tell the people that the line will be ready in two years. A politician once told that the line will be opened for service on 2003, but as you know it only did on 2009</i>	Transcript of the notes collected by one of the researchers during a Research related-meeting (approx. 60 min.) June 2008
	<i>Political compromises are a complete disaster! The catenary (the overhead line) project, was awarded in 2006, installation of the wires was contracted but the, platform was not there!”</i>	

	<p><i>“Politicians in Spain decide what needs to be worked and how long it will take. This is crazy as they do not understand what needs to be done...</i></p> <p><i>there is no time to carry out a feasibility study properly, thus evaluating infrastructure needs: there is no time to lose because the elections are in four years.”</i></p>	<p>Transcript of the telephone interview (approx. 60 min.)/ Interview with former HSL PM, December 1997</p>
Institutional influence	<p><i>“We were very task-oriented and not behavior-focused. We need a giant step to better organize. There were process guides, which described how to run things, but the way we lived life, the project had little to do with that”</i></p> <p><i>“I was responsible to select suppliers to initiate project modifications or construct the new components needed. If you know, GIF has a strong hierarchy, huge work packages are delivered to me, and I’m accountable for work approval and pricing our contractors/suppliers whom I actually do not contract and at times do not supervise”</i></p> <p><i>“We were awarded the catenary contract, in the first segment Madrid- Lleida on 2006. This was a complete ridiculous situation. It happens to know I can’t work, because the platform is not done, this as the installation of the overhead wires is made following other special works, e.g. platform. We lost money, equipment and other machines were blocked in the field. Due to our long cooperation, we did not take legal matters in consideration! “</i></p>	<p>Transcript of the telephone interview (approx. 60 min.)/ Interview with construction manager, April 2016</p> <p>Transcript of the face-to-face interview (approx. 60 min.)/ (Interview with facultative director, March 1998)</p> <p>Transcript of the telephone interview (approx. 60 min.) External online documents – audits and official reports/ Interview with Project Manager at Organization ‘C’ (contractor), April 2018</p>
Post-project future effects	<p><i>“It is the higher pressure we have - the schedule; due to political influence – they want to start the project; for them (politicians and proponents involved) it is important to start the project but not necessarily to get them done, at least this is the Spanish case.”</i></p> <p><i>“There are also changes, when the designed solution is not properly done; When this happened the contacted organization/ the provider tries to make money in such occasion. In that respect, they are opportunistic if they can. I believe it is a problem, because when you have the problem, and you change the solution approach from the one agreed– we have to ‘negotiate’ on the changes and foremost to agree on the pricing. Because we are overscheduled, we usually end-up agreeing”</i></p>	<p>Transcript of the notes collected by one of the researchers during a Research related-meeting (approx. 60 min.) with GIF management, April 1998</p> <p>Transcript of the notes collected by one of the researchers during a Research related-meeting (approx. 90 min.) with GIF management, July 1998</p>

Multiple mechanisms/ effects enabling fixed choices

Coordination effects	<i>“There were process guides, which described how to run things, but the way we lived life, the project had little to do with that... I think earlier the decision making in our projects were really discrete, and there was really less interaction needed among us, but I think right now, it helps a lot if you have a flexible contract in these dynamics. We need to shuffle things around, to change things, move them on. However, we depend very much in the support from the new Minister of Infrastructure”</i>	Transcript of the notes collected by one of the researchers during a Research related-meeting (approx. 60 min.) April 2008
	<i>“[T]ake the ERTMS system for example, it has been established for years, and there was a clear understanding of work to be performed. In my view, it has improved the production and maintenance costs while simplifying approval processes in the project by reducing the certification costs. Moreover, ERTMS system remain the same from project to project which enables easier installation and manufacturing.”</i>	Transcript of the telephone interview (approx. 90 min.)/ Interview with the Head of Infrastructure Projects at ADIF, June 2008
	<i>“When things go wrong that’s when the quality and team effort was tested, we either worked together and solved a problem or break apart and blamed each other. Several cases in our project demanded parties to work together, I hold all the risk of cooperation at all time and we needed a better solution to this”</i>	Transcript of the notes collected by one of the researchers during a Research related-meeting (approx. 60 min.) April 2006
Complementary effects	<i>“We were in project in pursue of joint objectives with our partners, we adhered to the usage of complementary management systems set by owner even though we were much advanced in certain terms – in technology adoption for instance”</i>	Transcript of the face-to-face interview (approx. 90 min.)/ Interview with the Engineer at Organization B, June 2008
	<i>“...during many changes we relied on BIM modelling to coordinate our work, we were able to process further in smoother manner; although there were also few cases where BIM for example complicated matters! ”</i>	Transcript of the face-to-face interview (approx. 60 min.)/ Interview with Project Manager at Adif, April 2016
Learning effects	<i>“Nowadays, it is a different system solution, it has a big influence to know the latest technologies influencing the bridge length for example. In that sense, it is important to have strong contacts with the contractor for a smooth delivery in infrastructure and for the purpose of learning. We need to learn more about the capabilities and the behavior of our contractors. Usually this means more expenses for Adif at the beginning, but we learn for future projects... My job is to run the development and construction program, to put in place arrangements for developing and implementing projects that would enable continues performance improvement. A very clear objective is to make Adif a modern owner by improving our working routines while learning from projects in international market, including our projects.”</i>	Transcript of the telephone interview (approx. 90 min.)/ Interview with the Head of Infrastructure Projects at ADIF, June 2008)

	<i>"I work together and closely with the design team, and I prioritize and reprioritize work along their requests. They are flexible to some extent; however, they got a program pattern and they need to deliver accordingly. We could improve the learning process and have mutual benefits."</i>	Transcript of the notes collected by one of the researchers during a Research related-meeting (approx. 60 min.) June 2017
Adaptive expectation effects	<i>"It was challenging to deliver our work chunk in project, I had to relate and analyze the work recurrently and intensively not only to our task at hand, but at the same time to more macro levels of analysis. "</i>	Transcript of the telephone interview (approx. 60 min.) / Interview with ADIF PM, October 2016
	<i>"We have schedule pressure, unfortunately in the design part, we don't have the opportunity to do proper design-sometimes we do in short time. We know as engineers that we will end up in troubles, however we follow procedures and regulations when changes are to happen..."</i>	Transcript of the telephone interview (approx. 60 min.)/ Interview with Civil Engineer at Adif, March 2017
Creating the action space		
Guarding/shielding effects	<i>"We have a factor called the social rentability, that is worth it!... for instance, if you introduce reasons that specific part of the project is not performing and is having problems due to communication for example – this argument is considered prior to financial rentability... So, the rentability of the line could sometimes never be managed at large... ones the decision for a change in project is taken, then we have the time (actually) to do the feasibility, cost benefit analysis, and accessibility... our engineers use macro-prices provided from the Ministry – so now the estimation of the change order is quite accurate as we have 20 years of experience... we work in a scale 1:1000 and avoid details."</i>	Transcript of the notes collected by one of the researchers during a research related-meeting with ADIF management, April 2017
	<i>"It seems like a well-known behavior, contractors tend to be very crafty, they disclose information and tell about problems only when they really have to, and it is good for their business."</i>	Transcript of the telephone interview (approx. 60 min.)/ Interview with CM at Adif, March 2018
	<i>'The problem is that such complex projects have grand magnitude and involve years if not decades. It is difficult to plan them, and you never have a perfect project, you need a lot of time and money to do a good project; and we usually engage in projects in a hurry. So, the better the design is, less business for the contractor – unfortunately the opposite holds. When changes happen, the contracted organization tries to make money in such occasion – they are opportunistic, indeed if they can'</i>	Transcript of the face-to-face interview (approx. 75 min.)/ Interview with Quantity Surveyor at Adif, July 2017
The temporary fix effects	<i>"Lots of unforeseen issues are to happen. We had pressure, and we had to fulfill the work processes in prompt. The problem was that the line is segmented, and each segment then is subdivided. When we do the</i>	Transcript of the face-to-face interview (approx. 90 min.)/

platform, then come other actors – we are engaged in civil work and not in telecommunication, nor in electrification, or signaling, each influences the work differently.”

Interview with a project team member at ADIF, March 2017

“Trying to do the things faster, means exactly the opposite. I don’t know..., I guess, it is just that due to political pressure, the management initiates the work packages to soon.”

I lack support and human resources to support my work and the colleagues. We were three Engineers and it was difficult to cover the project – it actually was ridiculous. It was impossible to take care of the work. I had to cope with 5 contracts at once, and we needed like 5 or 6 people to take care of the workload in the field. The only support was from the CyA contracts, the vigilantes for example, they were my eyes in the field. They approved the work as well, yet many problems aroused and change orders increased due to this problem...

Transcript of the face-to-face interview (approx. 60 min.)
Field notes collected during organization visit/ Interview with the Quality controller at ADIF, April 2017

It depends of the work, when there are complex works, there are vigilantes. Their scope of work is to control, the work done. They do not have a civil engineering qualification necessarily, but they have done that specific work for some time now. They have to fill in a form, volumes and double check the worked. They are part of the team contracted through CyA contract type”

“In my view, I’ve seen cases when construction companies, they go and speak with the local administration responsible in that region, and ask changes based on the regulative territory. So, when changes happen, it is because of the construction organization maneuver.”

Transcript of the telephone interview (approx. 45 min.)/
Interview with the Engineer at Organization C, June 2017

Paper II

Embeddedness and actors' behaviors in large-scale project lifecycle: Lessons learned from a High-Speed Rail project in Spain

Ermal Hetemi, Hans George Gemünden, Joaquin Ordieres-Meré

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Embeddedness and actors' behaviors in large-scale project lifecycle: Lessons learned from a High-Speed Rail project in Spain

Ermal Hetemi^{a,b,1}, Hans Georg Gemünden^c, Joaquin Ordieres^b

^a Department of Industrial Economics and Management, KTH Royal Institute of Technology, Lindstedtsvägen 30, 100 44 Stockholm, Sweden

^b Departamento de Ingeniería de Organización, Administración de Empresas y Estadística, UPM Universidad Politécnica de Madrid, C/ José Gutiérrez Abascal 2, E-28006, Madrid, Spain

^c Department of Leadership and Organization, BI, Norwegian Business School, Oslo, Norway.

Abstract

Despite wide-ranging research on large-scale infrastructure project performance, little is known about the role that project public institutional context and project owner's response capability plays in the governing process. Building on a theoretically driven approach and a case study, we first established a set of propositions and then substantiated this set through empirical illustrations. This study investigated the multi-actor Madrid–Barcelona high-speed rail line (HSL) project (1990–2017) with the use of social network analysis supplemented by qualitative evidence. The findings show that actors' behavior is affected by the project public institutional context, coupled with contractual commitments. A closer examination of the data found two factors that drive the escalation dynamics: (1) the timing mismatches—a ubiquitous feature of public sector project owners' organization—leading to the incapacity to influence governance during the project front-end and (2) owners' passive behavior during implementation. From the management perspective, an active owner with high project response capability is necessary for effectively interacting with contractors, and for selecting and managing both contractual and trust-based governance mechanisms effectively. Based on the findings, the authors offer theoretical and managerial implications for promoting the effectiveness of owner-contractor collaboration in large-scale infrastructure projects.

Selection and peer-review under responsibility of the IPMA.

Keywords: Governance inseparability, institutional environment, relational behavior, network analysis, case study.

Introduction

Large-scale infrastructure projects perform poorly in terms of cost and time (Flyvbjerg 2014), particularly in the public sector (Ling and Tran 2012; Ling et al. 2013). Dynamic (inter-)organizational contexts and complex processes characterize these projects (Gemünden, 2015; Chen *et al.*, 2017; Zheng *et al.*, 2018; Hetemi *et al.*, 2020). They involve diverse public and private actors over a specific period, which often leads to uncertainties, high transaction costs, and opportunism throughout the large-scale project lifecycle (Verweij *et al.*, 2015). Hence, large-scale infrastructure projects pose challenges in terms of managing procurement, design contracts, collaborative learning, and governance (Caldwell *et al.*, 2009; Caniels *et al.*, 2012; Manley and Chen, 2017; Shi *et al.*, 2018; Liu *et al.*, 2019).

Many scholars have focused on addressing these shortcomings suggesting methods to improve the performance of large-scale infrastructure projects (cf. Zheng *et al.*, 2018, 2019; Li, Han, *et al.*, 2019). For that purpose, scholars have focused their attention on the team integration based on relational theory (cf. Cao and Lumineau, 2015; Wang *et al.*, 2019). To facilitate the inter-organizational collaboration among the parties involved, relational governance, trust and relationships beyond the single contract are often cited (DeFillippi and Sydow, 2016; Xue *et al.*, 2017; Gao *et al.*, 2018; Zheng *et al.*, 2018; Qiu *et al.*, 2019). Extant literature has identified factors that

¹ * Corresponding author. Tel.: +46 8 790 76 58;
E-mail address: ermal.hetemi@indek.kth.se

hinder and promote inter-organizational collaboration. For instance, it has validated the positive relationships between the governing mechanisms and the overall project performance (see Li, Han, *et al.*, 2019). It has addressed multiple moderating effects of inter-personal relations and behavioral attributes, which were captured primarily through survey-questionnaires. However, it seems that few scholars have explored the governing process, and actors' behavior in practice and throughout the project lifecycle (cf. Sanderson, 2012). This is a critical gap, particularly when considering that the inter-organizational relations are intrinsically unstable and that the effect of governance mechanisms on project actors' behavior during the project lifecycle changes (Caniëls *et al.* 2012; Zheng *et al.* 2019). Indeed, there is a need for longitudinal empirical research, with a focus on project lifecycle, to investigate the project actors' behavior and the relational governing activities – at a substantial and more profound level of team integration: the network level.

The inter-organizational collaboration and the overall large-scale project performance can be affected by important contextual conditions (see Xue *et al.*, 2017). The first is the extent to which the organization is centered on the project delivery, and the second condition involves the public project institutional context (cf. Jacobsson and Linderoth, 2010; Qiu *et al.*, 2019; Zheng *et al.*, 2019). Regarding the first, recently, Winch and Leiringer (2016) – relying on government reports and other studies – showed that only a small proportion of infrastructure project delivery problems are caused by either supplier incompetence or externally generated risk events. According to them, 'overwhelmingly, the failures can be attributed to the public sector owner' (Winch and Leiringer, 2016, p. 8). Hence, they suggest a need for a 'strong project owner' and imply that the project owners, in general, lack the capability to identify and acquire operational generated knowledge that is critical to the large-scale project performance. The second, public project institutional context implies, for example, 1) the characteristics of procurement and project owners focus on the lowest-price tender policy (Ling *et al.*, 2013; Liu *et al.*, 2014). 2) the relations between project actors that are inclined by market-based interactions and are thus short-term focused (Dubois and Gadde, 2002; Doloi, 2013; Ling *et al.*, 2013; Manley and Chen, 2017), and 3) the project delivery method and types of construction contracts (cf. Rahman and Kumaraswamy, 2008), etc.

Given this backdrop, we regard the concept of *governance inseparability* (Argyres and Liebeskind, 1999) as a promising starting point for addressing the two key contextual conditions influencing the inter-organizational collaboration. The fundamental idea of governance inseparability underlines that the governance choice is actually more particularistic than the current discourse presents. In other words, focusing on the characteristics of isolated transactions seems insufficient to explain the large-scale project performance. Following Argyres and Liebeskind (1999, p. 49), contractual commitments play a crucial role, and they should be discussed in context. Hence, the regulatory environment and prior contractual obligations made by an organization can limit its ability to differentiate or change its governance mechanisms in the future. Building on this reasoning and other argumentative discussions underpinning institutional and transactions cost economics, we proceed to consider the context influence, in turn. We investigated the multi-actor Madrid–Barcelona high-speed rail line (HSL) project from the perspective of the project-owner organization (Adif). While the focus was intentionally placed on the project-owner, contractors and supplier's perspectives have also been examined to have an informed view of the owner's response capability. We advance a small and suggestive set of propositions throughout the project lifecycle with which to seed future theorizing.

This study extended the existing perspectives described above by exploring the inter-organizational interactions and actors' behavior: 1) in the context of the regulatory environment in Spain, which determines such interaction; and 2) sequentially, by discussing actors' behaviors throughout the project lifecycle. This approach enabled an explanatory power to the *evolving changes* regarding actors' embeddedness and their behavior throughout the project lifecycle. Project actors are viewed as embedded when they set relations in such a manner that can affect and be affected by other's behaviors and context. Therefore, we asked the following guiding question: *How does the regulatory environment affect the project actors' behavior and their governing activities in a large-scale infrastructure project, and how can public project owners deal with the opportunistic behavior of some of their providers?*

Apart from this introduction, the paper consists of four other sections. The next section provides the theoretical analysis, followed by a section addressing the research design. The subsequent section discusses the case analysis and findings, and the final section concludes the paper by discussing some of the managerial implications, study limitations, and suggestions for future research.

Theoretical Framework

Large-Scale Infrastructure Projects and Actors' Behavioral Patterns during the Project Lifecycle

The large-scale infrastructure project lifecycle comprises two important stages: 1) the project front-end, which includes the project definition, pre-execution activities, and network structuring; and 2) the implementation, which consists of the execution and operation activities (Morris 2013). These project stages are dramatically different, since project actors engage in different influential activities, with the project actors' flexibility and the project owner's response capability being crucial (Aaltonen and Kujala 2010; Winch and Leiringer 2016; Chen et al. 2017). Project actors' operational flexibility emerges from the contract's capacity to accommodate changes without breaking under the strain of changing conditions (Ling and Tran 2012). In this study, we aimed to explain the regulatory environment and project actors' behavior in the two distinct stages of the project lifecycle.

Project front-end.

At the project front-end, large-scale projects garner attention from politicians and promoters alike. They both seek visibility because a high profile helps them to be re-elected (the "political sublime," in the words of Flyvbjerg 2014, p. 9). Due to the political agenda, and the close bond with the election cycle (which is usually in four-year terms), large-scale projects' front-ends are characterized by a sense of urgency (Flyvbjerg 2014; Li, Lu, et al., 2019). As a consequence, at the project-front end, project estimates are "cooked": costs are underestimated, and revenues overestimated, to show overvalued economic development with undervalued environmental impact (Flyvbjerg et al. 2003, p. 84). These issues, and the occurrence of multiple delusions in practice, are facilitated due to negatively affected stakeholder groups being "kept in the dark." Particularly stakeholder groups that are not in a direct contractual relationship, e.g., local or non-governmental organizations concerned with environmental safeguards and the protection of the human rights of affected parties (Aaltonen and Kujala, 2010; Scott, 2012). The project front-end is inherently uncertain, and, when reaching a project "go" decision, fuzzy political influences often create a "smokescreen." Issues arise here often because budgets are often based on conceptual estimates for vague components rather than detailed specifications from properly planning and design. Therefore, we proposed the following:

Proposition 1—Project urgency, produced by powerful project promoters at the project front-end increases uncertainty and fosters a project degradation

Large-scale infrastructure projects involving government sponsors rely heavily on formal governance—governance mechanisms such as rules and procedures that are known as "authority" (Caniëls et al. 2012, p. 114). This institutional regulatory regime has a strong influence on the progress and the governance of these projects (Chi and Javernick-Will 2011; Zheng et al. 2019), so the role of the government as both regulator and stakeholder is peculiar. Multiple dyadic relationships are formed, based on detailed contracts (Williams and Samset 2010; Edkins et al. 2013). In this context, both parties want to maximize their share of the contract. Under such conditions, a conflict of goals arises between the project owner, who seeks to minimize the total investment, and the contractor or provider, who aims to accomplish the task with minimum effort and obtain its share promptly (Florice and Lampel 1998). In a public project context, however, the burden of this conflict tends to fall on the project owner, who seems to be "sandwiched" (Ning and Ling 2013, 2014).

On the one hand, the project owner has to respect its principal—the government authority—which is driven by a political agenda and by the media (van den Ende and van Marrewijk 2018). On the other hand, are the contractors, which may behave opportunistically. The project owner, therefore, has to deal with contingent issues streaming from this entangled relationship, known as "agency costs" (Florice and Lampel, 1998). Multiple governance mechanisms can be used as safeguards against opportunistic behavior (Jap and Ganesan 2000; Caniëls et al. 2012; Zheng et al. 2019), but within public projects, unlike private ones, the project owner is heavily influenced by the institutional environment—the meta-rules—and needs, at the same time, to maintain an arm's length relationship with contractors to avoid corruption (Ling and Tran 2012; Locatelli et al. 2017).

Existing research has stated that, at this stage, lowest-price bidding, reliance on long-term prequalification results, ambiguous contracts, and overreliance on subjective judgments invite opportunism (Doloi 2013; Shi et al. 2018; Le et al. forthcoming). Williamson (1979, p. 234) defined opportunism as "self-interested seeking with guile." Opportunism implies calculated efforts to mislead or confuse another party, based on incomplete or

misrepresented information. On the one hand, explicit contracts cannot ensure that the contractors will reveal private information to facilitate impartial arrangements (Zhou and Poppo, 2010). For example, when not convenient, some contractors do not follow the meetings periodically for the joint activity planning to provide their input and moderate the project costs.

On the other hand, the contracting system and the documents may be incomplete because of human bounded rationality, e.g., an incomplete contract or project document with fewer clauses or details that are not verifiable nor observable (Cao and Lumineau, 2015). Various studies have shown the negative impact of opportunism on inter-organizational relations (Rahman and Kumaraswamy 2008; Ling et al. 2013; Shi et al. 2018; Zheng et al. 2018) and on the overall performance of projects (Ke et al. 2015; Xue et al. 2017; Liu et al. 2019; Zheng et al. 2019; Caniëls et al. 2012). The problem is not only that the quality of the contract is deficient (i.e., that the documentation is not clear and detailed), but that it creates further avenues for opportunism in the next stage. Contractual loopholes, such as errors or ambiguous clauses, may lead to unforeseen rework, involving loss of efficiency, productivity, and time, as well as possible contractual claims and litigation (Lopez and Love 2012). Since some contractors know that the owner is vulnerable, they may lower their price to win the contract, expecting lucrative change orders based upon contract loopholes and subsequent claims to recover their costs (Rahman and Kumaraswamy 2008; Ning and Ling 2013; Shi et al. 2018; J. Liu et al. 2019). The issue of contract ambiguity or (in)completeness (i.e., legal tolerance and the latitude for speculation) is instrumental in causing adversarial relationships in complex projects (Pryke 2005, 2012). Therefore, we proposed the following:

Proposition 2—The greater the contract ambiguity, and the information asymmetry between the project owner and the contractors, the higher are the chances of opportunistic behavior

Implementation stage.

At the implementation stage, triadic and network relationships develop (Zheng et al. 2019; Verschoore and Adami 2020). In a public sector project context, these relationships are contractually-bounded and subject to institutional governing rules, which require competitive bidding (Henisz et al. 2012; Zheng et al. 2019). At this point, considering the large-scale project size and scope, the transaction volume is high (Williamson 1979). Hence, project owners must always assume some risks of governance inseparability. That is, the project owner will become constrained over time by the existing arrangements in place, which, to some extent, limits their scope and their strategic flexibility (cf. Argyres and Liebeskind, 1999).

Nevertheless, recent studies have stated that the repetition and frequency of interaction between the project actors, and the consequences generated trust, also sustain the network relations (Chen *et al.*, 2017; Hetemi *et al.*, 2020). Relational capabilities and transaction frequency can be seen as the effect of inter-organizational learning through repeated interactions with contractors. Consequently, it is critical for owners' response capability to learn from previous project activities, in order to analyze, process, understand, and act on the information obtained (cf. Winch and Leiringer 2016). This includes being selective about contractors and their opportunistic behavior (Shi *et al.*, 2018; Liu *et al.*, 2019).

Nevertheless, public project owners are generally passive throughout the project lifecycle: they fail to learn and achieve trusting cooperation with the contractors. Mainly because they rely heavily on external consultants and lack both contracting and relational capabilities (Winch and Leiringer 2016; Aerts et al. 2017). We link this lacking capability to the project owner's response capacity, which concerns the adaptive management of expectations in the context of unexpected, i.e., high uncertainty. As indicated earlier, during implementation, there is often much that is unexpected. Thus, being active is about the project owner's dispositions that shape their response capacity for learning, adapting, and acting accordingly. An active owner demonstrates the capabilities to interact effectively with the contractors or providers and is able to select and effectively use both formal contractual and trust-based governing mechanisms (Caldwell et al. 2009; Winch and Leiringer 2016; Zheng et al. 2018). In short, an active owner goes beyond traditional contract administration and established transactions. It addresses operational issues in-depth, i.e., relations and contractor's behavior with a greater sense of operational intent to avoid opportunism on the part of some contractors. Given that large-scale projects extend over decades, project owners based on the other parties' performance — such as contractors or suppliers'—during their earlier phases in projects, can learn and process to analyze and act on the knowledge obtained in-site. So, we proposed:

Proposition 3— The higher the degree of the owner's passivity, the higher the missed opportunity for learning, and the generation of trust, reducing value for money.

As Williamson (1996, p. 9) indicates, transaction cost economics concedes that comprehensive contracting is not a feasible option (because of bounded rationality). Yet it maintains that many economic agents have the capacities both to learn and to look ahead, perceive hazards, and factor these back into the contractual relation, thereafter to devise responsive institutions. Argyres and Liebeskind (1999, p. 54) adopted this view. They affirmed that it presents healthy tensions for the management, but that these tensions resolve more in favor of bounded rationality than in favor of foresight. In this view, in large-scale projects anticipating future hazards and opportunities seems almost impossible (Lenfle and Loch, 2010).

Given the above, active owner activities must take place during project implementation. In this stage, properly staffed owner's teams are important (Merrow 2011; Winch and Leiringer 2016). Besides, when the project proceeds to the implementation stage, some manipulation of the contractual loopholes becomes increasingly visible. The above implies that strategic misinterpretation may repeatedly occur throughout the project lifecycle and that some contractors' opportunism and the owner's passive role are integral to it (Winch 2013). In other words, the escalation dynamics are likely in this process. This issue is exacerbated since large-scale projects require financial resources (within) at all stages (Guo et al. 2014), often to meet internal performance targets. We assume that the decisions for financial resources are made in at least a bounded rational way and are not merely the result of random processes. However, when circumstances change in the process, the 'strategic misinterpretation' that precedes these decisions may restrict the project owner's response capacity. We therefore proposed:

Proposition 4—A deliberate strategic misrepresentation of forecasting outcomes enables the occurrence of multiple “delusions.”

Research design and methods

To gain an in-depth understanding of the governing process and actors' strategies and behavioral patterns during the project lifecycle, we selected a longitudinal case study design (Yin 2013) in order to analyze the multi-actor project: the Madrid–Barcelona HSL in Spain. We used the case of the HSL project to enhance our understanding of the developed theoretical propositions. The case study method was chosen for two main reasons: (1) it offered the opportunity to investigate processes in-depth and was widely accepted as suitable for gaining an understanding of a multidimensional phenomenon (Eisenhardt and Graebner 2007; Yin 2013); and (2) it afforded multiple sources of evidence such as, for example, direct observations, interviews, and document analysis, to improve the overall quality of the analysis and enable corroboration (Yin 2013). Our research strategy comprised both qualitative and quantitative approaches (Morgan 1998), aimed at different elements of the HSL project, including the institutional regulatory environment, public procurement legal implications, and the interplay of actors' in the context; hence, it involved an exploratory case relying on theoretical elaboration (Ketokivi and Choi 2014).

Case description.

The case study provided many examples of changing behavior, driven both by organizational politics and by adaption to project contextual changes. The major construction work of the project lasted for two decades (1990–2008); however, due to problems with contracts, and suspensions during 2009–2017, the project's network organization continuously rearranged the project's design and plans, redefining its scope. The HSL project ran from the early 1990s to 2009 and was ambitiously planned and designed to reach speeds of 350 km/h ($\approx$ 220 mph). It was intended to connect the Spanish capital of Madrid with the city of Barcelona (649 miles/1,045 kilometers distance) to substantially replace the existing air traffic route (Report 2012). The project definition started in the mid-1980s, and, on December 8, 1988, the Spanish Council of Ministers approved the project. The project was co-funded by the EU and the Spanish government. It was considered to be a crucial and prestigious project, since it connected Spain to the European high-speed rail network for competitive freight transportation, via the French border, from Barcelona. As the owner responsible for the management of the infrastructure, Adif divided the project work into three major sections (construction phases). The first section was Madrid–Lleida (443 kilometers), initiated in 1993–1995 and completed on October 11, 2003; the second section was Lleida–Tarragona (108 kilometers), which was completed in December 2006; and the third section was Tarragona–Barcelona (98 kilometers), which was completed in February 2008.

For its construction, 2,095 main contracts were awarded for €6.82 billion, with a total amount of tender for €7.55 billion, 38 complementary works contracts for an amount of €171 million and 9 emergency works for €239 million. The final cost amounted to a little under €9.00 billion, which originates an average price of €14.4 million per kilometer, with a 31.4% deviation from the initially planned prices, due to contract modifications, complementary and emergency works, price reviews and additional settlements (Report, 2013).

Data collection.

Data was collected over roughly 20 years, drawn from the contracting database (exported from the owner's enterprise resource planning), semi-structured interviews, participant observations, and secondary data sources (e.g., audit reports). The qualitative approach involved data collection during two periods, under the supervision of the third author, which allowed for a longitudinal view of the project over the entire lifecycle. We summarize the research data in Table 1. The process steps described here were more iterative than linear in character, and the main baseline moved sequentially, but there were often interactive steps.

Data collection method		Data collected
Semi-structured interviews	First interval (1996-2010)	40 interviews with the HSL PM, Adif Quality Controller, Head of Infrastructure Projects, Engineer at Organization B, project proponent and other relevant actors. Average duration was slightly over one hour.
	second interval (2015-2018)	12 interviews with the program managers and other relevant actors (project managers, construction manager at Adif, Organization 'A' Contractor PM, Organization B Supplier, Organization C Contractor PM). Average duration was slightly over one hour.
(Participant) Observations	First interval (1996-2010)	<ul style="list-style-type: none"> ○ participant observations, ○ group interviews, ○ Extensive informal communication
	second interval (2015-2018)	<p>The insider spent 2–3 days per week at the organization's offices and conducted observations:</p> <ul style="list-style-type: none"> ○ 7 management meetings; ○ Extensive informal communication; ○ Field notes for each of the days spent on site;
Document analysis	<p>In total more than 20 documents:</p> <ul style="list-style-type: none"> ➤ Internal program documents (internal financial and audit reports, overview presentations, internal organization and escalation matrices, lessons learned, and program tools, e.g., risk logs). ➤ Organization-wide guidelines and frameworks for project and program risk management. ➤ 90 pages of public material drawn from the press coverage of the project. 	

Table 1. Summary of data collection

The quantitative approach, first involving the use of social network analysis (SNA), measured the structural properties of the multiple contract packages of the HSL project, tracking change patterns and different contract flows. Second, we used a Bayesian approach to exploit the quantitative data and address areas of uncertainty stemming from actors' behavior in the project setting. Its application enabled the owner's response capacity to be assessed, vis-à-vis the selected provider. We will return to this point and explain the measurement in greater detail in the following section.

The data involved, for example, information about the tendered amount, the awarded amount, modifications to time and financial information, delivery dates, initially estimated duration, date contracted, contract winner, etc. Data formatting was necessary, so the data was imported into an SQL platform, which enabled querying and checking of the contractual flow, identification of relations from the beginning of the study, and their evolution during the project implementation. The dataset supporting the quantitative analysis covered more than 5,000 contracts relating to over 4,000 sub-segments of the HSL. It is worth noting that a single contract could apply to many sub-segments. The typology for those contracts covered eight different topics in different phases, from design to construction and maintenance. When considering the whole portfolio, the timespan extended from September 1996 until December 2016 and involved more than 1,700 different contractors. Information regarding

the awarded delivery dates and budget was also provided at the contract level, in such a way that deviations in both schedule and cost could be analyzed by contract level, time, segment, or contractor (see Fig. 1).

Fig. 1. Distribution of the cost overrun per construction (CONS) contract type per contractor.

Additional evidence, such as formal time-based progress reports and named certifications of work performed, were also available. These certifications involved more than 80,000 references from seven different classes, covering the regular and final certificates, but also non-regular ones. An additional set of incidents was recorded and analyzed, covering more than 30,000 issues relating to the different contracts. 81.7% of the total project costs originated from 666 works implementation (construction) contracts that had been awarded for an amount of €5.40 billion, with an initial saving of 10% on the bid price. However, as a consequence of the modifications of the contracts, the formalization of 34 contracts for complementary works and 9 emergency works, the price reviews and the additional settlements, the total cost of execution of the works amounted to €7.32 billion, 35.5% higher than the award price of the original contracts. Besides, 555 files for extensions and term extensions were processed, for an average period of 4.5 months per file. Table 2 shows the number of contracts and incidents throughout the project implementation. During the project implementation, 69 change orders were formalized, and 14 contracts for complementary works and 8 for emergency works were awarded, which, together with the price reviews and additional settlements, raised the total cost of the works initially contracted to €3.03 billion, which represented an increase of 49.6% (Report, 2013). Hence, the initial saving of 9.2% in the bidding price of the contracts ended with a cost increase of 35.8% compared to what was initially planned.

	No.	Imports*
Main Contracts	666	5.406.322
Modifications	141	622.824
Contracts for complementary	34	161.128
Contracts for emergency works	9	239.867
Price revisions contracts	355	477.579
Liquidation and additional others	481	418.405
Total	1.686	7.326.125

Table 2. Contracts and incidents in the implementation of the HSL Madrid-Barcelona

* figures in thousands of Euros

Figure 2 shows the number of contracts awarded per contractor and their type. 33% of the contracts were for the execution of works, 30% for technical assistance, 13% for supply contracts, 3% for services, 16%

corresponded to agreements and spending files, and the remaining 5% were minor contracts. As can be seen in Fig. 2, repeated collaboration exists, as the same organization plays different roles in the HSL project, e.g., as a contractor, and at times as a supplier of specific elements of the project. Besides, Fig. 2 partly illustrates that the construction of infrastructure involved a large network of contractors and suppliers. However, more than 74% were awarded to approximately 10 contractors — if we consider the consortiums UTE [in Spanish: *Union Temporal de Empresas*] among these 10 organizations. That is, the 10 UTEs were present in almost seven out of every ten euros' worth of work contracted.

Fig. 2. Number of contracts awarded per contractor/ provider and type

The available dataset provided fine-grained information that enabled a detailed analysis and was useful for comparing and contrasting the qualitative evidence (Pryke 2012). The overall collected data were organized according to themes (e.g., the institutional environment, public procurement law, structural and relational coordination, contracting information, etc.). These themes were further analyzed to identify patterns of activities during the project lifecycle. The rich data and the project lifecycle view, we argue, effectively served and complemented our analysis.

Case analysis

The relational structure of the HSL project.

To identify the actors' behavior patterns and their influence within the HSL project, it is worth analyzing the centralization of meaning for the whole network. Hence, the focus is on what Pryke (2012, p. 91) referred to as the *degree of point centrality*. Actors' centrality refers to the node that describes an actor's importance in the network. Centralization, in general, relates not to the relative prominence of the points, but the overall compactness or integration of the network, as reflected in its shape—an eigenvector. Thus, following Pryke (2017, p. 18), the actor's prominence or centrality is indicated by the size of the node, so “nodes which are large relative to other nodes indicate prominence.” The measurement of the degree of points' centrality is based on the analysis of contractual relationships and information exchange in the network. It has been argued that the centrality value reflects both authority and power in the network (Wasserman and Faust 1994; Verschoore and Adami 2020). However, high centrality in a contractual project network is no guarantee of control over events or the activities of other actors in the setting (Pryke 2012, 2017). Pryke (2012) suggested that the extent to which centrality affects the degree of control and authority in the network is contingent on the structure of the whole network, primarily on the extent to which the central actor can influence groups and the network as a whole. Thus, centrality relating to actors' prominence needed to be considered for the main actors; particularly, the effects on these actors' behavior, which was influenced by the procurement strategies and the institutional environment. Consequently, we highlighted the prominence of the project owner in the contractual and information exchange network of the

project. In the analysis that follows, basic and relevant formulae, relating to each SNA key concept, were instructive and useful (see Wasserman and Faust 1994; Pryke 2012).

Fig. 3. Relational structure of the contractual flow

Figure 3 shows the HSL project's contractual flows when a construction segment is considered. It outlines the contract-by-contract relations of the owner and the direct/indirect ties with contractors and other suppliers based on the lump sum contract type. Such relations underlined the coordination structure of the HSL project as a result of competitive procurement logic and a dyadic mindset (cf. Verschoore and Adami 2020); however, Figure 3 also shows some relational structures. Since we tracked these relationships through the contractual database, the interfaces within the UTE packages were the responsibility of the contractor consortia and unknown to the public sector owner. Considering that this data referred to the implementation stage, it was expected that greater cohesion would be achieved at this stage (Steen et al. 2018; Verschoore and Adami 2020). In the following, Figure 4 shows the HSL project information flow.

Fig. 4. Relational structure of the information flow

As can be compared (see Fig. 3, and 4), the contract conditions did not reflect the information flow patterns, or, consequently, an actor's centrality; hence, the point or degree of centrality was relatively high since Adif had a relatively large number of primary connections. The differences in an actor's centrality across the relational structure of the contractual network and the information flow highlighted what might be referred to as a 'lack of correspondence in forms of governance within the inter-organizational network' Pryke (2012, p. 93). The figures above show that the HSL project was relatively well connected, considering the high level of contractual compactness, mainly because of Adif's high degree of centrality. However, even though Adif related to other actors by the shortest possible routes, few actors were connected to an actor other than Adif. More numerous contractual links, therefore, provided more opportunities for contractual disputes (cf. Pryke 2012). Collaborative procurement, by contrast, has fewer contractual links, since it focuses on a relatively small number of influential actors (Pryke 2012; Verschoore and Adami 2020).

Having considered the compactness of the HSL network, we directed our attention to the centrality, which showed that the network was rather owner-centric, with an eigenvector value of 0.828. Considering the project owner's centrality, a value greater than 0.50 was unsurprising, reflecting the classic "star" structure of contractual relationships see Table 3 (cf. Pryke 2012). The high centrality, we argue, was closely related to the fact that the Adif organization managed the project and was considered to be the future operator of the HSL. In addition, Adif entered into direct contracts with specialist suppliers and all-important providers with critical roles in the project. Thus, Adif was influenced by the need for unambiguous contractual relationships, which led to the almost exclusive use of dyadic contractual relationships. Anecdotal evidence gathered during the interviews indicates that Adif was understaffed and lacked monitoring capabilities "in the field," so Adif experienced many variations under the terms of the contract.

The above shows that the project owner (Adif) adhered to a traditional hierarchy of contractual conditions, which was reflected in its contractual centrality. According to Pryke (2012, p. 75), "comparison of the centrality values in contractual, incentive and information exchange networks, for a given actor, provides a measure of the maturity of a particular actor role within a procurement approach." Consequently, it would have been wrong to conclude that a high level of centrality within a classic star network is effective for monitoring and information processing.

The network had to be critically analyzed in terms of incoming and outgoing information or payments (Pryke 2012). It was useful, at this point, to turn our attention to the in-degree/out-degree data relating to the project owner. In-degree refers to the number of connections where information is incoming (i.e., the changes reported by the contractors and third parties), and out-degree refers to the opposite. An examination of this data helped in understanding whether the information was weighted toward the receipt of information relating to variations by the (sub) contractor. Particularly, it helped understand whether the role of the project owner remained central during the information flow: whether Adif was involved in the dissemination of information or the receipt of information relating to variations by the (sub) contractors. The high amount of in-degree information (see Table 3) showed that the financial control function reflected change orders and modifications made by the (sub) contractors, implying Adif's negligible involvement. The level of knowledge dissemination by both Adif and the contractors was less impressive our qualitative data suggested. We noted that the HSL project was mostly effective, but with limited scope, contract management, control data gathering networks, and ineffective dissemination networks. This was a major factor in the HSL project being delivered late and over budget (i.e., it overspent on subcontracting).

In summary, the use of traditional procurement, and project owners' lack of reliance on long-term relationships and supply chain management, led to significant incidents, characterized by a high level of reporting (see Table 3, the in-degree information). In turn, the situation was exacerbated by the owner's limited degree of monitoring capacity. Therefore, the approach to procurement and the management of project implementation had an influence on the project actors' behavior and their potential opportunism. The approach adopted by the owner, when considering a large amount of in-degree data, consequently led to a project owner with low prominence and passive behavior. In other words, the very low profile of owner's communication networks, coupled with the high number of in-degree incidents reported—the modifications—indicated that the project owner lacked effective monitoring of the project.

We discuss the empirical findings for conditions where the network analysis requires much in-depth explication in connection with each reported interaction during the HSL project lifecycle.

Measurement	Contractual	Information
Number of actors	23	23
Density of the network	0.555	0.327
Centralization	0.828	0.849
Average path length	1.889	1.285
Centrality of project	0.968	0.378
In-degree of project	15	15
Out-degree of project	28	2
Transitivity	0.072	0.075
No. of isolates	1	4

Table 3. Properties of the HSL project relational structure

A relational approach for project owners to proactively adapt and select contracting parties based on their behavior.

By exploiting the contract database, it was possible to devise a quantitative rule indicating substantial deviations during the first third of the contract period. The rule stipulated that, when one contract had more than three incidents (meaning claims for modifications, requests for cost adjustments, etc.) during the first third of its duration, it qualified as a significant cost overrun (> 17%). Accordingly, the larger the number of incidents (during this period, but also cumulatively), the higher the potential for escalation of costs and time. The confidence in this rule was over 83% (see Table 4). Considering that this rule applied to the HSL project case over time, it implied that the project owner lacked effective control measures and actions; thus, its behavior was passive.

Data Query: > idf [idf\$num<3 & idf\$duration > 10,]			Incidents			Total
Contract Id	Origin (year)	Duration (months)	Num.	Ini.	Fin.	Cost overrun (%)
2914	2009	12.0	2	1	1	4.23
3313	2009	11.5	2	0	1	0.00
393	2010	11.0	1	0	0	0.82
3683	2010	13.0	0	Inf	- Inf	0.00
3822	2011	12.0	0	Inf	- inf	0.00
5087	2014	12.0	1	1	1	0.00
Data Query: > idf [idf\$num>9 & idf\$duration > 10,]						
1861	1998	20.0	11	0	4	10.60
1086	2001	17.5	12	0	7	27.66
2294	2003	21.0	13	1	6	38.56
4782	2005	26.0	15	1	10	39.41
2908	2007	26.0	16	0	9	28.95
4361	2008	19.0	15	1	7	11.52
5158	2010	22.0	13	0	6	25.48

Table 4. Analysis of contractor behavioral patterns: number of incidents and escalation in cost

Note: **Num.** – total number of incidents throughout the contract; **Ini.** – timespan (years) for the first incident since the starting of the contract; **Fin.** – timespan (years) for the last incident since the starting of the contract

The figures show, for the same type of contract, a systematic cost escalation bias over time, independent of the contractor involved (see Table 4). As indicated earlier, this was an indicator that no effective measures had been implemented during the contract implementation to deal with them, apart from the already established formal governing rules. Figure 5 illustrates the contractual behavioral patterns, where it becomes clear that no significant reduction in project over-costs is found along the program time when considering different contractors. The above again demonstrates a lack of response capability on behalf of the owner.

Fig. 5. Contractor's behavioral patterns indicating overrun (over and over again)

We then turned to develop the means for improving the project owner's response capacity. This implied adaptation, via small steps, changes in the owner's behavior relating to cohesion and flexibility, broadly influencing the long-term development of these complex projects. The Bayesian analysis provided this means (i.e., a comparison between the participants in the project network during the bidding process and their behavior's influence on the contract implementation). By exploiting such elements of knowledge, the factors abstracted from and identified in, in-network participants' resulting relations can be determined. To this end, cumulative experience from past contracts is crucial for an owner's response capacity. Bayesian inference, within theories of choice, is closely related to subjective probability, often called Bayesian probability (Zhang 2011). Bayesian inference is widely used in a range of disciplines (e.g., in the defense field [Williams et al. 2009, p. 347] and the construction field [Hwang 2016]), and its use in the project management discipline is computationally favorable (Han et al. 2008; Kim 2015).

In the following equation (1) we distinguish Bayes' theorem, which can be written as $P(\Theta)$ a prior distribution of a set of parameters Θ ; $P(D | \Theta)$ is the conditional probability that a particular outcome D would be observed, given Θ ; $P(D)$ is the marginal distribution of the outcome D ; and $P(\Theta | D)$ is the posterior distribution of Θ given D :

$$P(\Theta | D) = P(D | \Theta) * P(\Theta) / P(D) \quad (1)$$

As established previously, the main underlying logic was that the owner's response capacity would be contingent on the behavior of the provider to which the contract had been awarded. The additional element of knowledge was understood in terms of costs/benefits, and the main variations would be due to delays in outcome delivery and cost overruns if we accepted no infringement of the scope. The posterior distribution reflected both the information known a priori (i.e., included in the prior distribution) and the objective information contained in the likelihood function. It centered on a point that represented a compromise between the preliminary information and the data. The project owner's understanding and response capacity could be improved as the sample size increases (Box and Tiao 2011).

The above was a first-order hypothesis; when a second-order (i.e., more refined estimation) approach had been established, delving into the incremental evaluation of the outcome when an earned value management system was used became possible (see also Kim 2016). To manage the numerical solution of these problems, a Gibbs sampler with the Markov chain Monte Carlo (MCMC) technique was employed (Smith and Roberts 1993). For a simple approach, the Metropolis algorithm was selected (cf. Altekar et al. 2004), the application of which enables the checking of the value creation after selecting the bid winner—the provider. The main point to analyze was that different contractors behave in different ways regarding risk and proactivity. It can be seen in Figure 6, which

shows the posterior estimated density of probability for cost variations from two different contractors for the same type of contract.

Fig. 6. Probability distribution of cost variation per contractor

According to Figure 6, and using the RStan tool (Stan Development Team 2018), we derived the potential cost overrun and delay forecasting for the next construction/civil engineering work contract in the HSL project, depending on the selected contractor (see Table 5).

Contractor	Foreseen cost-overrun (%)	Foreseen Delay (%)
A	3.9	0
B	-1.5	12.1
C	2.5	16.6
D	0.4	43.8
E	7	9,3
F	0.7	1
G	5	27.6

Table 5. Expected cost and delay for the next CONS construction work contract to be awarded

The means introduced here contrary to subjective judgments of decision-makers provide some objective tools for active owner behavior, which can reduce the transaction costs from unobservability. Yet, as indicated earlier, in the context of public projects, an arm's length relationship with contractors is advisable.

Discussion of Findings

Project front-end stage: Definition and Investment preparation phase (1993-1999)

On December 9, 1987, the Spanish Council of Ministers decided that the new infrastructure should be built using high-speed parameters and with the gauge that predominated in other European countries, i.e., 1,435 mm. Thus, high-speed trains began to be developed in Spain, first the Madrid–Seville HSL (471 km), which went into operation in April 1992, and then the Madrid–Barcelona HSL.

The institutional environment and legal boundaries orchestrating project actor's interaction in the HSL project setting: The rail and transportation industry, has been progressively relying on the contractual relationship. Thus, the institutional environment and the regulatory regime warranted a closer examination of how it influences the HSL project governing processes. Within the HSL project, the importance of the regulatory environment was underlined at every stage. Particularly at the project front-end, and the idea was to engage local (sub) contractors in the project. In Spain, the formal authorization for project investment preparation is given by the Ministry of Infrastructure Development, which instructs the Sub-directorate of Railway Planning to prepare an informative study, i.e., a detailed planning document. This formal letter of approval of the legal order for GIF (former Adif) was issued at its meeting of May 23, 1997, initiating the start of the construction of the line, including the search

for funds to finance the new HSL. However, a detailed planning design had to be completed and approved, so that Adif can start the HSL project (Internal document; Project report, 2002). But Adif lacked authority since the design - the formal order was a strategic input from the sub-directorate of railway planning. To complicate further matters, the formulation of Environmental impact was delayed, and only fleetingly referred to in the project initiation (see also Report, 2003). The PM at Adif reflected the implications: 'There is no time to carry out a feasibility study properly or to evaluate infrastructure needs. There is no time to lose because the elections are in four years.' (Interview with former HSL PM, December 1997). Regarding this situation, the Adif Head of Infrastructure Projects: drew particular attention to the project urgency:

"When the project design was handed to ADIF for further development and delivery, we stepped in: 'the train' was running at full speed, and there was no way it could be stopped."

The regulatory environment influenced the tendering process greatly. The HSL project tendering was divided into three parts, closely guided by the management of contracts and the public procurement law [in Spanish: Ley del Contratos del Sector Publico]. As indicated earlier, following the rail industry guides, Adif procured different contract packages within the HSL project comprising tracks and civil work, signal systems, installations, energy systems. These types of work are inherently different, i.e., they required diverse competencies and resources. Consequently, Adif has procured the five types of work by contracting different contractors.

The public procurement law shaped the HSL management governing choices by reinforcing work divisions: procuring design consultants and implementation separately. Following the European tendering statutes and regulations for the sector (Dir.2004/18EC), the lion's share of the contract packages in the HSL project, over 75%, were tendered through prequalification. The procurement occurred at different points in time, considering that the line segmented in three major phases, and the project involved multiple contract packages. Design-Bid-Build (DBB) was mainly used, and Design-Build (DB) was used only for constructing heavy civil infrastructures, such as tunnels and bridges. Within DBB contracts, the contractors were not involved in the design and specification of the work, but the contractors could suggest alternative solutions posterior. That is, Adif discussed the solutions with the contractors. When they were technically equal and economically complementary to the settlement proposed in tendering documents, then Adif management advanced that solution.

Project urgency: the HSL project—become schedule-driven at the front-end, on catching on the decisions based on the electoral system, in our case study, elections based on four-year orders. Adif Quality Controller draws the attention on proponents and politicians influence:

"The Politicians, they want the work for tomorrow, and they rush to tell the people that the line will be ready in two years. A politician once told that the line would be open for service in 2003, but as you know, it only did in 2009."

In the same vein, The Quality Controller of ADIF during the interview highlighted:

"Trying to do things faster, means exactly the opposite. I don't know..., I guess, it is just that due to political pressure, the management initiates the tenders too soon."

In this context, the outcome is a failure of the HSL project. Other actions by the project's proponents included advertising the project as being environmentally friendly, but there were situations in which cost/benefit analysis and their influence were brushed aside. These actions illustrate behavior that has long been recognized in organizational studies (Cohen et al., 1972). Meaning for the project proposal to pass the selection process, it must be overly optimistic, and the cost-benefit analysis not fully considered. A project team member described this behavior during an interview:

'It is the higher pressure we have—the schedule—due to political influence: they want to start the project. For them (the politicians and proponents involved), it is important to start the project, but not necessarily to get it done. At least, this is the Spanish way.' (Transcript of the notes collected by one of the researchers during a research-related meeting with GIF management, April 1998)

The contract incompleteness – the latitude for speculation in the contract: The public procurement law advanced the lowest bidder winning. The HSL project was predominantly contractually oriented. Besides, the HSL project contract network had one isolated section—the in-house design team—which was part of the Ministry of Development, constituted a public authority, and therefore could not form a separate contract, see Fig. 3. This isolated actor's activities placed significant pressure on the project owner, leaving a gap in knowledge, and latitude for speculation, in the HSL network. It is noteworthy that the project owner and the design department of the Ministry of Development, at some point during the project, shared the same workspace and resided within a short

walking distance of each other, but far from the construction site. The implications of this for knowledge sharing and the mechanisms adopted were reported by Hetemi et al. (2020). Conclusively, the project owner's role in communication patterns did not correspond with its central contract network position (i.e., Adif's management took a completely hands-off approach). The interviews with the project owner's management showed that the implementation of the project design changes was a source of delay and that many change orders led to cost overruns.

Adif focused on competitive tendering and selected the providers based on the lowest bid/ price. Besides, due to the public tendering law, there were no long-term collaborative arrangements, i.e., procurement was based on a contract-by-contract relationship. Nevertheless, the process is much more complicated because the prequalification tackled on provider's justification of capabilities, which were based on previous work experience, project size, and productivity. Besides, the regulations required that there be multi-prime contracts and that the contracts be a lump sum, fixed price arrangements. That is, competitive tenders for both building works, and specialist packages were invited on an individual, lump-sum basis from the list of pre-qualified contractors (maintained by the project owner). The bids were evaluated primarily on cost grounds. The project owner list sometimes restricted the competence among potential contractors – the pool of qualified contractors was smaller. The cost criterion scores were adopted as indicators, thus, ranking the proposals closer to the average of the total acceptable bidding proposals, which was based on Adif estimations. Given the often-limited number of bidders as well as the regularity of the tendering providers, contractor strategizing was possible. In the case of Adif in general and in the HSL project context, however, there was a requirement stipulating that change orders for all transactions over the specific amount, 10 % need Adif's approval. The 10% legal tolerance created ambiguity and did not make the monitoring of the work impracticable only, but wide open for opportunistic abuse. Hence, we observed that there was neither a political will to examine the likely opportunistic behavior, nor sufficient resources at Adif to exploit these opportunities (Nguyen and Garvin, 2019).

Project front-end stage: Definition and Investment preparation phase (1993-1999)

From January 2001 to the entry into operation of the HSL Madrid-Barcelona, 356 main construction work contracts were awarded for €2.03 billion, with a drop of 9.2% on the price Bidding. Adif engaged in contract-per-contract relations with tier-one contractors. The project cost depends on meeting the schedule, while in the words of Merrow (2011, p. 309), being “rushed on the back-end leads to quality problems” as well. The Project Manager, on behalf of Contractor C, highlighted the following during the interview:

‘We were awarded the catenary contract, in the first segment Madrid- Lleida in 2006. This was a completely ridiculous situation. It happens to know I can't work because the platform is not done; this, as the installation of the overhead wires are made following other special works, e.g., platform. We lost money, equipment, and other machines were blocked in the field. Due to our long cooperation, we did not consider legal actions!’

Once the permission to start the implementation work was received, construction works were initiated. Yet, the start of the works was delayed in 30% of the contracts, the average delay being 7 months from the signing of the contract (Report, 2017). Although in many cases, as in the executed contract of works on the platform construction project for the Madrid-Zaragoza-Barcelona high-speed line, section: “Martorell-Río Llobregat,” the delay was 30 months. These delays were mainly because the bidding for the works contracts began without having begun the procedures of forced expropriation of the affected lands, giving rise to the suspension of the start of the works (Report, 2013).

Below is a detailed explanation of the event of incidents in some cases, which factor 65% of the cost of the sample analyzed, and which are considered especially relevant. For instance, within the section: “Tramo Hospitalet – La Torrasa” (Internal document, 31/04). Throughout the life of this contract, eleven extensions were authorized for the execution of the works, which meant a total increase of 38.5 months, 192.5%, compared to the initially agreed term. In the reasons for these extensions, reference was made to the incidents that occurred during the execution. In June 2006, the contractor presented the first proposal to modify the contract, which was justified by technical issues, and that implied significant modifications concerning the awarded project with high technical and economic repercussions, raising the contract price by €20.47 million (19%) and the execution period in 4 months. Adif management authorized the drafting of the modified project. However, this project was not approved due to a series of events that are described in the following paragraphs of this and culminated in the presentation

in April 2008 of a second proposal for the modification of the original project for the amount of €17.19 million and an execution period of 4 months, whose file was approved on April 20, 2009.

Similarly, within the section: “Olredola-Avinioynet del Penedes.” The contract was awarded on July 5, 2002, with a drop of 21.4%, for a price of €37.46 million and a term of execution of 22 months, with a reduction of 9% of the expected term. The incidents that arose during the execution of the contract (four extensions, a modification that also extended the term by another 4.5 months, three price revisions and two additional settlements plus a complementary works contract) raised the cost of the works initially foreseen in the main contract by 68.4%, and the execution period at 138.6% more than the initial term.

Numerous modifications have been detected in multiple contracts, and section projects that did not meet the requirements of article 101 of the public procurement law (Report, 2013, 2017). The above are a few illustrations from the main contracts. Article 101 mandates, to exercise the justification prerogative, the existence of new needs or unforeseen causes that must be duly justified in the file that motivates the modification. But, on some occasions, questions that responded to defects in the projects due to indefiniteness or omissions were classified as new needs or unforeseen causes. On other occasions, the modifications of the contracts were motivated by a faulty execution in construction, (by way of an example is expressly stated in one of the internal reports justifying the extension of the service contract of the infrastructure of the HSL project).

Being under the regulatory regime, Adif relied on formal governing mechanisms involving site control that required expertise in constant monitoring. Yet, Adif was often understaffed, one of the project team members highlighted this during the interview:

‘I lack support and human resources to carry out my work with colleagues. We have only three engineers, and it is difficult to cover the whole project—it’s actually ridiculous! It’s impossible to cover the work. I had to cope with five contracts at once, and we needed, like, five or six people to take care of the workload in the field.’ (Interview with the Quality controller at ADIF, April 2017)

The passive project owner: Adif did little in building relationships with the providers. It was worse for learning from provider’s behavior patterns – the learning processes were not adequately put in place. The initial database they set in place contained a lot of information but was ineffective. The account manager who maintained and updated this database/folder at Adif reflected of its impractical state:

“The idea is to capture the changes in the scope of work and track and address them properly in the next line segment. [But] after multiple entries, it became messy, and it is difficult to update it accordingly as it is not system-based. It relies on manual updates and has no automatic coverage reflecting the actual certificate of changes when they occur on site.” (Transcript of a research-related meeting with Adif management, November 2017.)

Moreover, Adif lacked integration and a smooth flow of communication. In the words of Merrow (2011, p. 162), “when companies do not cooperate internally, they become incoherent, and they become easy prey for opportunistic outsiders.” We found relationships between the contract type and the contractor’s/provider’s behavior. To this end, different contract types and diverse providers affect the contract differently through more contract changes or variation orders, including several unforced owner-proposed project changes (see project owners in degree, Table 3).

Multiple ‘delusions’: The project urgency, together with the contract ambiguity, set the scene for change orders, which included project choices in the form of negotiated agreements. These choices sometimes undermined project efficiency. Some project members blamed the contractors:

‘There are also changes when the design is not done properly. When this happens, contractors and suppliers try to make money. In that respect, they are opportunistic if they have the chance. So, when you have a problem, and you change the approach from the one agreed, you have to ‘negotiate’ the changes and, foremost, agree on the pricing. When we are over schedule, we usually end up agreeing.’ (Interview with the construction manager, October 2016)

In such conditions, the governing process was dominated by negotiations and compromises. Besides, some contractors often influenced the decisions by detecting problems and deciding solutions for the project. During the interview, the contractor expressed the following:

‘I’ve seen cases where construction companies go and speak with the local administration with responsibility for that region and ask for expected changes based on the regulatory territory; so, when changes occur, it is because of the construction organization’s maneuvers.’ (Interview with the Engineer at Organization C, June 2017)

The findings above outlined through the project lifecycle corroborated our theoretical analysis and propositions in sequence as well as extended our detailed case analysis with an in-depth case background.

Conclusions

Large-scale infrastructure projects, as temporally-limited and goal-oriented contexts, are characterized by two focal stages: 1) the project front-end and 2) project implementation, offering a unique setting for the study of inter-organizational relations and actors' behavioral patterns. Each lifecycle stage is delineated by distinctive constituents that affect both the governing activities and the project actors' behavior and strategizing (Hetemi *et al.*, 2020). However, although the existing literature has recently sought knowledge of inter-organizational relations and governance issues in large-scale infrastructure projects, the researchers developed static, non-time-related propositional statements instead of dynamic, time-dependent ones. The static propositions failed to explain the development of project actors' behavioral patterns during the project lifecycle. Also, the existing literature, for the most part, has provided a first-order view of dyadic project owner-contractor relationships, seeking to explain the effects of interpersonal relations and behavioral attributes for the potential governing activities and actors' behavior. By employing a project lifecycle perspective, and examining the actor's interdependencies from a network analysis perspective, this paper contributes a viewpoint that has largely been missing from the existing literature (cf. Söderlund 2011).

The case revealed strong concerns from responsible people at the front-end stages of projects. According to our informants, the priority at the front-end stage was to give impressions of progress. By promoting the efficient and quick public bidding process, to perform in front of the citizens. We observed it was strongly linked to the electoral cycles, introducing urgency in the project. To this end, Fig. 5 shows a piece of clear evidence for general election calls. Besides, semi-structured interviews confirm such behavior notably. Whereas the existing literature has stressed the importance of contract design in mitigating cost and time overruns (Winch 2010; Gao *et al.* 2018), this study found that an intricate contract design only partially explained the dynamics that drove escalation and other issues identified in the case analysis. Through empirical analysis, we positively confirm the proposition 1 that the project urgency induced by influential project promoters at the project front-end amplifies the project uncertainty and incapacitates well-prepared decision and implementation. The overpressure in the front-end reduces the quality of designed solutions and, in the end, influences the cost overrun to the final term for these contracts.

The findings explained above for the effects in proposition 1, have their logic continuation in proposition 2 – that the initially created urgency increases the likelihood of more ambiguous contracts. So, the created uncertainty has its actual impact during the implementation stage of the project lifecycle. It becomes clear from the case study, where the cost increase is not constant. It grows densely during the implementation stage due to modifications and faulty incidents which did not follow the requirements of article 101 of the public procurement law. In all the analyzed contracts in which modifications were made, the provisional continuation of the works was authorized. This action was justified because of the stoppage of the works during the processing of the modified ones supposed severe damage for the fulfillment of the execution terms that, nevertheless, were exceeded widely (Report, 2017). Besides the causes for the delay and the reasons for which it is considered that they are not attributable to the contractor were not clearly detailed in the files for processing extensions of contracts.

Figure 5 shows how different contractors have different expectations regarding the past pieces of evidence, as one of them manages to end up most of the contracts with over costs around 18% on average. In addition, the case analysis uncovered an interesting inconsistency concerning the optimal timing for coping with uncertainty in a large-scale project setting. While confirming the proposition 2 positively, we extend the dominant perspective in the engineering and project management literature which often confines uncertainty management to the early stages of projects, i.e., to the project front-end (e.g., Oh *et al.*, 2016; Samset and Volden, 2016). Such uncertainty management is non-effective (at least partially effective we found). In practice, we observed that due to the meta-rules and some opportunistic contractors' behavior, the project owner would not be able to take effective action at the front-end.

An active owner role remains vital as a project progresses through the detailed design phase and into the implementation phase. When we consider the implementation stage-related propositions, it appears as evident that the uncertainty influence is on the causes of escalation dynamics. The outcome of these recursive escalation dynamics explains the time and cost overrun of the Madrid–Barcelona HSL project. Therefore, it becomes critical that the owner profile becomes active – leveraging the response capability, trying to reduce such escalation, which

is precisely the point for Proposition 3 describing the negative consequences of project owner passivity. To this end, the case study has shown how the SNA tool can bring pieces of evidence for different providers exhibiting different dyadic relationship with the infrastructure owner when delivery and information flow is considered. Such an approach suggests that general governance rules need to be tailored accordingly. In this context, the effectiveness of project owners' management of uncertainty vis-à-vis the functionalities to be delivered, and their providers' behavior must be addressed proactively and on time. The above suggests that more attention needs to be given to the project actors' roles, their interdependencies, and the institutional context.

The presented case also enables us to see what can be evidenced as the deliberate misinterpretation of outcomes ending up with a different level of cost overrun. Those practices are attested from the data for many different contractors and types of contracts and presented just for two of them, see Fig 6. Those we also positively confirmed Proposition 4. The lessons learned from this case enabled us to develop strategies that project owners need to take on board to increase their response capability and become active (coping with what it was discussed at the level of proposition 3). Hence, after the bidding process, the winning contractor behavior should be closely monitored to help develop a specific risk management plan for execution vis-a-vis contractor's behavior and implementing specific mitigation actions looking to cope with its 'well-known actions/claims.' See table 5, where such knowledge shows the different expectations found depending on contractors' behavior. Hence, the case study was not only used as a confirmation for the proposition meaning, but it was made possible to derive specific tools providing additional added value knowledge for the owner, i.e., tools enabling the more active owner behavior. We discuss practical implications in the following section.

Practical implications.

To conceptualize the two available transaction sets, 1) the contract and 2) information exchange (flow), in the HSL project, a thorough network analysis was performed. The density and project owner centrality relating, in particular, to the latter set, was seen as a critical SNA measure for analyzing inter-organizational relations (cf. Pryke 2012). Considering that the different functional classes of these two network sets yield a measure of the maturity of a specific actor (see Pryke 2012; Verschoore and Adami 2020), it is proposed that changes in the actors' centrality might provide an essential measure of the structural and relational dynamics in project networks. Comparison of the centrality values in the contractual and information exchange networks, for a given actor, indicated a measure of the actor's role within the procurement approach, revealing the influence of the procurement approach on actors' behavior.

This study found that, in a large-scale project context, uncertainty accumulated in layers; it had roots in the public project institutional context (the procurement approach), contractual incompleteness or ambiguity, and the lack of relational governing mechanisms, among others. Therefore, monitoring the uncertainty relating to contractors' behavior is a reflective practice essential for project owners (Liu *et al.*, 2014). It is worth noting that one transaction does not provide an opportunity to learn about other parties' behavior. Still, repetitive operations allow for learning about the behavior of the other parties and the generation of trust. This is favorable in a large-scale project setting when considering that contractors are repetitive (i.e., each runs multiple contracts during the project lifecycle). We suggest that the focus should be on the large contractors and consortiums as they can impact project outcomes, see Fig. 2. Such an approach requires a broader perspective and understanding of the relevant data, and adequately staffed owners' teams are crucial.

Finally, a move was made to provide some means of first-tier analysis, as presented. By exploiting certain knowledge, the factors abstracted from and identified in, in-network participants' resulting relations could be retrieved. To this end, the Bayesian analysis was proposed to examine the participants in the project network during the bidding process and their behavior's influence on the contract implementation. The means proposed here can help project owners interpret the organization's explicit knowledge and encourage its utilization by measuring the regular incidents that contractors have exhibited on previous projects, using these measures to make the current project scoping more robust. Such internalization of knowledge, based on contractors' behavior, can stimulate learning processes across (sub) projects in large-scale infrastructure projects. The statistics indicated that providers' potential behavior demanded particular governing choices regarding contractor selection and monitoring (cf. Le et al. 2020). Thus, depending on the figures (see Table 5), the project owner's response capacity needs to be closely linked to the risk analysis of the contract implementation. The managerial implication of this new knowledge acquisition is crucial in bringing the uncertainties of the project setting from the unknown domain into the realm of risk, enabling the incorporation of such knowledge in a project risk management subsystem.

After that, specific mitigation strategies or contingency actions can be planned or adopted, yet their discussion falls beyond the scope of this paper.

Limitations and Future Research Directions

Although this research advances the understanding of formal and relational governance in large-scale infrastructure projects by exploring actors' behavioral patterns sequentially, and in view of the project public institutional context, some limitations should be recognized. First, we accept that our single case study on the Madrid–Barcelona HSL project has enabled only an analytical generalization of the findings (Eisenhardt and Graebner 2007). Despite providing an in-depth understanding, we encourage other scholars to examine the structural and relational aspects of governance using multiple-case studies.

Further research should continue to enhance the understanding of this relationship from other perspectives (see, for example, Liu et al. 2019). The elaboration, based on two contingent dimensions, namely project urgency and contract ambiguity (concerning Propositions 1 and 2), should not be understood as the analysis of a “typical large-scale project.” However, we confirm that the contingent dimensions indeed provide insights for a deeper understanding of projects beyond the traditional engineering approach. This line of work can be further extended to involve other contingent variables relating to contracts or the size of projects. Considering that project size influences governing practices, requiring different strategies and approaches for coping with uncertainty (see Gil and Pinto 2018), it would be interesting to investigate it across a different project and organizational sizes (e.g., adopting Flyvbjerg's [2013] typology). Besides, it can be observed from our case analysis that due to the traditional DBB system, separate entities in the government lead with different portions (design, legal, contracting, etc.). As illustrated by our case, this separate design and construction of the project owner placed significant pressure on the governing process, leaving a gap in knowledge, and latitude for speculation, in the HSL network. Hence, we suggest project owners introduce strong controlling of the engineering design and dedicate to facilitating the communication among these separate entities. We also suggest this line of work to advance further by investigating and proposing collaboration techniques among government entities.

Despite these limitations, we believe that large-scale infrastructure project contexts offer an excellent opportunity to examine the dynamics of relational parties' and actors' behavioral patterns. The propositions developed here need to be further empirically tested; thus, the individual propositions can be employed to build hypotheses and test them through quantitative research (e.g., questionnaire surveys). Testing the propositions in different empirical contexts would offer researchers a comparison across settings. It might be that the impact of specific elements captured here (e.g., project urgency, multiple delusions, and escalation dynamics) may differ. In particular, the identification of more nuanced aspects is needed, which are more likely to be considered by managers for large-scale project governance. For example, the active project owner and its response capacity proposed here may be further advanced to understand the implications of management choices in large-scale project settings across contexts (e.g., countries and industries). This would enable researchers to empirically investigate and enhance the generalizability of the findings to other fields. Conclusively, a lifecycle perspective could be further advanced and studied in different types of project contexts.

Data Availability Statement

Some or all data, models, or code generated or used during the study are available from the corresponding author by request (the database generated during the current study for the purpose of quantitative analysis is not publicly available, but the data sets are in our repository, and we could provide to the editor and the reviewers of the paper on reasonable request).

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Appendix C

Paper III

An institutional approach to digitalization in sustainability-oriented infrastructure projects: The limits of the Building Information Model

Ermal Hetemi, Joaquin Ordieres-Meré, Cali Nuur

Journal: Sustainability

Article

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

Ermal Hetemi ^{1,2} , Joaquin Ordieres-Meré ^{2,*} and Cali Nuur ¹

¹ Department of Industrial Economics and Management, KTH Royal Institute of Technology, Lindstedtsvägen 30, SE-100 44 Stockholm, Sweden; ermal.hetemi@indek.kth.se (E.H.); cali.nuur@indek.kth.se (C.N.)

² Departamento de Ingeniería de Organización, Administración de Empresas y Estadística, Universidad Politécnica de Madrid, C/José Gutiérrez Abascal 2, 28006 Madrid, Spain

* Correspondence: j.ordieres@upm.es; Tel.: +34-910677107

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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 criterion 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]	<i>Analyzes the changing patterns of professional work practices due to Building Information Model (BIM) adoption</i>	Cross-case analysis and in-depth interviews
[25]	<i>Proposes the virtual design and construction (VDC) framework that integrates an organization perspective with BIM, and other processes</i>	Conceptual framework
[60]	<i>Investigates the effects of BIM on construction project organizations using social network analysis (SNA)</i>	Comparative case study with a longitudinal SNA
[61]	<i>It aims to further understand the barriers to BIM implementation and how these barriers are related to BIM maturity</i>	In-depth multiple case studies
[62]	<i>Investigates how external factors promote the adoption of BIM technology</i>	Online survey using structural equation model and confirmatory factor analysis
[21]	<i>Anchoring in industrial 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</i>	Qualitative case study involving interviews
[29]	<i>Explores the relation between BIM adoption motivations and BIM implementation</i>	Case studies and interviews with various actors per project
[28]	<i>Explores how BIM implementation process is pursued and its associated effects, i.e., the intra- and inter-organizational challenges</i>	Qualitative case study involving interviews
[63]	<i>Investigates reflective learning as a mechanism of change during BIM implementation</i>	Qualitative case study involving interviews
[24]	<i>Puts forth the BIM ecosystem concept and explores BIM-related products, processes and people in this ecosystem.</i>	Conceptual framework
[56]	<i>Examines how BIM affects inter-organizational partnerships across tiers and within firms’ boundaries</i>	Comparative case study using semi-structured interviews
[11]	<i>Analyses the systemic innovation-related needs and decision patterns of architecture, engineering and construction (AEC) actors and the challenges associated with BIM diffusion</i>	Interviews with focus groups and professionals
[27]	<i>Explores BIM adoption in view of Maslow’s motivational theory on the hierarchy of needs</i>	Interviews with focus groups and field observations
[64]	<i>Investigates UK’s construction industry to understand BIM adoption</i>	Mix method combining qualitative interviews and survey questionnaire
[36]	<i>Analyses the readiness of the AEC industry concerning the product, processes and people for BIM adoption decisions</i>	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)
<i>Goal</i>	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
<i>Accountability</i>	Public, end-users	Government, clients, and end-users	Professional community, management, collaborators Professional obligation and shared understandings
<i>Basis of compliance</i>	Expedience (i.e., regulative pillar of institutions) (Scott, 2014)	Expedience and professional obligation (i.e., regulative and normative pillar of institutions)	(i.e., normative and cultural-cognitive pillar of institutions) (Scott, 2014)
<i>Logic understanding</i>	Accountability and control	Accountability and control, and at times appropriateness	Instrumentality and at times; orthodoxy
<i>Accountability mechanisms</i>	Policy polls, a referendum Regulations and standards related to BIM implementation	Independent audit Business case and benefits management	Professional and administrative oversight Project management best practice, engineering IT norms, raw data BIM engineering best-practice, project outcomes
<i>Input</i>	BIM deployment (5–10-year time horizons)	Benefits report	Tensions due to several engineering and project backgrounds
<i>Performance metrics</i>	Intricate institutional work involving multiple experts	Tensions due to external and internal powers	

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.

<p><i>"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)</i></p> <p><i>"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)</i></p> <p><i>"For the purpose of BIM implementation, we at the moment are relying on external technical assistance (consultants)" (Organization A)</i></p> <p><i>"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)</i></p> <p><i>"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 consultant, we will identify and decide how we will model the current data in our work process" (Organization B)</i></p> <p><i>"We have not identified any KPIs (i.e., key performance indicators) yet" (Organization B)</i></p> <p><i>"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)</i></p> <p><i>"(...) 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></p> <p><i>"(...) I don't know how to refer to the colleagues in charge, perhaps the 'integrators' (referring to the BIM Coordinators)" (Organization C)</i></p> <p><i>"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)</i></p> <p><i>"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)</i></p>

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	<ul style="list-style-type: none"> - 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 	<ul style="list-style-type: none"> - 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 	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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. 	<ul style="list-style-type: none"> - 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. 	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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 legitimization. Concurrently, engage in internal technical dialogues—pursuing professionalization. 	<ul style="list-style-type: none"> - 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. 	<ul style="list-style-type: none"> - 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. <p>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</p>

Table 5. Cont.

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

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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