EGOS 2018 – Sub-theme 52: Projects for Innovation: Managing Novelty and Uncertainty
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Paving the way to digital innovation: megaprojects, institutions and agency

Abstract

As a social construct, innovation is influenced by and influences its context. This ongoing study includes a proposed approach and indicative findings to increase our understanding of digital innovation in the context of construction. Megaprojects, due to their embeddedness, longevity and pervasiveness offer a rich research setting to understand the interplay of institutions, agency and digital innovations. Data are collected using systematic literature review and analysed using synthetic strategies. Emergent findings reveal the importance of social actors moving across megaprojects and institutions and influencing digital innovation. Institutional push for digital innovation is detached from relevant technological emergence. Megaprojects are ideal vessels to capture and understand the generation of digital innovation.

Introduction

Innovation refers to a new product, service or process (Abernathy & Clark, 1985). Novelty and innovations are often observed in projects (Shenhar & Dvir, 2007), however they affect and are affected by their environment beyond project-based limitations. Innovations rely on good projects and context affects them (Shenhar & Dvir, 2007). This relation between innovation and their context is holistic and relates to a structurational view based on Giddens (1984). Thus, looking beyond projects, into their institutional context and individual agency, is needed to understand innovation. This paper addresses this issue by laying out the theoretical background and proposing a methodology for a substantial future study into how organisational context, institutional setting and individual agency shape digital innovation in megaprojects. Because of their longevity and involvement of numerous actors, as well as their potential to activate debates and mobilise different agents of the built environment, megaprojects are ideal for studying the institutional forces that shape and ae shaped by innovation.

The last decades, management and organisation scholars problematised the widening of their field. Any organisational unit or agent shape and are shaped by their environment or

structure, also called embeddedness (Giddens, 1984). As projects are inseparable and essentially embedded into their issue, organisational and institutional contexts are quintessential for understanding and managing projects (Blomquist & Packendorff, 1998). Not only should projects' relational context be continuously managed, but their wider institutional environment also merits equal management focus (Blomquist & Packendorff, 1998). Similarly, Söderlund (2004) acknowledged that whereas project management discipline has its '*intellectual roots'* in process planning and a taylorist approach of workflows, it transformed into a hybrid field which incorporates many strands of Social Science.

The relation between projects and innovation is well documented in scholarship. Davies (2014) recognised two contrasting models of project-based innovation; one optimal, emphasising planning and formal processes and another, adaptive, governed by uncertainty and adaptation. Accordingly, individual agency, informal processes, tacit knowledge and context shape projects through innovation. This paper focuses on the adaptive model of innovation (Davies, 2014), which due to uncertainty in projects is more likely to meet the demands a highly dynamic context. After contextualising it around digital innovation in construction megaprojects, it approaches project-based innovation from institutional and agential aspects to understand how it develops for and by projects. Using the concept of *institutional logics,* suggested by Friedland and Alford (1991) as an initial theoretical lens, this study will investigate the relation between megaprojects and their institutional setting to understand the emergence of digital innovation in the built environment.

Theoretical background

Institutional view of innovation

Gidden's structuration theory suggests that projects shape and are shaped by their environment: they have a mutually constitutive relationship and are embedded in a wider context (Giddens, 1984). This insight calls for understanding projects and innovations as not only being capable of shaping their environment, but also being shaped by it, according to the duality of structure and agency in structuration (Giddens, 1984). From the dual nature of structure and agency, more emphasis was given on the former than the latter. Friedland and Alford (1991) introduced the term institutional logics to stress the importance of the relations between agency (behaviour, values, intentions) and context (individuals, organisations,

institutions). Contextual heterogeneity, pluralism and innate complexity hinder the observation and implementation of innovation. For Rogers *et al.* (2005) heterogeneity is central in his diffusion of innovations theory, and acknowledging the influence of such heterogeneous institutional contexts in macro-scale phenomena offers a grounded grasp of innovation in projects. The importance of the institutional context in the practice and research of construction industry is highlighted by replacing the term Architecture, Engineering and Construction (AEC) industry with the Built Environment, indicating a set of actors and forces beyond the traditional demand and supply chain, including clients, developers, policy-makers and users.

Through a national system of innovation lens (Bengt-å Lundvall, 1998), success in innovation has to do with micro-level behaviours pertinent to long-term relations, non-price relationships and cultural context (Bengt-Åke Lundvall, Johnson, Andersen, & Dalum, 2002). At a macro-level, interactive learning in national systems of innovation are determined by the interplay of informal and formal factors (Bengt-Åke Lundvall et al., 2002). The mixture among time horizon (short- or long-term relationships), trust (the expectation of consistency) and rationality (communicative or instrumental), constitute the informal institutional dimensions that influence innovation in a national setting (Bengt-Åke Lundvall et al., 2002). Additionally, formal national institutional arrangements such as laws, policies, industry strategy and task groups constitute the context of innovation. Bengt-å Lundvall (1998) stated that innovation contributes to a vibrant economy and that it embraces uncertainty as opposed to rational decision-making. Institutions are important in the discussion of innovation, because they determine how agents behave in an environment of "on-going innovation and fundamental uncertainty" (Bengt-å Lundvall, 1998).

Innovation footprint of megaprojects

Undoubtedly, there is strong relation between projects and innovation (Shenhar & Dvir, 2007) and potentially megaprojects, due to their longevity, multi-stakeholder engagement and pervasiveness in the institutional setting are ideal vessels to study innovation. Megaprojects and Project-Based Organisations (PBO) (Hobday, 2000) are closely linked as the latter is a vehicle for delivering the former. Megaprojects are projects of massive, significant scale with long delivery phases that span across years or even decades. Usually, megaprojects carry societal value due to their functions, e.g. infrastructure. Apart from societal impact, megaprojects as usually notorious for poor delivery performance (Flyvbjerg, 2014). Among

others, scholars usually emphasise on their front-end management, the promoter's role (Gil & Pinto, 2016), their embeddedness (Blomquist & Packendorff, 1998) and the involvement of numerous external stakeholders. Construction megaprojects and their PBOs have bespoke nature, characterised by large uncertainty. However, megaprojects are undoubtedly long-standing, and behave as organisations.

Megaprojects and PBOs depart from the traditional notion of project temporality and uniqueness. First, Sydow, Lindkvist, and DeFillippi (2004) explained that despite the fact that organisations usually outlive their projects, the two have similar learning mechanisms. Whereas there is a general notion of temporality of PBOs, Brookes, Sage, Dainty, Locatelli, and Whyte (2017) questioned that the "dichotomy of durability between a longer lasting organisational milieu and an ephemeral project". Second, project typologies, such as those of transportation and oil and gas sectors, allow for a degree of repetition. Repetitiveness may account for less uncertainty and more predictability, even in unique, long-standing, and complex projects (Davies & Brady, 2000), due to the "economics of repetition".

Innovation in construction – Research setting

Innovation has been traditionally typified into incremental (evolutionary) by involving gradual minor changes, and radical by engaging in completely new approaches (Abernathy & Clark, 1985; Burns & Stalker, 1961). In construction, which is largely project-based (Morris, 2004), innovation is considered to have a slow uptake. Innovation in construction is of various types around products, e.g. new materials, and processes (Nam & Tatum, 1997), e.g. novel workflows and digital technologies. Historical advancements in hardware and software gave new Information Technology (IT) capabilities to megaprojects (Whyte & Levitt, 2011). This study focuses on 'intangible' innovation caused by digital technologies that affect construction processes through digitisation, currently known as digital transformation. Digital technologies are at the forefront of construction innovation as digital platforms (Yoo, Boland Jr, Lyytinen, & Majchrzak, 2012) that are highly pervasive and both need and allow for process re-engineering.

In the last decade parts of the construction industry have been transformed by 'wakes' of innovation in project networks (Boland Jr, Lyytinen, & Yoo, 2007). From digital three-dimensional (3D) representations of built assets until automated design and construction processes using Building Information Modelling (BIM) – a three-dimensional data modelling

approach – and various realities (Whyte, Bouchlaghem, Thorpe, & McCaffer, 2000), the construction sector has witnessed changes in technologies, work practices and knowledge across multiple communities (Boland Jr et al., 2007). Various advancements in IT can be seen as construction innovation. Following similar trends in other sectors the advancement of construction IT has evolved within the context of Digital Economy. According, various digital artefacts and functionalities alter the way construction megaprojects are designed and delivered (Whyte & Lobo, 2010). Lobo and Whyte (2017) studied UK megaprojects and how the project setting affects digital delivery and discussed how the complex institutional forces affected the project setting of these megaprojects. Our work will navigate across the same similar megaproject setting but additional focusing on the impact of institutions and agency upon digital innovation, as megaprojects are typically seen as temporary with institutionalised termination (Lundin & Söderholm, 1995).

Research gap

Drawing upon the above conceptualisations, innovation as a social phenomenon is deeply embedded in its historical and institutional context, thus delving into its embeddedness, provides insights into the politics of networked innovation. Focusing on this embeddedness helps understand the politics (macro-level) of networked innovation (Swan & Scarbrough, 2005) that affect organisational innovation (micro-level). Additionally, individual actors and firm-centric agency may facilitate wakes of innovation (Boland Jr et al., 2007) and use formal and dynamic approaches to influence their networks. After all, the interplay between actors, agency and institutions is implied by their relations, as actors' roles and positions in networks are institutionally predicated (Abdelnour, Hasselbladh, & Kallinikos, 2017). Through institutionalised roles, individuals become social actors and exercise agency (Abdelnour et al., 2017).

There is additional room to understand how digital innovation unfolds over time through the interaction of afore-mentioned components: megaprojects, institutions and agency (social actors). By mapping the relationships among agency, institutions, megaprojects and digital technologies, we can infer their role in the emergence of digital innovation. Rather than focusing on the organisational view of developing innovations (Hobday, 1998), this paper focuses on the institutional structure, hierarchical or networked, agency and processes that influence innovation, drawing upon the context of "national systems of innovation" (Bengt-å

Lundvall, 1998) of the United Kingdom (UK) construction sector and the theoretical lens of "networked innovation" (Swan & Scarbrough, 2005).

To this end, the intersection of the three literature streams of megaprojects, institutions and agency are the theoretical setting of this study and the digital innovation is the context. This could have presented as a 'Venn diagram' but because the inter-relations among these concepts are not yet defined, as this research sets out to do so, the concepts are illustrated as having vague and not yet defined relations. Figure 1 illustrates the theoretical framework of the study as a loosely coupled systems of themes and concepts including the three main theoretical areas (namely institutions, agency and megaprojects) and the area of problematization (namely digital innovation in the built environment). The smaller circles in figure 1 represent other projects and agents that depending on their analysis and inter-relations might play a role in shaping digital innovation in the built environment.

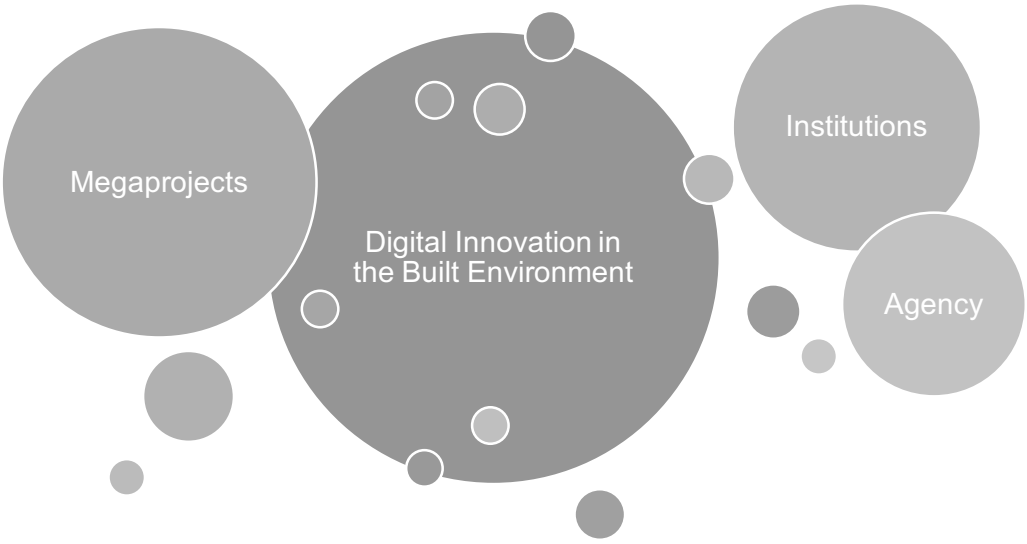

Figure 1: Theoretical setting of the study framed around megaprojects, institutions and agency and its context, digital innovation in the built environment.

Proposed research approach

To explore the relationship between digital innovations and megaprojects in their institutional and organizational context, this study will collect data on selected megaprojects in the UK, spanning from 1985 to contemporary, ongoing project, thus covering a significant time period that in the process of digitisation in construction industry. Four completed and two current megaprojects or 'breakthrough projects' (Shenhar & Dvir, 2007; Wheelwright & Clark, 1992) will be studied, namely High Speed 1 (HS1) or the Channel Tunnel Rail Link,

Heathrow Terminal 5, the London Olympics, Crossrail, Thames Tideway and High Speed 2 (HS2). Data will be collected using systematic literature review methods (Petticrew & Roberts, 2008) thus providing an unbiased and replicable account of the existing substantial body of literature relating to the institutional setting, the role of individual agency, and digital innovations in these megaprojects.

Due to the emphasis on institutional lens, both grey and scientific literature has been reviewed consistent to a networked view of innovation in the context of construction. Where little existing literature is found, particularly in current megaprojects such as Thames Tideway and HS2, additional data will be collected using interviews with senior actors. By combining retrospective and contemporary data in this way a substantial longitudinal study will be generated (Pettigrew, 1990).

The data will be analysed using Langley's (1999) recommendations for using synthetic strategies to analyse process data, as is appropriate for a longitudinal study comprising multiple case studies (six megaprojects). Such analytic techniques have been employed by researchers for example to explore decision-making in fast changing environments (Kathleen M. Eisenhardt, 1989). The predictive potential of such analysis (Langley, 1999) increases the potential value of the study's findings.

Data and Discussion

These findings draw upon selected existing literature from the scientific literature on megaprojects and digital innovation, and grey literature, e.g. government strategies, industry reports, commercial information and anecdotal data on social actors. Accordingly, this dataset informed the following four aspects of the study's theoretical framework, outlined in Figure 1. Drawing on literature identified by the authors, indicative findings are summarised and presented below in Figure 2. Figure 2 plots megaprojects, institutions and agency against the timeline of digital innovation in construction through the lens of Figure 1. This graphic visualises the inter-relations among megaprojects (setting), policy reports (institutions), key champions of change (agency) and digital transformation (innovation).

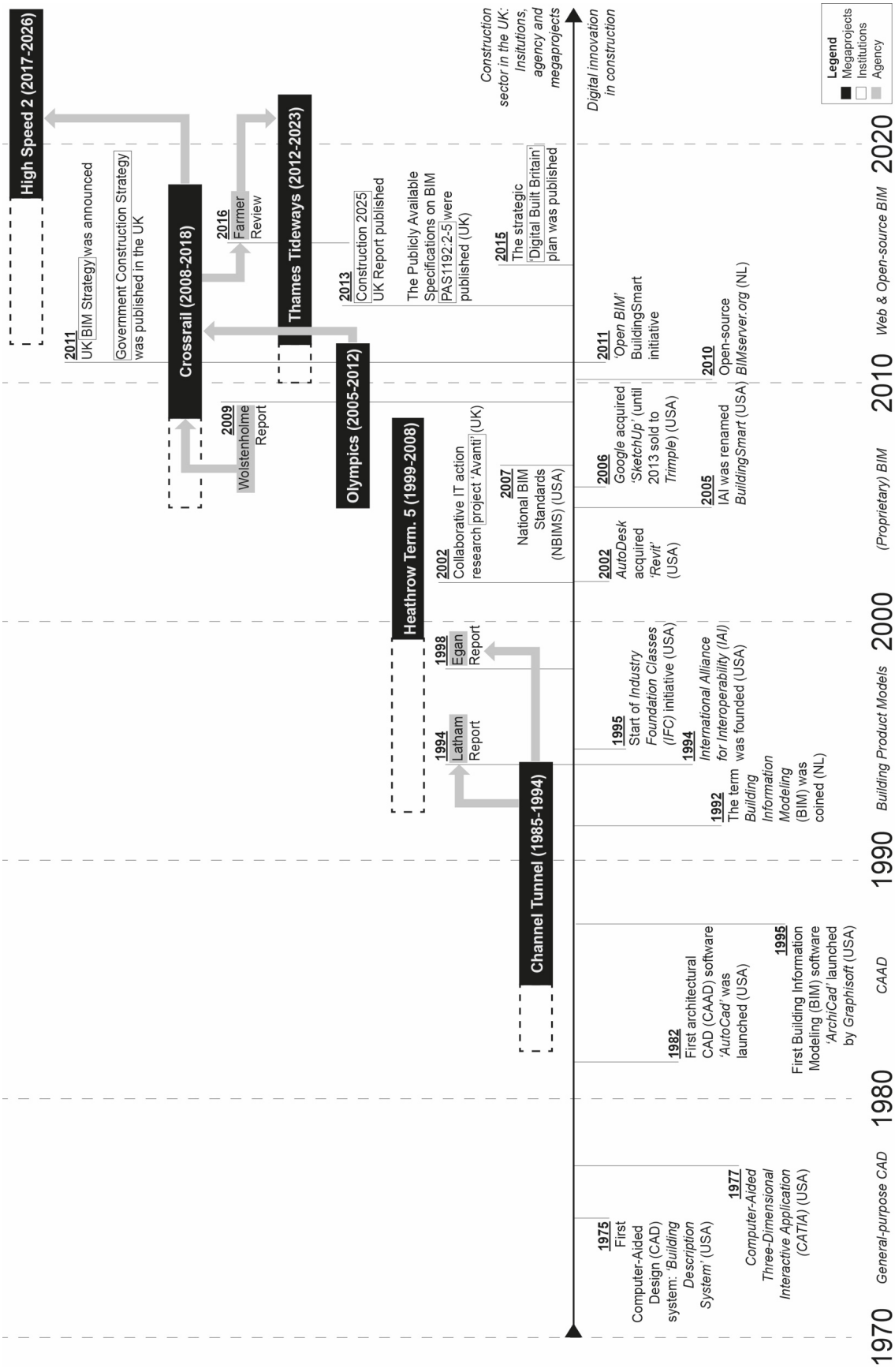

Figure 2: Timeline of digital innovation in construction influencing and being influenced by megaprojects, institutions and agency in the UK.

Megaprojects as a setting for digital innovation

We drew on descriptions of megaprojects and institutional projects in order to identify six megaprojects for in depth study. Firstly, Lundin & Söderholm's described megaprojects as having temporal character but also of institutionalised termination, as being both fluid and strategic (Lundin & Söderholm, 1995). From this we hypothesized that megaprojects, with the range of organisations and institutions involved, could also be described as institutional projects. Holm (1995) defines institutional projects as political projects that engage various institutions by necessitating collective action to generate new institutions of political actors. In chronological order, the six projects identified for detailed study are: the Channel Tunnel Rail Link (CTRL, otherwise known as HS1) which (1985-1994); Heathrow Terminal 5 (1999-2008); the London Olympics 2012 (2005-2012); Crossrail (2008-2018); Thames Tideway (2012-2023) and High Speed Two (2017-2026). Of these, the final three projects are current (at the time of writing, Crossrail is not yet finished but is due to open in late 2018). The projects are all based in the UK, to allow analysis of a common institutional environment and set of actors.

Initial research suggests that each of these megaprojects has a strong relationship with digital innovations. For instance, Harty (2005) draws on the digital practices used at Heathrow Terminal 5 to find the 'unbounded nature' of digital technologies, thus drawing attention to the important area of interorganizational working that continues to challenge construction practitioners and researchers today. In his later work, Harty and Whyte (2010) draw on the same megaproject to observe the 'hybrid practices' being employed by practitioners – a theme that persists in contemporary AEC research. Heathrow Terminal 5 also served as a setting for the study of innovation in megaprojects by Davies, Gann, and Douglas (2009) and their influential model of systems integration. This is developed in the later study by Davies and Mackenzie (2014) drawing on systems integration in complex projects, which are conceived as a 'system of systems'. Other research drawing on the London Olympics as a setting finds that the trajectories of learning has a legacy beyond the built assets created but on the individuals and professions involved (Grabher & Thiel, 2015). The Innovation strategy followed at Crossrail has been the subject of considerable scholarly and practitioner attention (DeBarro et al., 2015).

The papers and their findings reviewed here are indicative only but show the rich research settings that megaprojects make in developing our understanding of innovation, specifically

digital innovation, in the AEC industry. Future research would develop this promising approach by to conducting a systematic literature review of studies pertaining to these projects.

Government industry strategy reports influencing digital innovation

The UK has seen various government reports issued over the years to articulate and communicate the vision of how to improve construction and infrastructure sector. These reports are typically about innovation and changing the business as usual in the sector. In all these strategy reports, there is a tendency to introduce innovations successful in other sectors and attempt to adapt them to construction. Examples of such visions in the past improvement agendas are partnering, supply chain management, lean philosophy. Not surprisingly, all of these visions were imported from other sectors, such as. aerospace and manufacturing (Bresnen & Marshall, 2001), confirming that the construction industry has a tradition in importing and not producing technological innovations but (Pavitt, 1984). A few scholars challenged the extent to which such innovations in construction are indeed applied and effective (Fernie & Tennant, 2013), accusing construction industry strategists of uncritically adopting "management fashions" (Green, 2011) and defending business as usual.

The first construction strategy to specifically link to call for change in digital innovation, namely by adopting BIM, was the 2011 Government Construction Strategy (GCS) (Office, 2011). GCS defined as an objective that the Government "will require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016" (Office, 2011). The strategy further outlined the plan of operationalising this vision by issuing mandates at the end of each year leading up to 2016 in the form of Publicly Available Specifications (PAS). In 2013, the Government issued "Construction 2025: Industry Strategy for Construction", reaffirmed the strong position with regards BIM and digital way of working in the built environment and emphasised on a joint commitment to the BIM vision and programme through partnership between government and industry and close collaboration of these two institutions. The visions further explained the firm stand in ensuring all centrally (governmentally) procured projects would be delivered through a BIM-based approach, eventually leading to a wider offsite manufacturing strategy. In 2016, the 2016-2020 GSC was issued by the cabinet Office and the Infrastructure and Projects Authority (IPA), which built upon the 2011 strategy, emphasising on BIM and Digital

Construction as “an important part of the strategy and is helping to increase productivity and collaboration through technology” (Office, 2016).

As well as developing policy interventions, the UK government stimulated and facilitated innovation development and diffusion with the market as institutional projects (Holm, 1995). In the context of digital and IT adoption in construction, the Avanti project (2002) was such a collaborative or institutional project, whose objective was to enable effective collaboration among project partners (Morgan, 2017) through the use of two-dimensional digital design. These collaborative projects can implement improvement agendas policy and share the vision when firms lack the confidence and means to invest in own Research and Development capacity.

Agency of digital change

Through an institutional lens, apart from the government intervention presented above in the form of GCS pushing for digital innovation and BIM adoption, two inter-connected reports were instrumental in influencing the institutional context of innovation in construction. First, the Latham (1994) was published that paved the way to the (1998) Egan Report (Green, 2011). Both of the Latham (1994) and Egan (1998) Reports aimed at improving the performance of the sector, which was a recurring theme throughout them, and called for increased integration and collaboration among the supply chain. The Latham (1994) Report was titled “Constructing the team” and criticised the industry for being adversarial, ineffective, fragmented, and with low value for money for the client. To avert this situation, it proposed the adoption of partnering in order to increase teamwork and collaboration (Latham, 1994) supported by digital technologies. The Egan Report (1998) was titled “Rethinking Construction”, followed the same themes and proposed: (1) committed leadership, (2) client-driven construction, (3) process and team integration, (4) quality-driven operations and (5) people-focused construction (Egan, 1998).

The Egan Report (1998) as an outcome of the Channel Tunnel project (see Figure 2) was placing strong emphasis on the use of digital technologies to improve construction performance. Almost two decades after, the Wolstenholme et al. (2009) Report “Never waste a good crisis” after collaboration with Constructing Excellence, a construction industry body, reviewed the success of these 1994 and 1998 reports. It was concluded that despite these coordinated efforts from the Reports, the proposed improvements or innovation had not been

readily adopted in construction. The Wolstenholme et al. (2009) Report directly influenced the Crossrail project, as Andrew Wolstenholme was a chief executive. Most recently, the Farmer (2016) Review "Modernise Or Die" commissioned by the Construction Leadership Council at the request of the UK Government resonated with Wolstenholme et al. (2009) regarding (1) productivity losses and (2) lack of collaboration, additionally highlighting (3) lack of innovation and (4) skills shortage as persistent issues of construction. The Farmer (2016) Review calls for urgent action in light of the recent ongoing the newly-announced megaprojects in the London and the South-East. While it focuses on the UK construction sector as a whole, Crossrail is used as a case study and Thames Tideway as a case for applying the lessons learnt.

Another form of agential intervention in the setting of digital innovation in the built environment was the government support of the PAS mandates announced in the 2011 GCS (Office, 2011). The UK Government created the UK BIM Task Group, a government-funded group, managed by the Cabinet Office, in 2011. This included practitioners seconded by their employers to support the success of the UK BIM mandates and it was governmentally funded until 2016 and later disbanded. After it was disbanded, some of its members formed the UK BIM Alliance, which was publicly-funded until 2017 to continue the efforts for increased adoption and implementation of BIM.

Digital innovation milestones in construction

In this inter-connected, institutional setting in the UK built environment, megaprojects, institutions and agency were activated to support digital innovation. Presently, BIM is considered the most representative digital technology and information aggregator in construction globally. Although it is approached from the UK perspective in this study, it is helpful to understand its relevance and importance and potentially other institutional inter-relations by reviewing how it evolved globally. BIM is not only a domain of digital artefacts, but has historical roots in the long process of structuring and standardizing building information across construction sector (Laakso & Kiviniemi, 2012). Whereas the term BIM was introduced in 1992 (van Nederveen & Tolman, 1992), its underlying principles were not entirely novel for construction. BIM has evolved from efforts for structuring and consistently representing information and knowledge about building artefacts, which was a predominant line of thought in the 1970s (Eastman, 1999), under the term '*building product model'*.

Inspired by automotive and aeronautical engineering, around mid-1980s, initiatives in the USA for '*building product model'* definitions were developed for exchanging building information amongst Computer-Aided Design (CAD) applications (Eastman, 1999), replacing error-prone human interventions. The aim was to design and construct reliable facilities commissioned by the USA Department of Defence. CAD was in a sense a predecessor of BIM. Building product modeling advancements followed the long-standing debate on the computerization and digitalization of construction (Eastman, 1999). Industry Foundation Classes (IFC) is probably the most popular and long-lived data exchange format for construction and is supported from various commercial BIM applications. Against widespread belief, BIM is not completely newly-found, but the result of evolving efforts by industry consortia to structure building information (East & Smith, 2016).

From a product modeling perspective, BIM is a relatively old concept. However, BIM could be still branded as an innovation, because mandating it through policies and institutionalising it is something entirely new for construction, as it impacts project delivery in a novel way. The National BIM Standards (NBIMS) in the USA was founded in 2007 and mandated BIM use in government projects. BIM is an evolving concept and scholars and practitioners move towards more broad descriptions of BIM, such as 'Building Information Management' (Becerik-Gerber & Kensek, 2009), "digitally-enabled working" (Dainty, Leiringer, Fernie, & Harty, 2017) and digitization (Morgan, 2017) and digital innovation, to capture numerous associated innovations. Table 1 summarises the afore-described key studies that contributed to the evolving nature of BIM towards digital innovation. The lower part of Figure 1 contains data on the evolution of the concept of digital in the built environment by Papadonikolaki (2018 (In press)) as seen below in Table 1.

Table 1: Key studies and milestones in the evolution of the concept of Building Information Modeling (Papadonikolaki, 2018 (In press)).

Year	Milestone	Source
1992	Introduction of term **building information modeling**	(Van Nederveen and Tolman 1992),
1994	International Alliance for Interoperability (IAI) was founded	(Bazjanac & Crawley, 1997)
1995	Start of Industry Foundation Classes (IFC) initiatives	(Bazjanac & Crawley, 1997)
1999	**Building Product Models** book was published	(Eastman 1999)
2005	IAI was renamed BuildingSMART	Buildingsmart.org

2007	National BIM Standards (NBIMS) in the USA was founded	Nationalbimstandard.org
2008	BIM Handbook was published	(Eastman, Teicholz, Sacks, & Liston, 2008)
2009	Introduction of **Building information Management** concept	(Becerik-Gerber & Kensek, 2009)
2011	The UK BIM strategy was announced	(GCCG, 2011)
2015	The **Digital** Built Britain strategic plan was published	(HMG, 2015)

Key observations

These indicative results illustrate the value of adopting a longitudinal, contextual and multiple level approach to exploring networked innovation in construction. Such an approach can generate rich insights into innovation in the industry. For example, the longevity and institutional pluralism of Crossrail (2008-2018) makes it an ideal vehicle to study the inter-relations between megaprojects, institutions and agency. Senior managers from London Olympics (2005-2012) worked in Crossrail and currently at the HS2 (2017-2026). At the same time, Crossrail started with two- dimensional deliverables and ended in three-dimensional digital deliverables throughout its duration. Whereas it started well before the UK BIM mandates, was delivered in BIM was one of the first UK projects to become PAS1192-compliant and use BIM as a digital platform for other innovations, such as laser scanning and augmented reality. Therefore, movement of ideas and leadership around digital innovation took place. Andrew Wolstenholme, Chief Executive of Crossrail explained about the inception of a BIM Academy in partnership with Bentley software (Munsi, 2012):

"The Academy will support the Government Construction Strategy by increasing the use of BIM in the construction industry and creating a lasting legacy of best practice in innovation. The training received at the Academy will also help contractors use the knowledge and skill gained here on other major projects such as HS2."

By studying the longitudinal process of digital innovation emerging from the interplay between a series of megaprojects, institutional change and agency, a number of tentative observations emerge:

- The advancements on digital innovation peaked mid 1980s.
- Whereas research in digital innovation in construction started in the United States of America (USA) it shaped UK megaprojects and institutional setting.

- Institutional support for digital started mid 2000s in the USA and 2010s in the UK.
- There is a disconnect between institutional push (macro-level) and open-source initiatives (micro-level) for digital innovation (see 2010s).
- Individual agency affected and was affected by projects and institutions:
    - The Channel project influenced and lead to 1994 and 1998 reform agendas.
    - Senior managers from London Olympics worked in Crossrail and now HS2.
    - The 2009 update of the 1998 report influenced the organisation of Crossrail.

Contribution to theory and knowledge

The study focused on innovation in megaprojects from an institutional and managerial perspective and offered new data to this stream of literature. The research contribution of this study is at two levels. First, at a middle-range theory level, the study added to the knowledge base of digital innovation in the built environment research by structuring and synthesising an alternative view of existing empirical data on digital innovation and IT adoption in the AEC. Through this study, the institutionalisation of digital innovation in the UK is central findings that calls for rethinking and re-organizing megaproject management. Second, at a general management theory level, the study added to our understanding of digital innovation and digital transition in an analytic way that revealed the interdependences among megaprojects and institutional settings. To this end, the built environment is a research setting that due to its slow pace of IT adoption can be ideal for identifying inter-relations among various institutional and organisational entities. After all, understanding the politics at a macro-level of networked innovation (Swan & Scarbrough, 2005) can support the understanding of organisational innovation at a micro-level.

Future research strategy

This is an ongoing study and the authors will attempt to unpack these phenomena in greater depth by additional data collection through interviews. The interviews with key informants and decision-makers in the projects identified above, will present an opportunity for reflection on their projects and the inter-relations among megaprojects, institutions and agency to understand digital innovation in the built environment. The mixture of methods from desk literature survey and interview will induce communicative validity (Sarantakos, 2005, p. 86) by involving the participants to check the accuracy of the data presented here and add depth and richness to them by prioritizing them and making the inter-relations.

Ultimately, the loosely coupled themes and concepts presented in the theoretical framework of Figure 2 will be crystallized and defined. After all, Merriam (1998) has previously acknowledge the need to increase the validity of case study methods and interviews towards defining relations and generating theory.

Interviews offer rich empirical data, however there are dangers of impression management and retrospective sense-making that often arises in interviews among isolated interviewees (Kathleen M Eisenhardt & Graebner, 2007). To avoid impression management and retrospective sense-making and only interview informants that are key to the phenomenon, we will employ a snowball sampling method, also known as chain-referral sampling. Although typically snowball sampling is employed to access hidden or hard-to-reach populations (Atkinson & Flint, 2001), for this study it will be used to identify the key informants of the timeframe indicated in Figure 2, that is at least three decades, six megaprojects and numerous executives and decision-makers involved. The snowball sampling will be initiated by the first megaproject identified, that is Channel Tunnel project (see Figure 2), and from a focus group of key agents and institutions involved in this, the subsequent groups of informants in the rest five megaprojects will be identified. The study will be interpretative and focus more on information richness, sense, and meaning (Yazan, 2015), than statistical generalisation. The research design will follow the flow of relations among megaprojects, institutions and agents already identified in Figure 2 and will attempt to replicate it in order to either validate it or update it.

Conclusions

By adopting a networked view of digital innovation, an alternative view of digital innovations is afforded. Digital innovations are produced and shaped by the interplay of institutional and organisational factors. The study contributes also to this by discussing the role of individual agents who moved across projects and institutions and influenced the context of digital innovation. Emergent findings presented here show the clear contribution of adopting such an approach to our understanding of how digital innovations are generated. In particular, it contributes to our understanding of the importance of megaprojects as potential loci of innovation in digital transformation.

Another emergent finding is surfaced with regards to the role of institutions and agents in leading digital innovation. From the data presented, although digital innovation in the built

environment has gradually matured technologically in its current form, the recent decade has seen it as a radical innovation. Digital innovation has essentially become mandated by standards and procedures in the UK and its novelty lies in its institutionalization.

The practical implications if this study is revealing the decision-making mechanisms that lead to digital transformation. Understanding the inter-relationships among key megaprojects, institutions, agents and how they influenced digital transformation will be help preparing for and identifying patterns and opportunities for managing the unprecedented pace of emerging digital technologies that influence the industry. Apart from the built environment, these findings are valuable for other sectors, because the built environment allow us to study this relatively slow transformation over three decades and identify mechanisms and inter-relations that are hardly noticeable in other sectors, where the pace of innovation is more accelerated.

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