Unravelling project ecologies of innovation: A review of BIM policy and diffusion

Eleni Papadonikolaki

University College London, Bartlett School of Construction and Project Management

Abstract

As the concept of Building Information Modelling (BIM) gains traction in the construction industry, many studies have been attracted to understanding its adoption in firms (micro-level), implementation in projects (intermediate level), and diffusion across the industry (macro-level). This is a theoretical paper which mobilises contextual theories from Social Science and Project Management, such as institutional logics and project ecologies respectively, to map and rationalise the various social layers activated in diffusing BIM innovation across different national contexts (countries). Drawing upon data about Anglo-Saxon and corporatist-type national business systems, there is currently a mismatch between their BIM innovation diffusion strategy – which unfolds in a top-down and bottom-up manner respectively –, and their intended outcomes. This study highlighted that the diffusion of BIM innovation has been seen as disruptive in the United Kingdom and incremental in countries such as the Netherlands and Norway. Apart from mapping various social layers activated in BIM diffusion, this study outlines implication for policy-makers and practitioners, by stressing that not only global solutions for BIM diffusion are probably misguided, but re-establishing the links between project and context is a comprehensive approach to dismiss the rhetoric of BIM panacea and a sensible way to increase BIM diffusion and effective BIM implementation in projects.

Keywords: building information modelling, construction projects, project ecologies, innovation, diffusion.

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Introduction

Innovation is considered the introduction of new artefacts or processes (Abernathy & Clark, 1985). Traditionally innovation has been typified as either incremental – evolutionary and involving gradual minor changes – or radical – revolutionary and engaging in completely new approaches (Abernathy & Clark, 1985; Burns & Stalker, 1961). Whereas projects are usually deemed temporary organisations and hardly able to connect with similar preceding or future endeavours, they are excellent vessels to implement and study innovation (Shenhar, Dvir, & Shulman, 1995). Thus, project management (PM) and innovation are closely related. However, innovation impacts the wider industry environment – in this case of construction – beyond project-based limitations. Therefore, although innovations are observed in projects and any successful innovation relies on a sound project (Shenhar & Dvir, 2007), their context affects them and pushes or suspends change.

Similarly, there are many voices in PM asking for a more comprehensive treatment of the discipline (Söderlund, 2004a, 2004b), during its constant evolution the last few decades. Indeed, we could observe two schools of Project Management (Söderlund, 2004a) as it has gradually shifted from tool-oriented approaches for assisting with the execution of actions, towards complex and dynamic set of process- and behaviourally-driven considerations. It is because of these behavioural and relational forces that it is valuable to explore change and innovation in projects, in order to grasp the contextual pluralism of projects and innovation. After all, projects have been used to achieve organisational change, process improvement, and IT implementation (Davies et al., 2011).

This paper investigates the interactions of PM with innovation and change, drawing upon a recent hop topic in construction industry: the adoption and diffusion of Building Information Modelling (BIM). Undoubtedly, innovation diffusion relates to a macro-level of the industry, whereas innovation adoption relates to a micro-level. Entities adopt an innovation at a micro scale, e.g. a firm, and ultimately innovation is diffused at a macro-level (Rogers, Medina, Rivera, & Wiley, 2005), that is the industry. This paper attempts to connect these different levels to understand BIM innovation and its impact on project management. Using the concept of *project ecologies,* initially suggested by Grabher (2002), as a theoretical lens, it attempts to understand various nuances of context in projects, which are in turn deemed important for implementing innovations. The paper looks at the context of BIM innovation in projects through the lens of project ecologies, as innovation affects and is affected by various structures of the institutional environment, such as individuals, project teams, firms, supply chains, state, and markets.

Given that construction– which is project-based – is considered slow in technology take-off and adopting technological innovations (Davies & Harty, 2013), probably only looking at innovation adoption within projects does not help diffusing and adopting innovations to support PM – as opposed to looking at projects' context. This is a theoretical study aiming to untangle the projects' context that influences BIM innovation diffusion, and is structured as follows. First, the theoretical background and research gap on innovation diffusion, BIM, and contextual frameworks is offered. Second, the methodological rationale and the methods deployed are presented. In the ensuing sections, the data analysis, discussion confronting the existing literature, and implications for practice are presented. The paper concludes with a recapitulation of main points and thoughts for further research.

Theoretical background and Research gap

BIM as a construction innovation

Diffusion of innovations

Before discussing BIM as a technological innovation in construction, a review of key terms and definitions of innovation are necessary. The diffusion of innovations model (Rogers, 2003) describes the process by which innovations spread via communication channels across a social system over time. According to Rogers (2003) some innovations spread relatively rapidly while other innovations spread slowly depending on (a) their novelty, (b) the ideas' compatibility with existing values, beliefs, and experiences, (c) their ease to comprehend and adapt, (d) whether new ideas are tangible, and (e) whether they could be broken down for trial.

As most real-life systems are hardly linear, but instead highly complex, similarly when looking at innovations and how these unfold, multi-scale phenomena and operations contribute to complexity. For example, local interactions in networks (micro-scale) contribute to the emergence of global structures (macro-scale) and behaviours (Rogers et al., 2005). Therefore, multiple and repeated micro-scale behaviours and actions of adoption from entities contribute to the generation of macro-scale phenomena, that is diffusion (Rogers et al., 2005). In a sense, the micro-scale of adoption is the aggregate of macro-scale diffusion, but again these aggregates are characterised by heterogeneity and diversity at various contextual and cultural levels. Indeed, even firms delivering similar services or products are highly heterogeneous.

The construction industry is largely project-based (Morris, 2004). Undoubtedly, construction projects are deemed unique, as they display high demand and supply variability (Towill, 2009). Therefore, the various construction projects upon which construction industry is organised are also highly heterogeneous and complex. According to Rogers et al. (2005)

"*acknowledging the centrality of heterogeneity is also consistent with Actor-Network Theory, which, along with diffusion of innovations theory, points to the alignment of social and technical systems in heterogeneous networks*". Similarly, as we strive to understand and deploy innovation in projects, acknowledging multi-scale phenomena and heterogeneous institutional contexts is a promising way forward for managing complex projects.

Building Information Modelling history and precursors

Every project can be seen as a temporary nexus of contracts (Turner, 2016). At the same time, contracts can be considered highly structured and formalised types of – binding – information. After all, for Winch (2002; 2005) projects are nexuses of processing information. According to Winch (2015, p. 112), neo-institutional perspectives when applied to construction project management can generate insights on "*how actors construct the reality around them through interaction, thereby performing scripts and routines to generate organisation*". Therefore, thinking about transmission and reception of information and appropriate systems for its control and rationalisation are innate aspects of PM. Simultaneously, using such project information systems is part of routine project work and, as a consequence, possibly affect information processing, learning, and knowledge within and beyond project boundaries.

It is useful, thus, to consider BIM as not only innovation, but a 'systemic innovation' as it influences multiple levels of the system of construction industry (Taylor & Levitt, 2007). Proponents of digital innovation in construction claim that BIM is one of many 'digital objects' (Whyte & Lobo, 2010) that induce change in the coordination of construction projects. However, when discussing BIM as an innovation, it is probably interesting to examine its historical roots and precursors, as BIM is not only a domain of digital artefacts but the result of a long process of structuring and standardising building information for construction projects (Laakso & Kiviniemi, 2012).

BIM is not entirely new for construction projects as it has evolved from efforts for structuring and consistently representing information to capture knowledge about building artefacts, which was a predominant line of thought in the 1970s (Eastman, 1999). In the United States of America (USA) initiatives in the mid-1980s for '*building product model'* definitions were developed for exchanging building information amongst computer applications (Eastman, 1999), and replacing the error-prone human intervention (Dado, Beheshti, & van de Ruitenbeek, 2010). The advancements in building product modelling joined the long-standing debate on the computerisation and digitisation of construction (Eastman, 1999). Therefore, – contrary to popular belief – BIM is not a newly-found technological innovation, but the natural evolution of these long-standing efforts of industry consortia to structure building information (East & Smith, 2016), also known as building product models.

Based on the above, BIM is essentially a "*multifunctional set of instrumentalities for specific purposes that will increasingly be integrated"* (Miettinen & Paavola, 2014) and affects various actors across the AEC lifecycle, while policies, processes, and technologies interact to generate a digital building design (Succar, Sher, & Williams, 2012). BIM could be described as a domain of loosely coupled Information Technology (IT) systems for generating (authoring tools), controlling (model checking tools), and managing (planning tools) building information flows intra- and inter-organisationally, based on principles of information systems' interoperability.

Yet, BIM could be still branded as an innovation for construction, as despite its content-related features are already familiar for at least some actors of the supply chain – and particularly the lower-tiers – implementing it in projects from all supply chain actors is something entirely new and, thus, challenging for project management. The novelty lies at various policies prescribing BIM-related contract addendums and workflows in project delivery. Undoubtedly, as it has already been acknowledged, BIM not only affects the representation of building product information, but also the actors of multi-disciplinary project teams (Bryde, Broquetas, & Volm, 2013; Dossick & Neff, 2010). Thus, whereas it is a technological innovation, BIM has been linked not only to coordination of technological artefacts, but also complex socio-technical processes to align actors and information (Liu, van Nederveen, & Hertogh, 2016; Papadonikolaki, 2016) across different levels, such as projects, supply chains, and markets.

Contextual views in management

The end of the 20th and the beginning of the 21st century found project management scholars problematising on the widening of PM. Given that projects are inseparable and essentially embedded into their issue, organisational, and institutional contexts (Blomquist & Packendorff, 1998), traditional PM might not be appropriate for managing complexity in projects. Therefore, not only this relational context of projects should be continuously managed, but also looking for issues at the wider institutional environment that might affect the project (Blomquist & Packendorff, 1998). Similarly, Söderlund (2004a) acknowledged that whereas project management discipline has its '*intellectual roots*' in process planning techniques, it has been in a transition from a Taylorist approach of organising project workflows to a broad field which incorporated many strands of Social Science. Subsequently, as innovations are necessary for improving and managing projects, looking at them as social constructs can but offer a more comprehensive view of PM.

Institutional logics in management

Following on other disciplines, construction projects management has developed multi-disciplinary sensitivities and opened up to Social Science, and particularly Psychology, Sociology, Philosophy, and Organisational Theory. Among others, the issue of embeddedness, rooted in Giddens (1984), calls for understanding projects as not only being capable of shaping their environment, but also been shaped by it. However, as between the dual nature of structure and agency, more emphasis was given on the former than the latter, Friedland and Alford (1991) introduced the concept of '*institutional logics*' to rationalise the relations between agency – that is behaviour, values, and intentions – and its context, e.g. individuals, organisations, and institutions (Friedland & Alford, 1991). Family, community, religion, state, market, professions, and corporations are some levels of institutional logics in the Western culture from micro- to macro-scale for understanding individuals, organisations, and markets.

In the context of innovation, institutional logics could be a useful framework for understanding its diffusion among individuals and organisations. Whereas there are many detailed and visionary studies of how innovation unfolds at intra-organisational (Peansupap & Walker, 2006) and project-based settings, there are not a lot of evidence of how innovation unfolds at a macro-scale. With regard to intra-organisational levels of exploring the adoption of technological innovations, most studies have been looking at Technology Acceptance Models (TAM) and their updated version, Unified Theory of Acceptance and Use of Technology (UTAUT). However, such models and relevant studies by isolating and problematising only on two types of institutions – that is individuals and organisations – essentially overlook the contextual impact of innovation.

Only a few studies have looked at technological innovation at a macro-level, in an attempt to connect all individual, organisational, and institutional levels. Indeed, those are insightful, as they offer a comprehensive view of how these innovations unfold, avoiding the pitfalls of rhetoric strategies and impression management that would be resulted by only looking at intra-organisational levels (Leiringer & Cardellino, 2008). However, while comparing BIM innovation between the United Kingdom (UK) and Finland (Khosrowshahi & Arayici, 2012), or among the UK, Sweden, and France (Davies et al. 2015), different nuances exist. Whereas the construction industry and institutional environment of the West is treated as one entity – an aggregator of various local contexts of state, market, and other institutional logics – it is in fact made up of various national business systems.

Project ecologies

Alongside the institutional environment, individual and organisational aspects contribute to the relational space within which innovation unfolds (Grabher & Ibert, 2012). This 'relational space' denotes various social interactions ranging from micro-, to meso-, and macro-scale (Grabher & Ibert, 2012). As the concept of *project ecologies* has previously generated interesting insights into the field of project-based learning, could potentially generate useful insights into the process of diffusing BIM as an innovation across construction, using projects as vessels for popularising change, given the fact projects could transfer the 'anchoring' of knowledge, learning, and innovation to organisations (Drejer & Vinding, 2006).

Project ecologies is a conceptual framework for analysing the context of projects, by essentially also considering projects as an institutional logic. Given that institutional logics are usually disconnected from project-based considerations, where knowledge, learning, and innovation are essentially calcified, project ecologies offer a more comprehensive way of looking at innovation. According to Grabher and Ibert (2012), the organisational layers of project ecologies are the:

- Core team of the project;
- Firms involved in the projects;
- Epistemic community, including clients, suppliers, and corporate groups, and
- Personal networks, including personal, professional, or a-spatial (online) networks.

The importance of project ecologies for understanding BIM diffusion

A number of previous studies have discussed the institutional environment of BIM innovation, however not linking it back to its impact on PM. After all, Kreiner (1992), had suggested that learning and innovations are inseparable of organisation theory and project management discipline. Although the concept of project ecologies has provided rich insights into project-based learning, probably widening its base – drawing upon additional institutional logics – by recognising all pertinent actors in play its multi-layered architecture to include additional contextual features might be a promising way forward for understanding the adoption and diffusion of BIM innovation. In particular, apart from looking at the core team, the firm, the epistemic community, and the personal networks (Grabher & Ibert, 2012), this paper also looks at other institutions, such as state, market, and long-term networks to depict the whole ecosystem that is mobilised in innovation diffusion. Figure 1 illustrates the emerging social layers around project teams discussed in this study, that is project ecologies.

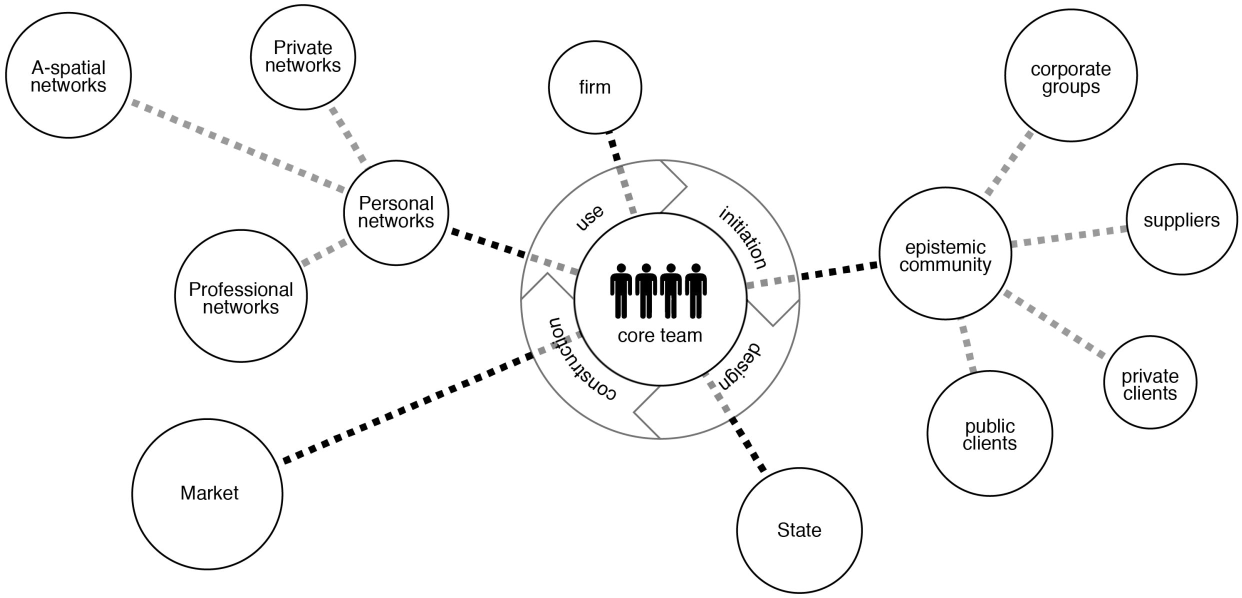

Figure 1: Emerging project ecologies pertinent to BIM innovation in construction markets.

Simultaneously, as both content-related aspects of innovation are responsible for the growth of each innovation, this paper does not engage in generalising about the diffusion of any innovation in construction, which might encompass contractual, material, technical, technological, and various other innovations. Instead it only focuses on the technological, IT-driven innovation that falls under the umbrella of BIM. At the same time, as BIM is not yet another innovation *hype* (Dainty, Leiringer, Fernie, & Harty, 2015) for construction, but has emerged from a complex history of standardisation and 'push strategy' of efforts in the realm of construction IT, particularly from lower tiers of the supply chain (Eastman, 1999). Therefore, no historical analysis of general construction innovation has been attempted in this study, as the content of each innovation per se is important from rationalising its emergence.

Apart from content-related reasons to approach BIM innovation as a unique phenomenon, there are contextual reasons. Currently, there are many voices supporting the transferability of lessons-learned from BIM innovation across countries (Davies et al. 2015; Khosrowshahi & Arayici, 2012). However, it is important to understand the extent to what policies are compatible and transferable across markets, as transferability has been previously suggested for BIM (Wong, Wong, & Nadeem, 2010). Only then, any mimetic mechanism for diffusing BIM innovation in countries and adopting it in projects could be justifiable and sustainable. Thus, there is still room for additional understanding how innovations are adopted and diffused and probably looking at projects and their context could help in this regard.

Methodology, methods, and data

Methodology

The study follows an exploratory methodology to unravel the contextual circumstances of projects through which the adoption and diffusion of BIM innovation takes place in construction, via the conceptual lens of project ecologies. By reviewing various such contexts across the world, the study will also examine the possibility of transferability of such circumstances across national environments. Therefore, the main research question could be formulated as follows: "*How does the diffusion of BIM innovation in projects unfold across the world and what are the implications for project management?*".

In construction, we can distinguish three typologies of national business systems according to Winch (2002, pp. 24-25):

- the *Anglo-Saxon* type business systems, such as those of the USA and the UK, which primarily rely on liberal market values, the stock market, and display low levels of state regulations,
- the *corporatist* type systems, such as Germany and the Netherlands, which primarily rely on banks, and are driven by negotiation and coordination efforts between state

and market, as market is essentially considered a 'social partner' of the state. In the Netherlands, this corporatist culture is usually referred to as the 'polder model' culture (Winch, 2002, p. 31).

- the *state-led* systems, such as France and Japan, which display higher coordination between state and market than the corporatist type system.

We could probably categorise the Nordic countries, such as Denmark, Sweden, and Finland into the *corporatist* type system as well, along with the Netherlands and Germany. In Denmark, the local markets are also keen to negotiate and reach consensus, as the industry is regulated in terms of innovation and loosely regulated as to free market functions (Gottlieb & Jensen, 2016). In Sweden, there is both a centralised state control but also a dispute resolution culture (Bröchner, Josephson, & Kadefors, 2002), similar to that of the Netherlands. According to Taylor and Levitt (2007), Finland also displays a mixture of relational stability among its actors, fluid boundaries, and agents for network-level change, which indicate a *corporatist* type system.

Methods and data

Winch (2002, p. 26) categorises the regulatory system of construction markets as to legal, zoning, construction, labour market, and procurement regulations. However, unwritten rules governed by culture, ethics, and idiosyncrasies are also subtle aspects of projects' context. And as technology is also essentially a cultural phenomenon, adopting technological innovations, such as BIM, is defined and influenced by cultural values and idiosyncrasies. Based on the above arguments and categorisation, the paper draws upon the analysis of scientific literature and publicly-issued documentation in the area of BIM diffusion from mainly the Anglo-Saxon and corporatist type systems and in particular: the USA, UK, Netherlands, and some of the Nordic countries. Table 1 present the main data sources across various studied project national contexts:

Table 1:

Data sources on BIM diffusion across countries (bullets show whether they were included).

	National contexts					
Data sources	USA	UK	Netherlands	Denmark	Finland	Norway
Scientific literature	•	•	•	•	•	•
Publicly-issued mandate	•	•	N/A	•	•	N/A
Government report	•	•	•	•	•	•
Industry report	•	•	–	–	–	–
Web-pages	•	•	•	•	•	•
Anecdotal data	•	•	•	–	•	–

Data collection and analysis

BIM innovation adoption and implementation

Prior to analysing the data on the diffusion of BIM innovation across various national contexts, a brief review of other studies with similar objectives – including those without a project-focus, but with implications for PM – will be presented. As BIM increasingly attracts interest from various industry players, it inevitably becomes the object of high quality scientific research, which in turn carries implications for Higher Education. The research on BIM currently takes place in three broad categories:

- Adoption of isolated firms – usually based on individual perceptions of employees;
- Implementation in projects – case study analyses based on team's perceptions, and
- Diffusion at a macro-level – either focusing on specific professional categories or industry and national levels.

BIM adoption studies provide rich insights into intra-firm barriers and enablers for adopting this technological innovation. Son, Lee, and Kim (2015) and Ding, Zuo, Wu, and Wang

(2015) analysed BIM adoption in architectural firms in China using TAM, and found that individual perceptions and mistrust were key barriers to BIM. Ahn, Kwak, and Suk (2015) explored transformation strategies of contractors in the USA for successfully engaging in BIM work and concluded that those related to both technology infrastructure and relational aspects.

As adoption unfolds at a micro-scale and diffusion pertains to a macro-scale, implementation relates to an intermediate or meso-level, which significantly helps understanding the former. Similarly, BIM implementation studies range from technical to organisational and offer a grounded understanding of advantages and shortcomings of using BIM in projects. For example, it is through such studies that benefits in design management (Elmualim & Gilder, 2014), project management, i.e. time reduction, communication, and coordination improvement (Azhar, 2011), project performance (Bryde et al., 2013), collaboration, and coordination (Dossick & Neff, 2010) have been acknowledged. However, most BIM adoption or implementation studies, fail to describe the context of firms or projects analysed – this may very well mean that it was not described, not that it has not been taken into account or acknowledged whatsoever.

BIM innovation diffusion

Following the above, looking at BIM diffusion studies is probably the missing piece of the puzzle for grasping the way that BIM innovation unfolds across various contexts, and among others, whether this is evolutionary or revolutionary (Burns & Stalker, 1961). Succar and Kassem (2015, p. 65) described BIM implementation as a '*three-phased approach'* that includes readiness (pre-implementation), capability (actual implementation) and maturity (post-implementation) that firms should develop to successfully engage in BIM. In a project with numerous BIM-using firms, the dynamics of project-based BIM goals constantly change, given that firms carry various BIM readiness, capability and maturity levels, because of their different disciplines and sizes (Succar & Kassem, 2015; Succar et al., 2012) – essentially their heterogeneity. In the same paper, Succar and Kassem (2015) discussed ‘macro-BIM adoption’ and essentially analysed how BIM is diffused in markets with different characteristics and inform the development of BIM-related policies. Accordingly, they (2015) categorised BIM diffusion dynamics into *top-down*, *middle*-out, and *bottom-up*, depending on whether the pressure mechanism was downwards, horizontal, or upwards from the government, large firms, or small firms respectively.

Mobilising the above in the context of projects ecologies, in the USA, BIM use in projects has been mandated and regulated as early as 2007 from reports issued by governmental departments, local authorities, and professional industry associations. In Europe, to control the various nuances and instrumentalities of BIM, and prescribe BIM implementation to reap its acclaimed benefits, various national initiatives suggest quasi-contractual means of BIM-related agreements among the actors, e.g. pre-contract BIM Execution Plan’ (CPIc, 2013) under the efforts of the UK BIM Level 2 mandate, and ‘BIM Protocol’ Norm issued – but not mandated – by the Dutch Government Building Agency (GBA) (Rijksgebouwendienst, 2012), both of which are inspired from the – also not mandated – Norwegian equivalent ‘BIM Manual’ (Statsbygg, 2011). Also in the UK, many mandates in the form of Publicly Available Specification (PAS) have been issued to prescribe BIM use in project delivery, such as the family of PAS 1192 documents. Other European countries plan to follow a top-down route to BIM diffusion. France also plans to issue relevant regulations and mandate BIM use for all public buildings starting 2017 (Davies et al. 2015), and Germany will put in effect similar mandates by 2020.

Wong et al. (2010), after reviewing BIM-related initiatives in six countries suggested that for “*effective implementation of BIM in a country, both the public and private sector should work* *collaboratively to set up a suitable environment for the implementation of BIM*". However, not all national contexts could afford, allow, or incite suggested close collaboration between public and private bodies. Whereas "*policy makers can also adopt or adapt compatible BIM content types from other countries and thus reduce duplication of efforts*" (Kassem, Succar, & Dawood, 2015), any mimetic adoption or even adaptation should be tailored to recipient countries' context. Therefore, this study proposes that looking at the social layers of emerging project ecologies across countries, could support transferability of BIM innovation diffusion mechanisms, where appropriate. Drawing upon the previous and the data sources of Table 1, Table 2 presents actors currently mobilised in the national contexts for BIM innovation.

Table 2:

Cross-country comparison of social layers active (shown with bullets) or not in BIM diffusion.

Project ecologies	National contexts					
Social layers	USA	UK	Netherlands	Denmark	Finland	Norway
Core team	•	•	•	•	•	•
Firm(s)	•	•	•	•	•	•
Epistemic community:						
–Public clients	•	•	•	•	•	•
–Private clients	–	–	•	•	•	•
–Suppliers	–	–	•	•	•	•
–Corporate groups	•	•	•	•	•	•
–Long-term partners	–	–	•	•	•	•
Personal networks:						
–Private networks	•	•	•	•	•	•
–Professional bodies	•	•	–	–	–	–
–A-spatial (online) networks	–	•	•	•	•	•
State regulation	•	•	–	–	•	–
Market	•	•	•	•	•	•

Discussion and Implications

Understanding innovation diffusion through project ecologies

By mapping and understanding the project ecologies of BIM innovation across countries, this study offered an understanding of BIM innovation and a reflection of how policy-makers and practitioners could deal with change and innovation in an industry that increasingly becomes global and networked. Discussing innovation always applies to both micro- and macro-levels. In the case of project learning, the firm is the prime locus of cumulative learning (micro-level), whereas the project (meso-level) is the locus of disruptive project learning (Grabher & Ibert, 2012), through pertinent contextual (macro-level) determinants. Potentially similar considerations should be mobilised when discussing BIM innovation, considering that innovation is established incrementally in firms and radically in projects that influence and are influenced by their environment (see Giddens' (1984) structuration). Additionally, various personal networks and lateral institutions contribute to the solidification of knowledge, learning, and innovation.

Widén, Olander, and Atkin (2013) explored and proposed the importance of engaging and controlling key stakeholders, such as innovation brokers, role models and risk-takers, early during the innovation diffusion process. In a project, various organisational layers from Table 2 could play such critical roles, and therefore it is important not only to map them, but to appropriately engage and, if necessary, manage them. Similarly, as explained, although the innovation– that is BIM – might be equally popular across countries, because of the varying composition of national project ecologies, different equilibria should be sought in each context. Therefore, this study outlined implications for policy-makers and public clients interested in pulling BIM diffusion in national markets (CIC, 2011), especially since this innovation has emerged from a push strategy (Eastman, 1999) decades ago. As the European Union BIM task group currently works on a European-wide BIM handbook, contextual sensitivities are necessary for informing any generalised decisions. Simultaneously, a contextual understanding of projects is paramount for successfully managing innovation change management as projects are – relatively – discrete plateaus where usually innovation is implemented and observed.

Typologies of BIM innovation diffusion

Whereas this study mapped and analysed project ecologies of BIM innovation per country, the analysis will be clustered around national business systems (Winch, 2002). Subsequently, two tentative typologies were observed, that is of the Anglo-Saxon and corporatist types systems. Surprisingly, among this sample, countries with higher state regulation, such as the Netherlands and Norway, have not regulated BIM – at least for the moment –, whereas countries with lower regulation, such as the USA and the UK, have mandated BIM use. This becomes evident when looking at Table 2 having in mind the national business system categorisation of Winch (2002, pp. 24-25) and especially the Anglo-Saxon and corporatist types systems, as the USA and the UK fall under the former category, while the rest countries into the later.

First, it is surprising that in the UK, a country with less state involvement and a more *laissez-faire* mentality, there are numerous politicised decisions for pulling BIM innovation. However, the USA almost seem to have lost momentum regarding BIM innovation, as since it became a mandated policy in 2007, not a lot of additional traction has been gained (McGraw-Hill, 2014a). For example, one might expect that during the decade that followed their mandate, the majority of the USA construction firms would have been using BIM, which is not what industry reports reveal (McGraw-Hill, 2012, 2014b). However, additional nuances manifest when looking at specific national business systems. For example, the decision of both the USA and the UK of mandating BIM use in public projects, has different implications, as the two countries naturally have differently intertwined institutions and government policies – that is social infrastructure. In the UK, it is the government who is the biggest construction client. Probably also because different states of the USA are involved in regulating social infrastructure, it is challenging to ensure continuity to the development of government legislation. As the percentage of public procurement and social procurement in the UK is higher than the US, e.g. hospitals and schools, correspondingly more construction businesses are influenced from the newly introduced BIM mandates.

Second, with regard to the Netherlands and the Nordic countries, although BIM is not globally mandated (see Table 2), both SMEs and large construction firms are keen to use it in projects (Davies et al. 2015; Papadonikolaki, Vrijhoef, & Wamelink, 2016). Especially Norway and the Netherlands, that published their publicly-issued BIM-related guidelines in 2011 and 2012 respectively, have not mandated BIM use, but enjoy a high level of BIM innovation diffusion. However, given the relatively small size of these economies, these countries are not usually at the forefront of industrial reports on BIM, such as those from McGraw-Hill (2012, 2014b). The personal, informal, and long-term relations among firms in this context category (Bröchner et al., 2002; Gottlieb & Jensen, 2016), probably play a role in diffusing BIM innovation from a middle-out perspective.

On a different note, it is surprising that professional bodies in these countries have not yet participated in the policy-making process, similarly to what the Royal Institute of British Architects (RIBA) and the American Institute of Architects (AIA) in the UK and the USA respectively have been doing. Therefore, the corporatist types system countries have not yet attempted to regulate BIM and rely on mostly bottom-up initiatives, whereas the Anglo-Saxon type system countries – drawing upon Winch's categorisation (2002, pp. 24-25) – have by following top-down BIM diffusion strategies. The only exception to this phenomenon, might be considered the fairly recent (December 2016) decision of the UK about placing the PAS 1192-2 under public revision, which reflects the effort to involve various layers of the project ecologies in BIM diffusion and probably a relevant 'cultural shift'. Indeed, probably such a cultural shift in the UK might have already started to take place, as another industry report highlights that in the UK, as opposed to the USA, design and construction teams are more keen and proactive to use BIM without owners' request (McGraw-Hill, 2014a, p. 9).

Potentially, any generalisation and transferability of BIM mandates and regulations only make sense when firms compete within a truly global construction market, for example during international architectural competitions, where BIM use had been in instances required as early as 2008. There is a need to develop sensitivities even when discussing (BIM) innovation as a universal phenomenon of a global market, especially when this is as fragmented as construction. For example, when discussing BIM and procurement, various researchers concluded that Integrated Project Delivery (IPD) is contractually appropriate, although it is not globally applicable (Holzer, 2015; Sebastian, 2011). Thus, generalisation and mimesis based on solely the economic growth or power of national business systems is error-prone if not combined with a wider acknowledgement of the social context and infrastructure (see Figure 1).

Proposed actions for BIM innovation diffusion

BIM innovation is seen either as incremental or radical – and disruptive – in various contexts. This observation relates to a macro-level perspective. As innovations are strategically adopted and implemented in projects, innovation not only depends on the market level, but also on micro-, meso-, and macro-level institutional components, such as individual perceptions, core project team, firms, clients, suppliers, other groups and networks, and naturally state. Depending on the previous components, each project unfolds in different project ecology (Grabher & Ibert, 2012). Undoubtedly, synergy among these social layers is preeminent for innovation change management. At the same time, rethinking the composition and weights of these components of project ecologies per context (country), facilitates not only the understanding of innovation diffusion, but could also mobilise key actors – such as professional associations – for ensuring innovation progress smoothly, especially in 'top-down' – or pull – innovation diffusion.

Similarly, Dainty et al. (2015) challenged the effectiveness of industry-wide mandates and policies for BIM diffusion on the grounds that such policies are usually discontinued for lack of political influence – similarly to past reform agendas from as early from 1934 and 1944 until Sir Latham (1994), and Sir Egan (1998) reports. However, it seems that in the UK the political influence grows strong. Fernie, Leiringer, and Thorpe (2006, p. 98) noted the '*need for contextual thinking and sensitivity within organisational studies and in the discourse mobilised by the contemporary reform movement in the construction sector'*. Undoubtedly, both contextual thinking and the acknowledgement of the particulars of each innovation are necessary for understanding its diffusion. After all, Kale and Arditi (2006) had previously acknowledged that while innovation is diffused across the industry, idiosyncratic characteristics of innovation could also evolve over time. This previous observation is probably true with BIM, considering how it has evolved the last decades following a push strategy under a different name – that is building product models. Therefore, it is not surprising to observe adjustments in the diffusion of innovation – as this unfolds and changes –, composed of essentially hybrid mechanisms between top-down and bottom-up strategies, as for example in the UK recent decision to place the BIM mandate under public revision.

Concluding remarks

This paper concludes with the observation that both contextual and content-specific aspects unfold with regard to the diffusion of BIM innovation and these ingredients should be acknowledged and respective sensitivities should be developed when managing construction projects. On the one hand, in the case of BIM innovation diffusion, the diffusion process should not be uncritically compared and assessed in conjunction with past construction innovations, as this approach essentially neglects the historical antecedents of innovations – in the present case of BIM – and naively obscures the identity of innovation. Essentially, BIM has been approached from policy and research bodies, as a disruptive or radical innovation, given that it has been recently mandated across few countries. However, the reality is that the concept of BIM and its underlying implementation principles were introduced in the construction industry a few decades ago following, thus, an incremental path of innovation in a push strategy. BIM has been perceived as disruptive only based on the strict mandatory character that the various national public policies have attributed to it, e.g. in the USA and UK. In the context of the Nordic countries and the Netherlands, BIM diffusion appears incremental.

On the other hand, it is essential to acknowledge, that local contexts and culture play a critical role to BIM innovation, as various – usually incongruent – social layers are activated during the diffusion of BIM innovation, from firms, public sector policy-makers, industry consortia, until professional, personal, and a-spatial networks (Table 2). And naturally, the innovation diffusion process immensely affects the implementation of innovations in projects. Mapping and comparing the involvement of these various actors across countries, two mechanisms of top-down versus bottom-up BIM diffusion can be deduced. From this cross-country comparison of the ecologies of BIM diffusion, it is evident that the efforts to diffuse

BIM in an ‘one-size-fits-all’ fashion are not only misguided, but also potentially threatening for industry productivity, satisfaction, and performance. Applying, thus, global solutions in not yet global industries, such as construction, could bring adverse effects to not only innovation diffusion, but also to PM.

Future research around this area would include interviews with stakeholders with various roles across this mapped multi-scale context of BIM innovation across countries in a snowball sampling technique. As in the increasingly global phenomenon of BIM innovation knowledge and insight reside in various actors, recruiting future interviewees from among their professional acquaintances, might be a promising way forward to capture the multi-level ramifications for understanding and managing innovation. Preferably, also insights into already bench-marked and key projects with BIM implementation would be desirable to connect implementation-oriented and diffusion-centred experience.

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