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ORGANIZING FOR DIGITIZATION IN FIRMS: A MULTIPLE LEVEL PERSPECTIVE

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This paper explores how an established organization in the AEC industry is responding to radical, potentially disruptive, digital technologies. As the pace of digitization accelerates, so the ability of firms to adopt technologies effectively is becoming increasingly important. Evidence from other industries shows that radical technologies can create significant disruption in industry structures, institutions, and organizations. This paper draws on a multiple level, longitudinal analysis of the process followed by one incumbent firm in developing digital capabilities. Data covers a 15 year period and charts the implementation of BIM at institutional, organizational and user levels. Findings suggest that organizing for digitization in firms is a process involving these multiple levels and that alignment between them enables the adoption of technologies.

Keywords: Digital technology; disruptive innovation; sustaining innovation; technological change; firms; BIM; institutional change

INTRODUCTION

The AEC industry has experienced substantial technological change in the last 50 years (Gann, 2000). As a number of recent reports have emphasised, the pace of technological change influencing the industry is accelerating substantially and coming from a diverse set of interdependent technologies (see for example ICE, 2017; Farmer, 2016; HM Government, 2015). While many other industries have also experienced rapid digitization, the AEC industry's low profit margins and productivity rates make it 'ripe for digitization' (McKinsey, 2015). The process of digitization involves the transformation of:

> "existing socio-technical structures [that were] previously mediated by non- digital artefacts or relationships into ones that are mediated by digitized artefacts and relationships with newly embedded digital capabilities" (p7, Yoo, Lyytinen, Boland, & Berente, 2010).

Experience from other more highly digitized industries shows that established high-performing firms often fail in the face of radical technologies, such as those being adopted in the AEC industry (Christensen, 1997). Radical technologies can give rise to disruptive digital innovations that change existing industry architectures

(Henderson & Clark, 1990). In the face of accelerating technological change that threatens to disrupt the AEC industry, how then are firms responding? The capability to use and implement technologies effectively is becoming a key competitive differentiator between firms and will determine whether technologies disrupt or sustain organizations and industry architectures (Christensen & Overdorf, 2000). Scholars of technology and organizations have moved away from technologically deterministic views to place emphasis on the context of use (Orlikowski, 1996), recognising that the individual user is central in enacting technological change in organizations (Orlikowski, 1992). Recent studies adopting this perspective in the AEC industry find that the diffusion of digital innovations in firms is non-linear, influenced by changes in the innovation and firm context (Shibeika & Harty, 2015). The interplay between institutional actors, the socio cognitive environment, and the market and production environment all influence the adoption and use of ICTs (Jacobsson, Linderoth, & Rowlinson, 2017). While these studies shed light on the critical issue of why firms are often unable to realise the benefits of technological change (Gann, 2000), the nature of the relationship between the factors influencing technological adoption in firms operating in the AEC industry remains unexplored, despite the growing importance of organizations developing such capabilities.

This paper addresses this gap by providing a multiple-level view of one firm's efforts to adopt a new technology. It does so through longitudinal case of an established, firm's adoption of Building Information Modelling between 2000-2015. This data is presented at multiple, embedded levels – at institutional, firm and user levels – in order to explore the relationship between them. It contributes to a growing body of studies looking at the implementation of BIM in organizations (for example Jacobsson & Linderoth, 2010; Jacobsson, Linderoth, & Rowlinson, 2017; Linderoth, 2017). This paper proceeds as follows. It reviews digitization in the AEC industry, and the application adoption of these technologies or how they are used in context. It then presents the case study and discusses the findings from this case. The findings add support to studies showing the importance of the institutional environment in influencing technological implementation in firms. It extends these studies by unpacking the nature of this relationship, suggesting that mutually constitutive relationship exists between institution, firm and users whereby they change and are changed by each other.

DIGITIZATION OF THE AEC INDUSTRY

The products and production of the built environment have experienced extensive technological change since the mid-1900s (Gann, 2000). On one hand, technology has extended the art of the possible: from Sullivan's Chicago skyscrapers of the late 19th century, made realisable because of the availability of steel frames and elevator technology, to the complex infrastructure and building forms of the present day. On the other, the production of the built environment has also experienced a transition along the innovation spectrum, from incremental to more radical digital innovations, a term used in this paper following Slaughter's definition of an innovation as the application of a new idea (1998). From the transition in the 1980s from paper-based drawing to Computer Aided Drafting (CAD) to create visual representations, to 3D CAD applications (Gann, 2000), to the ongoing adoption of BIM technologies, like other industries and consumers the AEC industry has experienced substantial technological change in the last 50 years. Today the industry is moving towards radical, and potentially disruptive digital technologies. This is reflected in a number of industry reports published in recent years which identify additive manufacturing, artificial intelligence and robotics, automation of knowledge work, advanced materials, advanced manufacturing, Internet of Things; big data and complex analytics, virtual and augmented reality, advanced applications of BIM, mobile devices, energy storage and renewable energy and Blockchain as digital technologies driving the process of digitization.

Building Information Modeling (BIM) is the latest group of technologies to be introduced to the construction industry. Drawing on parametric modelling techniques widely used in other industries, the use of these technologies enables an accurate digital model to be developed. Information is embedded in every object in the model, thus the digital models is commonly described as a "database with drawings". This common model forms a knowledge repository or manual of the built asset and can be used for its entire life cycle, after maintenance for operation purposes.

Technologies in use

While the consequences of digitization in the AEC are not only positive, indeed the recent move to adopt BIM has revealed its 'dark side' (Davies and Harty, 2012) and current debates abound around cyber security risks presented in the digital built environment, the accelerating rate of digitization appears inevitable. Positively the emergence of novel digital technologies present opportunities to create digital innovations, created through the application of technologies (Slaughter, 1998). However the application of these technologies has often proved a challenge for the AEC industry and its firms, and to realize the promised benefits of technological change. Early research notes that the outcome of firms' efforts to implement ICTs was far removed from the benefits envisaged (Salter and Gann, 2003). A comparative study between the adoption of CAD and virtual reality technologies found that the lack of end user involvement in firms' implementation processes hinders take up (Whyte & Bouchlegham, 2002). More recent studies of BIM adoption develop these findings. BIM is viewed as an "unbounded innovation" requiring collaboration between many firms for implementation to be successful (Harty, 2005), its use demands, rather than creates, greater collaboration between its users (Dainty et al, 2017). In an industry that continues to struggle with collaborative working, this is a key challenge in using BIM and a major contributor to the industry's sluggish rate of adoption. Institutional and industry setting is vital in considering BIM use (Jacobbson et al, 2017). Actors' sensemaking is central to their use of BIM, which is in term highly influenced by the institutional environment (Linderoth, 2017). Recent theoretical papers have argued that the adoption and use of ICT in the industry is a result of the interplay of related factors including the socio-cognitive environment, institutional actors and the market and production environment, suggesting that the outcomes of the interplay between these factors can be aligned or misaligned with the ICT (Jacobsson et al, 2017). This paper provides an empirical study of this theory; study the adoption of a potentially disruptive technology by an incumbent organization in the AEC at multiple levels.

METHOD

In keeping with the aim of this paper, the data presented is drawn from a single, embedded case study, suitable for developing a detailed understanding of a process of change (Van De Ven & Poole, 1995). Through this research method "thick descriptions" (Geertz, 1994) were generated, strengthening the transferability and reliability of this study, thus addressing a potential weakness of single case study designs (Lincoln and Guba, 1985). The selection of the case was crucial and driven by the ability to "shed empirical light about theoretical concepts or principles" (Yin, 2009: 40). The case study firm presented in this paper, referred to henceforth by the pseudonym Design Partnership, is a large and mature multidisciplinary design consultancy. This leadership position is apparent in the considerable size of the firm and the breadth of its work. Because of this, the firm has significant influence across the construction industry and its supply chain. Design Partnership has a strong reputation for creativity which is apparent in its innovative approach to using digital technologies at organisational and project level (see for example Criscuolo, Salter, & Sheehan, 2007). This study was developed in collaboration with Design Partnership meaning data were collected through deep access to the firm. The author was able to collect data on the process of BIM implementation at Design Partnership over a 15-month period, between July 2013 and September 2014. During this time, she was embedded in the organisation as a researcher, spending one or two days per week in Design Partnership's UK head office. In order to build a longitudinal view of the process of BIM implementation at Design Partnership over time, she collected contemporaneous and retrospective data. In collecting retrospective data, she maintained a critical awareness of the validity and accuracy of the data gathered. The recollections of informants regarding BIM implementation gathered during semi-structured interviews, was particularly vulnerable to "informant inaccuracy" (Bernard, Killworth, Kronenfield and Sailor, 1984). Such informant inaccuracy potentially has significant detrimental effects on the quality of data collected (Bernard et al, 1984).In order to minimize the impact of potential inaccuracy, she collected data from a number of sources, following Pettigrew's advice for conducting longitudinal studies using retrospective data (1990). Thus she achieved data triangulation and increased the credibility of the case (Lincoln and Guba, 1985). Data were collected using qualitative research techniques and drawn from a number of sources including interviews, archived information, internal meetings seminars and regularly updated field notes, as shown in Table 1. Semi-structured interviews form the central source of data collection. Interviewees were purposefully drawn from a variety of professional disciplines. They came from a range of roles and seniority levels in the firm. Additional external data were collected to correlate Design Partnership's implementation process with external events. The sources of this data included semi structured interviews with 9 external individuals instrumental in setting institutional policy, and regulatory standards for BIM implementation, external media, websites and relevant conferences.

	Number of interviews	Meetings / seminars	Archived information	Other
Design Partnership	34	Launch of BIM strategy in UK Meetings of BIM strategy team	Background reports DP journal. Others	Regular field notes External reports and academic papers
Industry	9	Conferences External media and website Websites		
Other firms	11		Internal documents	

Table 1: Data sources

RESULTS

Founded 70 years ago, Design Partnership employs some 11000 staff working from 38 countries. It is a multidisciplinary professional services firm, employing staff from various backgrounds whose work involves high levels of collaboration across disciplines, professions and organisations. It is sufficiently flexible to meet the demands of dynamic environments and has the capabilities needed to create complex products. It developed these capabilities through its highly skilled and innovative workforce. The institutional and organizational context for considering BIM implementation at Design Partnership is illustrated in Figure 1. This presents an overview of technology implementation as a long-term process at Design Partnership, from 2000 until 2015. Three temporal stages in the implementation process are evident which were identified through significant events that serve as temporal breakpoints. The time period of the longitudinal study covers a significant period the implementation of BIM across the UK and global construction industry.

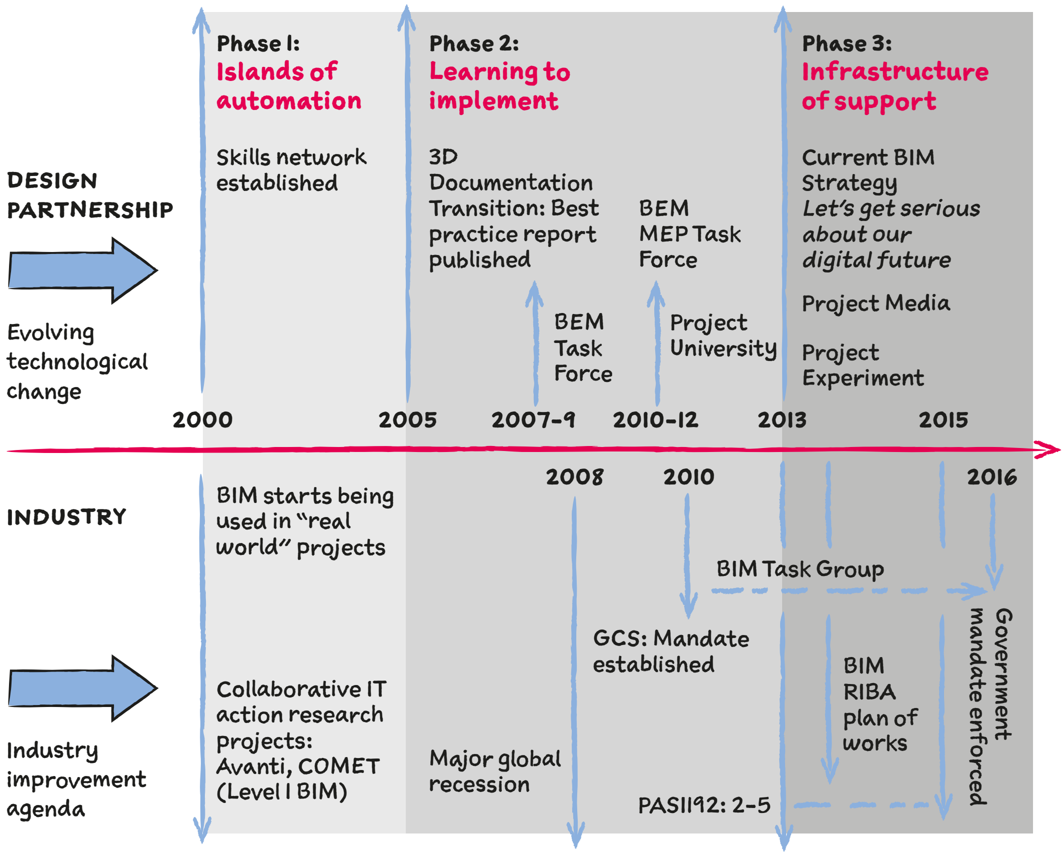

Figure 1: Three phases of implementation of BIM at Design Partnership and industry

PHASE 1: ISLANDS OF AUTOMATION

The first phase identified in this study starts in 2000 and extends to 2005. It marks the initial adoption of BIM in the built environment industry and at Design Partnership. Externally awareness in the potential of BIM was emerging. In 2000, BIM was being used on real world projects (Grilo & Jardim-Goncalves, 2010). Government funded research projects explored the use of collaborative digital technologies in live projects. These research projects demonstrated the potential that BIM held for improving the efficiency of work and quality of output in the UK built environment industry. However they also hinted at the scale of the disruption that BIM-enabled working would bring to the industry. As well as learning to use new and complex software, behaviour, cultures, standards and processes would need changing.

Before 2000, Design Partnership had adopted new technologies with minimal organizational intervention. For example, the transition from paper based to digital drafting, using Computer Aided Drawing, was achieved through evolutionary methods. Based on this past experience, the firm initially took a similarly hands-off strategy to implementing BIM. It employed a bottom up approach that foresaw individual BIM enthusiasts driving BIM implementation across Design Partnership. As a member of the current BIM implementation team recalls:

"We had an evolution about 10 years ago to 3D drawing but it was still only physical objects that we were looking at. So it was a relatively easy transition and one born out of necessity: if you were doing something really complicated it made sense to do it in 3D. We thought that the evolution to BIM was going to be similar."

During this period, use of BIM in the firm remained resolutely the domain of the technological enthusiasts. The dominant perception of BIM in Design Partnership was that BIM is an irrelevance: as one senior business leader at the firm explained, "most people felt that BIM was nothing to do with what Design Partnership does". During this initial phase, a lack of engagement amongst leaders and practitioners in Design Partnership led to minimal progress in implementing BIM. Without the organizational and institutional structures in place, the isolated innovations of technological enthusiasts working in islands of automation were unable to advance technological implementation. The hands off approach adopted by leadership proved insufficient to progress implementation of BIM.

PHASE 2: LEARNING TO IMPLEMENT

During Phase 2, between 2005-2013, implementation of BIM in Design Partnership remained patchy, limited to "pockets of people who could see the light" – a growing group of practitioners who began using BIM in their everyday work. During this time, BIM attracted significant institutional attention as policy makers, business and industry leaders realized its potential but also the challenges that adoption presented and the scale of change needed. Early in this phase the industry experienced the impact of a major economic recession. Understandably, BIM implementation took a backseat during this time, but attracted attention once again with the publication of Government's 2011 construction strategy. In it, Government uses its position as procurer and client of 40% of the Built Environment industry to drive through BIM adoption by mandating its use on public sector projects from 2016. It also draws attention to the cost and time savings that could be generated through the use of BIM. In an industry struggling with profitability and efficiency, this was an attractive proposition. The effects of this mandate can be seen at institutional level.

At Design Partnership, technology was permeating almost all aspects of work. Interest grew in the use of new technologies and their potential to aid design processes and outputs. Designers at the firm were seeing opportunities to begin using BIM in their work. External studies provide a detailed accounts of Design Partnership's development of an electronic knowledge management system, or an expert 'yellow pages' (Criscuolo, Salter and Sheehan, 2007). Dodgson et al's study the use of simulation technologies in Design Partnership, and show how these technologies can foster innovation in inter organizational projects (Dodgson et al, 2007). The proliferation of technology at work made the challenges of adopting BIM more apparent. It was clear it required more deliberate organizational intervention than previous technological change and involved changes reaching far beyond the IT department. As a Director in Design Partnership explained, the magnitude of the change and level of disruption to the organization meant that:

"Almost every member of staff needs to be told what it [BIM] means and that it's going to change their job description – it is that disruptive."

PHASE 3: INFRASTRUCTURE OF SUPPORT

The third phase of BIM implementation at Design Partnership occurs between 2013 and 2015. During this time, BIM implementation at the firm aligned with institutional changes. The Government mandate was laid out in the GCS report in 2010. Institutions began publishing policies and standards that were formed during Phase 2, facilitating the use of BIM. Standards were introduced with the publications of documents such as PAS 1192-2 that laid out the specific requirements for achieving Level 2 BIM. The professional institutions aligned their routines with the use of BIM: for example, in 2013 the Royal Institute of British Architects published a new Plan of Works to accommodate BIM-working in its project stages; the Construction Industry Council also published similar guidance in 2013.

Reflecting this, a step change occurred at Design Partnership in its approach to implementing BIM. Its Chairman launched its current strategy at the firm's AGM, indicating clearly that the implementation of BIM had become a key strategic issue for the business. The objective of the strategy is to standardize BIM across Design Partnership with all work being routinely undertaken in a "BIM fashion" by 2014. This strategic shift indicated that BIM was no longer the domain of a few technical enthusiasts but involved every member of staff in the organization. A range of mechanisms provided this infrastructure of support. For example, users were provided with information and guidance, explaining the abundant terminology that surrounds BIM and detailing guidance in using BIM. Focused training was delivered that caters for different disciplines and levels of seniority. Existing organizational routines were adapted to incorporate BIM working, for example virtual design reviews are added into standard project reviews; extensive guidelines are available on producing BIM execution plans as part of the briefing process. Measurable targets and being established that link to individual and business performance and reward. Targets include the number of projects with BIM execution plans and virtual design reviews, and rates of staff training. A survey has been developed, based on the BIM Project Execution Planning Guide developed by Pennsylvania State University's Computer Integrated Construction Research Group, which measures various dimensions of BIM use on projects. Human Resources are developing individual performance measures of BIM relating to different job functions, production, management and leadership, which will be used for future recruitment and performances reviews.

DISCUSSION

This study presents a detailed view of how an established firm in the AEC industry responds to technological change and implements new technologies in its everyday work. Three phases show the mutually constitutive relationship between users, the firm, and institutions operating in the AEC industry. This finding builds upon past research that establishes that diffusion of innovation in firms is influenced by changes in the innovation and firm context (Shibeika & Harty, 2015) by demonstrating how the relationship between institutional, firm and users influences implementation efforts. Use of technology is enabled by alignment between these levels, and constrained when they are misaligned. For example, during Phase 1 a few technological enthusiasts in Design Partnership were using BIM. The firm invested limited resources in implementation, opting instead to take a hands-off approach and rely on evolutionary change to effect implementation. During this time use of BIM is isolated, confined to individual BIM enthusiasts. Phase 2 is a transitory stage, during which time Design Partnership learns about BIM. During Phase 3, alignment is created between institutions, the firm and users of BIM in Design Partnership. An *infrastructure of support* is created which affords widespread use of BIM technologies in the firm. In this phase, adoption of BIM is a key business issue for Design Partnership, as shown by strong senior leadership support, investment and strategic direction. The firm acts as a filter between users of BIM and the wider ecology, influencing and responding to changes at both levels. It achieves this by offering targeted training that acknowledges the variety of users, by diffusing information and by increasing involvement with industry and institutional bodies. Attempts are made by Design Partnership to open discussions between producers of BIM software and its practitioners. During Phase 3 users of BIM are becoming increasingly innovative and confident in using BIM. Their skills in using BIM are growing, both technically and with regards to the organizational routines needed to use it in everyday work. Learning is cyclical and often extends beyond organizational boundaries.

An important limitation of this study relates to its research design. While the single case study used here was suitable for the study's topic and theoretical approach, single cases have limited generalizability (Yin 2009). This is addressed by playing close attention on increasing the transferability of the study by generating thick descriptions (Lincoln and Guba, 1985) and through careful selection of the case. However this limitation does raise a number of possibilities for future research. For example, how does a smaller, less influential firm organize for digitization? Whyte argues that the peripheral position of SMEs disadvantages them in the adoption process (2013). Similarly, Dainty and colleagues argue in their recent paper that existing SMEs have been disadvantaged in the recent adoption of BIM as they do not have the resources to dedicate to technological change (2017). As this study shows that the process of adopting new technologies involves firms responding to and affecting external change and support internal practices, large incumbents have the resources and often the influence to affect wider institutional change and are able to devote considerable management resources to internal implementation efforts. Is this situation changed as digitization brings more radical technologies? Are SMEs better placed to respond to future technological change?

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