Construction Management and Economics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rcme20

Value implication of digital transformation: the impact of the commodification of information

Mustafa Selçuk Çıdık & David Boyd

To cite this article: Mustafa Selçuk Çıdık & David Boyd (2022): Value implication of digital transformation: the impact of the commodification of information, Construction Management and Economics, DOI: 10.1080/01446193.2022.2033287

To link to this article: https://doi.org/10.1080/01446193.2022.2033287

Published online: 07 Feb 2022.

CONSTRUCTION MANAGEMENT AND ECONOMICS
https://doi.org/10.1080/01446193.2022.2033287

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Value implication of digital transformation: the impact of the commodification of information

Mustafa Selçuk Çıdık[a] and David Boyd[b]

[a]The Bartlett School of Sustainable Construction, University College London, London, UK; [b]School of Engineering and the Built Environment, Birmingham City University, Birmingham, UK

ABSTRACT

The transforming construction agenda argues that digitalization enables better value by addressing coordination challenges. However, this claim poorly articulates how value is constituted, and ignores the problems with digitalization in real-life practices. The paper presents a finer-grained analysis of the value implications of digitalization in a critical discourse, organized in two parts, using the two value creation logics in construction as proposed by Bygballe and Jahre and the concept of "commodification" as proposed by Prudham. Through a critical literature review, the first part argues that digitalization mainly supports "production value creation logic" focussing on the integration of business processes at an organizational level, while creating challenges for "project value creation logic" by hampering mutual adjustment in situated practices. The second part conceives of digitalization as "commodification of information" to expose the complex set of processes causing digitalization to impact differently on the two value creation logics. It reveals that digitalization elevates the digital exchange value of information above its situated use value, and so, it systematically shifts the social and business contexts of coordination. Thus, digitalization shifts what, how, by whom and to whose advantage, value is created and captured, making it a politicized change with implications for management and policy.

ARTICLE HISTORY
Received 12 August 2020
Accepted 19 January 2022

KEYWORDS
Commodification; digitalization; information technology; value

Introduction

The transforming construction agenda in the UK is urging the industry "to rethink how they create and deliver whole life value through the application of digital technologies and new manufacturing techniques" (Jones *et al*. 2019, p. 3). This involves a new value proposition that brings together strategy, capabilities and assets, value delivery mechanism and value capture capacity, in order to address market demand. Hence, construction firms are encouraged to change their business models in order to drive, or at least adapt to, such transformation, by changing the ways in which they create and capture value (Jones *et al*. 2019). This transformation agenda aims to enable the Digital Built Britain strategy (HM Government 2015) which laid out an extremely comprehensive list of benefits to be realized in building design, construction, and operation, plus export opportunities, by having a built environment that is fully digitally integrated in all its operations and functions (i.e. digitalization). The strategy presents the idea of digitalization as key to achieving those benefits by bringing together delivery suppliers, client sectors and operational managers in a grand alliance that addresses the coordination challenges in the building life cycle (Scarponcini 1996, Cicmil and Marshall 2005, Becerik-Gerber *et al*. 2012, Bygballe *et al*. 2016) and creates advanced performance through modelling and big data (e.g. HM Government 2015). Similar strategic policies in many countries (e.g. Wong *et al*. 2011, Victorian Government 2016, EU BIM 2018) have driven construction research around this theme of digitalization. Thus, integrated digital technologies, such as those used for Building Information Modelling (BIM), have attracted extensive interest from construction researchers and practitioners alike; but this has been from an overwhelmingly positive perspective on such technologies with little critical analysis. As a result, the current dominant rhetoric of digitalization assumes that integrated digital technologies are key enablers of better inter-organizational coordination both within and between different life-cycle phases (e.g. Bryde *et al*. 2013, Love *et al*. 2014). Hence, much research

CONTACT Mustafa Selçuk Çıdık selcukcidik@gmail.com The Bartlett School of Sustainable Construction, University College London, London, UK

supports a wholesale change from the established practices in order to "transform construction" into an industry that delivers better value through the greater use of integrated digital technologies. As a result, disruptions to historically established work practices caused by the adoption of such technologies have been welcomed as they have been seen and expressed as the perfectly acceptable pains of change to be suffered on this digital path for a better future (Lavikka *et al.* 2018).

Despite the rhetoric and policy drive to increase the use of integrated digital technologies in construction for better value, there has been a lack of research about how this value is constituted, where it emerges and who benefits from it. According to Vass (2017), the small number of studies that explicitly focus on the value of BIM and digitalization (e.g. Kim *et al.* 2017, Lu *et al.* 2015, Giel and Issa 2013) lack a theorization of what value means, and implicitly adopt a limited view of value that is only understood through potential financial, strategic and operational outcomes of coordinating business processes at the organizational level. This lacks an appreciation of the value that results from the everyday social interactions of individuals, groups and social networks. These social interactions are crucial for people to coordinate, and progress with, their day-to-day tasks as they address the unfolding requirements of the project (Vass 2017). In line with this argument, there is a growing number of critical studies of BIM and digitalization that demonstrate the problems posed by digitalization for coordination, based on everyday social interactions in the dynamic setting of construction projects. These studies challenge the view that digitalization is an unquestionably value-adding phenomenon (e.g. Dossick and Neff 2011, Harty 2005, Whyte 2013, Merschbrock and Figueres-Munoz 2015, Kokkonen and Alin 2016, Çıdık *et al.* 2017a, 2017b, Gade *et al.* 2019, Paavola and Miettinen 2019, Akintola *et al.* 2020, 2021). Thus, there is an apparent contradiction in the literature about the value implication of, and the way that value is constituted in, the increased use of integrated digital technologies in construction. Hence, what is required is an analysis of the way value is created through construction operations, how the new digital ways of working impact on these, and why there is a contradiction in interpretation.

This paper addresses these questions in a critical discourse in two parts, using the two value creation logics of Bygballe and Jahre (2009) in Part 1, and the concept of "commodification" as proposed by Prudham (2009) in Part 2. Drawing upon Bygballe and Jahre (2009), the first part of the paper highlights that value in construction projects is enabled not only by coordinating business processes through formalization and standardization (i.e. production value creation logic) but also by coordinating emerging requirements of project tasks through social mutual adjustment (i.e. project value creation logic). This is followed by a critical review of the literature on BIM and digitalization to argue that digitalization mainly supports the mode of coordination required by the production value creation logic, while creating challenges for the mode of coordination required by the project value creation logic. The second part of the paper uses the concept of "commodification" (Mosco 2009, Mandel 2002, Prudham 2009) to analyze the underlying reasons for this phenomenon. It reveals that the development and operation of digitalization systematically shifts the social and business contexts within which coordination takes place by changing how, why, and what, information is demanded and produced. This shows that digitalization increasingly turns information into a standardized commodity (i.e. commodification of information) that is produced mainly with considerations of enabling formal digital exchanges, at the expense of its usefulness for context-specific situated use in everyday practices, where mutual adjustment is supposed to happen. Hence, it is argued that digitalization creates a systematic shift towards the production value creation logic, away from the project value creation logic, changing the overall configuration of how value is created and captured in construction. Based on this analysis, the discussion highlights that digitalization is not a neutral change that unquestionably adds value, and shows that digitalization needs to be reframed as a politicized change that reconfigures what kind of value is created (and lost) with different benefits and costs for projects and various actors. It is concluded that management and policy must recognise digitalization as the driver of a politicized transformation by acknowledging the commodification of information and its impact on what, how and by whom value is created, negotiated, and captured in construction.

Part 1 – digitalization and the two value creation logics in construction

The two value creation logics in construction

Bygballe and Jahre (2009) present a detailed analysis of the requirements for creating value in construction projects, and in particular the value created from coordinating the various work streams and supply chains that comprise projects. Their analysis draws a distinction between construction projects and firms, thus looking at coordination at multiple levels from situated activities to project management and to business management. Their work makes use of the ideas of Stabell and Fjeldstad (1998) on business value who distinguished between (i) technology that delivers value by transforming inputs into outputs, (ii) technology that resolves unique customer problems, and (iii) technology that brings value by accommodating better exchange with customers. Stabell and Fjeldstad (1998) refer to these as value chains, value shops and value networks, and use the work of Thompson (1967) on coordination requirements to determine the different needs of each value creating logic.

Bygballe and Jahre (2009) translate this into a construction setting by referring to value shop and value chain logics as project and production value creation logics. Production value creation logic primarily requires coordination of business processes across the supply chain. It is useful for the transformation of raw materials into products where activities involve pooled or sequential interdependencies (Thompson 1967). Value is created through standardization, allowing improvement through repetition and formalized planning, providing cost efficiency (Bygballe and Jahre 2009). By contrast, project value creation logic primarily requires coordination of the day-to-day tasks by project practitioners managing the unfolding requirements of the project (Bygballe and Jahre 2009). It is useful in unique and undetermined situations where activities also require reciprocal interdependence (Thompson 1967) involving mutual adjustment. Under the project value creation logic, value is created through reputed success and learning across projects in order to overcome context-specific client problems (Bygballe and Jahre 2009). It involves activities such as problem finding, making choices and tight observation and control of ongoing events.

Bygballe and Jahre (2009) make it clear that construction involves both these value creation logics, and successful companies and projects have a way of balancing the adoption of these logics in their practice through interactions. In construction firms there is a tension between departments because of these different logics, and this extends to the network of organizations that comprise the project. Therefore, a key part of successful management in construction is to facilitate interaction "…between internal functions within the company, with suppliers and customers in the supply chain, and finally between different supply chains involved in … [the] project…" (p. 703). In relation to value creation, their study identifies the importance of project and production value creation logics in different circumstances but importantly sees the balancing of these as being a fundamentally important activity to enable the optimum value.

Digitalization and the two value creation logics

Digitalization can be defined as the socio-technical process of applying digital technology across social and institutional contexts in ways that shift the organizing logic and render digital technologies an infrastructure (Tilson *et al.* 2010, Yoo *et al.* 2010, Unruh and Kiron 2017, Koch and Windsperger 2017). Therefore, although the use of computers in the construction industry has been developing for many years, arguably the early years were not part of what is now called digitalization because computers were initially tangential to the operation of the industry, merely tools for reporting, calculation and communications (e.g. Muspratt 1983).

The idea of an integrated delivery and operation of the built environment through digitalization to create better overall value has been very seductive worldwide because of the promise of radical improvements (e.g. Eastman *et al.* 2011, Bryde *et al.* 2013, Love *et al.* 2014, Oh *et al.* 2015, HM Government 2015). This has been reinforced by the numerous reports published by global consultancies (e.g. McKinsey & Company 2018) and software developers (e.g. Autodesk 2017), which suggest that digitalization is no longer optional (McKinsey & Company 2018), creating a hype about the benefits of digitalization (Fox 2014). This hype has justified, and even encouraged, extensive transformations in the life cycle of buildings (Love *et al.* 2014), project delivery models (Whyte 2019), professional roles (Sebastian 2011) and even the meaning of "professionalism" (Jaradat *et al.* 2013) in the construction industry. There has even been a promotion of a new project management conceived of as project management 2.0 (Levitt 2011), where work is conducted faster through the continuous availability of real time digital information.

However, the way in which this value is understood follows from the theory of the "business value of IT" developed in information systems research (e.g. Melville *et al.* 2004, Kohli and Grover 2008). This theory focuses only on the potential improvements to strategic, financial and operational outcomes at business process level for a particular organization (Vass 2017). This is apparent in studies about the value added by BIM and digitalization which implicitly adopt such a limited view of value, without theorizing value as a concept. For instance, Kim *et al*. (2017) measured the value added by BIM in a single project based on the contractual budget of the issues that appeared in monthly BIM reports. Lu *et al*. (2015) focussed on transactions through time-effort distribution curves but came to the limited conclusion that BIM involved more work early in the process. Giel and Issa (2013) undertook a return-on-investment study using three case studies finding a positive return in each, though at vastly different levels. In these studies, the value gained from digitalization results from standardization and advance planning of interorganizational interactions, delivering benefits such as project cost and time reductions as well as the formation of strategic business partnerships. As a result, what is expressed as the value-added by BIM and digitalization in the extant literature predominantly considers Bygballe and Jahre's (2009) production value creation logic, which is mainly concerned with optimizing the supply chain as a production system with a focus on economies of scale and capacity utilization for cost reduction.

Nevertheless, social interactions through which mutual adjustment is accomplished in situated practices are also critical for coordination in construction projects as projects get defined and executed iteratively and progressively to address their unique unfolding requirements. It is the effect of BIM and digitalization on this aspect of construction projects that has been highlighted as problematic in a growing number of empirical studies. For example, based on the findings of her in-depth case study of a design project, Moum (2010) finds that practitioners did not use digital technology during their design collaboration meetings as it had "…limited abilities for being the actual medium of the 'design conversation'" (p. 561). Similarly, she reports that the formalization of design through digital integration created challenges in dealing with the iterative aspects of design development which require mutual adjustment, as such formalization imposed a linear view of design process. Whyte (2013) also undertakes an in-depth case study of a design project and finds that practitioners had to work with physical models and move outside the digital medium to be able to make sense of some specific design challenges pertaining to a particular part of the structure that they were developing. She states that, although the integrated digital systems were widely used as part of the design process, the engineers faced challenges in using inflexible databases and took advantage of the "gaps" between the integrated digital technologies, which allowed them to mutually develop an extended understanding of the problem at hand. Again, based on an in-depth case study, Çıdık *et al*. (2017a) report four vignettes from the practices of a construction project to demonstrate that digital integration cannot handle the multiple systems of work used by different project actors, and thus simplifies and systematizes the practices. The vignettes demonstrate a set of situations where the push for maintaining digital integration contradicts the context-specific needs of the practitioners and hampers their mutual adjustment.

Other empirical studies also show digitalization creating challenges for coordination in situated practices either by curtailing meaning making or disabling dialectic inquiry. Paavola and Miettinen (2019) critique the use of BIM tools in a collaborative building design setting. They find that the idealized policy processes had to be interrupted for the team to negotiate understandings. This contradicts the BIM rhetoric of idealized efficient practices which mostly require adaptation to specific circumstances. Whyte (2011) sees the changes brought by integrated digital infrastructure as requiring hybrid (digital and non-digital) practices which contrast with the interactions anticipated in practice and formal policy guidance. The hybrid practices had to be implemented because people develop different relationships with the digital objects and pragmatically develop ways of achieving their goals. Gade *et al*. (2019) also consider the BIM-mediated design process, especially how BIM tools shape the production of the design. They comment that "the BIM-modellers' primary motivation was to ensure the progression of the design development and not to optimize the use of BIM tools, and this meant that the improvisations [as a result of dialectic inquiry] caused inconsistencies in the BIM-model" (p. 348). This stopped practitioners from using the BIM tools to evaluate the performance of the design solution. Making a similar argument, Dossick and Neff (2011) claim that BIM only made some of the tasks more efficient while constraining others, such as finding solutions to interdisciplinary design challenges which require ongoing mutual adjustment. Further, Akintola *et al*. (2020) show how implementation of BIM creates several contradictions in practice between the previously established and newly implicated tools, rules, and roles. Significant concerns about the utility of digitalization in addressing the needs of mutual adjustment in construction practices have been further highlighted by Harty (2005), who demonstrates the need to work against the set technological procedure in practice and Merschbrock and Figueres-Munoz (2015), who explore the hidden skills of workarounds.

Problems have also been reported regarding the utility of, and buy-in to, the current approach to digital asset data due to its rigid structure and complexity, which do not support the needs of practice (Alnaggar and Pitt 2019); although digitalization has been widely advertised as the driver of dramatic efficiency increases for facilities management. Overall, these empirical studies imply that digitalization actually creates challenges for what Bygballe and Jahre (2009) labels project value creation logic, which is mainly concerned with problem solving and collaborative sense making relying on reputation, experience and economies of scope.

Therefore, there seem to be different implications of digitalization on the two value creation logics. The dominant rhetoric and majority of the literature adopts a limited understanding of value with a focus on potential improved strategic, financial, and operational outcomes as a result of business process integration across the supply chain. However, this ignores the value implications of the situated day to day coordination necessary for mutual adjustment. The next part of the paper provides an analysis of this conflict of logics and presents the processes that underlie it through the concept of commodification of information.

Part 2 – digitalization of construction through the lens of "commodification of information"

This part of the paper will conceive of digitalization as "commodification of information" to reveal that digitalization systematically shifts the social and business contexts within which coordination take place by changing how, why, and what information is demanded and produced. The term "commodification of information" refers to a change regarding how information is valued. The analysis will present a set of complex technical and economic processes that determine digitalization's development and use these to argue that digitalization creates a distinction between the digital exchange value of information and the situated use value of information and elevates the former above the latter. This argument will be used to claim that it is this digital-driven change to how information is valued that shifts how coordination is done, which in turn causes a shift in what value is created and how, as highlighted in Part 1. Thus, conceiving of digitalization as the commodification of information enables a new lens through which to understand the value implication of digitalization in construction, and explains the critical observations in the literature presented in Part 1.

Generally, the value of information is determined by what can be done with it, or in other words, what it enables. What can be done with information depends on the technological infrastructure within which it is conceived. In this regard, commodification of information due to digitalization involves digital devices (e.g. hardware), services (e.g. software, platforms), infrastructure (e.g. fast internet connection and cloud storage), and content (e.g. datasets, BIM objects). Therefore, revealing the technical and economic processes behind the operation of these integrated digital technologies in construction, makes it possible to understand the change in how information is valued. The conceptual background of this argument will be presented first, followed by a more detailed explanation of its operation in construction through construction literature and examples from practice.

Conceptual foundations

According to Appadurai (1986) commodities can be seen at a basic level as things "intended for exchange, regardless of the form of the exchange". According to Marxist analysis, within a capitalist system, commodity specifically refers to any good or service produced to be traded in a market, rather than for direct consumption/use (Mandel 2002). Marx (1990) distinguishes between use and exchange values to highlight the divorce of the exchange equivalent (e.g. price) - by which the commodity is valued in an exchange context - from the usefulness of the commodity for direct use/consumption. Hence, the defining characteristic of a commodity is its distinct and elevated exchange value rather than its use value. In a similar way, Appadurai (1986) suggests that "the commodity situation in the social life of any "thing" [can] be defined as the situation in which its exchangeability (past, present or future) for some other thing is its socially relevant feature" (p. 13). Commodification is then the "process of transforming things valued for their use into marketable products that are valued for what they can bring in exchange" (Mosco 2009, p. 2). As Sayer (2003, p. 343) states "commodification, as a change from producing what previously or otherwise might have been simply use values, to producing … for their exchange value, tends to induce a change in normative values and hence a major cultural shift: by elevating exchange value over use value, questions of what is good, give way to the question of what can be sold at a profit". This separation of exchange value from use value is key to understanding the implication of digitalization on how information is valued in construction.

Baron (2001) and Huizing (2007) explain that commodification of information is constituted both technically (i.e. through how information technology operates) and economically (i.e. through the changing information demands of people). Importantly, these two processes are inextricably interweaved as they implicate and shape each other. Commodification can develop from economics to technology or from technology to economics. For example, as Adair (2010) argues, one of the main economic processes that contribute to the commodification of information is the fact that the value of information commodities is depleted through obsolescence, rather than consumption or repeated use. This aspect technically manifests itself in the way in which digital technology, as the major media for information transactions, is developed and sold, in such a way that older digital devices, services, infrastructure and content are made incompatible with the newer ones in order to ensure continuing profits. Moreover, the way information technology and management are technically constituted creates the wider social, cultural and economic processes which drive the commodification of information. For example, Huizing (2007) suggests that the objectivist view of information, which considers information as having universal objective meaning that is independent from its producer and user, is the technical aspect that allows the optimization of the exchange transactions for maximizing market efficiency and economic value. In this sense, information management and technology drive commodification of information by attributing an economic value to information exchanges based on their transactional efficiency, which is not related to the subjective and context-dependent informational content (i.e. the situated use value).

Digitalization as commodification of information in construction

In the following, it is argued that the increasing use of integrated digital technologies for coordination creates a strong economic argument for construction to be about digital information exchange, thus, elevating the digital exchange value of information above its situated use value. This transforms the "how", "why" and "what" of information production, exchange/distribution and use, in a way that drives commodification of information; thus, causing what Sayer (2003) calls "a change in normative values" attached to information in construction. This argument will use Prudham's (2009) four processes of change which describe "commodification as interlinked processes whereby:

- production for use is systematically displaced by production for exchange;
- social consumption and reproduction increasingly rely on purchased commodities;
- new classes of goods and services are made available in the commodity-form; and
- money plays an increasing role in mediating exchange as a common currency of value" (p. 125, our formatting).

These processes of change are used to frame and exemplify the argument that what is happening in the digitalization of construction is commodification, i.e. the digital exchange value of information is elevated above, and thus dominates, its situated use value.

Production for use is systematically displaced by production for exchange

In digitalization of construction, the previous production of information, which was for situated and personalized use, is displaced by production of information for pre-defined, standardized and formalized universal digital exchange. This process of change involves digital technology seeking to define the activities in construction as digital activities of data creation and exchange; thereby overturning previous practices. This is done through investing in a technological system with rules and authority whilst at the same time problematizing past practice. This technical constitution of digitalization changes information needs and demands, with tacit economic implications.

The way in which information technology is technically constituted is a major determinant of why, how and what information is produced. Digital technology's rigidly structured way of dealing with information drives commodification through what Huizing (2007) calls "objectivization," that is, shifting information production to forms that are standardized, discrete and clearly bounded so that they can be digitally exchanged efficiently. Digital technology can only perform planned actions (Suchman 1987) that are hard-wired and coded within it, requiring pre-defined inputs and giving pre-defined outputs ultimately in the form of digital data. This standardization, formalization and bounding into objects, modules and platforms creates discreteness and a requirement for pre-defined transactions to connect these discrete objects; thus, forming ideal commodities. As a result, digital technologies require human-based task structures and work processes to be formed around this objectivized logic in order to provide its promised benefits. This aspect of digital technology has been previously captured as an "ordering device" (Çıdık *et al.* 2017a), or having "materiality" (Paavola and Miettinen 2019), to explain the hard-to-resist transformational power that the technology has on the practices in which it is used. In this paper, the commodifying logic is a key aspect of digital technology, which underpins the major shifts in the ways in which information is specified, produced, communicated, used and stored in construction.

The past ways of operation of construction projects allowed participants to have their idiosyncratic ways of producing and working with information. Digitalization requires pre-determined, formal and standardized rules and structures, thus, overturning the flexible production of information. Çıdık *et al.* (2017a; 2017b), Neff *et al.* (2010) and Harty (2005) all show how construction practice is distorted by digitalization by separating digital tasks and construction tasks in practice. Some researchers have argued that in practice, people end up having "hybrid" practices (Whyte 2011) or digital technology is put to the side as a burden or a barrier to accomplish the mutual adjustment in situated practices (Gade *et al.* 2019). So, in several use cases the information demand determined by digitalization does not address the situated needs of people and hamper mutual adjustment. And yet, such information continues to be demanded to keep the digital technology up and running to be able to get any benefits from digital technology.

The formal objectified structure of digital technologies determines what information is demanded to accomplish a task through digital processes. Thus, it creates an imperative for digital exchanges that, in the end, might or might not address the real information needs of practitioners. This is evident in the guidance provided for the construction industry which does not highlight construction task-based needs but focuses on formalizing and standardizing, the types of data, the data content, and digital workflows (e.g. International Standards Organization 2018). In digitally-enabled coordination of construction projects, such as when using a federated BIM model, the only way forward becomes producing information according to the structures imposed by digital technology, even though that information is not always what is needed to enable mutual adjustment for the project and so may interrupt these processes of situated practice. The inherent variance in previous situated practices is highlighted as problematic due to their uncertain outcomes, and it is asserted that digital coordination overcomes this by structuring coordination. However, such structuring happens without acknowledging the differences in tasks and creates requirements for superfluous information. For example, formal structures are imposed on various actors in the project already in the inception stage through documents such as the BIM Strategy and BIM Execution Plan, which detail software, version numbers, data types etc. to be used. Overall, digital technology requires all those who work with it to follow the technology's ways of working with information to derive benefits of process coordination, even though this comes at the expense of situated mutual adjustment in several use cases. Thus, by overturning the business and social contexts of information production in construction, digitalization creates a situation where production of information for use is superseded by production of information as digital data for formalized and standardized digital exchanges, which has the effect of prioritizing digital exchange value over situated use value.

Social consumption and reproduction increasingly rely on purchased commodities

The second process of change underpinning commodification highlights the self-referential nature of digital technology (Yoo *et al.* 2010): in order to use information produced in a digitally integrated system, digital technology is required. Therefore, taking part in digital data exchange requires constantly making purchases in four domains of digital technology: devices (e.g. hardware), services (e.g. software), infrastructure (e.g. fast internet connection and cloud storage), and content (e.g. datasets, BIM objects). In fact, the more the tasks and processes are digitalized, the more devices, services, infrastructure and content need to be purchased to be able to operate within a digitally-enabled project where digital technology is the major means for information transactions and coordination. For example, it is increasingly the case that automated site quality control checks are undertaken by laser scanning the real situation on the site and comparing the resulting point cloud with the design information model. To undertake this process, organizations either need to purchase/rent laser-scanning equipment in addition to their existing hardware and software or outsource this service to a specialist sub-contractor. This is presented as a necessary and value adding activity. However, its usefulness depends entirely on the presence and type of other information in the design model. This exemplifies how the digital exchange value of information is elevated above its situated use value due to the self-referential nature of digital technology.

In construction management literature, the costs associated with getting involved in a digitally-enabled construction project, such as software licencing fees and hardware purchases, have been reported as one of the main problems of BIM implementation (Liu *et al*. 2015, Hilburg 2020). There are also less visible costs associated with other forms of commodities that need to be purchased to be part of a digitally-enabled project, such as consultancy costs for organizational transformation, and training and certification costs. Overall, as the pre-planned digital data exchange displaces the situated information needs to deal with emerging situations, digital exchange starts to be seen and treated as the norm, which requires all industry to increasingly invest in digital technology-related commodities to remain operational in the market. This in turn further reinforces how the production of information for use is systematically displaced by production of information for digital exchange.

New classes of goods and services are made available in the commodity-form

This third process of change reveals how digitalization of construction is a self-expanding process. The disconnect between the digital exchange and the situated use values of information establishes the condition for the creation of novel and extraneous classes of standardized information and associated services which are set formally and operate in a commodity form. Such new digital goods and services are formed technically but driven economically. These goods and services were not needed or demanded before digitalization but reinforce and expand the changes explained in the processes above. Kallinikos (2007) calls the information growth due to digitalization a self-referential process that is "out-of-control", as he explains below:

> Rather than being the outcome of haphazard incidents, the expansion and growth of information is a systemic and for that reason an intrinsic characteristic of the contemporary world. It is closely associated with sophisticated storage and updating mechanisms, the online availability and the combinability of technological information that coincide with an increasingly interoperable ecology of computer-based technologies. There is a complex pattern of mutual implication of information with the technologies by which it is produced and mediated, whereby the one reinforces the other, in an iterative cycle of interactive sequences. The expansion and growth of information are mediated by an increasing array of sophisticated information processing and communication technologies. In turn, such an expansion and growth of information feeds back on technological development by acting as the springboard for further diffusion and the social or organizational embeddedness of these technologies as a means of organizing, taking advantage of and generally dealing with data and information (p.50).

The constant emergence of novel classes of information complements and reinforces the two processes discussed above by continuously extending the scope of digital information exchange, and thus, the digital technology to make use of them. An example of a novel class of information and associated service are BIM objects and the companies that create BIM objects for the construction suppliers' products. Although BIM objects can themselves be seen as a class of novel information, the different attributes that they contain also evolve over time, which requires these digital objects to be updated with these new attributes. Such an expansion in the classes of standardized information and the corresponding formal processes of coordination does not necessarily address the situated needs of users as highlighted in IET 2020. As the article states: "a great deal of money has been wasted producing 3D objects that are unnecessary, overly complex and don't even go in the model. This is embarrassing for the people who were mis-sold BIM objects, and it is difficult to admit such a mistake. But we mustn't blame the actors in this game – they were misinformed or misunderstood" (IET 2020). Similarly, there is a concept of building information model quality assurance, which is performed through checking the various levels of data in the model for them to be consistent and comply with the BIM standards used in the project. There is purpose-built software to perform these checks and produce reports about the "health" of the information model. This is merely a rule-based check of software rules and standards (e.g. file format compatibility issues) and says nothing about whether the informational content of the digital data is accurate or what is wanted in a given context.

Money plays an increasing role in mediating information exchange as a common currency of value

This final process of change highlights how information is increasingly priced based on the costs of the digital elements and processes necessary for creating and using that information. This results from a shift in focus away from the utility of information and its ability to deal with specific circumstances, towards how information can be transacted effectively for standardized digital exchange. At this point, the use value gets subsumed by discussion about potential benefits of digitalization for the firm/project, thus, the decision making becomes more about transactional efficiency and not about the utility of what is paid for. Hence, the cost of information for coordination becomes exposed to the externalities brought into projects due to digitalization (e.g. software and hardware providers). These externalities involve not just the purchase of IT hardware, infrastructure, software and content but also the way that the construction industry has to change its operation to be about IT operations - including changes to organizational structures, organizational procurement, and management systems to integrate IT into construction. As a result of these changes, the information which previously did not exist, or circulated largely outside direct monetary exchange, is brought into the nexus of a market. The ever-increasing digital exchange orientation of information production in the form of digital data, the increasing reliance on purchasing digital technology and related services to make any use of information, and the constant emergence of novel information classes and associated services, result in the valuation of information in monetary terms in a way that has not happened before. It is in this sense that money plays an increasing role in mediating information exchange: as a result of the displacement of utility of information for situated use from primary to secondary concern.

For example, information repositories, data drops, digital deliverables and their quality/details are increasingly recognized as core parts of construction project contracts and are priced and given a monetary value within contracts. This is largely different from the non-digital practices where only certain actors (e.g. architects and engineers who can copyright their designs) would trade information for money but only really with an intention of immediate situated use of information for the erection of the building/structure. The valuation of digital exchangeability of information in terms of money is different as it affects how projects are organized and managed and includes the future use of information. The ensuing uncertainty about what is good and necessary information opens opportunities to extend the scope of digital goods and services that need to be purchased. Within this context, information and information systems are priced directly or indirectly in the construction supply chain. Importantly, often what determines the client's price here is the value of pre-defined future digital information exchanges rather than the utility of that information for situated needs of the project in the first place. The literature in construction management provides examples (e.g. Khajavi *et al*. 2019) where digital information produced using BIM could not be used for subsequent building operation management as first anticipated. The pricing of information commodities then are critical parts of construction pricing, but these centre around the cost of enabling digital information exchange rather than the enhanced value associated with the needs of practice. Paradoxically, the transformation of information into a commodity that is priced on the basis of its digital exchangeability creates the necessary condition for the previously discussed three processes to accelerate, which in turn makes the valuation of information more and more about the price for digital exchangeability.

Discussion

The above analysis highlights that the rigidly structured (process 1), self-referential (process 2), and self-expanding (process 3) nature of integrated digital technologies underpins a shift in the social and business contexts within which information is produced, exchanged/distributed and used. It also shows that as the digital exchange value elevates above the situated use value of information, "money", rather than "utility," becomes the common currency for value (process 4). This fuels further commodification encouraging new and existing players to focus on differentiating, elevating and controlling the digital exchange value of information at the expense of its situated use value. Therefore, these inter-connected and mutually reinforcing changes, which disrupt the "how," "why," and "what" of the information people need and use in practice, lead to a change in the normative values attached to information.

Ultimately, it is this change to how information is valued (i.e. commodification of information) which reconfigures the way in which coordination is done, thus, eventually changing what and how value is created and captured in construction. On the one hand the commodified information (with its elevated digital exchange value) imposes coordination based on formalization and standardization of business processes and transactions, thus, supporting the production value creation logic. On the other hand, such commodification suppresses unstructured information and dialectical inquiry that enabled coordination based on mutual adjustment in situated practices, thus, it creates challenges for the project value creation logic. As a result, this analysis reveals that digitalization is a much deeper and controversial change than is currently appreciated in the dominant rhetoric and literature which suggests that it is an unquestionably value-adding development. Hence, this discussion will reframe digitalization as a politicized change (i.e. affecting the politics of value) that systematically shifts what value is created and captured, how, and by whom to provide insights for policy and management to adequately steer digitalization. The first part of the discussion will consider the impact of digitalization on the way in which the two value creation logics could be negotiated. The second part will highlight the role of the IT industry as a new key actor that has a large stake in commodification of information, as this industry aims to capture more value from the construction industry through the development and marketing of digital technologies.

The changing balance between the two value creation logics

In their expression of the two value creation logics in construction, Bygballe and Jahre (2009) emphasize that production and project value creation logics are in tension due to their different value and cost drivers, underpinned by the different views on how construction is organized (i.e. as a production supply chain vs. as a temporary organization to address unique project needs). These different views have been previously debated in construction research most notably by Winch (2002, 2006) and Koskela and Ballard (2006). Winch (2002, 2006) argues that the particular configuration of the business world of construction constitutes the project as a suitable form of delivery, highlighting the critical role of project value creation logic. The project value creation logic undertakes "uncertainty reduction" with clients engaging in a "future perfect" strategy that requires a long and fraught path to completion. Winch (2006) therefore criticizes a supply chain view of construction, applied from manufacturing industries (Koskela and Ballard 2006), for being inherently backward looking, which only makes sense if the future is like the past and when operations are repetitive. Hence, although the production value creation logic might be advantageous in some situations, if it is made the only, or the dominant, value creation logic, this means changing not only the delivery of buildings but also what buildings are. This is the first sense in which the balancing of the two value creation logics is an issue of politics of value in construction.

Furthermore, the ideas of customization and the uniqueness of projects was explored by Gosling *et al.* (2015) in their analysis of the engineering to order supply chains characteristic of construction. This characteristic is a response to extreme variability in the construction market, which cycles between overactivity and underactivity. The project value creation logic then is also necessary to deal with the fragmentation and sub-contracting used to reduce costs and manage risks in such a business environment. The production value creation logic requires a move to high fixed capital manufacturing based on repeatability and it involves the management and marketing of the standardized product. Thus, the way that project and production value creation logics are operationalized are quite different with different key benefits to construction projects and firms. For this reason, any change in management or organizational methods (such as digitalization) needs to be considered in terms of the implications on how the two value creation logics are balanced in practice. This is the second sense in which the balancing of the two value creation logics is an issue of politics of value in construction.

According to Bygballe and Jahre (2009) interactions within both the construction firm and the project are key for balancing the two value creation logics to enable optimum value. These interactions allow for negotiations about and adjustments to managerial and organizational approaches, and it is here that, the politics of value are negotiated in practice. However, by conceiving of digitalization as commodification of information, it becomes clear that digitalization makes it increasingly difficult to balance the two value creation logics through such interactions. The practical manifestation of this is demonstrated in Çıdık *et al.* (2017a), who show how digitalization limits the ways conflicting logics can be resolved. Akintola *et al.* (2020) provide a similar explanation regarding the nature of the change induced by digitalization, and claim that digital-driven transformation happens by inducing dysfunctions created within the systems and resolving them. Furthermore, as emphasized by both Çıdık *et al.* (2017a) and Akintola *et al.* (2021) such dysfunctions manifest themselves in practice alongside the arguments about benefits and efficiency of production value creation logic, which are reinforced by new formal roles, professional guidance, and processes created to enable digital integration. It is against such a background that the negotiation and rearrangement of the two value creation logics is disabled. Thus, a substantial part of digitalized construction work becomes about digital information exchanges and data management, and the role of the information manager becomes critical. Repercussions of this can be seen in construction research where the topics of interest have become interoperability, information documentation, level of detail, software version control, cyber security, digital legacy etc. In this view, building has become secondary to the IT platform environment, and thus, subsumed by it (as shown in International Standards Organization 2018).

The conception of digitalization as commodification of information provides an overarching explanation of the inherently political nature of digital-driven change in construction. It exposes how technical development and economic arguments of digitalization, as a self-expanding process, become intertwined disabling the negotiation of the two value creation logics. Importantly, it reveals that the argument of value-adding digitalization is incomplete, as it ignores the declining utility of information for addressing situated needs, which are critical to creating optimum value for construction firms and projects. As a result, by turning information into a commodity, digitalization reconfigures what value is created and captured, how and by whom, in construction, rather than unquestionably adding value to firms and/or projects. One of the actors that has a large stake in this new value configuration is the IT industry, which is discussed in the next section to highlight its interest in further driving commodification of information and affect the politics of value in construction.

The role of the IT industry in commodification of information in construction

This section discusses the economics of the information technology (IT) industry and its relation to the commodification of information in construction. It will argue that the fundamental business principles adopted by the IT industry reinforce the elevation of the digital exchange value of information and control it to make profits. Thus, the economics of the IT industry reinforce the commodification of information in construction and the systematic shift towards the production value creation logic. More importantly, the IT industry has an interest in taking control of the construction process by increasing the use of digitalization and capturing digital exchange value. This further highlights the politicized nature of digitalization.

A peculiar economic aspect of the IT industry is that, once developed, its products (e.g. software or data) can be cheaply and easily reproduced. For this reason, the IT industry uses a number of profit-accessing methods including intellectual property, pricing, switching costs, scale economies, transaction costs, system coordination and contracting (Varian *et al.* 2004). Software companies develop ever more sophisticated ways of securing their software through, for example, continual upgrades and planned obsolescence (Adair 2010). Such problems of technical compatibility created by the IT industry are then used to control the elevation of digital exchange value of information as well as the capture of that value. Issues caused by such strategies have recently surfaced in an open letter written to the CEO of Autodesk (Hilburg 2020) by a group of top 25 UK architecture firms. The burden of technical incompatibility can be so high for practitioners that 8 out of the 25 firms signed the letter anonymously "out of fear of potential reprisal from Autodesk" as stated by Hilburg (2020). This demonstrates the economic power of large IT providers and how exchange value is elevated and controlled.

Furthermore, the IT industry exploits switching costs which effectively lock in users (Klemperer 1995). The rigidly structured nature and complexity of the IT products make it expensive for organizations and users to switch to other suppliers, particularly due to the cost of learning the idiosyncrasies of proprietary systems. As stated by Varian *et al.* (2004) "the cost of installing an Enterprise Planning System was eleven times greater than the purchase price of the software" (p. 21). This switching cost allows IT providers to maintain profits without needing to accommodate the needs of the user and so improve use value. This makes it unnecessary to invest in development and leads to the IT industry operating by maintaining market penetration through acquisition. Profits are used to maintain a monopoly through business dealing and market power which is assisted by being a large-scale enterprise. For example, Autodesk's purchase of Spacemaker (an artificial intelligence-enabled urban design platform) for $240M (O'Hear 2020) shows that money and effort are invested in maintaining dominant market positions rather than in improving software. Thus, competition can be limited by the way business is conducted by the IT providers. This phenomenon is also studied as "digital debt," which limits the "digital options" of users (Rolland *et al.* 2018). Ultimately, such strategies by IT providers make the creation and control of digital exchange its primary concern.

The monopoly position of large-scale IT providers may be offset by government regulation or by market disruption from new entrants (Christensen 1997) who have a different economic ideology. Thus, the dominant players in the IT industry must manage the development of both regulation and IT standards to help maintain their monopoly positions as this elevates the entry barrier for new players, forcing them to technically and/or commercially align with the major players and their products. Varian *et al*. (2004) state that this monopoly position produces "less benign consequences, such as political lobbying, the accumulation of excess capacity, premature entry" (p. 28). For example, the idea of standardization, although promoted as part of production value creation logic in construction, has limited attraction to the IT industry. Rather, as pointed out by Varian *et al*. (2004) "established networks or proprietary standards prefer not to interconnect" (p. 35). That is, those with the monopoly have a negative incentive to support open standards as this allows other players to advance. Ultimately, this benefits the large-scale IT providers at the cost of the construction industry who are forced to engage with the problematic interoperability or use a single platform supplier; thus, enhancing the IT industry profit by elevating their control of digital exchange.

In sum, dominant players in the IT industry sell a "complete solution" rather than a "technology", telling practitioners how their offering must be used to reach full functionality, which involves a suite of products and processes that are technically and/or commercially aligned with their offering. This allows such dominant players to be part of creating the industry business processes involving training, standards and the complementary products; thus, these dominant players maintain their profit and give themselves some control over the market. Being involved in government committees, industry committees and research strategies is a valuable investment to control the market to the benefit of their solution, to lock in the construction industry to their products and to extract more profit. In a similar loss leading way, the provision of free software to universities and the provision of training and research money to universities maintain a dominance against other players and ensure a familiarity in use of their solutions in future users. These are all activities that sustain the dominating role of the IT industry in controlling the elevation and capture of the digital exchange value of information.

Conclusions

Practitioners, policy-makers and academics alike aspire to increase overall value in the building life-cycle through digitalization. However, this trend has been mainly driven by a limited view of value in construction, with an overwhelmingly positive discourse on digitalization and severely limited scepticism. This paper has developed a theoretical basis for understanding the value of digitalization and explaining the growing number of empirical studies that demonstrate persistent problems with digitalization in practice. Through a critical discourse using the value creation logics of Bygballe and Jahre (2009) and the concept of "commodification" as proposed by Prudham (2009), it exposes technical and economic problems in adding value through digitalization in construction. Firstly, it shows that value in construction requires acknowledging and accommodating both production value creation logic and project value creation logic. It is shown using previous studies on BIM and digitalization that digitalization mainly supports the production value creation logic while hampering the project value creation logic. An analysis of digitalization as commodification of information exposes the complex set of processes that underpin such divergent impacts on the two value creation logics. It demonstrates that digitalization is a self-expanding process which systematically shifts the business and social contexts towards elevating the digital exchange value in coordination, emphasizing the production value creation logic over the project value creation logic which relies on mutual adjustment in situated practices. Such reconfiguration of what value is created and captured, how and by whom, reframes digitalization as a politicized process where the negotiability of the two value creation logics become hampered. Additionally, the economics of the IT industry drive it to invest in the control of digital coordination to capture a major part of the value generated.

These arguments highlight the need for managers and policy-makers to be more aware when steering digitalization in construction. Practitioners' resistance to change, work arounds (Merschbrock and Figueres-Munoz 2015), and hybrid practices (Whyte 2011) must not be understood as reducing value but as needing positive support in digitalization. Managers should see such reactions as symptoms of the issues with project value creation logic and create organizational measures to address them. In this sense, the growing literature on business model innovation is particularly relevant to addressing the divergent implications of digitalization. However, unlike the current trend of asking the question of "how digitalization can be maximized through new business models", the main concern must be enabling the right balance between production and project value creation logics by creating the right environments and flexibility for project negotiations to take place.

The reframing of digitalization as a politicized change highlights the importance for policy making to recognize the far-reaching implications of commodification of information due to digitalization, and the major role of the IT industry in it. This calls for an open approach to digitalization through regulation and public ownership. First, regulation of the IT industry and its products is needed to prevent monopolistic behaviour and rentiership. There have been growing calls to put regulation in place to discourage market power behaviour and companies investing in developing payment models rather than products (Mazzucato 2018). As a result, governments worldwide have recently started to consider intervening in the commercial strategies of large-scale IT providers (CMA 2020). Governments and professional bodies in construction should consider the commodification of information that results from such commercial strategies, and deliver regulations to offset them. Second, measures need to be taken providing public infrastructure and encouraging digital commons. There is growing interest in these topics, such as the idea of "managing crucial parts of the data economy as public infrastructure" (The Economist 2017), which involves creating openness in the ownership and governance of the digital economy. This requires governments to take responsibility for supporting businesses, including the construction industry, in developments which meet their use value needs. Public support should be directed towards developing solutions that are fully open in terms of (1) architecture (hardware and software); (2) compliance with standards; (3) transparency and inclusiveness of governance; (4) innovation for value creating not value extraction; (5) prohibition of purposive lock-in mechanisms; and (6) an open regime of intellectual property (Teixeira 2015; Setzke *et al.* 2019).

Finally, future research and policy must acknowledge the rather complex value implications of digitalization as well as the problem of commodification that underpins them. For example, to blame construction people and organizations for the failure of IT development hides the commercialization of IT and the invasive nature of commodification. Thus, academics and policy makers need to be more critical in their promotion of digitalization and not engage in a simple negative criticism of the construction industry. Further, they must acknowledge their own vested interest created by the system of funding that supports digitalization, and be more cautious about its exaggerated promotion. The concern that the construction industry is backward, must be viewed from a deeper understanding of the operation of the construction industry which can identify where real improvement can happen. Thus, more practice-based studies must be undertaken into the reality of using digital technologies. This must include a more critical review of papers supporting this hidden commodification to encourage more analytical work on the creation of value in the construction industry.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Mustafa Selçuk Çıdık http://orcid.org/0000-0002-8965-5200
David Boyd http://orcid.org/0000-0002-3775-7125

References

Adair, S., 2010. The commodification of information and social inequality. *Critical sociology*, 36 (2), 243–263.

Akintola, A., Venkatachalam, S., and Root, D., 2020. Understanding BIM's impact on professional work practices using activity theory. *Construction management and economics*, 38 (5), 447–467.

Akintola, A., *et al.*, 2021. Distilling agency in BIM-induced change in work practices. *Construction innovation*, 21 (3), 490–522.

Alnaggar, A., and Pitt, M., 2019. Lifecycle exchange for asset data (lead): a proposed process model for managing asset dataflow between building stakeholders using BIM open standards. *Journal of facilities management*, 17 (5), 385–411.

Appadurai, A., 1986. Introduction: commodities and the politics of value. In: A. Appadurai, ed. *The social life of things: commodities in cultural perspective*. Cambridge, UK: Cambridge University Press, 3–63.

Autodesk, 2017. Constructing with the power of digital [online]. Available from: https://damassets.autodesk.net/content/dam/autodesk/www/AEC-Solutions/pdf/fy18-aec-construction-manifesto-single-page_EN-US.pdf. [Accessed 8 Mar 2021].

Baron, P., 2001. Databases and the commodification of information. *Journal for the Copyright Society of the USA*, 49 (1), 131–163.

Becerik-Gerber, B., *et al.*, 2012. Application areas and data requirements for BIM-enabled facilities management. *Journal of construction engineering and management*, 138 (3), 431–442.

Bryde, D., Broquetas, M., and Volm, J.M., 2013. The project benefits of building information modelling (BIM). *International journal of project management*, 31 (7), 971–980.

Bygballe, L.E., and Jahre, M., 2009. Balancing value creating logics in construction. *Construction management and economics*, 27 (7), 695–704.

Bygballe, L.E., Swärd, A.R., and Vaagaasar, A.L., 2016. Coordinating in construction projects and the emergence of synchronized readiness. *International journal of project management*, 34 (8), 1479–1492.
Christensen, C., 1997. *Innovators dilemma*. Boston, MA: Harvard Business School Press.
Cicmil, S., and Marshall, D., 2005. Insights into collaboration at the project level: complexity, social interaction and procurement mechanisms. *Building research & information*, 33 (6), 523–535.
CMA, 2020. *CMA advises government on new regulatory regime for tech giants* [online]. Available from: https://www.gov.uk/government/news/cma-advises-government-on-new-regulatory-regime-for-tech-giants. [Accessed 08 Mar 2021].
Çıdık, M.S., Boyd, D., and Thurairajah, N., 2017a. Ordering in disguise: digital integration in built-environment practices. *Building research & information*, 45 (6), 665–680.
Çıdık, M.S., Boyd, D., and Thurairajah, N., 2017b. Innovative capability of building information modeling in construction design. *Journal of construction engineering and management*, 143 (8), 04017047.
Dossick, C.S., and Neff, G., 2011. Messy talk and clean technology: communication, problem-solving and collaboration using building information modelling. *Engineering project organization journal*, 1 (2), 83–93.
Eastman, C., *et al.*, 2011. *BIM handbook: a guide to building information modeling: for owners, managers, designers, engineers, and contractors, 2nd ed.*. Hoboken, NJ: Wiley.
EU BIM, 2018. *Handbook for the introduction of building information modelling by the European public sector* [online]. Available from: http://www.eubim.eu/handbook/. [Accessed 8 Mar 2021].
Fox, S., 2014. Getting real about BIM. *Critical Realist Descriptions as an Alternative to the Naïve Framing and Multiple Fallacies of Hype. International Journal of Managing Projects in Business*, 47 (3), 405–422. 10.1108/IJMPB-12-2013-0073
Gade, P.N., *et al.*, 2019. A holistic analysis of a BIM-mediated building design process using activity theory. *Construction management and economics*, 37 (6), 336–350.
Giel, B.K., and Issa, R.R., 2013. Return on investment analysis of using building information modeling in construction. *Journal of computing in civil engineering*, 27 (5), 511–521.
Gosling, J., *et al.*, 2015. Principles for the design and operation of engineer-to-order supply chains in the construction sector. *Production planning & control*, 26 (3), 203–218.
Harty, C., 2005. Innovation in construction: a sociology of technology approach. *Building research & information*, 33 (6), 512–522.
Hilburg J., 2020. Autodesk issues a response after architects speak out over Revit [online]. The architect's newspaper. Available from: https://www.archpaper.com/2020/07/autodesk-issues-a-response-after-architects-speak-out-over-revit/.[Accessed 8 Mar 2021].
HM Government, 2015. *Digital built Britain: level 3 building information modelling – strategic plan*. London: Department of Business Innovation and Skills.
Huizing, A., 2007. Objectivist by default: why information management needs a new foundation. *In*: A. Huizing and E.J. De Vries, eds. *Information management: setting the scene*. Oxford: Elsevier, 73–90.
IET, 2020. The future of construction is not 3D BIM objects [Online]. Institution of Engineering and Technology. Available from: https://communities.theiet.org/blogs/948/7054. [Accessed 17 Feb 2021].
International Standards Organization, 2018. ISO 19650. *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – information management using building information modelling — Part 1: Concepts and principles*. https://www.iso.org/standard/68078.html.
Jaradat, S., Whyte, J., and Luck, R., 2013. Professionalism in digitally mediated project work. *Building research & information*, 41 (1), 51–59.
Jones, K., *et al.*, 2019. *Changing business models: implications for construction*. Transforming Construction Network Plus. Digest Series, no.1. https://majorprojects.org/resources/changing-business-models-implications-for-construction/
Kallinikos, J., 2007. *The consequences of information: institutional implications of technological change*. Cheltenham, UK: Edward Elgar Publishing.
Khajavi, S.H., *et al.*, 2019. Digital twin: vision, benefits, boundaries, and creation for buildings. *IEEE access.*, 7, 147406–147419.
Kim, S., *et al.*, 2017. Measurement of construction BIM value based on a case study of a large-scale building project. *Journal of management in engineering*, 33 (6), 05017005.
Klemperer, P., 1995. Competition when consumers have switching costs: an overview with applications to industrial organization, macroeconomics, and international trade. *The review of economic studies*, 62, 515–539.
Koch, T., and Windsperger, J., 2017. Seeing through the network: competitive advantage in the digital economy. *Journal of organization design*, 6 (1), 1–30.
Kohli, R., and Grover, V., 2008. Business value of IT: an essay on expanding research directions to keep up with the times. *Journal of the association for information systems*, 9 (1), 23.
Kokkonen, A., and Alin, P., 2016. Practitioners deconstructing and reconstructing practices when responding to the implementation of BIM. *Construction management and economics*, 34 (7–8), 578–591.
Koskela, L., and Ballard, G., 2006. Should project management be based on theories of economies or production? *Building research & information*, 34 (2), 154–163.
Lavikka, R., *et al.*, 2018. Digital disruption of the AEC industry: technology-oriented scenarios for possible future development paths. *Construction management and economics*, 36 (11), 635–650.
Levitt, R.E., 2011. Towards project management 2.0. *Engineering project organization journal*, 1 (3), 197–210.
Liu, S., *et al.*, 2015. Critical barriers to BIM implementation in the AEC industry. *International journal of marketing studies*, 7 (6), 162–171.
Love, P.E.D., *et al.*, 2014. A benefits realization management building information modeling framework for asset owners. *Automation in construction*, 37, 1–10.
Lu, W., *et al.*, 2015. Demystifying construction project time–effort distribution curves: BIM and non-BIM comparison. *Journal of management in engineering*, 31 (6), 04015010.
Mandel, E., 2002. *An introduction to Marxist economic theory*. Chippendale, NSW, Australia: Resistance Books.

Marx, K., 1990. *Capital: a critique of political economy*. Vol. 1. Trans. Ben Fowkes. New York: Penguin.

Mazzucato, M., 2018. *The value of everything: making and taking in the global economy*. London: Allen Lane.

McKinsey & Company, 2018. Voices on infrastructure: harnessing the promise of digital [online]. Available from: https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Voices%20on%20Infrastructure%20Harnessing%20the%20promise%20of%20digital/Voices-on-Infrastructure_Harnessing-the-promise-of-digital.PDF. [Accessed 8 Mar 2021].

Melville, N., Kraemer, K., and Gurbaxani, V., 2004. Review: information technology and organizational performance: an integrative model of it business value. *MIS quarterly*, 28 (2), 283–322.

Merschbrock, C., and Figueres-Munoz, A., 2015. Circumventing obstacles in digital construction design: a workaround theory perspective. *Procedia economics and finance*, 21, 247–255.

Mosco, V., 2009. *The political economy of communication*. 2nd ed. London, UK: Sage.

Moum, A., 2010. Design team stories: exploring interdisciplinary use of 3D object models in practice. *Automation in construction*, 19 (5), 554–569.

Muspratt, M.A., 1983. Computers for the construction industry. *Project management quarterly*, 14 (3), 45–52.

Neff, G., Fiore-Silfvast, B., and Dossick, C.S., 2010. A case study of the failure of digital communication to cross knowledge boundaries in virtual construction. *Information, Communication & society*, 13 (4), 556–573.

Oh, M., *et al.*, 2015. Integrated system for BIM-based collaborative design. *Automation in construction*, 58, 196–206.

O'Hear, J., 2020. *Spacemaker, AI software for urban development, is acquired by Autodesk for $240M* [online]. Tech Crunch. Available from: https://techcrunch.com/2020/11/17/spacemaker-ai-software-for-urban-development-is-acquired-by-autodesk-for-240m/. [Accessed 8 Mar 2021].

Paavola, S., and Miettinen, R., 2019. Dynamics of design collaboration: BIM models as intermediary digital objects. *Computer supported cooperative work*, 28 (1), 1–23.

Prudham, S., 2009. Commodification. In: N. Castree, D. Demeritt, D. Liverman and B. Rhoads, eds. *A Companion to environmental geography*. Chichester, UK: Wiley-Blackwell, 123–142.

Rolland, K.H., Mathiassen, L., and Rai, A., 2018. Managing digital platforms in user organizations: the interactions between digital options and digital debt. *Information systems research*, 29 (2), 419–443.

Sayer, A., 2003. (De) commodification, consumer culture, and moral economy. *Environment and planning d: society and space*, 21 (3), 341–357.

Scarponcini, P., 1996. Editorial: time for an integrated approach to facility management. *Journal of computing in civil engineering*, 10 (1), 3.

Sebastian, R., 2011. Changing roles of the clients, architects and contractors through BIM. *Engineering, construction and architectural management*, 18 (2), 176–187.

Setzke, D. S., Böhm, M. and Krcmar, H., 2019. Platform openness: a systematic literature review and avenues for future research [online]. *Proceedings of International Conference on Wirtschaftsinformatik (WI)*, Siegen, Germany. Atlanta, Georgia: AIS. https://aisel.aisnet.org/wi2019/track07/papers/9/.

Suchman, L. A., 1987. *Plans and situated actions: the problem of human-machine communication*. Cambridge, UK: Cambridge University Press.

Stabell, C.B., and Fjeldstad, Ø.D., 1998. Configuring value for competitive advantage: on chains, shop, and networks. *Strategic management journal*, 19 (5), 413–437.

Teixeira, J., 2015. On the openness of digital platforms/ecosystems. *Proceedings of the 11th International Symposium on Open Collaboration,* 19-21 August 2015 San Francisco, California. New York: Association for Computing Machinery, 1–4.

The Economist, 2017. Data is giving rise to a new economy [online]. The Economist. https://www.economist.com/news/briefing/21721634-how-it-shaping-updata-giving-rise-new-economy. [Accessed 8 Mar 2021].

Thompson, J. D., 1967. *Organizations in action*. New York: McGraw-Hill.

Tilson, D., Lyytinen, K., and Sørensen, C., 2010. Digital infrastructures: the missing IS research agenda. Research commentary. *Information systems research*, 21 (4), 748–759.

Unruh, G. and Kiron, D., 2017. *Digital transformation on purpose [online]. MIT Sloan management review*. Available from: https://sloanreview.mit.edu/article/digital-transformation-on-purpose/. [Accessed 8 Mar 2021].

Varian, H. R., Farrell, J., and Shapiro, C., 2004. *The economics of information technology: an introduction*. Cambridge: Cambridge University Press.

Vass, S., 2017. *The business value of BIM: elaborating on content and perspective*. Thesis (PhD). Royal Institute of Technology, Stockholm, Sweden.

Victorian Government 2016., *Construction technologies: sector strategy*. Melbourne: Department of Economic Development, Jobs, Transport & Resources

Whyte, J., 2011. Managing digital coordination of design: emerging hybrid practices in an institutionalized project setting. *Engineering project organization journal*, 1 (3), 159–168.

Whyte, J., 2013. Beyond the computer: Changing medium from digital to physical. *Information and organization*, 23 (1), 41–57.

Whyte, J., 2019. How digital information transforms project delivery models. *Project management journal*, 50 (2), 177–194.

Winch, G. M., 2002. *Managing construction projects: an information processing approach*. Oxford: Blackwell.

Winch, G.M., 2006. Towards a theory of construction as production by projects. *Building research & information*, 23 (4), 571–573.

Wong, A.K., Wong, F.K., and Nadeem, A., 2011. Government roles in implementing building information modelling systems. *Construction innovation*, 11 (1), 61–76.

Yoo, Y., Henfridsson, O., and Lyytinen, K., 2010. Research commentary—the new organizing logic of digital innovation: an agenda for information systems research. *Information systems research*, 21 (4), 724–735.