BIM INVESTMENT: UNDERSTANDING VALUE, RETURN AND MODELS OF ASSESSMENT

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ABSTRACT

As adoption of the BIM methodology (building information modelling) grows, so too do levels of investment in new technologies, processes and organisational change. However due to complexity at the project level, where BIM implementation (and integration) occurs, it can be difficult for firms to evaluate the benefits, costs and risks of investment. This paper reviews existing research surrounding BIM, its value, the return on investment (ROI) and models of assessment. The author draws on information systems (IS) and construction information technology (IT) research so as to explore the requirements of a BIM investment evaluation methodology. Difficulties in applying existing models are identified, revealing the need for a value chain approach that accounts for the project lifecycle. The paper describes the salient outcomes of interest linked to firm level adoption and project based implementation of BIM and discusses the implications relative to measuring their return.

Keywords: Building Information Modelling, Value, Return on Investment, Information Systems, Productivity Paradox, Stakeholder Theory.

1 INTRODUCTION

Designing, constructing, and maintaining the built environment is a creative and collaborative process; making it knowledge intensive and generative. BIM is increasingly being shown as a more effective way to support these processes, having potential to reduce inefficiencies within a highly fragmented sector and instantiate changes in unsustainable practices. BIM is defined by Eastman et al. (2008) as a ‘modelling technology and associated set of processes to produce, communicate, and analyse building models’. This model-driven approach is contingent to the generation of a smart, shared and computable 3D model. Among other things, the 3D model can have workflow scheduling (4D) and cost (5D) data linked to it. Thus BIM is not simply a technology; it involves strategies relating processes and people that allow its use. It is therefore more accurate to refer to BIM as a methodology.

Over the past five years the benefits of BIM in use have been documented by numerous research studies providing data to support its positive value and thereby encouraging wider adoption (Becerik-Gerber & Rice 2009). In Australia, a study on the economic impacts of BIM shows a steady increase in its adoption (Allen Consulting 2010). Growth in technological,
process and organisational investments required by the methodology has therefore followed. However a recent survey of business prospects shows that AEC firms are becoming more conservative about new technology investments due to rising cost pressures and pessimism in the sector at the uncertain economic outlook (AI Group 2013). In this environment, many BIM investments may be seen as incongruous to further decline in construction output value; economic uncertainty may make it easier for participating project firms to express doubts about the value of investing time, money and energy in implementing BIM. Indeed some AEC leaders interviewed as part of this study described BIM in the current climate as “a luxury rather than a necessity”. To some this way of thinking may confirm that BIM investment decisions are being poorly thought through and examined. Most often BIM investment decisions are initiated and taken during the planning and procurement phase of projects and based on rough estimations of future costs and risks. A poor decision-basis will affect AEC firms and projects in a variety of ways, influencing the ability to achieve higher levels of integration, leading to incomplete implementation and failure to realise through-life value (Jupp 2013). Such a poor decision-basis can also affect a firm’s motivation to innovate and promote strategic and operational change at the organisational level.

In this frame, the author seeks to make sense of the value, returns and assessment methods surrounding the technological, process and organisational investments required to adopt BIM (at the firm level) and implement BIM (at the project level). The author draws on information systems (IS) and construction information technology (IT) research so as to discuss the role of ‘information influence’, the ‘productivity paradox’, and ‘stakeholder theory’ in a value chain approach that accounts for the project lifecycle. Difficulties in applying existing models to the situation of BIM investment analysis are identified revealing the need for a tailored approach. The paper therefore accounts for the shortfalls in current approaches and describes the salient outcomes of interest linked to firm adoption and project implementation relative to BIM investment activities. Finally, the implications of this research and its limitations are discussed.

2 BIM AND CONSTRUCTION OUTPUT TRENDS

Despite the downturn in construction output value, the sector appears to be continuing to invest in BIM. This trend is acknowledged in the US (McGraw Hill 2012), UK (NBS 2012) and Australian (Allen Consulting 2010) construction sectors, where evidence of BIM adoption and spending is well documented. In Australia, a study of the economic impacts of BIM (Allen Consulting 2010) shows a steady increase in its uptake, with approximately 25% of architects, 17.1% of engineers, 11.8% of contractors and 5.3% of owners using BIM on 30% of projects. Confirming these findings, a 2012 survey by the Australian Bureau of Statistics (ABS 2012) shows that investment in new technologies across the construction sector grew at an average annual rate of 20 % (ABS 2012), with an increased proportion allocated to software; showing that
expenditure focused on software (35.3%), hardware/telecommunications (33.2%) and internet/cloud based computing applications (28.2%).

The impact that a continued slowdown in economic conditions will have on BIM investment is uncertain. After a decade of rapid growth, construction output value in Australia has experienced a general downward trend (ABS 2013), softened in part by the mining boom where AEC firms have diversified into the resources sector (De Valence & Runeson 2011). Forecasts predict construction output value will take some time to return to previous levels and that AEC firms may need to respond to changes in business conditions by reviewing business overheads and operating expenditure, of which BIM IT and associated process and organisational change requirements can represent a significant proportion. This may already be occurring, with a report by the AI Group (2013) revealing that 28.6% of the sector’s CEOs surveyed expect to lower IT spending in 2014 (compared with 2012 levels), with an estimated 8.4% point drop in companies intending to increase IT spending. AEC firms appear to be attempting to address the challenge of making essential economies without compromising necessary IT and infrastructure modernisations imperative to the future (Underwood & Khosrowshahi 2012).

What is significant about this situation for assessing BIM investment concerns varying patterns of investment which has implications for measuring the benefits, costs and risks in the long term. Variations in the scale and rate of adoption across different types and sizes of AEC firms and different levels of implementation across project types may affect the share of gains experienced from BIM investment. Due to the growing concern about ROIs from BIM expenditure in the current economic climate there is need to re-think approaches to measurement methods to evaluate its impact, value and return.

3 IMPACT, VALUE AND RETURNS

A growing number of studies have sought to identify the impacts of BIM. A review of the literature found that between 2003 and 2013, 1440 studies were published, and determined that in the past five years more than 86 articles investigate its impacts on business value and 165 articles investigate its impact on project performance (e.g. Carroll 2009, Ireland 2009, Becerik-Gerber & Kensek 2010, Rowlinson et al. 2010, Sebastian & van Berlo 2010). Three themes emerge with respect to BIM’s impact, namely its impacts on: professionals’ tasks and roles; quality of production; and costs and efficiency. Other studies have however suggested that in some cases BIM can be counter-productive, reducing productivity in the first one to two years of adoption and producing negative impacts on team performance when experience levels are low (Eisenmann & Borinara 2012). Dossick & Neff (2010) describe the negative impacts of BIM in two case studies. From these cases poor leadership in implementation was responsible. A lack of evidence also surrounds the impact of BIM in operations and maintenance (Jupp 2013).
Studies of BIM’s impact show that its value is both intangible and tangible and can be categorised at two levels: project value and a firm’s internal business value. A vast range of impacts are identified at the project level, and whilst this list is by no means exhaustive, project value can be derived from: higher levels of data integration, more clearly defined deliverables between parties, higher quality 3D data from all parties particularly consultants and manufacturers, increased collaboration and technical skills, greater clarity in contracts supporting BIM, reduced in overall project duration, reduced construction cost, growth in BIM skills across the project supply chain, increased functionality of BIM software, and use of smart technologies and mobile devices on site. Business value can therefore be gained from the ability to: reduce errors and omissions in documents, market new business to clients and maintain repeat business with past clients (sustainable competitive advantage), reduce work, offer new services, reduce workflow cycle time, increase profits, reduce claims/litigation, and assist in recruiting and retaining staff. Value is therefore more often associated with the ability of BIM to save project delivery time and costs that can then be directly translated into firm level productivity gains driven by improvements to information sharing, design quality, transparency, accountability, decision making, sustainability, and labour markets (Allen Consulting 2010).

Despite a number of researchers investigating the impacts and value of BIM, research on assessment methods that measure the benefits, costs and risks of new technological, process and organisational change is nascent. Whilst measures of BIM investment are lacking, studies have tried to identify how ROIs are perceived. Industry surveys undertaken in Australia (Allen Consulting 2010) and the US AEC industries (McGraw-Hill 2012) have shown that most BIM users perceive a positive ROI reporting 64% and, 62% respectively; although not evenly across firm types, where e.g., 83 % and 74% of contractors reported a positive ROI compared to only 50% and 37% of engineers.

The impacts, value and ROI that can be associated with BIM investment may therefore be difficult to measure. Lack of meaningful evaluation can lead to poor investment decisions. Decisions that are inadequately justified or whose benefits, costs and risks are poorly managed may hinder understandings of the value of BIM. A carefully considered BIM investment evaluation method that establishes objectives aimed at increasing the likelihood of successful organisational and project performance (while reducing costs) is therefore required.

4 ASSESSMENT MODELS AND FOUNDATIONAL THEORIES

To begin a roadmap for BIM investment evaluation and identify its requirements current models of IS and IT investment assessments are reviewed before discussing theories foundational to understanding the value of a system.
4.1 Models of Assessment

As a methodology BIM can be thought of as an information system (IS). IS incorporates complementary networks of software and hardware which inter-relate with and depend on activity and process systems. Within the field of IS research, the evaluation of IS/IT investment is an established area of research that has evolved over the past 35 years. A variety of methodologies for evaluating or measuring associated ROIs have been developed. These methodologies include: 1) Information Economics (IE); 2) Real Options Valuation (ROV); 3) Balanced Scorecard (BSC); 4) Economic Value Added (EVA); 5) Return on Management (ROM); and 6) Multi-Objective Multi-Criteria (MOMC). Four categories can be identified based on: type of measurement (qualitative or quantitative); level of measurement (system, process, or organisational); degree of complexity; and those that are multi-objective multi-criteria. Within each approach a number of objectives for IS/IT investment evaluation may be considered including (Farbey et al. 1992): (1) enabling an organisation to make comparisons of the merit of different investment projects competing for limited resources; (2) enabling organisations to gain competitive advantage, to develop new business, to improve productivity and performance; and (3) as part of the process of justification for a project.

Construction IT researchers have adopted IS approaches, and in doing so, many methods have been shown to be difficult to apply to the sector (Kumar 2000). Criticisms are due to failures to account for their impact on construction processes and organisation, nor capture hidden costs, intangible benefits and risks (Love et al. 2006). Andresen et al. (2000) argue that the more complex methods, such as IE and ROM, have failed due to a lack of awareness and large operational requirements. Other barriers include the construction sector’s low profit margins and perceptions of IT as a process of consumption rather than capital expenditure (Love & Irani 2001, Irani & Love 2002). Early estimates of ROI may be plagued by limited scope definition and prepared under time pressure (Trost & Oberlender 2003). Specialists in different areas of the sector engaged in the task of IT investment evaluation may have little or no knowledge of consequences at different levels within the organisation or project. Researchers also argue that some methods suffer from difficulties in quantifying intangible benefits (DeLone & McLean 1992). Applications of IS/IT investment evaluation methods to construction have therefore been shown as inadequate to many of the sector’s defining features (Dehlin & Olofsson 2008).

These arguments can be extended to the evaluation of BIM, which must not only encompass investments in new ITs, but also in process re-engineering and organisational changes. Thus, many of the traditional appraisal approaches are inadequate in anticipating the consequences of BIM investment, and as a result negative impacts may be highlighted as benefits are not properly evaluated, included and weighted against the costs and risks that the investment can be expected to generate. BIM must be considered as a multidimensional construct requiring multiple
measures to evaluate it as a system that accounts for the project’s value chain and lifecycle as well as firm level attributes.

In research relevant to these requirements, a model by Dehlin and Olfosson (2008) proposes method of IT investment assessment which utilises a predefined benefit category structure and variable list based on the principles of the Information Systems Success (ISS) model (DeLone & McLean 1992). The evaluation and risk handling procedures are also inspired by the firm level PENG model by Dahlgren et al. (1997). Yet, whilst these features make Dehlin and Olfosson’s method it easier for users to identify tangible benefits and costs as well as intangible and hidden effects of investment, the model is project-oriented and IT investment specific. To address deficiencies in the evaluation of BIM investment, a methodology that spans both firm and project levels and includes process and organisational investments is required.

4.2 Revisiting Theoretical Foundations

IS research has identified and helped understand the ‘theory of communication’, ‘information influence’ and the ‘productivity paradox’. In management and finance fields, another stream of research based on ‘stakeholder theory’ has helped explain contradictions in evaluations of outcomes. The importance of these theories is discussed with regard to a value chain and lifecycle approach to BIM investment evaluation.

**Communication and Information Influence:** In a bid to understand and assess the value of a system, two key theories are pertinent. The first is Shannon and Weaver’s (1949) mathematical approach to a theory of communication which defines an information system that acts as the information source sending information through a system to a recipient. It is divided into three levels; a technical level representing the system’s accuracy and efficiency, a semantic level addressing the success in conveying the message, and an effectiveness level which measures the effect the information has on the recipient. The second theory is Mason’s (1978) work on ‘information influence’. Mason adopted Shannon and Weaver’s theory and revised it according to a product-oriented approach. Replacing ‘Effectiveness or influence’, Mason defined three categories: receipt of information, influence on receipt, and influence on system; also renaming the technical level and semantic level to the production and product level (Lindfors 2003). Following these approaches numerous researchers have created IS assessment models from various viewpoints, including Lindfors (2003) and DeLone and McLean (1992), see Table 1.

<table>
<thead>
<tr>
<th>Source</th>
<th>Technical level</th>
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<th>Effectiveness or influence</th>
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<td>Shannon &amp; Weaver (1949)</td>
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<td>Mason (1978)</td>
<td>Production</td>
<td>Product</td>
<td>Receipt</td>
<td>Influence on Receipt</td>
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<td>DeLone &amp; McLean (1992)</td>
<td>System quality</td>
<td>Information quality</td>
<td>System Use</td>
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<td>System Use</td>
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<td>User satisfaction</td>
<td>Individual impact</td>
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Table 1. Assessing the value of a system (source Lindfors 2003)
Productivity Paradox: The productivity paradox is the observation that it is impossible to prove that IT has an influence on firm productivity (Brynjolfsson 1993). In the 1990s, IS researchers established that although the number of computers had more than tripled between the 1970s and the 1990s, productivity stagnated; IT investments did not appear to have had a positive effect on productivity (Brynjolfsson 1993). Four types of explanations have been offered: measurement error, time lag, redistribution of profit, and mismanagement of IT. Measurement errors are linked to the fact that inputs and outputs may not be properly measured. Time lag refers to the fact that the actual impacts of IT might not have an immediate effect, and period of learning, adjustments, and reorganisation may be necessary. Redistribution of profit means that there are effects linked to the introduction and use of IT, but these are sometimes positive and sometimes negative, with an overall zero sum effect. Finally, IT mismanagement means that the absence of effects might be linked to IT not being properly implemented or managed. We can apply the productivity paradox and these four explanations to the AEC context to better understand some of the issues identified in the studies analysing the impact and value of BIM and the shortfalls in applications of IS/IT investment assessment methods to construction.

Stakeholder theory: originated from management studies and was initially used to describe how managers work. Stakeholder theory (Freeman 1984) is based on two key questions. First, “What is the organisation’s goal?”, which leads to consider the value created by the firm or project from the point of view of all its stakeholders. The second key question is: “What is management’s responsibility to stakeholders?” This question is posed to gain a better understanding of what type of relationship exists between managers and the various stakeholders and to decide how much consideration should be given to each. In construction research Jones and Wicks (1999) offer a convergent stakeholder theory that explains stakeholder actions and reaction to change. Their approach accords with triple bottom line (3BL) principles, which envisages performance success defined as not only meeting financial performance measures but also environmental and social responsibility performance. Although stakeholder theory is relatively recent and more so in AEC research, the pluralist approach afforded by this theory is appropriate to the problem of understanding how to assess BIM investment. So as to reflect the multi-faceted concerns of the building development process, a more holistic view of the impacts and associates stakeholders of BIM implementation is required so as to incorporate the multilateral relationships across the project lifecycle, highlighting the significance of the BIM investment relative to the entire value chain. This is due to the fact that BIM implementation affects many different stakeholders and how they generate information as well as communicate and collaborate with other stakeholders during project implementation, even though these parties may not have the same interests in the implementation or voice the same opinions.
5 TOWARDS A MODEL OF BIM INVESTMENT EVALUATION

Based on a review of the literature, IS/IT investment evaluation methods applied to the construction context so far lack specific focus on the level of analysis, stage of lifecycle, and areas of the sector. The levels of analysis suggested involve product, project, or firm levels, but a combined approach is lacking. The project level has received most attention; this might be because the principal drivers for IT investment are often created at the outset of a project. BIM investment could however be assessed in different stages of the project lifecycle including the design, preparation, construction, and maintenance. Applications of IS/IT investment methods typically focus on how investments are managed within a single project and there is a lack of focus on project stages relative to investment as well as a lack of focus on different parts of the construction sector. None of the research articles considered investment at a specific stage of the project lifecycle or from the point of view of the project lifecycle in general. Moreover, none discuss accurate measurement and proper indicators for BIM investment assessment during each project phase that are pertinent to different stakeholders.

With few exceptions, methods tend to rely on a small number of indicators of pre-conceived impacts and do not consider a wider range of consequences – this is significant to the wider benefits associated with BIM in both firm and project settings. Yet, whether they are foreseen or not, beneficial or adverse, the impacts appear to be numerous – at both firm and project levels. It is therefore important to give consideration to the numerous stakeholders involved throughout the value chain. Conventional measures of IS/IT investment therefore under represent the extent and range of impacts, value and ROI that can take place within the construction sector when firms invest in BIM. This is for two main reasons. Firstly, current methods of IT assessment only take a narrow view of the sector. To present a fuller picture of BIM investment assessment the situation should be analysed from a wider built environment perspective that includes the design, delivery and use of facilities and reflect this wider value chain. Secondly, even within this wider perspective, conventional measures do not well represent the ROI that can occur from BIM investments. In assessing the value, impacts and ROI, the a wider range of consequences through life must be defined - from BIM’s introduction to its (potential) ongoing use in operation and maintenance – in terms of costs, efficiency, quality and safety, project outcomes, changes to professionals’ roles and tasks, etc.

There is a need to go beyond simple financial assessments of the ROI of BIM and take into account the nature of the stakeholders involved, the specific nature of the implementation context, and the wide range of outcomes resulting from BIM investment decisions. How one uses BIM across the project lifecycle relative to the interests of stakeholders with the value chain would seem to be more important than simply how much is spent on adopting at a firm level and implementing at a project level. Although this paper is not detailed enough to make concrete proposals,
two recommendations can be made. Firstly, a range of impacts is taking place that is not captured or even acknowledged by existing IS/IT investment methods. More should be done to raise awareness of the significance of BIM investment assessment not just during project planning but continued and ongoing analysis. This would directly benefit companies and improve system level metrics. Secondly, a value chain approach would provide a more flexible and holistic model that can be used at both company and project levels throughout different phases of the project lifecycle and produce meaningful assessment data and information.

To develop a value chain approach to BIM investment assessment, further research in the form of surveys and case studies are being undertaken to confirm the deficiencies in the investment assessment methods identified. Case studies of BIM investment motivated by project and firm requirements will therefore aim to illustrate the wider range of impacts and value so as to demonstrate the proportion that is picked up by conventional IS/IT investment evaluation methods.

REFERENCES

ABS 2012, Australian System of National Accounts, Cat no 520.4.0/ 2011/12


