An Overview of BIM Adoption in the Construction Industry: Benefits and Barriers

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Abstract

Purpose – Building Information Modeling (BIM) is a revolutionary innovation in the construction industry to virtually design and mange projects throughout the building lifecycle. Although Estonia is one of the foremost countries in the Information and Communications Technology (ICT) sector, BIM adoption in the Estonian construction industry is still lagging behind other countries. This paper is part of doctoral research that aims to determine the barriers to BIM adoption and develop a framework for effective implementation of BIM in the Estonian construction industry. The purpose of this paper is to examine the status of BIM adoption, BIM benefits and common barriers to BIM adoption in the construction industry worldwide.

Design/Methodology/Approach – The methodology used in this study is a literature review of journal articles, conference proceedings and published reports from various sources.

Findings – This study showed BIM benefits through building lifecycle phases and explored the BIM adoption rate in the construction industry of various countries. Eighteen barriers to BIM adoption were also identified.

Research Limitations/Implications – The study presented is limited to a literature review – some related literature may have been missed.

Practical Implications – The main practical significance of this study is that the findings can be used to inform a further survey to model the barriers to BIM adoption in the Estonian construction industry.

Originality/Value – This study offers information on BIM adoption in the construction industry and will form the basis of further research.

Keywords Building Information Modeling, Virtual design and construction, Construction industry, BIM adoption, Benefits, Barriers

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1. Introduction

The construction industry is a significant contributor to the socio-economic development of any country. Nevertheless, owing to the complexity of the construction industry, it faces several challenges such as low productivity, poor quality, rising cost, construction waste, delays and lack of information sharing among project stakeholders. BIM offers the potential to address these challenges and improve construction industry performance. BIM is an innovative technology and process to virtually design and manage construction projects (Azhar, 2011a).

BIM has been adopted in the construction sector over the last two decades and it has the capacity to transform and enhance performance by decreasing inefficiencies, improving productivity and increasing collaboration among project stakeholders (Abanda *et al.*, 2018). Adoption of BIM offers the visualisation of design, fast creation of alternative designs, automatic examination of model reliability, production of reports and building performance forecasting (Sacks *et al.*, 2010). Despite the potential benefits of BIM, its implementation rate has been slow owing to various barriers (Walasek and Barszcz, 2017).

As in other countries, BIM is gaining the attention of Estonian construction practitioners. However, there are many challenges which affect BIM adoption in Estonia (Karafin *et al.*, 2016). Tüvi (2017) states that there is a need to investigate the barriers to BIM adoption in the Estonian construction sector. This paper examines the status of BIM adoption, BIM benefits and the common barriers to the adoption of BIM in the global construction industry as a basis for developing a framework for effective implementation of BIM in the Estonian construction industry.

The structure of the paper is organised as follows: the methodology is presented in Section 2, and BIM adoption in various countries of the world is explained in Section 3; in Section 4, potential benefits are illustrated. Section 5 shows common barriers to BIM adoption and the conclusion is drawn in Section 6.

2. Methodology

It is imperative in a literature review to describe clear boundaries to limit the research (Seuring and Muller, 2008). The literature considered for this study was published between 2008 and 2018 and in English. The literature review was not restricted to particular journals. The Scopus search engine was first used to identify scholarly work containing BIM benefits and barriers to BIM adoption. The Scopus search engine was considered because it is one of the largest databases; it has a high level of quality control and covers multidisciplinary research areas. In order to collect relevant papers for this study, the following keywords and Boolean phrases were used: ([Building information modelling OR Building information modelling OR BIM OR Virtual design and construction OR VDC OR 3D modelling] AND (Adoption) AND [Benefits OR Advantages] AND [Barriers OR challenges] within [Title/ Abstract/ Keywords]). 63 relevant papers were collected. In addition, to increase the relevant literature, particularly for information on BIM adoption rates, some non-Scopus papers, survey reports and academic theses were also considered. Thus, a total of 88 publications were examined to address the purpose of this study.

3. BIM Adoption Global Scenario

BIM adoption means "the successful implementation whereby an organisation, following a readiness phase, crosses the 'Point of Adoption' into one of the BIM capability stages, namely, modelling, collaboration and integration" (Succar & Kassem 2015). The BIM adoption has significantly increased around the globe particularly in the developed countries over the past years.

The United States is one of the pioneers in BIM development and adoption in the construction industry (Wong *et al.*, 2010). In the US, the General Services Administration (GSA) in 2003 launched the "National 3D-4D program" with the goal to form strategy to gradually implement 3D, 4D and BIM for all major public projects (Wong *et al.*, 2010). In 2007, the GSA included BIM for spatial program validation for all its projects (Burgess *et al.*, 2018).

In 2014, the European Commission announced directive 2014/24/EU, which recommends member states' use of specific electronic tools such as BIM for public works contracts and design contests (European Parliament, 2014). In the United Kingdom, the government has mandated a minimum of Level 2 collaborative BIM on all publicly financed projects from 2016 (Burgess *et al.*, 2018).

The Scandinavian countries are at the forefront in BIM adoption (Smith, 2014). In the Netherlands, the Government Buildings Agency has mandated the use of BIM for public projects in 2011 (Cheng and Lu, 2015). Research conducted in Germany, France, Brazil and Austria showed that BIM is gaining wide adoption in these countries (Matarneh and Hamed, 2017). In Estonia, a survey was carried out among 297 firms and revealed that 51 per cent of respondents are already using BIM or planning to adopt it over the next 5 years (Usesoft AS, 2016).

Singapore and South Korea lead BIM adoption in Asia and mandated the use of BIM in all public funded projects by 2015 and 2016, respectively (Cheng and Lu, 2015).

In Hong Kong, the government mandated the use of BIM in the design and construction phases of all public projects (Development Bureau Hong Kong, 2017). The Japan Federation of Construction Contractors (JFCC) formed a BIM Specific section under its Building Construction Committee to promote BIM adoption (Jin *et al.*, 2015).

According to Yang and Chou (2018), the BIM adoption rate is less than 30 per cent in the Middle East. Gerges *et al.* (2017) state that BIM adoption is relatively low in Africa. Table 1 indicates the BIM adoption rate in different countries.

4. Potential benefits of BIM adoption

Various research studies have been performed relating to BIM adoption in construction projects which have found many advantages over traditional construction practices. Table 2 shows BIM benefits in different phases of the building lifecycle.

Country	BIM adoption rate (year and source)
Australia	67%, 2016 (Red Stack BIM services, 2016)
Canada	78%, 2018 (MaCabe *et al.*, 2018)
China	67%, 2014 (Jin *et al.*, 2015)
Czech Republic	25%, 2016 (Malleson, 2016)
Denmark	78%, 2016 (Malleson, 2016)
Estonia	51%, 2015 (Usesoft AS, 2016)
Japan	46%, 2016 (Malleson, 2016)
Poland	23%, 2015 (Juszczyk *et al.*, 2015)
United Kingdom	74%, 2018 (Malleson, 2018)
United States	79%, 2015 (Gerges *et al.*, 2017)

Table 1.
BIM Adoption Rate in Various Countries

Phases	Benefits of BIM use
Pre-construction	• Better concept and feasibility (Eastman *et al.*, 2011) • Effective site analysis to understand environmental and resource-related problems (Azhar *et al.*, 2011b) • Improve effectiveness and accuracy of existing conditions' documentation (Kjartansdottir *et al.*, 2017) • Effective design reviews leading to sustainable design (Khosrowshahi, 2017) • Enhancement of energy efficiency (Eastman *et al.*, 2011) • Resolve design clashes earlier through visualizing the model (Latiffi *et al.*, 2016) • Enables faster and more accurate cost estimation (Khosrowshahi, 2017)
Construction	• Evaluation of the construction of complex building systems to improve planning of resources and sequencing alternatives (Kjartansdottir *et al.*, 2017) • Effective management of the storage and procurement of project resources (Eastman *et al.*, 2011) • Efficient fabrication of various building components offsite using design model as the basis (Enshassi *et al.*, 2018) • BIM allows better site utilization (Deshpande and Whitman, 2014) • Reduce site congestion and improve health and safety (Khosrowshahi, 2017)
Post construction	• BIM record model can help in decision-making about operations, maintenance, repair and replacement of a facility (Kjartansdottir *et al.*, 2017) • Makes asset management faster, more accurate and with more information (Husain *et al.*, 2014) • Ability to schedule maintenance and easy access to information during maintenance (Enshassi *et al.*, 2018)

Table 2.
BIM Benefits Through the Building Life Cycle

5. Barriers to BIM adoption

Elmualim and Gilder (2014) examined the hindrances to adoption of BIM in the USA, Canada, the UK, Ghana, South Africa, China, India and Australia. Their findings showed that the main barriers are deficiency of capital, BIM benefits not outweighing the implementation costs, unwillingness to start new workflows and BIM being too risky from a liability perspective.

A survey by Enterprise Ireland revealed that barriers in BIM adoption are the lack of client interest, insufficient expertise, lack of training, unavailability of standardised tools and protocols and issues related to data ownership (McAuley *et al.*, 2017).

Ismail *et al.* (2017) examined BIM adoption in China, India, Pakistan, Sri Lanka, Malaysia, Indonesia, Thailand and Vietnam. They highlighted that the main barriers to BIM adoption were cultural resistance, longer processes, high investment cost, lack of awareness and demand and uncertainly about the return on investment (ROI).

Hosseini *et al.* (2016) described the barriers to the adoption of BIM in Australia. The barriers were sub-contractors not having sufficient knowledge about BIM, clients' lack of awareness about BIM benefits, high cost of BIM implementation, high cost of training and unwillingness to change current construction culture. Obstacles to BIM adoption in the construction industry of New Zealand are high initial cost, training issues and cultural resistance (Harrison and Thurnell, 2015).

The literature review shows that both developed and developing countries faces barriers in BIM adoption. Table 3 summaries the barriers to BIM adoption in the construction industry.

Barriers	Reference
High initial cost	(Ismail *et al.*, 2017)
Lack of awareness about BIM benefits	(Latiffi *et al.*, 2016), (Gerges *et al.*, 2017)
Inadequate training on the use of BIM	(Eadie *et al.*, 2014) (Park and Kim, 2017)
Resistance to change current construction industry culture	(Ganah and John, 2015) (Sahil, 2016)
Insufficient governmental support	(Enshassi *et al.*, 2016)
Legal issues	(Bosch-Sijtsema *et al.*, 2017)
Lack of interest from clients	(Sahil, 2016)
Lack of support from top management	(Ganah and John, 2015)
Doubts about ROI	(Eadie *et al.*, 2014)
Lack of BIM experts	(McAuley *et al.*, 2017)
Data ownership issues	(Park and Kim, 2017)
Longer process (takes longer time to develop the model)	(Ismail *et al.*, 2017)
Lack of demand from the contractors	(Gerges *et al.*, 2017)
Sub-contractors are not interested in using BIM	(Hosseini *et al.*, 2016)
Absence of contractual requirement for BIM implementation	(Ahmed *et al.*, 2014)
Complexity of the BIM model	(Ahmed *et al.*, 2014)
Interoperability between software programs	(Park and Kim, 2017)
Lack of standardized tools and protocols	(McAuley *et al.*, 2017)

Table 3. Barriers to BIM Adoption

6. Conclusions

This study overviewed the current situation of BIM adoption, benefits and common barriers to BIM adoption in the construction sector. The literature review shows that BIM is an emerging technology and process in the construction industry and can offer numerous benefits to the construction stakeholders. It can be observed that the BIM adoption rate varies from country to country. Some countries like the US, the UK, the Scandinavian countries and Singapore lead BIM adoption. Despite the benefits of BIM, there are various barriers which affect the BIM adoption rate. The findings of this study will be used to develop a survey instrument for determining potential barriers to BIM adoption in the Estonian construction industry. The next phase of this research will involve a large-scale survey of construction industry stakeholders and the development of a framework for effective BIM implementation.

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