Rethinking digital construction: a study of BIM uptake capability in BIM infant construction industries

Purpose of this paper

Practitioners have reported a minimal and non-use of BIM, especially in small and medium-sized organisations and BIM infant construction industries. This development calls for a reappraisal of organisations' strength in capabilities required for BIM uptake towards the target of global construction digitalisation. This study aims to assess the BIM Level 2 uptake capability of organisations in a BIM infant construction industry and identify the underlying interactions between the capability criteria.

Design/methodology/approach

The study employed a multivariable analysis of fifteen descriptors identified from the people, process, policy, finance, and technology domain. Data collection was done in a BIM infant construction industry, Nigeria. Verification of the descriptors and an evaluation of BIM uptake capability in organisations was done. Seventy-three (73) responses were received within the selected context and data analysis was done with mean weighting and Exploratory Factor Analysis (EFA). Maximum Likelihood extraction and Direct Oblimin rotation were used.

Findings

Factor analysis revealed three factors that explained 53.28% of the total variance in the BIM Level 2 uptake capability of construction organisations. The factors are workforce capacity and continuous development, an affinity for innovation, and strength in physical and operational facilities.

Research implications (if applicable)

This study provides an overarching and insightful discussion on BIM uptake capability and construction digitalisation with evidence from a BIM infant construction industry.

Practical implications (if applicable)

The findings of this study are a piece of valuable empirical evidence on Level 2 BIM uptake capability. This empirical situation analysis will inform the advocacy for the advancement of BIM and enhanced utilisation of building information. Evidence on the capability performance of the BIM infant industry has been revealed.

What is original/value of paper

The outcome is expected to stir debate on the preparedness of organisations to further exploit the benefits of BIM in BIM infant construction industry. Examination of the capability for a particular phase of BIM is scanty in the literature.

Keywords: BIM, organisational capability, innovation diffusion, technology acceptance, factor analysis.

Introduction

Over the years, the construction industry has faced a lot of criticism for its under-utilisation of technology, reduced output, carbon emission and seeming inefficiency (Green, 2016; KPMG, 2016). These shortcomings have been linked to the fragmentation of the project delivery system, but this challenge was meant to be addressed via the emergence of Building Information Modelling (BIM) (Ciribini et al, 2016). Howard and Bjork (2008) submitted that the advancement of BIM within the UK construction industry offers construction professionals and society a great help, even though, there is much more to accomplish. For instance, Rodgers et al. (2015) stated that about 45% of contracting firms are BIM compliant in South Australia with a 79% adoption rate reported in the United States of America (USA) in 2015 (Gerges et al., 2017) and 73% adoption rate reported in the United Kingdom (UK) in

2020 (Bain, 2020). Based on events and growing client focus on whole-life value, there has been advocacy for advancement in the direction of research and practice from just building information modelling to digital twinning of buildings and the built environment (Wilkinson, 2019). There is the need to put building information to more meaningful use, whereas there appears to be a gap in the actual deployment of BIM in practice. Therefore, putting building information to a more meaningful use might be difficult. Hence, a clear understanding of BIM uptake capability status is germane. Issues on BIM uptake, capability, and maturity assessment have been identified and approached from different perspectives (Babatunde et al, 2020; Giel and Issa, 2014; Mahamadu et al., 2017; Sebastian and Berlo, 2012; Smits et al., 2016) but with limitations. These studies among many others presented different views about BIM capability, meaning and uses (Yilmaz et al., 2019) and BIM maturity (Smits et al., 2016). Variables in the studies were outlined and analysed for different contexts of evaluation and none focused on capabilities for being BIM-Level 2 compliant, a necessarily focused capability appraisal. Noticing some complications in the literature, the Centre for Digital Built Britain (2020) highlighted a lack of precise distinction between, readiness, capability, and maturity as one of the challenges of previous works on BIM assessment. The need to bypass this confusion and to establish the capability of organisations for being BIM-level 2 compliant birthed this study. Note that BIM levels 1 to 3 involve differing degrees of modelling and collaboration before full integration and complete interoperability. Therefore, there is the need for a purpose-crafted, more focused appraisal or reappraisal of organisations' strength on capabilities required for a stated BIM status towards the target of global construction digitalisation.

A report by the Centre for Digital Built Britain (2020) introduced some terminologies to enhance precision in the meaning of words used in BIM discussions. These terms might help in contextualising the discussions in this study. The terms are BIM compliance - the fulfilment of mandated requirements, BIM readiness - preparatory activities towards BIM uptake, BIM capability - ability needed to engage in a BIM process, this relates to the availability of BIM tools and protocols, and BIM maturity which refers to the extent of BIM capabilities within an organisation usually measured on a progressive scale of 'ad-hoc to 'optimised'. BIM maturity has also been described with expressions indicating the magnitude of sophistication of BIM resources and scope of activities (Succar, 2010) from levels 0 to 3. This study aligns with the above definition of 'BIM capability' and assessed the capability of organisations for operating at the Level 2 BIM process alone, Level 2 BIM is also the collaborative (model-based collaboration stage) BIM stage (Succar, 2009). BIM level 2 involves the independent creation of a discipline-based model which can be assembled to form a federated model. Such a model usually includes construction programme/time data (4D) and cost data (5D) (Tekla Campus, 2021). The UK government mandated the use of level 2 BIM on all centrally procured government projects in 2016. Therefore, BIM Level 2 is a good benchmark to appraise capability in a country like Nigeria. Generally, the capability of a firm is defined as the combination of competencies, knowledge, skills, resources, strengths, and societal networks used to coordinate a set of activities to achieve goals (UNISDR, 2009; Yen-Tsang et al., 2012). This study examined the capability for Level 2 BIM compliance by construction organisations, it is an account of a BIM infant construction industry.

The study scope is Lagos State, Nigeria. Nigeria operates a three-tier government system i.e., Federal, State and Local government. Nigeria is the biggest economy in Africa and Lagos State boasts of huge investment in properties and infrastructure. It also stands as a front-liner in technological innovation adoption and is recognised by citizens and others as a hub for technological advancements in Africa (Ibukun and Ackerman, 2019). Lagos state was therefore adjudged an appropriate geographical scope. Despite the acknowledged technological potential, the capability status and the spread of BIM in Nigeria have been stagnant (Ibrahim and Bishir, 2012), limited (Hamma-adama et al., 2017; Olugboyega and Aina, 2018), organisation restricted (Onungwa et al., 2017), and largely a stage 1 BIM industry (Hamma-adama et al., 2017). These attributes confirmed the BIM infancy status of the territory even as the region among other regions was also described to be at the BIM infancy stage by Saka and Chan (2019). Similarly, while discussing BIM uptake in Asian developing countries, Ismail *et al.* (2017)

acknowledged the BIM infancy status across regions and Kushwaha and Adhikari (2016) highlighted the BIM infancy status of the construction industry in India. Also, Jayasena and Weddikkara (2013) discussed the BIM infancy of the Sri Lankan construction industry. The Nigerian Construction Industry is a significant contributor to the country's Gross Domestic Product (GDP), and it is driven by both the public and private sectors. The government provides a key infrastructure through revenues and loans to meet the infrastructure deficit, the infrastructure stock is reported to be 30% of Gross Domestic Product (GDP) as against the 70% recommended by the World Bank (Adeshina, 2021). Despite the existence of only 2D and 3D BIM use in the Nigerian construction industry (i.e., BIM level 0 and level 1) (Olugboyega and Aina, 2018), some challenges have been reported. Babatunde (2020) reported top challenges to include the cost of hardware and software, the uncertainty of where to start, interoperability issues, high cost of training, lack of government support, resistance to change, limited skill and difficulty with learning BIM. The study classified a list of 25 challenges into three main factors which are the inadequacy of BIM specialists, standards, and protocols; high initial outlay, weak BIM skills and resistance to change. Babatunde's findings were largely supported by the submission of Olanrewaju *et al.*, (2020). Given the submissions, it appears that the tendency of effective deployment of level 2 BIM is uncertain, though there is a global desire for construction industry digitalisation. Hence, the need to examine BIM level 2 uptake capability becomes important.

Given the background, the objective of this paper is to assess BIM Level 2 uptake capability in the BIM infant industry and identify the underlying interaction between uptake capability criteria. The findings of this study are a piece of valuable empirical evidence on Level 2 BIM uptake capability in a BIM infant construction industry. Empirical situation analysis such as this study is necessary before further advocacy on the advancement of BIM and enhanced utilisation of building information. The remaining part of this paper is sections on literature review, research method, findings and discussion of findings and a conclusion section.

Literature review

The innovation diffusion theory

The innovation diffusion theory (Rogers and Singhal, 2003) is useful for studying the adoption and spread of information technology (IT) (Rogers and Singhal, 2003; Venkatesh et al, 2003). The spread of innovation is usually influenced by the environment and the support or capability available for the deployment of such innovation. The theory was adopted as an overarching framework in this study to describe why some regions could have been tagged BIM infants, while some others are not, the theory explains how innovation diffuses in stages from early to late adopters. Interestingly also, the Level 2 BIM is another innovation level for organisations. Based on the submission of the theory, innovation refers to an idea or technology which is unfamiliar to a system, organisation or individual. The innovation diffusion theory highlighted stages that include knowledge, persuasion, and a decision to accept or reject an innovation (Mohammadi et al, 2018). Discussing further, Venkatesh et al (2003) and Mohammadi et al. (2018) highlighted the influences on the persuasion stage to include the organisation's perception of relative advantage, compatibility, complexity, trialability and observability, all of these will be influenced by the social system or environment and the organisation's current capability or vision. This study discusses below the environment "BIM infant construction industry" and "BIM uptake capabilities" and goes ahead to assess the BIM uptake capability of organisations.

BIM infant construction industry

The Nigerian construction industry has been tagged a 'BIM infant industry' because it is adjudged to be largely entrenched with Computer Aided Design (CAD), two-dimensional (2D) and some three-dimensional (3D) modelling (i.e., BIM level 0 and level 1) among other attributes (Saka and Chan, 2019). The Nigerian construction sector is projected to grow in the coming years after experiencing a

7.7% decline in 2020 due to COVID-19. Currently being implemented is a 30-year infrastructure growth plan ending in 2043, it is aimed at driving the infrastructure stock up to 70% of the GDP (Adeshina, 2021). Infrastructure shortage has been reported to be conspicuous in the areas of transportation and affordable housing. Available records indicate that the Nigerian government currently builds around 2,000 houses per year out of a projected need of 700, 000 to close the deficit (Adeshina, 2021). Generally, the Nigerian construction industry is faced with a range of problems such as inefficiency, cost and time overrun, and dispute. Amid the challenges are an array of opportunities for business and general industry growth. One of the popular challenges is the insufficient supply of houses. The housing needs are being addressed through state government-led strategies such as owner-occupier schemes. The government is also supporting the mortgage industry through schemes such as waivers on initial payments. Interestingly, private sector developers are also harnessing the opportunities in the construction sector by delivering residential estates and collaborating with partner organisations and governments to deliver other infrastructures such as seaports and roads. The industry is experiencing a shift in the use of disruptive technologies as it is in several countries of the world as there are expectations concerning the spread of innovation for enhanced competitiveness and improved overall performance. According to Bossink (2004), the entrenchment of innovation for operations within and beyond is a huge image-building opportunity. It is believed that the digital disruption anticipated across sectors will also significantly penetrate the Nigerian construction industry. It is shocking to realise that the construction and real estate industry has been behind other sectors in the use of information and communication technology (Ezeokoli et al., 2016, Kane et al., 2015, Oladapo, 2007). To strengthen the diffusion of digital innovation in the industry and harness the benefits of digital transformation, Building Information Modelling (BIM) is one of the procedures being entrenched. Interestingly, strengthening the BIM deployment requires collaboration, the right teams and resources, an appropriate mindset, managerial and operational level support, and the unison of related initiatives. However, general digital transformation has been impeded by factors such as a shortage of suitable professionals, limited availability of skills, inadequate managerial support, limited knowledge, and difficulties in coordinating resources and teams (Ezeokoli *et al.,* 2016).

The embrace of BIM has been reported in the Nigerian construction industry, but it is largely a stage 1 BIM, existing studies have also largely been on industry awareness, benefits, and challenges of BIM (Babatunde et al, 2020, Hamma-adama et al., 2017, Kori and Kivinemi, 2015). Ibrahim and Birshir (2012) submitted that the potential of BIM is yet to be fully explored, even in the year 2020, Babatunde et al (2020) reported a slow move toward BIM. Few Architects adopted BIM to enhance design presentations, and there are currently no clear government legislations that mandate the use of any level of BIM in Nigeria even though, the government is supposed to be the main driver of adoption. Ibrahim and Birshir (2012) described the use of BIM in Nigeria as stagnant and Hamma-adama et al. (2017) and Olugboyega and Aina (2018) submitted that the use of BIM is limited to 2D and 3D designs by Architects and Structural Engineers and design visualization by other professionals. Better commitment has been visible in some other countries; some governments have mandated the use of BIM on some projects.

Apart from the production of 2D and 3D models, the ability of BIM in fostering collaboration among the design team and contractors is appealing and recognised (Gray et al., 2013 and Gholami et al., 2013). According to Onungwa et al. (2017), there is very limited awareness and knowledge of BIM technology in Nigeria (Onungwa et al., 2017); this is evident in the lack of trained staff on BIM. Kori and Kivinemi (2015) revealed that large and medium firms were found to be leading BIM adoption in Nigeria among Architectural, Engineering and Construction (AEC) firms while the small firms are less advanced regarding policy and process adherence, therefore, have less adoption. The reported BIM uptake is also organisation-restricted, there is very limited evidence of collaboration on inter-organisational activities (Onungwa et al., 2017); it is largely a Stage 1 BIM (Hamma-adama et al., 2017). Structural and services designs are still popularly done on the conventional CAD (2D) system with few (mostly Architects) utilising the 3D CAD system for visualisation purposes (mostly) or as a presentation drawing (Hamma-adama et al., 2017; Kori and Kivinemi, 2015). Ding et al (2014) and Koutamanis (2020) summarised the dimensions of BIM with one of the phases being the focus of uptake capability considered in this study, that is, Level 2 BIM which usually covers 3D BIM +Time + Cost information. The term 'BIM infant industry' used in this study represents a region identified to be at Phase 0 (CAD) and early Phase 1 (2D and part of 3D), phase 1 also involves the use of best practices, standards, user guides, and guidance on the production of drawings, specification, work schedule, among others. Concerning these attributes, literature has confirmed that BIM use in Nigeria is still largely 2D with 3D mainly used within organisations by Architects and Structural Engineers (Hamma-adama et al., 2017; Olugboyega and Aina, 2018).

BIM uptake capability

Succar (2010b) classified "BIM capability" into phases which include pre-BIM, object-based modelling, model-based collaboration, network-based integration, and post-BIM. Each of the phases is characterised by technology, process, and policy steps. Previous literature has classified BIM usage into levels 0 to 3 (Bew and Richards, 2008) and Pre-BIM (Level 0), object-based modelling (1), model-based collaboration (2), network-based integration (Level 3) and Post-BIM (Succar, 2009). Level 0 is simply the use of computer-aided design (or CAD tools) to create drawings, Level 1 involves progression from CAD to produce suites of 2D information and non-federated 3D models. Level 2 involves the production of a federated model available in a common data environment operated in a file-based library management system. Succar (2010) differentiated between the minimum requirement for uptake of the different BIM stages 1 to 3. At stage 1, the organisation can possess BIM authoring software such as Revit and communication are disjointed. In stage 2, the model-based collaboration stage, BIM is expected to be operated effectively on a multidisciplinary collaborative BIM project. At stage 3, object-based models are expected to be shared on a network-based collaborative platform with an interdisciplinary exchange of interoperable data. Succar highlighted a post-BIM stage whereby virtual-integrated Design, Construction and Operation (viDCO) tools and concepts incorporate policies and other intelligence information. Succar (2012) recognised that each stage has a differing process, policy, and technological requirements. The process dimension covers activities and workflows, policy requirements relate to benchmarks and guiding principles and documents while the technological perspective covers hardware, software, and network resources. Other studies classified capability criteria into competence, resources, culture, attitude, cost, personnel, strategy, information management, team structure, hard and software (CIC, 2013; Dib et al, 2012, and Mahamadu et al., 2017). Mahammadu et al (2017) highlighted 11 main BIM qualification criteria for construction pre-qualification and selection. The criteria include staff qualification, staff experience, organisation experience, administrative and strategic capacity, physical resources, specific BIM modelling capacity, reputation, technology readiness, organisational structure, and cost. Some other studies have also outlined some relevant capability variables targeted at different purposes (Giel & Issa, 2014). Ahmed and Kassem (2018) also produced a unified BIM taxonomy that highlighted the capability for BIM uptake. To become BIM Level 2 compliant, capability relating to the variables highlighted by the studies is expected to be built. Kassem and Succar (2017) aggregated literature to describe BIM capability as the abilities gained via the implementation of BIM tools, workflows, and protocols, it is characterized by evolutionary phases. Kassem and Succar (2017) examined BIM capability diffusion across the three BIM stages of modelling, collaboration, and integration in 21 countries through three BIM fields of technology, process, and policy. The result revealed an uneven distribution of the Diffusion Rates across countries, the countries engaged are mostly developed countries and the number of respondents per country ranged from 2 to 7 with Portugal and the United Kingdom having 10 and 16, respectively.

Summarily, the uptake capability of BIM in this study refers to the measure of satisfaction with the requirements for operating on Level 2 in the BIM maturity scale (Succar, 2010). Stage 2 maturity requires integrated data communication and data sharing between the stakeholders to support this collaborative approach. Model server technology and cloud computing are not expected to be in use at this stage. After careful consideration and synthesis of relevant criteria mentioned in the literature, a list of measures for uptake capability was drafted (Table 1). Each measure should be read with reference to BIM Level 2.

Table 1: Synthesised Capability variables

Measures of uptake capability	Literature sources
1. Understanding of the benefits of BIM adoption (orientation on usefulness)	Yilmaz et al., 2019; Ahmed and Kassem (2018); Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012
2. General awareness on BIM (Company knowledge)	Yilmaz et al., 2019; Ahmed and Kassem (2018); Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
3. Cost of acquisition and maintenance of relevant facilities	Yilmaz et al., 2019; Ahmed and Kassem (2018); Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
4. Perception of ease of use (of Level 2 facilities)	Yilmaz et al., 2019; Ahmed and Kassem (2018); Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
5. Current level of use of BIM-related facilities such as CAD	Yilmaz et al., 2019; Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012
6. Available structure for continuous training of staff	Yilmaz et al., 2019; Ahmed and Kassem (2018); Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
7. Readiness to immediately work on a BIM-based project	Yilmaz et al., 2019; Ahmed and Kassem (2018); Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
8. Affordability of the cost of training existing staff	Yilmaz et al., 2019; Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
9. Availability of well-trained staff on BIM	Yilmaz et al., 2019; Ahmed and Kassem (2018); Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
10. Workflow, practices, and procedural changes necessary to adopt BIM are not problematic	Yilmaz et al., 2019; Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
11. Current workers' experience and knowledge of BIM usage	Yilmaz et al., 2019; Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
12. No tendency to outsource BIM-related activities (Company orientation & strategy)	Yilmaz et al., 2019; Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
13. Level of understanding of legal and contractual issues involving BIM	Yilmaz et al., 2019; Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
14. BIM usage level within the past two years	Yilmaz et al., 2019; Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013
15. No desire to retain the use of the traditional method (Desire for a change)	Yilmaz et al., 2019; Ahmed and Kassem (2018); Mahammadu et al., 2017; Giel & Issa, 2014; Succar 2012; CIC, 2013

Research method

Research approach

The survey approach was found suitable and utilised in this study because it is a systematic method of gathering data from a sample (Tan, 2011). The approach is a systematic method that allows a numerical quantification of phenomena and inference-making. It was utilised in this study to obtain relevant background information of respondent organisations and quantify the level 2 BIM uptake capability of construction organisations, through the quantification of uptake capability measures presented in a questionnaire. The uptake capability measures presented in the questionnaire were an outcome of literature synthesis (see Table 1).

Population and sampling

The questionnaire respondents were selected from construction consulting and contracting organisations in Lagos, Nigeria. Lagos is at the forefront of technological innovation and adoption in Africa with technological hubs that influence technology adoption across several practices and services (Ibukun and Ackerman, 2019) though with reported limited BIM use. Respondents with at least a fundamental BIM-related experience such as engagement with 2D CAD were engaged. Since the population or the sample frame of respondents in this category could not be established, a non-probability sample was utilised as supported by other construction management studies (Zhao et al., 2014). Specifically, the purposive sampling method of the non-probability sampling approach was adjudged suitable and therefore adopted. This is because the method allows the selection of closely related respondents or cases that satisfy stated criteria to represent a population. According to Teddlie and Yu (2007), in purposive sampling, respondents are selected because they satisfy some specifically stated conditions. In this study, the condition is the possession of a 2D CAD BIM-related experience.

Questionnaire design and administration

The first aspect of the questionnaire contains a set of questions meant to capture the background information of respondents. In the second section of the questionnaire, respondents were asked to respond to questions about their organisations concerning the capability criteria on a five-point Likert scale ranging from very high (5) to very low (1). The questionnaire was administered in two stages, during the first stage of the study, the capability variables extracted from the literature were made available to organisations for them to rate the variables' suitability for assessing BIM Level 2 uptake capability (1^{st} stage – variable suitability verification), the stage was meant to eliminate less relevant factors. After collating respondents' submissions on the suitability of the variables, the questionnaire with the list of measures was redistributed to assess the organisations' BIM Level 2 uptake capability (i.e., 2^{nd} stage). Eventually, 73 responses were received from consultant and contracting organisations in each round.

Methods of data analysis

IBM SPSS Statistics version 28 was used for data analysis. Analysis methods such as mean score, One-way Analysis of Variance (ANOVA) and exploratory factor analysis were utilised. Mean score was used to weigh the uptake capability variables, and ANOVA was used to test the difference in responses of the contracting and the consulting organisations. ANOVA is used to compare the mean or test the difference between the means of two or more independent groups (Maxwell *et al*., 2018). One-way ANOVA and independent sample t-test are based on the same set of assumptions (Kim, 2014) and a researcher can choose either of the methods to compare the mean of two groups. ANOVA has been adjudged suitable and used to test the significance of the difference in the mean of two groups across different fields including the construction industry, such studies include Emerson (2017), Gangwar & Goodrum (2005), Rahman (2014) and Sow (2014). Authors such as Ross and Wilson (2017), Eddington (2015) and Larson-Hall (2009) provided further discussions on the adequacy of ANOVA with two groups. Interestingly, ANOVA can also be used to compare the mean of more than two groups, and it seems to be more popular for this role. Jamieson (2004), Norman (2010) and Sullivan and Artino (2013) supported the use of the above methods with Likert scale data. Factor analysis was used to identify the underlying interaction between the uptake capability variables. A Cronbach alpha score of 0.77 was recorded for the 15 variables being subjected to factor analysis. The Cronbach alpha is a measure of the internal consistency of a scale, its value ranges from 0 to 1. Internal consistency represents how the variables or tests measure the same construct; it is an indicator of validity with values closer to 1 representing higher consistency (Tavakol & Dennick, 2011). According to Norusis (2008), factor analysis is used to produce a factor grouping that represents many interrelated variables in smaller groups. It is used to reduce and regroup factors. In this study Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was used to establish the appropriateness of factor analysis. The KMO value ranges from 0 to 1 and the closer to 1 the greater the assurance that factor analysis will yield reliable and distinct factors. A KMO minimum threshold of 0.50 is recommended (Norusis, 2008) but 0.626 was recorded in this study. The analysis shows a Sig. = 0.000 and exploratory factor analysis proceeded. Maximum Likelihood extraction and Direct Oblimin rotation were used. The potential influence of the uptake capabilities on each other cannot be completely ignored. This explains the choice of Maximum likelihood extraction and Direct Oblimin rotation method adopted for the Exploratory Factor analysis (EFA). The Direct Oblimin oblique rotation method is recommended for interpreting the underlying interaction between variables when there is a tendency for correlation between them.

Results and Discussion

Background information on firms and respondents

Table 2 presents the summary of respondents and their firms. Table 2 shows that 37 (50.7%) contracting and 36 (49.3%) consulting construction organisations participated in the study. The respondents in the organisations include Architects, Quantity Surveyors and Engineers. The professional capability of the respondents is encouraging as 48% of the respondents are registered (chartered) members of their respective professional bodies. The result also shows that 50.7% have completed an undergraduate degree while 23.3% have a postgraduate degree as their highest academic qualification. Additionally, 61.6% of the respondents stated they have been involved in not less than 25 construction projects while 9.6% have been involved in the delivery of 51 projects and more. The result indicates that professionals and organisations using BIM and relevant to BIM are well represented. The respondents are also well educated and have the adequate construction industry experience to provide valuable information.

Table 2: Summary of respondent's demographic data

Variable	Number	Percentage
Type of construction organisation		
Contracting	37	50.7
Consulting	36	49.3
Professional membership		
Fellow	6	8.2
Corporate/Chartered	29	39.7
Probationer	38	52.1
Academic qualification		
Master of Science	17	23.3
Bachelor of Science	37	50.7
Higher National Diploma/Postgraduate Diploma	13	17.8
Others	6	8.2
Projects handled by respondents		
Above 76	2	2.8
51 to 75	5	6.8
26 to 50	21	28.8
1 to 25	45	61.6
Role in organisation		
Architecture	15	20.5
Quantity Surveying	25	34.3

Project Management	20	27.4
Civil/Service Engineering	13	17.8

Suitability of the measures for appraising BIM level 2 uptake capability

Table 3 shows the rating, using mean scores, of the suitability of the variables for assessing BIM Level 2 uptake capability. The decision rule was to eliminate the variables with a mean value less than 2.50 out of 5.00, this is to ensure the content validity of the questionnaire to be used for organisational uptake capability assessment. This approach was utilised by Badu et al. (2012) and Babatunde and Perera (2017), though variables with mean scores of at least 3.00 were to be selected in those studies. Eventually, none of the uptake capability variables scored below 2.50 out of a maximum of 5.00, so, none was eliminated. Table 3 also shows that none of the variables had a mean score less than 3.00 for the contracting and the consulting organisations, respectively. To identify any difference in the perception of the respondents (contracting or consulting) on the suitability of the variables, one-way ANOVA was done to test the hypothesis of no significant difference based on the type of organisation. The significance level was set at 0.05 as adopted by other studies such as Olanrewaju *et al* (2020). Table 3 shows that there is no statistically significant difference in the perception of the suitability of the variables at $p > 0.05$ level for the 15 uptake capability measures. This implies that both contracting and consulting organisations agree that the variables are adequate for assessing the BIM Level 2 uptake capability of organisations. Although, differences could be noticed in the mean values of each of the variables across the groups, such as "perception on ease of use of Level 2 facilities" with (mean score = 3.92, SD = 0.92) and (mean score = 3.72, SD = 1.00) for contracting and consulting, respectively. Despite the disparity in the ratings, no significant difference was revealed by the one-way analysis of variance. For instance, concerning the variable "perception on ease of use of Level 2 facilities", $F(1, 71) = 0.76$, $p = 0.386 > 0.05$, the type of firm did not have a significant impact on opinions on its suitability for uptake capability assessment. Since all the variables scored above the average mark of 2.50, they were all considered suitable for the succeeding stage of the research. In the succeeding stage, respondents were asked to rate their organisation's BIM Level 2 uptake capability. Presented in Table 4 is the outcome of the rating.

Table 3: Suitability of measures for appraising uptake capability

Measures of uptake capability	**Contracting Mean**	**Contracting SD**	**Consulting Mean**	**Consulting SD**	**Overall Mean**	**Standard Deviation (SD)**	**Rank**	**F**	**Sig (*p-value*)**
Understanding of the benefits of BIM adoption	4.08	1.01	3.81	1.06	3.95	1.03	1	1.29	0.26
General awareness on BIM	3.76	1.09	3.97	0.89	3.86	0.99	2	0.83	0.36
Cost of acquisition and maintenance of relevant facilities	3.89	0.92	3.81	0.98	3.85	0.94	3	0.14	0.71
Perception on ease of use of Level 2 facilities	3.92	0.92	3.72	1.00	3.82	0.96	4	0.76	0.39
Current level of use of BIM related facilities such as CAD	3.78	1.13	3.81	0.92	3.79	1.02	5	0.01	0.93
Available structure for continuous training of staff	3.89	0.77	3.56	1.11	3.73	0.95	6	2.27	0.14
Readiness to immediately work on a BIM-based project	3.68	0.94	3.74	1.08	3.70	1.00	7	0.06	0.80
Affordability of the cost of training existing staff	3.56	0.94	3.83	0.97	3.69	0.95	8	1.52	0.22
Availability of well-trained staff on BIM	3.84	0.90	3.43	0.92	3.64	0.92	9	3.66	0.06
Workflow, practices, and procedural changes necessary to adopt BIM are not problematic	3.64	0.99	3.61	1.08	3.63	1.02	10	0.01	0.91
Current workers' experience and knowledge on BIM usage	3.76	0.93	3.31	1.06	3.53	1.01	11	3.74	0.06
No tendency to outsource BIM related activities	3.35	1.18	3.56	1.08	3.45	1.12	12	0.59	0.44
Level of understanding of legal and contractual issues involving BIM	3.43	1.26	3.33	1.39	3.38	1.31	13	0.10	0.75
BIM usage level within the past two years	3.22	1.05	3.21	1.12	3.21	1.07	14	0.00	0.95
No desire to retain the use of the traditional method	3.38	1.04	3.03	1.25	3.21	1.15	15	1.70	0.20

Organisations' rating on BIM level 2 uptake capability

Table 4 shows the ranking in descending order of 15 BIM Level 2 uptake capability descriptors, according to the overall average mean scores. The mean score for contracting firms ranged from 3.24 to 3.97 while it ranges from 3.22 to 4.03 for consulting and 3.34 to 3.89 for the overall average mean. It is interesting to observe the differences in the ranking of the organisations on the uptake capability criteria. Contracting organisations scored highest on the descriptor "perception on ease of use of Level 2 facilities" (mean = 3.97; SD = 0.96) while the criteria ranked 6th based on the assessment of engaged consulting organisations (mean = 3.67; SD = 0.89). The variable had the second-highest overall mean score (mean = 3.82; SD = 0.93). Merely looking at the means scores, the values seem not to be extremely far apart, the analysis of variance (ANOVA) test used to verify the hypothesis of no difference in the rating of contracting and consulting organisations indicated that there is no statistically significant difference in the rating of organisations "perception on ease of use of Level 2 facilities", $F(1, 71) = 1.99$, $p = 0.16 > 0.05$ (Table 4). Concerning "general awareness on BIM", contracting organisations were rated high, 2nd of 15 indicators (mean = 3.81; SD = 0.81) while it was rated 4th on the order of uptake capability with respect to consulting firms (mean = 3.72; SD = 1.14), it was number 3 based on the overall mean (mean = 3.77; SD = 0.98). ANOVA test also confirmed that there was no statistically significant difference in the ratings of the two types of organisations on this variable, $F(1, 71) = 0.15$, $p = 0.7 > 0.05$ (Table 4). Based on the overall mean, the mean values of the top five uptake capability descriptors ranged from 3.67 to 3.89. The top five descriptors are "Understanding of the benefits of BIM adoption" (mean = 3.89; SD = 0.97), "perception on ease of use of Level 2 facilities" (mean = 3.82; SD = 0.93), "General awareness on BIM" (mean = 3.77; SD = 0.98), "Current workers' experience and knowledge on BIM usage" (mean = 3.67; SD = 0.93), "Current level of use of BIM related facilities such as CAD" (mean = 3.67; SD = 1.13). ANOVA test also confirmed that there was no statistically significant difference in the ratings of the organisations on the top 5 and on a total of 14 out of 15 descriptors. Olugboyega and Aina (2018) submitted that 2D and 3D BIM are largely in use in Nigeria. Interestingly, the mean scores according to organisation types and the overwhelming non-statistically significant difference among the organisations signify the consistency of organisations on uptake capability and this indicates a prospect for advancement in the use of BIM, i.e., BIM Level 2 and beyond.

One interesting discovery is the existence of a statistically significant difference in the BIM level 2 uptake capability descriptor of organisations in terms of "available structure for continuous training of staff" (overall mean = 3.50, $F(1, 71) = 5.92$, $P = 0.02 < 0.05$). This implies that the type of firm affects the structure available for training in BIM infant industries. The descriptor ranked 2nd for consulting firms while it is the 14th for contracting organisations but placed 10th based on the overall average mean. The top five uptake capability descriptors largely capture the fundamental requirements for level 2 BIM use. Succar et al (2012) highlighted the importance of appreciating how BIM resources need to evolve in harmony with each other to achieve successful and productive deployment of BIM. The descriptor "No desire to retain the use of the traditional method" was rated lowest (overall mean = 3.34; SD = 1.10) with no significant rating difference based on firm types at $p = 0.36 > 0.05$. The capability descriptor ranked lowest, but the mean score is not extremely far from the criteria that were rated 1st and 2nd (understanding of BIM level 2 benefits, mean = 3.89 and perception of ease of use of level 2 facilities, mean = 3.82). This raises thoughts on the uptake capability of the organisations and the actual readiness to progress to BIM Level 2, there seems to be a measure of desire to retain the use of traditional approaches, because "no desire to retain the use of the traditional method" scored lowest. Further, finance has been highlighted as a challenge to BIM in previous studies (Gerges et al., 2017) and to the digitalisation of design and construction processes across regions (Sawhney and Knight, 2022), contracting and consulting organisations do not differ statistically in the mean rating of finance-related BIM Level 2 uptake capability descriptors, i.e., affordability of the cost of training and cost of acquisition of relevant facilities (Table 4). Although the mean score ranking of the descriptors differs based on the type of organisation, none of the mean scores is noticeably low to signify the non-affordability of training and facility acquisition in either organisation.

Table 4: Organisations' scores on BIM Level 2 uptake capability

Measures of uptake capability	Contracting Mean	Rank	Contracting SD	Consulting Mean	Rank	Consulting SD	Overall Mean	Standard Deviation (SD)	Rank	F	Sig (p-value)
Understanding of the benefits of BIM adoption	3.76	4	1.09	4.03	1	0.81	3.89	0.97	1	1.45	0.23
Perception on ease of use of Level 2 facilities	3.97	1	0.96	3.67	6	0.89	3.82	0.93	2	1.99	0.16
General awareness on BIM	3.81	2	0.81	3.72	4	1.14	3.77	0.98	3	0.15	0.70
Current level of use of BIM related facilities such as CAD	3.59	7	1.14	3.74	3	1.12	3.67	1.13	4	0.31	0.58
Current workers' experience and knowledge on BIM usage	3.78	3	0.92	3.56	11	0.94	3.67	0.93	4	1.10	0.30
Cost of acquisition and maintenance of relevant facilities	3.51	9	0.93	3.72	4	0.88	3.62	0.91	6	0.97	0.33
Readiness to immediately work on a BIM-based project	3.65	6	0.86	3.56	11	1.28	3.61	1.08	7	0.12	0.73
Availability of well-trained staff on BIM	3.53	8	1.00	3.64	7	0.96	3.58	0.98	8	0.23	0.63
Workflow, practices, and procedural changes necessary to adopt BIM are not problematic	3.72	5	1.03	3.44	13	1.03	3.58	1.03	9	1.31	0.26
Available structure for continuous training of staff	3.24	14	0.95	3.77	2	0.88	3.50	0.95	10	5.96	0.02
No tendency to outsource BIM related activities	3.32	11	1.25	3.58	10	1.05	3.45	1.16	11	0.92	0.34
Affordability of the cost of training existing staff	3.27	13	0.90	3.61	9	0.93	3.44	0.93	12	2.52	0.12
Level of understanding of legal and contractual issues involving BIM	3.24	14	1.19	3.63	8	1.14	3.43	1.17	13	1.97	0.17
BIM usage level within the past two years	3.30	12	1.10	3.39	14	1.05	3.34	1.07	14	0.13	0.72
No desire to retain the use of the traditional method	3.46	10	1.02	3.22	15	1.17	3.34	1.10	15	0.85	0.36

Exploratory factor analysis – underlying interactions

This study went further to conduct an exploratory factor analysis to establish the underlying interaction of BIM Level 2 uptake capability variables using the scores obtained from the ratings of organisations on uptake capability. Exploratory factor analysis reveals the interaction or underlying relationship between observed or measured variables and unobserved constructs. This is meant to aid the interpretation of the BIM Level 2 uptake capability of organisations in a BIM infant construction industry. A minimum Eigenvalue of 1.0 was used as a factor selection criterion and this resulted in the extraction of three (3) factors. An Eigenvalue quantifies the amount of variance in variables explained by a factor. The factor with the highest eigenvalue has the highest variance, and so on. The eigenvalue is used by a researcher to determine the number of factors to interpret in factor analysis. Usually, interpreting factors with Eigenvalues greater than one has become a common standard among other approaches, this is known as the Kaiser-Guttman rule (Pohlmann, 2004). The selected factors explained a cumulative variance of 53.28% in the BIM level 2 uptake capability of the organisations. The percentage explained is above the recommended minimum of 50% (Fornell, & Larcker, 1981) and compares reasonably with the 58.68 % obtained by Osei-Kyei and Chan (2017) and 56.04% of Gao et al (2016). The factor loadings are presented in parenthesis in front of each factor group constituents with corresponding eigenvalues also stated for each factor. It should be recalled that variables are meant to be interpreted with a focus on BIM Level 2 uptake capability.

A reliability test, also described as a check for internal consistency was carried out separately on each of factors 1, 2, and 3 using Cronbach's Alpha, a value of 0.720, 0.665, and 0.730 was obtained, respectively. Since all the factors have alpha scores above the recommended minimum threshold of 0.5 (Hairs et al, 2010), it can be concluded that the three (3) factors are reliable factor groups. The last set of variables was decided after it was checked and confirmed through the "Cronbach value if variable is deleted" function in factor analysis that nothing else could enhance the Cronbach values. It should be noted that some variables out of the initial 15 variables have been eliminated by factor analysis as they could not contribute enough to any of the factors based on an inclusion factor loading threshold criterion of 0.40. Factor analysis revealed three (3) factor groups that explain a total of 53.28% of the variability in uptake capability as discussed below. The potential influence of the uptake capabilities on each other cannot be completely ignored. This explains the choice of Maximum likelihood extraction and Direct Oblimin rotation eventually adopted in this study. It is a much more rigorous exploratory factor analysis approach, and it is believed to generate very reliable results. The options do not assume that factors exist independently, but rather exhibit a measure of correlation. "Workforce capacity and continuous development", "affinity for innovation", and "Strength in physical and operational facilities" were the three factors extracted in this study. This has several implications but one important one among them is the fact that it shows the directions in which capability exists in BIM infant construction industries.

Presented in Table 5 is the summary of the exploratory factor analysis.

Table 5 Summary of exploratory factor analysis

Factors	**Factor loading**	**Cronbach's Alpha**	**Variance explained (%)**
Workforce capacity and continuous development	0.962	0.720	20.34%
	0.445		
Affinity for innovation	0.879	0.665	13.32%
	0.656		
	0.474		
	0.443		
Strength on physical and operational facilities	0.804	0.730	19.62%
	0.735		
	0.561		

Factor 1: Workforce capacity and continuous development

Workforce capacity and continuous development are indeed important to BIM Level 2 uptake. Unfortunately, Sawhney and Knight's (2022) report on construction digitalisation across continents among other studies identified the availability of skilled persons as a challenge to the construction industry. Olanrewaju et al (2020) also emphasised the importance of training for BIM deployment. The BIM infant construction industry is naturally expected to experience inadequacy in this area. However, based on the constituents of 'Factor 1' the main issue appears to be how to effectively harness the available capacities and coordinate them to achieve BIM targets. Factor 1 explains the highest variance among the factors with 20.34%. The variable with the highest loading is the availability of well-trained staff on BIM (0.962), followed by the second component "availability of structure for continuous training of staff on BIM" (0.445). This factor has an Eigenvalue of 2.856. Since issues of staff capacity and staff training involve workforce capacity and protocol for workforce development, Factor 1 was named "*Workforce capacity and continuous development"*. Onungwa et al (2017) submitted that there is very limited knowledge of BIM in Nigeria. Of course, there are different levels of knowledge on BIM, a more recent picture shows that there is considerable knowledge, especially among those that have a CAD experience. As pointed out by Onungwa et al (2017), there is very limited evidence of collaboration among organisations. In the context of this research, Onungwa's submission can be interpreted to mean that further development is needed to boost the workforce's capacity and knowledge to effectively function in a collaborative BIM Level 2 environment. Note that BIM Level 2 involves the incorporation of data for construction sequencing and cost data (Tekla Campus, 2021) while BIM level 3 requires a central hosting site where the single federated model is maintained. Capable staff and continuous staff development are germane to the effective deployment of information and communication technology-related facilities. Capabilities and skills are clear strategies required for facilitating BIM deployment (Ma *et al*, 2020). Building capabilities have frequently been identified as a challenge in developing countries (Newton and Chilese, 2012). Awareness and training in BIM remain a key issue industry-wide (Saka and Chan, 2019; Babatunde *et al*, 2020). Despite the general industry-wide challenges, inferring from the constituents of Factor 1, the crop of organisations with BIM experience in the industry have workforce capacity suitable for BIM Level 2 uptake. There are also opportunities for training and development, but the mode and the richness of the skill development opportunities will have to be explored further.

Factor 2: Affinity for innovation

This factor explains 13.32% of the variance, the components are 'no tendency to outsource BIM-related activities (0.879)', the current level of use of BIM-related facilities such as CAD (0.656) and understanding of the benefits of BIM adoption (0.474), no desire to retain the use of the traditional method (0.443). This factor has an Eigenvalue of 1.898. Factor 2 was named 'affinity for innovation' based on the meaning of the contributory constituents, the constituents describe organisations' orientation, the extent of the currently existing acceptance of a phase of BIM and a desire for further change and improvement. These attributes are entities describing the affinity of the organisation to new concepts. This underlying relationship looks interesting because logically the existing level of use of BIM-related facilities can greatly affect an organisation's tendency to outsource BIM-related activities or projects. The retention of these variables implies that they all significantly contribute to Factor 2. It also implies that the surveyed organisations have understood the benefits of BIM which according to literature include improved visualisation, productivity, constructability, and clash reduction (Newton and Chilese, 2012). The affinity of an organisation for innovations is a huge step towards progressing to subsequent levels of BIM. Chan et al (2019) stated that resistance to change as well as an organisational structure that does not support BIM is among the top two barriers to BIM implementation in Hong Kong. Gerges *et al* (2017) also identified resistance to change as a key inhibitor. Resistance has always been a challenge to the uptake and advancement on the ladder of innovations but resistance to innovation is sometimes borne out of a lack of capacity and uncertainty of when or how skills can be built (Dibrov, 2015). The existence of a devoted team might help in further tackling this challenge in any organisation and this will enhance the uptake of BIM level 2 in BIM infant industries. A further drive for government mandate will also help adoption (Saka and Chan, 2019) and progression to BIM level 2. The emergence of "Affinity for innovation" as a factor is an indication that the BIM infant industry is open to innovative strategies.

Factor 3: Strength in physical and operational facilities

Saka and Chan (2019) among other studies highlighted the importance of software and other resources to the BIM process. Previous studies have also described BIM as a technology-oriented process, and inadequate physical and operational resources have been highlighted as a key concern to BIM utilisation (Olanrewaju *et al*, 2020, Saka and Chan, 2019). However, this study set out to establish BIM Level 2 uptake capability and factor 3 - *strength in physical and operational facilities* emerged as a factor. This suggests that relevant facilities are not completely unavailable but perhaps require better coordination to achieve specific BIM goals. Factor 3 explains 19.62% of the variance and it consists of three components which are: BIM usage level within the past two years (0.804), current workers' experience and knowledge of BIM usage (0.735), and readiness to immediately work on a BIM-based project (0.561). This factor had an Eigenvalue of 1.177. The use of a stage of BIM especially in the past two years signifies the presence of relevant facilities, current workers' experience, and knowledge highlights operational capacity, while the readiness to immediately work on a BIM-based project highlights the company's readiness to serve, even at a higher phase of BIM. These attributes denote the existence of physical and operational facilities, hence, the name of Factor 3. The 19.62% of the variance explained by the factor is the second-largest variance explained by the extracted three. Ibrahim (2012) described BIM usage in Nigeria as stagnant, but Hamma-adama et al (2017) submitted that BIM is only limited to the use of 2D and 3D architectural and structural models with the evidence of usage across small to large organisations. The "usage of BIM in the past 2 years" as a measure of uptake variable is an organisation's continuous engagement with relevant BIM facilities. The retention of these measures by factor analysis describes the significance of their contributions to this factor. This implies that the BIM infant industry has strength in physical and operational facilities. This outcome tends to contradict the findings of studies that highlighted the non-availability of technological facilities and resources as a barrier (Babatunde *et al*, 2020, Ma *et al*, 2020, Olanrewaju *et al*, 2020, Saka and Chan, 2019). Actually, it is not contradictory, the current study focused on firms with BIM experience, they might be the ones with the needed BIM facilities. Nevertheless, this study submits that the physical and operational facilities required for BIM Level 2 are available, this was inferred based on the constituents of factor 3. If there are no facilities, the three constituents of this factor will not emerge. Bew and Richards (2008) illustration of maturity indicate that growth occurs in phases. Importantly too, Succar et al (2012) highlighted the importance of appreciating how BIM resources need to evolve in harmony with each other to achieve successful and productive deployment of BIM, once there is a compromise of facilities the tendency of effective implementation becomes uncertain. There is always room for an increase in facilities, organisations can surely become better.

Conclusions

This study presented the outcome of a questionnaire survey that aimed at examining BIM Level 2 uptake capability in a BIM infant construction industry. Fifteen uptake capability assessment measures, meant to be interpreted in the context of BIM Level 2, were identified from literature synthesis. The measures were verified by professionals and confirmed suitable for the purpose. The topmost five measures with respect to organisation mean ratings are: understanding of the benefits of BIM adoption, perception of ease of use of Level 2 facilities, general awareness of BIM, the current level of use of BIM-related facilities such as CAD, current workers' experience, and knowledge on BIM usage (Table 4). The finding suggests that both contracting and consulting organisations are well-positioned to deploy BIM Level 2, mean scores are greater than 2.5 for all the capability assessment measures (Table 4). The mean score and ratings of the uptake capability measures differ among contracting and consulting firms, but the differences are not statistically significant. This implies that both contracting and consulting firms are both capable and ready to partake in BIM Level 2 process. The factor analysis identified three components (workforce capacity and continuous development, affinity for innovation, and strength in physical and operational facilities) that summarise BIM Level 2 uptake capability in a BIM infant industry. The components are a highlight of the significant attributes relevant to BIM Level 2 uptake and available in the BIM infant industry.

Significant contributions and implications

The significant contributions of this study include the identification of ordered BIM Level 2 uptake capability measures. The measures can be utilised in other studies for organisation assessment or other relevant purposes. Another significant contribution of the study is that it provides an insight that enhances understanding of the significant capabilities (workforce capacity and continuous development, affinity for innovation, strength in physical and operational facilities) available to explore for comprehensive BIM Level 2 deployment in Nigeria and potentially, other BIM infant construction industries. The perspective of capabilities available to exploit has not received significant research attention, more focus has previously been on barriers and general drivers to BIM adoption. Another main contribution of this study is that it expanded efforts made towards assessing BIM uptake by exploring the uptake capability of organisations on a specific BIM Level, BIM Level 2.

This study provided some practical and theoretical implications. Firstly, the identified level of BIM Level 2 awareness, perception of ease of use, understanding of benefits, as well as experience and knowledge in the construction industry implies that efforts made towards canvassing for the use of BIM is yielding results, BIM infant industries have huge potential for progress in BIM. Secondly, contracting organisations need to invest more in the training structure for BIM Level 2 and related skills, significant attention also needs to be placed on developing skills on BIM legal and contractual issues. Thirdly, the findings of the study imply that the capabilities needed to significantly improve the construction industry largely exists in BIM infant industries, they only must be intentionally and fully exploited for the right causes. The existence of significant capabilities such as workforce capacity, an affinity for innovation, and strength in physical resources is an indicator of great potential for BIM Level 2 deployment and general construction industry growth. It is a path to participating in the global construction digitalisation agenda. This study presents an empirical image of BIM infant construction industries from one angle of construction digitalisation, this is expected to influence the perception of the global society about the BIM Level 2 potentials of BIM infant industries. This study also provides policymakers and BIM strategists with information on the capabilities available to explore towards achieving BIM Level 2 goals in the BIM infant industry. Irrespective of existing thoughts and information on the uptake capability of firms in BIM infant construction industries, the empirical results in this study should steer debate, self-appraisal, and a rethink of organisations' disposition to collaborative BIM uptake and usage. It is understood based on the principles of variation in technology adoption patterns initiated by diverse reasons captured by innovation diffusion theory and others, that innovation cannot diffuse at the same pace in countries and organisations. Three pillars that can facilitate the deployment of BIM Level 2 in a BIM infant industry have been identified by this study.

Limitations and recommendations for future studies

Despite the contributions of this study, some limitations can be highlighted. In terms of geographical coverage, data was collected in single construction industry, a BIM infant industry, but caution should be applied while generalising the findings. Future research should consider a wider coverage, such as more than one BIM infant construction industry. Also, future research can adopt qualitative methods such as interviews, this will allow further probe into BIM Level 2 uptake capabilities and how the capabilities can be better harnessed. Lastly, future studies can expand and further refine the list of uptake capability measures utilised in this study.

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