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Building Information Modelling (BIM): Drivers, barriers and socio-economic benefits

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Abstract:
Building information modeling (BIM) is promoted as a change agent capable of eliminating industrial complexity, increasing productivity and bringing down the high costs associated with insufficient interoperability. The aim of this study is to investigate related issues on BIM, with the intention to enhance its implementation and benefits in Nigeria. The study's objectives are to examine the drivers and barriers; and also assess the socio-economic benefits of BIM in the Nigerian construction industry. Lagos State was chosen as the research area due to the volume of ongoing developments in the State. Construction professionals working in consulting, contracting and client organizations constituted the population of this research. Responses from these targeted respondents were collected using purposive sampling strategy. A total of 100 structured questionnaires were circulated, and 55 of them were returned appropriately, indicating 55% response rate. Statistical tools including frequencies, percentages, mean scores, and ranking were used to analyze the data. The study revealed the key drivers for BIM implementation in Nigeria as professionals' training and preferences for BIM. The study also uncovered several barriers impeding BIM implementation, out of which societal beliefs amongst the industry players and lack of proof of financial benefits are topmost. Moreover, better project quality and performances were the socio-economic benefits of BIM discovered. The study concludes that although there are 19 barriers to the adoption of BIM in Nigeria, the most significant are societal beliefs and the absence of concrete evidence of financial benefits of BIM. The implication is that BIM usage can be enhanced in Nigeria if professionals take conscious effort in determining and documenting the financial gains of BIM on their projects. The study recommends strategies should be developed to mitigate the barriers impeding BIM implementation, especially in the areas of lingering societal beliefs and the absence of concrete evidence of financial benefits. This can be achieved via the objective acceptance of the technology by the contractors without any conflict of interests.

***Keywords*: Barriers, Benefit, Building Information Modeling, Drivers, Socio-economic.**

1.0 Introduction

The construction sector is faced with difficulties in striving to stay up-to-date with the pace of technological innovation and preferences of stakeholders and end users. Aghimien and Oke (2015) noted that a client who commissions a building project will at least anticipate receiving a building that meets his requirements for quality, time and cost. Stakeholders focused their efforts on building a system that is sustainable and efficient to make the construction industry competitive globally (Ojelabi, Omuh & Olushola, 2019). Such efforts resulted in the creation of a computerized tool termed Building Information Modelling (BIM). Takim, Harris, and Nawawi (2013) noted that the use of BIM in the building sector has resulted to beneficial change in the built environment. The introduction of BIM into the built environment has transformed the construction sector. BIM is a driver for advancement and increased efficiency in the built environment (Bui, Merschbrock & Munkvold, 2016). Abdullah and Ibrahim (2016) posit that BIM was created as a framework for addressing the limitations of conventional Computer Aided Drawing (CAD) systems, by offering a functional digital interface that integrates essential details of a building in an electronic filing system that is utilized by the various project stakeholders. BIM was characterized as a virtual display of a project's functioning aspects (Aouad, Wu, Lee & Onyewobi, 2014). BIM possesses the ability to change the way the building industry operates, culminating to continuous improvement and expected changes that will improve contractual parties' collaboration and project success (Azhar, 2011). It provides numerous benefits to the building industry, including structural health monitoring, quantity measurement, cost control, coordination, 4D scheduling, clash detection, facility management, improved customer satisfaction, resource allocation, transparency and accountability in decision making, optimized site layouts and site logistics to mention a few (Volk, Stengel & Schultmann, 2014; Kushwaha 2016).

However, despite the drivers and benefits associated with BIM, there remain obstacles to its deployment to construction. According to Babatunde, Udeaja and Adekunle (2020), BIM has not been generally adopted by Architectural Engineering and Construction (AEC) organizations in developing nations. The reasons cited include the construction industry's structure; lack of access to relevant technology and framework; lack of BIM technical know-how and awareness; individual perspective; absence of adequate BIM guidelines; working environments; and initial large capital outlays. Similarly, Gardezi, Shafiq, Nuruddin, Farhan and Umar (2014) believe that impediments to its adoption include shortage of experienced staff, BIM ownership, necessity of a standardized BIM methodology, suitable technological interface and high implementation cost. In this regard, Jadhav and Ghadge (2016) opined that barriers to BIM implementation include personal attitudes toward BIM adoption; workers' attitudes toward new technology; risks associated with using unproven moves and methods; data inoperability; and compatibility of digital design information. BIM tools are also costly, sophisticated and difficult to get (Fatima, Saleem & Lamgir, 2015).

According to Waterhouse and Philp (2013), BIM implementation rose in the UK from 13% to 39% between 2010 and 2012, but awareness decreased from 43% to 6%. Between 2008 and 2012, the AEC sector in the United States increased its use of BIM from 28 percent to 71 percent, while China's use greatly increased. It was believed that the design and construction of the Beijing Olympic Stadium in China would have been impossible without the use of BIM. Other notable projects procured with BIM in developed nations include the Paris Museum, which involved 10 companies from around the world; China's Shanghai Tower, which has a 120° spiral rotation to reduce wind loads against the glass façade by 24%, with a $58 million construction cost savings; and the Sutter Health Eden Medical Center in Castrol Valley, California, U.S.A., which was built in five years instead of seven years with a strict budget. There are no known such national projects in Nigeria constructed with BIM, signifying that Nigeria is yet to embrace BIM fully-fledged due to several issues. Thus, this study aimed at investigating issues related to BIM implementation in Nigeria. The study's objectives are to identify the drivers of BIM; examine its significant barriers and assess the socio-economic benefits in the Nigerian Construction Industry (NCI). This study will contribute significantly to the implementation of BIM, in addition to solving some of the barriers impeding BIM in Nigeria.

2.0 Literature Review

2.1 Drivers for Building Information Modelling Adoption

The drivers for BIM adoption, according to Sinclair (2012), are establishing collaborative and integrated working methods; teamwork among all designers on a project; new procurement routes and forms of contracts aligned with the new working methods; the presence of employees with BIM experience; software interoperability; and the development of BIM standards. Validation of BIM tools; top management support; and integration and coordination between professions are also facilitators of BIM (Tsai, Monn & Hsieh, 2014). Moreover, Kiani, Sadeghifam, Ghomi and Marsono (2015) reckons that government support; staff training; decreased price of BIM software; teaching BIM in universities; provision of legislation on BIM usage; and organisation cultural change are among BIM facilitators. Additionally, Takim *et al.* (2013) revealed that regulation, policy and policy standards, economic demand in the AEC industry, contractors' benefit and competitive advantages are the topmost drivers of BIM adoption. In the same vein, Zahrican, Ali, Haron, Pointing and Hamid (2014) opine government's support and enforcement of BIM implementation, promotion of BIM training programs, top management support and grant programs for BIM training as the main factors that drive BIM implementation. Similarly, Lee, Yu and Jeong (2013) reported that topmost drivers of BIM adoption are government and client pressure of BIM utilization, provision of training programs, forcible requirement of BIM utilization through company's policy at the organisation levels and the individual or organizational confidence in the utilization of new technology. Whereas, topmost drivers of BIM according to Eadie, Odeyinka, Browne, Mahon and Yohanis (2014) are government pressure, client and competitive pressures.

2.2 Barriers to Building Information Modelling Implementation

BIM implementation in the construction sector is confronted with barriers despite its benefits, availability of its software and technology. This is partly due to the need for definite transaction business process models; adequate practical methods for purposeful exchange of meaningful information between industry-process tools users; and computable digital design data (Bernstein & Pittman, 2004; Oh, Lee, Hong & Jeong, 2015). According to He, Wang, Luo, Shi, Xie and Meng (2017), the estimated dissemination rate of BIM among parties has remained lower than previously anticipated. In this regard, Azhar, Khalfan and Maqsood (2012) reveals BIM risks and barriers as technology and process related. Technology related includes lack of BIM standards for model integration and management by multidisciplinary team. Currently, each organization adopts their standards since there's none generally acceptable, which can create inconsistencies. Another one is interoperability of BIM software applications. The process-related risks include legal, contractual and organizational risks. A notable danger is the lack of determination of BIM data ownership and the necessity to safeguard it through copyright laws and other legal channels (Azhar, Nadeem, Mok & Leung, 2008). Similarly, Ku and Taiebat (2011) identify BIM constraints as high costs, stakeholder resistance, learning curve and lack of experienced employees, interoperability, lack of legal/contractual agreement and lack of collaborative work methods and modeling standards. Moreover, Olanrewaju, Cileshe, Babarinde and Sandanayake (2020) identified lack of understanding, absence or ineffectiveness of government programs and high cost of execution. Additionally, Howard, Restrepo and Chang (2017) investigation on the factors impeding the adoption of BIM in the UK found that users' perceptions of BIM is a barrier. According to Eadie *et. al.* (2014), the degree of change necessary, lack of supply chain buy-in and lack of flexibility are the biggest obstacles to BIM adoption. According to Mohammed, Hasnain and Quadir (2019), the biggest obstacles to BIM adoption include lack of demand and supply for BIM, unqualified architects and engineers, owners who are uninformed of the benefits of BIM, and lack of organizations encouraging construction businesses to use BIM. As a result, Zahrican *et. al.* (2014) discovered lack of government/client demand, as well as lack of knowledge of BIM as barriers to adoption. Similarly, Nanajkar (2014) discovered that the expense of software and hardware, lack of staff training, aversion to change and the delayed acceptance of technology are all impediments to BIM adoption. According to Kiani *et. al.* (2015), the biggest barriers to BIM adoption include lack of legislative authority, shortage of skilled BIM software operators, high software prices, uncertainty about the benefits of using BIM and lack of customers' demand.

2.3 Socio-economic Benefits of Building Information Modelling Implementation

Using BIM can provide an array of benefits. The inclusion of a digital system that could be used across a building's life cycle; increased design versatility; enhanced drawing accuracy; improved performance; conflict identification; easier equipment; asset maintenance and management; and increased safety are a few of these benefits (Li, Wang, Wang, Luo, Kang, Wang & Jiao, 2014). Other benefits include contributions to the advancement of design (Newton & Chileshe, 2012). Adopting BIM provides a number of advantages, from project design and planning through construction to operation and maintenance. Budget-related, schedule-related, design-aspect-related, communication-related and documentation-related benefits of BIM were categorized by Latiffi, Mohd, Kasim and Fathi (2013). Baddeley and Chen (2015) further identify benefits of BIM, such as improved collision detection, greater coordination, better synchronization, better project scheduling and the ability for the project team to access and query project data. Ahzar *et. al.* (2015) opined that BIM is advantageous to owners, designers, builders and facility managers in a variety of ways. Eastman, Eastman, Teicholz, Sacks and Liston (2011) enumerated the following advantages of BIM for project owners: early design evaluation to accomplish project objectives; simulation of activities to ascertain building performance and maintainability; low financial risk due to good estimated costs and reduced change orders; effective project marketing through the use of 3D renderings and walk-through graphics; and all details of buildings and systems in single files. According to Al-Ashmori, Othman, Rahmawati, Amran, Sabah, Rafindadi and Mimic (2020), the most significant advantages of adopting BIM in Malaysia include time and cost estimates for design changes; increased productivity and efficiency; elimination of design clashes; improved multi-party communication and maintenance of synchronized communication; identification of time-based clashes; integration of scheduling and planning for construction; and monitoring and tracking of construction progress. Increased team and member integration beginning with the project's early design phases will optimize the advantages of employing BIM (Porwal & Hewage, 2013). According to Bryde, Broquetas and Volm (2013), for BIM to be effective, integration and cooperation amongst diverse project teams must be improved. Indeed, the improved information availability and enhanced information management are reasons for the benefits of BIM (Dainty, Moore & Murray, 2006; Ahuja, Yang & Shankar, 2009). Emmanuel-Eze, Ugulu and Egwunatum (2021) posited that exposing other stakeholders and contractors to the benefits of BIM might encourage and accelerate the industry's use of the technology (Ibrahim, Hasim & Jamal, 2019). Knowing the advantages of a new method might cause demand and supply to increase, resulting in the development of a market (Emmanuel-Eze et al., 2021). Makabate, Musonda, Okoro and Chileshe (2021) argued in favor of greater research into the advantages of BIM in order to promote its usage and adoption in the architecture, engineering and construction sectors. According to Matarneh and Hamed (2017), the top benefits of BIM in Jordan's construction industry include minimizing re-work throughout construction; increasing productivity; reducing dispute; clash detection; enhancing collaboration and communication; improving visualization; improving project documentation; using a quicker and more efficient method; improving quality; and enhancing design review. BIM makes it possible to visualize the constructed environment, improves the accuracy of predicted field conditions and allows greater off-site material prefabrication (Rajedran & Clarke, 2011).

3.0 Research Methodology

Survey research was the research strategy adopted for this investigation in Lagos State. This study area was chosen because it is the largest city in Africa with a population of over 25 million as at the first quarter of 2022. Construction professionals working in consulting and contracting companies in Lagos State constituted the study's population. The targeted respondents were professionals who have used BIM on their projects. A sample of 100 respondents from the population were chosen via purposive sampling technique. The purposive sampling approach, according to Maxwell (2005), is a kind of sampling in which specific participants or situations are purposefully chosen for the significant information they may supply. Self-administered questionnaires were used in the survey to collect data from the respondents. The questionnaire comprised four sections, A to D. Section A comprised the demographic data for the respondents and organizations. Section B focused on identifying the drivers of BIM using a 4-point Likert scale, with 1 denoting strongly disagree, 2 denoting disagree, 3 denoting agree and 4 denoting strongly agree. Section C assessed the significance of 19 barriers based on development and technology using a 5-point Likert scale, with not significant (1) being the least important and most significant being the topmost significant (5). While Section D concentrates on the benefits of BIM, 1 indicates strongly disagree, 2 indicates disagree, 3 indicates agree, and 4 indicates strongly agree on a 4-point Likert scale. A total of 100 questionnaires were distributed to the respondents on purpose. A total of 55 copies were correctly filled and returned, representing response rate of 55%. The data obtained were analyzed with the statistical package for social sciences (SPSS) version 23.0. The statistical tools deployed were frequency distribution, percentages and mean scores.

4.0 Results and Discussions

4.1 Demographic Information

The demograhic information of the respondents and organizations are shown in Table 1.

Table 1 reveals that 69.1% of the respondents work in consulting organizations, 24.6% in contracting organizations, while 7.3% in client organizations. About 12.7% of the respondents work in firms that are between 1-10 years old in the construction industry, 16.4% in organizations that are between 11-20 years old and 70.9% in firms that are above 20 years old. The respondents' profile further shows that 13% of the respondents have Higher National Diploma (HND) degree, 45% hold B.Sc. degree, 40% have Masters degree and 2% have PhD degree. Additionally, 16.36% of the respondents are members of the Nigerian Institute of Building (NIOB), 34.55% are members of the Nigerian Institute of Quantity Surveyors (NIQS), 34.55% are members of the Nigerian Institute of Architects (NIA), while 14.55% are members of the Nigerian Society of Engineers (NSE). Also, 34.55% are Architects, 16.36% are Builders, 34.55% are Quantity surveyors, while 14.55% are Engineers. Besides, 27.27% of the respondents have work experience of between 1-5years, 34.55% have 6-10 years, 14.55% have 11-15 years, 9.09% have 16-20 years, while 14.55% have above 20 years.

Table 1 Demograhic Information

Description	Frequency (n)	Percentage (%)
Type		
Consulting	38	69.1
Contracting	13	23.6
Client	4	7.3
Total	**55**	**100**

Description	Frequency (n)	Percentage (%)
Years in Business		
1 – 10	7	12.7
11 - 20	9	16.4
Over 20 years	39	70.9
Total	**55**	**100**
Academic Qualification		
HND	7	12.73
B.Sc.	24	43.64
M.Sc.	22	40.0
PhD	2	3.64
Total	**55**	**100**
Designation		
NIA	19	34.55
NIOB	9	16.36
NIQS	19	34.55
NSE	8	14.55
Total	**55**	**100**
Designation		
Architect	19	34.55
Builder	9	16.36
Quantity Surveyor	19	34.55
Engineer	8	14.55
Total	**55**	**100**
Experience		
1 - 5	15	27.27
6 - 10	19	34.55
11 – 15	8	14.55
16 - 20	5	9.09
Over 20 years	8	14.55
Total	**55**	**100**

4.2 Drivers of BIM in the Nigerian construction industry

Fourteen drivers were investigated by the respondents and their mean scores and ranks are presented in Table 2. The criterion for selecting a driver is anyone with a mean of 3 and above (i.e. agree) on the Likert scale used. Thus,11 of the 14 were selected as drivers, presented in their descending order of selection in Table 2. Ranking highest is training of professionals with a mean score of 3.45; professionals preference for BIM ranked 2nd (3.35), whilst clients' satisfaction with BIM on projects ranked 3rd (3.27). It thus suffices to say that, there are several drivers for the adoption of BIM in the Nigerian construction industry. However, issues related to more professionals' training and preference for BIM technology are paramount. Training is a crucial requirement for better performance and can raise personal competency levels. Training of more professionals on BIM technology can improve the capabilities, knowledge and skills of the professionals. The role of professionals in driving BIM cannot be overlooked; because of its significant contributory effect on the use of BIM. The task of professionals should go beyond performing technical functions and move on to that of facilitating the adoption of BIM in a complex, dynamic construction environment and according to the growing emphasis in the project management area. Olatunji and Sher (2010) asserted that training of building professionals and the cooperation of stake-holders are considered drivers of BIM technology. Wong and Jang (2010) also noted that the use of BIM by construction professionals requires increased technical training; while, Ede (2014) established that BIM technology marks a paradigm shift for building professionals and construction firms in a bid to satisfy construction clients.

Table 2 Drivers for BIM Adoption in the Nigerian Construction Industry

S/N	Drivers	1	2	3	4	N	TS	MS	RK
1	Training of professionals	4	3	12	36	55	190	3.45	1
2	Professionals' preference	2	4	22	27	55	184	3.35	2
3	Clients' satisfaction with BIM-executed projects	3	3	25	24	55	180	3.27	3
4	Interdisciplinary project-based training	2	7	21	25	55	179	3.25	4
5	Affordability of BIM software and facilities	6	2	19	28	55	179	3.25	4
6	Availability of BIM libraries	4	5	21	25	55	177	3.22	6
7	Incentive programs for the use of BIM	3	7	21	24	55	176	3.20	7
8	Effective collaboration and commitment of professional bodies	6	7	15	27	55	173	3.15	8
9	IT-Driven procurement methods	4	5	26	20	55	172	3.13	9
10	Increase in BIM researches	4	6	28	17	55	168	3.05	10
11	Clients' interest and understanding	4	10	23	18	55	165	3.00	11
12	Codes' mandatory use of BIM	3	10	28	14	55	163	2.96	12
13	Governments' enforcement schemes	6	10	25	14	55	157	2.85	13
14	Governments' legislations	6	12	23	14	55	155	2.82	14

1= Strongly Disagree, 2= Disagree, 3= Strongly Agree, 4= Strongly Agree, MS= Mean Score, N=Number of respondents, TS= Total Score, RK= Ranking

4.3 Significant barriers to the adoption of BIM in the Nigerian construction industry

Nineteen barriers to the adoption of BIM were measured and the mean scores are presented in Table 3. Table 3 identifies significant barriers to the adoption of BIM in the Nigerian construction industry in two categories, development and technological.

Development-based barriers: possible societal beliefs that linger amongst the industry players is the topmost in significance among the 19 (3.33). This is followed in descending order by non-existent of proof of financial benefits (3.20) and limitations empowered by legal and contractual issues (3.11). The opinion of the industry players, informed by their personal belief on BIM goes a long way in convincing clients to use BIM on projects. The industry players are viewed as professionals who are knowledgeable enough to understand the technicalities required in project to attain a successful delivery. As such opinion that is expressed has the potential of either facilitating or discouraging the adoption of BIM in the industry. For the adoption of BIM to witness approval by the populace therefore, industry players must hold a positive belief on its performance, such that potential clients and other industry players would see the need for the adoption. However, the industry players seem not to hold a positive view as regards the adoption of BIM, rather majority yet stick to traditional means of implementing construction. Additionally, for the adoption of BIM to be fully accepted and integrated in construction, most industry construction professionals would require the proof of financial benefits which does not exist. Construction professional are keen on returns on investment as they implement construction project and would readily decline in cases where returns are not guaranteed. Most time, the positives characterized with the adoption of BIM has always been based on project recording a better performance in time, cost and quality among other variables. Focus is hardly on the financial proof of the viability of BIM, hence could serve as a barrier in its adoption. On the issue of limitations empowered by legal and contractual issues, constructional professionals are expected to act in respect of any agreed contract reached on projects, thus, deviation from the stipulated standards may result to conflicts between clients and professionals. Olatunji and Sher (2010) cited that there are inherent problems that limit the use of BIM in the construction industry that must be tackled in the Nigerian context, suggesting the need for well-developed practical strategies. Kolo and Ibrahim (2010) added that inefficiency, lack of capacity to satisfy clients, non-compliance with standard and weak collaborative procedure are the major problems of BIM. The three least significant among the 19 barriers include lack of trained professionals (2.53); lack of partners who have the required knowledge base and experience on BIM (2.49); and lack of technological awareness (2.45). Training has its contributory role it plays in ensuring the adoption of BIM in the construction industry. There appear to be deficiency in training as regards the construction industry, evidenced by the poor performance identified with the industry as it were. As much as there are no sufficient trained professionals pertaining to BIM technologies and partners who have the required knowledge base and experience, the adoption may be difficult to integrate in the construction industry. Of importance more so is technological awareness, whereas there seems to be low awareness among the key industry players on the deliverables of BIM.

Technology-based barriers: highest ranked in significance in this category are BIM’s requirements and protocols (3.13); and consistent internet connectivity (2.98). As it were, the feature of on and offline requirements of BIM is such that places higher demand on users, while this seems not appreciated by the users. The technological environment of BIM is such that is versatile, making the minimum changes necessary to the pre-existing contractual arrangements on construction projects. The aspect of consistency of the internet connectivity further adds to the demands of BIM pertaining. The intermittent nature of internet connectivity is a serious barrier, due to inability to connect to the remote server to carry out functions. Kolo and Ibrahim (2010) established that many change efforts involving the wider adoption of BIM technology have failed miserably, in part due to the inability of many construction firms to integrate effective and efficient interconnectivity. Least ranked in this category are lack of BIM software standardization (2.65); and high cost of integrated software/models (2.62). Standardization of BIM software is intended to provide project consistency and give the project owner the intended format, influencing performance and ensuring that the overall BIM deployment is sustainable. BIM standards that are consistent are especially important when managing many projects with numerous stakeholders, contractors and end users. However, some project owners wind up using their own standards instead of being vigilant about developing and maintaining such standards, which leads to issues in the long term. Further, high cost of integrated software/models poses its barriers, the cost concept been a sensitive one in the construction industry, where efforts are most put into reducing cost and ensuring there is no record of overruns in cost.

Table 3 Barriers in the Nigerian Construction Industry to the Adoption of BIM

S/N	Barriers	1	2	3	4	5	N	Ts	MS	GR	OR
Development Based											
1	Possible societal beliefs that linger amongst the industry players	5	13	10	13	14	55	183	3.33	1	1
2	Non-existent of proof of financial benefits	8	13	6	16	12	55	176	3.20	2	2
3	Limitations facilitated by legal and contractual issues	9	7	18	11	10	55	171	3.11	3	4
4	Clients not interested in the use of the BIM	12	11	12	7	13	55	163	2.96	4	6
5	Lack of demand for the implementation of the BIM Technology	7	14	17	11	6	55	160	2.91	5	8
6	Serious resistance to changing the system	13	12	11	5	14	55	160	2.91	5	8
7	Non-compliance of other stakeholders to the rules of implementation	6	16	19	7	7	55	158	2.87	7	11
8	High entry cost	19	9	6	6	15	55	154	2.80	8	13
9	Lack of policies and legislation to enforce the adoption of BIM	14	13	11	8	9	55	150	2.73	9	14
10	Lack of trained professionals	18	10	14	6	7	55	139	2.53	10	17
11	Lack of partners who have the required knowledge base and experience in BIM	19	10	15	4	7	55	135	2.45	12	19
12	Lack of technological awareness	19	10	15	4	7	55	135	2.45	12	19
Technological											
13	BIM's requirements and protocols	5	11	20	10	9	55	172	3.13	1	3
14	Consistent internet connectivity	9	8	21	9	8	55	164	2.98	2	5
15	High cost of internet connectivity	12	8	16	9	10	55	162	2.95	3	7
16	Poor power supply	10	10	19	8	8	55	159	2.89	4	10
17	Access to fast internet connectivity	14	8	13	12	8	55	157	2.85	5	12
18	Lack of BIM software standardization	15	8	19	7	6	55	146	2.65	6	15
19	High cost of integration software/models	16	9	17	6	7	55	144	2.62	7	16

1= Most Significant, 2= More Significant, 3= Sometimes Significant, 4= Least Significant, 5= Not Significant, MS= Mean Score, N=Number of respondents, GR=Group Ranking, OR= Overall Ranking

4.4 Socio-economic benefits of BIM.

The study also investigate the socio-economic benefits of BIM. The mean score of socio-economic benefits of BIM adoption is presented in Table 4. The highest ranked in 1st position is better quality (3.56); next comes enhanced project performance (3.16); and reduction in construction errors (3.51). All construction stakeholders benefit greatly from BIM's influence on the entire project outcome. BIM provides socio-economic benefits, serving its purpose throughout all phases of construction projects, delivering advantages in terms of better design quality, ease of implementation, information sharing capability, reduction of construction costs and design errors, shorter completion periods and enhanced energy efficiency. According to Becerik-Gerber and Rice (2010), BIM is viewed as a tool that enables the construction industry to increase efficiency by fostering good communication and teamwork amongst all parties from the planning stage through project execution and completion. The least ranked benefits are reduced Requests for Information (RFI) (3.25); reduction in risk levels (3.16): and reduction in the rate of accidents (2.95). There are other benefits that BIM offers, however, the impact of BIM technologies in this respect seems very low. RFIs are generally required to clarify information in the contract documentation or to provide information that was not complete at the time the contract was agreed. It deals more with information dissemination related to the project contract. However, RFIs should become far less necessary as a result of BIM, which should provide better, more thorough and coordinated information to the whole project team. Additionally, every construction project carries some amount of risk, but using BIM has a way of lowering that level throughout the project life cycle. Greater assurance is provided as a result, and projects are effectively completed and their primary objectives are satisfied. BIM can also provide excellent chances to assist detect dangers, hence enhancing health by lowering accidents and fatalities.

Table 4 Socio-economic Benefits of BIM

S/N	Socio-economic benefits	1	2	3	4	N	TS	MS	RK
1	Better quality	0	2	20	33	55	196	3.56	1
2	Enhanced project performance	1	0	22	32	55	195	3.55	2
3	Reduction in construction errors	0	5	17	33	55	193	3.51	3
4	Improved communication and teamwork	0	3	23	29	55	191	3.47	4
5	Design errors detection	0	4	22	29	55	190	3.45	5
6	Efficient cost control	0	4	23	28	55	189	3.44	6
7	Increased labour productivity	0	5	22	28	55	188	3.42	7
8	Resolution of conflicts	0	7	23	25	55	182	3.33	8
9	Cost saving	2	4	24	25	55	182	3.31	9
10	Improved return on investment (ROI)	0	7	24	24	55	182	3.31	9
11	Client/customer satisfaction	1	8	21	25	55	180	3.27	11
12	Reduced RFIs	1	6	26	22	55	179	3.25	12
13	Reduced risk level	2	8	24	21	55	174	3.16	13
14	Reduction in the rate of accidents	2	17	18	18	55	162	2.95	14

1= Strongly Disagree, 2= Disagree, 3= Strongly Agree, 4= Strongly Agree, MS= Mean Score, N=Number of respondents, TS= Total Score, RK= Ranking

5.0 Conclusions and Recommendations

The study investigates issues on BIM implementation in Nigeria. The study's objectives are to identify the forces behind BIM's usage, determine significant barriers and ascertain the socio-economic benefits of BIM in the Nigerian Construction Sector (NCS). The outcomes of the investigation lead to the following conclusions:

1. The main drivers behind BIM adoption in the building industry are professional preference and training amidst several others of lesser consideration. This indicates that receiving proper training is essential for enhancing performance and can raise individual competence levels, which in turn enhance professionals' preferences.
2. Although there are 19 barriers to the adoption of BIM in Nigeria, the most significant are societal beliefs and absence of concrete evidence of financial benefits of BIM. The implication is that BIM usage can be enhanced in Nigeria if professionals take conscious effort in determining and documenting the financial gains of BIM on their projects.
3. There are 14 socio-economic benefits of BIM deployment, the most prominent are better project quality delivery and enhanced performance. This implies that all parties involved in construction will profit greatly from BIM's influence on the final project output.

Based on the inferences made from the study's conclusions, the following recommendations are made:

1. To ensure greater acceptance of BIM in the Nigerian construction sector, frequent training of experts in BIM technologies should be looked into. This may be done by having workshops, seminars, and other BIM-related events held by their professional associations and other organizations in the construction sector.

2. Strategies should be developed to mitigate the barriers impeding BIM implementation especially in the areas of lingering societal beliefs and the absence of concrete evidence of financial benefits. This can be achieved via the objective acceptance of the technology by the contractors without any conflict of interests.

6.0 References

Abdullahi, M., & Ibrahim, Y.M. (2016). Building information modeling. A paper presented at 3-Day Workshop/Annual General Meeting of the Nigerian Institute of Quantity Surveyors, available at: http://niqs.org.ng/wp-content/uploads/2016/ (accessed 20 August 2018).

Aghimien, D. O., & Oke, A. E. (2015). Application of value management to selected construction projects in Nigeria. *Developing Country Studies*, *5*(17), 8-14.

Ahuja, V., Yang, J., & Shankar, R. (2009). Benefits of collaborative ICT adoption for building project management. *Construction Innovation*, *9(3)*, ISSN:1471- 4175.

Al-Ashmori, Y. Y., Othman, I., Rahmawati, Y., Amran, Y. M., Sabah, S. A., Rafindadi, A. D. U., & Mikić, M. (2020). BIM benefits and its influence on the BIM implementation in Malaysia. *Ain Shams Engineering Journal*, *11*(4), 1013-1019.

Aouad, G., Wu, S., Lee, A., & Onyewobi, T. (2014). *Computer Aided Design Guide for Architecture,* *Engineering and Construction.* London: Routledge, Taylor and Francis Group.

Azhar, S., Nadeem, A., Mok, J. Y., & Leung, B. H. (2008). Building Information Modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects. In *Proc., First International Conference on Construction in Developing Countries (ICCIDC – I)*, Karachi.

Azhar, S. (2011). Building information modeling (BIM): trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering, 11*(3), 241-252.

Azhar, S., Khalfan, M., & Maqsood, T. (2012). Building Information Modeling (BIM): Now and Beyond. *Australasian Journal of Construction Economics and Building, 12*(4), 15– 28.

Babatunde, S. O., Udeaja, C., & Adekunle, A. O. (2020). Barriers to BIM implementation and ways forward to improve its adoption in the Nigerian AEC firms. *International Journal of Building Pathology and Adaptation*, *39*(1), 48-71.

Baddeley, M., & Chang, C. (2015). *Collaborative Building Information Modelling (BIM): Insights from behavioural economics and incentive theory*. London: Royal Institution of Chartered Surveyor (RICS)

Becerik-Gerber, B., & Rice, S. (2010). The perceived value of building information modeling in the US building industry. *Journal of Information Technology in Construction (ITcon)*, *15*(15), 185-201.

Bernstein, P. G., & Pittman, J. H. (2004). Barriers to the adoption of building information modeling in the building industry. Autodesk building solutions.

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

Bui, N., Merschbrock, C., & Munkvold, B. E. (2016). A review of Building Information Modelling for construction in developing countries. *Procedia Engineering*, *164*, 487-494.

Dainty, A., Moore, D., & Murray, M. (2007). *Communication in construction: Theory and practice*. London: Routledge. DOI: https://doi.org/10.4324/9780203358641

Eadie, R., Odeyinka, H., Browne, M., Mahon, C., & Yohanis, M. (2014). Building information modeling adoption: an analysis of the barriers of implementation. *Journal of Engineering and Architecture*, *2*(1), 77-101.

Eastman, C. M., Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*. John Wiley & Sons.

Ede, A. N. (2014). BIM: case study of a duplex building project in Nigeria. *International Journal of IT, Engineering & Applied Sciences Research*, *3*(4), 25-28.

Emmanuel Eze, C., Ugulu, R. A., & Egwunatum, S. I. (2021). Green Building Materials Products and Service Market in the Construction Industry. *Journal of Engineering, Project & Production Management*, *11*(2).

Fatima, A., Saleem, M., & Alamgir, S. (2015, December). Adoption and scope of building information modeling (BIM) in the construction industry of Pakistan. In *Proceedings of 6th International Conference on Structural Engineering and Construction Management*, Kandy, Sri Lanka, 90-99.

Gardezi, S. S. S., Shafiq, N., Nuruddin, M. F., Farhan, S. A., & Umar, U. A. (2014). Challenges for implementation of building information modeling (BIM) in Malaysian construction industry. *Applied Mechanics and Materials* , 567, 559-564, Trans Tech Publications Ltd.

He, Q., Wang, G., Luo, L., Shi, Q., Xie, J., & Meng, X. (2017). Mapping the managerial areas of Building Information Modeling (BIM) using scientometric analysis. *International journal of project management*, *35*(4), 670-685.

Howard, R., Restrepo, L., & Chang, C. Y. (2017). Addressing individual perceptions: An application of the unified theory of acceptance and use of technology to building information modeling. *International Journal of Project Management*, *35*(2), 107-120.

Ibrahim, H. S., Hashim, N., & Jamal, K. A. A. (2019). The potential benefits of building information modeling (BIM) in construction industry. In *IOP Conference Series: Earth and Environmental Science*, 385 (1), IOP Publishing.

Jadhav, S., & Ghadge, A. N. (2016). Application of building information modeling in construction projects–A critical review. *International Journal of Engineering Research*, 26-31.

Kiani, I., Sadeghifam, A. N., Ghomi, S. K., & Marsono, A. K. B. (2015). Barriers to implementation of building information modeling in scheduling and planning phase in Iran. *Australian Journal of Basic and Applied Sciences, 9*(5), 91-97.

Kolo, B. A., & Ibrahim, A. D. (2010). Value management: How adoptable is it in the

Nigerian construction industry. In *Conference Proceedings of West Africa Built Environment*, (pp. 653-663).

Ku, K., & Taiebat, M. (2011). BIM experiences and expectations: the constructors' perspective. *International Journal of Construction Education and Research*, *7*(3), 175-197.

Kushwaha, V. (2016). Contribution of building information modeling (BIM) to solve problems in architecture, engineering and construction (AEC) industry and addressing barriers to implementation of BIM. *Int. Res. J. Eng. Technol*, *3*(1), 100-105.

Latiffi, A. A., Mohd, S., Kasim, N., & Fathi, M. S. (2013). Building information modelling (BIM) application in Malaysian construction industry. *International Journal of Construction Engineering and Management*, *2*(4A), 1-6.

Lee, S., Yu, J., & Jeong, D. (2015). BIM acceptance model in construction organisations. *Journal of management in engineering*, *31*(3), 04014048.

Li, J., Wang, Y., Wang, X., Luo, H., Kang, S. C., Wang, J., & Jiao, Y. (2014). Benefits of building information modelling in the project lifecycle: construction projects in Asia. *International Journal of Advanced Robotic Systems*, *11*(8), 124.

Makabate, C. T., Musonda, I., Okoro, C. S., & Chileshe, N. (2021). Scientometric analysis of BIM adoption by SMEs in the architecture, construction and engineering sector. *Engineering, Construction and Architectural Management*, 29(1).

Maxwell, J. A. (2005). *Qualitative Research Design: An Interactive Approach (2nd Ed.)*. Thousand Oaks, C.A: Sage.

Matarneh, R.T., & Hamed, S.A. (2017). Exploring the adoption of building information modeling (BIM) in the Jordanian construction industry. *Journal of Architectural Engineering Technology,* *6*(10), 1-7. DOI: 10.4172/21689717.1000189

Mohammed, A., Hasnain, S. A., & Quadir, A. (2019). Implementation of building information modelling (BIM) practices and challenges in construction industry in Qatar. *Journal of Engineering Research and Reports, 9(1),* 1-9.

Nanajkar, A. (2014). Implementing building information modeling (BIM) at AEC firms in India. Unpublished MSc Thesis, North Dakota State University of Agriculture and Applied Science.

Newton, K., & Chileshe, N. (2012). Awareness, usage and benefits of building information modelling (BIM) adoption–the case of the South Australian construction organisations. *Management*, *3*, 12.

Oh, M., Lee, J., Hong, S. W., & Jeong, Y. (2015). Integrated system for BIM-based collaborative design. *Automation in construction*, *58*, 196-206.

Ojelabi, R. A., Omuh, I. O., & Olushola, A. (2019). Assessment of Building Information Modeling Uptake in the Management of Construction Projects. *Interdependence Between Structural Engineering and Construction Management*, *29*, 1-6.

Olanrewaju, O. I., Chileshe, N., Babarinde, S. A., & Sandanayake, M. (2020). Investigating the barriers to building information modeling (BIM) implementation within the Nigerian construction industry. *Engineering, Construction and Architectural Management, 27(10),* 2931-2958.

Olatunji, O. A., & Sher, W. (2010). Legal implications of BIM: Model ownership and other matters arising. In *Proceeding of the18th CIB World Building Congress,* Salford, UK.

Porwal, A., & Hewage, K. N. (2013). Building Information Modeling (BIM) partnering framework for public construction projects. *Automation in construction*, *31*, 204-214.

Rajendran, S., & Clarke, B. (2011). Building Information Modeling: safety benefits and opportunities. *Professional Safety*, *56*(10), 44-51.

Sinclair, D. (2012). *BIM Overlay to the RIBA Outline Plan of Work.* London, UK: Royal Institute of British Architects (RIBA).

Takim, R., Harris, M., & Nawawi, A. H. (2013). Building information modeling (BIM): a new paradigm for quality of life within architectural, engineering and construction (AEC) industry. *Procedia-social and behavioral sciences*, *101*, 23-32.

Tsai, M. H., Mom, M., & Hsieh, S. H. (2014). Developing critical success factors for the assessment of BIM technology adoption: part I. Methodology and survey. *Journal of the Chinese Institute of Engineers, 37(7),* 845-858.

Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings—Literature review and future needs. *Automation in construction*, *38*, 109-127.

Waterhouse, R., & Philp, D. (2013). *National BIM Report 2013.* London, UK: RIBA Enterprises Ltd.

Wong, J., & Yang, J. (2010). Research and application of building information modelling (BIM) in the architecture, engineering and construction (AEC) industry: a review and direction for future research. In *Proceedings of the 6th International Conference on Innovation in Architecture, Engineering and Construction (AEC)* (pp. 356-365). Department of Civil and Building Engineering, Loughborough University, UK.

Zahrican, Z., Ali, N. M. A., Haron, A. T., Ponting, A. M., & Hamid, Z. A. (2014). Exploring the barriers and driving factors in implementing building information modelling (BIM) in the Malaysian construction industry: A preliminary study. *The Journal of the Institution of Engineers, Malaysia*, *75*(1).