HAMMA-ADAMA, M. and KOUIDER, T. 2019. What are the barriers and drivers towards BIM adoption in Nigeria? In Skibniewski, M.J. and Hajdu, M. (eds.) Proceedings of the 2019 Creative construction conference (CCC 2019), 29 June – 2 July 2019, Budapest, Hungary. Budapest: Diamond Congress Ltd [online], pages 529-539. Available from:https://2019.creative-construction-conference.com/downloads/

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2019

Available online at 2019.creative-construction-conference.com/proceedings/
CCC 2019
Proceedings of the Creative Construction Conference (2019) 000–000
Edited by: Miroslaw J. Skibniewski & Miklos Hajdu

Creative Construction Conference 2019, CCC 2019, 29 June - 2 July 2019, Budapest, Hungary

What are the Barriers and Drivers toward BIM Adoption in Nigeria?

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Abstract

The 'digitalization and collaboration' or Building Information Modelling (BIM) in the construction industry has been gaining momentum in the recent academic engagements. Despite its existence in many industries (i.e. publishing, retailing, financial and travel services) for over a decade, the construction industry is yet to catch up with them. This is due to several challenges whose existence are more dynamic and perhaps generic than static to various countries. The challenges are mostly defined, but their impacts are frequently varied with boundaries; and the same applied to drivers toward a successful BIM adoption. This study aims to establish barriers and drivers to adopting BIM across Nigerian construction industry professions for synchronization and collective engagements. Primary data was fetched from professional stakeholders (Architects, Engineers, Builders, Quantity Surveyors, Project Managers and Planners) using online structured questionnaire. A total of 68 valid responses were analyzed using descriptive statistics. The study reveals a significant improvement in awareness level with much better adoption rate; however, the utilization level remain very limited due to lack of clarity, knowledge and guide. Lack of expertise within organizations and within project team as well as lack of standardization and protocols (in descending order) were found as significant barriers to BIM adoption. On the other hand, availability of trained professionals to handle BIM tools, proof of cost savings by its adoption and the BIM software affordability (in descending order) were found as the significant drivers to achieving a quick and effective BIM adoption. Recommendations were made based on the study findings.

Keywords: adoption; barriers; BIM; construction; drivers; Nigeria

1. Introduction

Building Information Modelling (BIM) is the process of creating a digital model of a building or infrastructure facility. The fundamental idea behind BIM is to create and share the right information at the right time throughout the design, construction and operation of a building or facility, in order to improve efficiency and decision making (CIOB). This new paradigm shift in the construction industry is gaining high recognition both in the academic discuss (research) and the industry (application). However, its wide (universal) adoption is facing ordinary challenges but yet persistent within the industry and across the world. These challenges are more the same rather than different; although their significance and uniqueness vary with country. On the other hand, the drivers that facilitate its adoption have similar trend with the barriers.

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BIM is similar to other technologies or innovations, it comes with challenges and barriers while in adoption and implementation process [1,2]. Barnes and Davies [3] revealed the most perceived barriers against BIM adoption by organisations as issue of readiness, high cost of training, and cost of technology investment (hardware and software). This readiness could be the ability to agreeing to change (awareness driven) or technology and manpower readiness. Construction industry is widely known to be conventional and resistive to changes [4]; however, this new technological process has come to stay.

Eadie et al [5] worked on the identification of barriers to BIM adoption and their order of importance, this study revealed so much to the UK BIM adoption strategy and more importantly directing to the most significant barriers as to allow adopters pay more attention to them. However, solving one or more barriers without resolving all will not bring the end to challenges on BIM adoption [1]. Some studies from Nigeria reveal some barriers to adopting BIM [6,7], but not to common professionals or wide market (macro scale).

This study is aimed to fill the gap of differentiating by order of importance, the common barriers vis-a-vis to drivers toward BIM adoption to the stakeholders in Nigerian construction market. This will allow a unified action by policy makers and players in the industry to achieve a common goal.

2. Literature Review

BIM is amongst the most discussed subjects in the AEC and perhaps the most discussed area of development in the AEC process. There are huge development, research and effort to implementation of this new innovative process. Hjelseth [8] compiled five years publications (2007-2017) from Automation in Construction in the field of BIM, his statistics reveal high (>70%) concentration on interoperable technology perspective than collaborative processes. Thus, suggests more to awareness of the real understanding and how BIM influences AEC activities. On the other hand, some investigator believed that researchers have concentrated mostly on adoption and non-adopters, investigating the barriers and drivers, development of models and frameworks [9,10]; albeit there is irregularity in the adoption as well as the implementation across the globe and across different disciplines.

There are several investigations and study on BIM development and usage around the globe. McAuley et al [11] mapped the global overview of BIM adoption, Africa is the only living continent who does not have representation. Interestingly, lessons were set to learn at country levels, especially their respective adoption trends. Several countries around the world have being striving to preserve the digital shift, for example, USA, UK, Australia, Singapore, South Korea, Denmark, Russia and Finland to mentioned but a few are the front runners [11]. There are bodies that survey the BIM adoption and provide Noteworthy BIM Publications (NBPs) from many of these countries, so as to maintain guide and also keep track of the BIM progress. BIM Innovation Capability Programme (BICP) – Ireland; National BIM Reports by National Building Specifications – UK; NATSPEC – Australia; and SmartMarket Report by McGraw Hill Construction – USA are some of the bodies. For world-wide assessment of BIM adoption and its business value, McGraw Hill Construction remains the only source of NBPs [11,12].

In the recent academic discuss, there are several investigations on social aspect of BIM adoption, such as readiness, awareness, level of adoption, capabilities (stages) as well as barriers and driver toward the adoption and implementation [13]. Such efforts (by countries and organisations) played a significant role in revolutionising the adoption process [14]. Sequential studies conducted regarding the challenges faced while adopting BIM were found to be continuous, starting with [6], to [13,15 and 16].

Wang et al [6] also compiled and ranked some challenges faced by Mechanical, Electrical and Plumber (MEP) firms in Nigeria, lack of technical expertise on BIM tools utilisation, lack of awareness of BIM technology as well as high cost of investment on staff training, process change, software and hardware upgrade were the most critical barriers. While Onungwa et al [7] reveal lack of skilled personnel, lack of internet connectivity, and reluctance of other stake holders to use BIM, lack BIM object libraries and lack of awareness of the technology as the main barriers to BIM adoption. Albeit citing lack of adequate support or motivation from leaders and political office holders and lack of trained personnel who are abreast of the latest development in technology as the earlier identified challenges. They also lamented the BIM knowledge gap where most Architects learn on the job as no training is mostly offered.

In NBS report [17], barriers to BIM adoption are named under two umbrellas, internal (i.e. lack of training, expertise and funds to invest) and external (i.e. lack of client demand and lack of big projects that require BIM). The most recent compiled barriers by [13] were grouped into five categories, these include personal, legal, management, cost and technical for convenience in analysis [15]. There are twenty-two compiled BIM adoption barriers that were extracted from 62 publications. Table 1 of [15 p.768-770] presents the summary of the barriers; however, that does not necessarily apply to the entire professional fields, organisations and countries as common. For example, UK reported 18 barriers in their continuous BIM assessment survey [17 p.35], and these barriers are not exactly as those extracted by [15] or those in [6]. However, there are several similarities and common terms across the lists. For example, Khosrowshahi [18] reported many barriers to adopt BIM across UK and assert that the barriers are commonly on organisational readiness. Table 1 below summarises the compiled potential barriers to BIM adoption in Nigeria.

Table 1. Barriers to BIM adoption

S/No.	Barriers to BIM adoption	Reference
1	Lack of expertise within the organisations	[1,6,16,19,20,21,22,23]
2	Lack of expertise within the project Team	[6,16,22,23]
3	Lack of standardisation and protocols	[6,16,22,24]
4	Lack of collaboration among stakeholders	[6,16,24]
5	High Investment Cost	[20,25,26,27,28,29,30,31]
6	Legal issues around ownership, IP & PI insurance	[19,22,26,32,33,34,35,36,37,38]
7	Lack of client demand	[6,22,23,24,39]
8	Lack of infrastructure	[6]
9	Lack of government policy	[6]
10	Industry's Cultural resistance	[20,40,41,42,43]
11	Lack of additional project finance to support BIM	[19,22]
12	Resistance at operational level	[22]
13	Reluctance of team members to share information	[6,19,20,]
14	Return on Investment (ROI) issue	[25,31,43]

Lack of expertise, training and cost are consistently remaining amongst the major barriers to BIM adoption across some countries. Countries like UK [17,44,45,46,47], Malaysia [22] and Nigeria [6,7,48] are example of such. In the UK lack of expertise is attributed to the underperformance of the Higher Education Institutions (HEIs) with mostly low levels of engagement with the industry [49]. While in Nigeria, students are generally trained on ‘file based collaboration’ – 2D and 3D CAD and HEIs are not technically ready to offer BIM training at all [50].

Drivers to adopt innovation are simply the facilitators to adopt the new product or process [23]. The facilitators are the enablers, as resolving the barriers ease the innovation adoption, the same way the drivers support the adoption process. Potential drivers mostly fall under empowerment, leadership, and creative culture; and most barriers are interlinked with drivers. In most cases, removing a barrier is literally providing a motivator. For example, solving lack experts/trained personnel on BIM means providing training on BIM. Table 2 below summarises some potential drivers from previous studies.

Table 2. Drivers to BIM adoption

S/No.	Drivers to BIM adoption	Reference
1	Availability of trained professionals to handle the tools	[23,51,52,53]
2	BIM Software affordability	[54,51,55]
3	Enabling environment within the industry	[55,56]
4	Clients’ interest in the use of BIM in their projects	[54,23,24,31,56,57,58]
5	Awareness of the technology among industry stakeholders	[23,55,59]
6	Cooperation and commitment of professional bodies to its implementation	[55,60]

7	Proof of cost savings by its adoption	[54,23,61,62]
8	Cultural change among industry stakeholders	[23,53]
9	Government support through legislation	[54,23,28,39,53,63]
10	Collaborative Procurement methods	[64]

3. Method

Review of literature (as secondary source) was the first step, serving as precedent and baseline to the study, primary data is also involved in this study and was collected within a period of five (5) months. An online questionnaire survey tool (google form) was used for the data collection. In an effort to determine the target population, interested parties were quite insignificant (in number) as the study subject awareness appear low [65]. A mixture of purposeful sampling and snowball method were adopted in sampling and data collection procedure. Purposeful sampling [66] was adopted to allow the researcher selects only the participants who possess the qualities necessary to provide meaningful input and reliable assessment of the study context and snowball [67] was utilised in generating substantial (in both quality and quantity) responses.

A quantitative research approach is adopted for this study. To achieve a wide coverage, considerable response rate, bias free response and free from privacy issues [68], quantitative research method therefore adopted. A structured questionnaire survey was used for the primary data collection. The questionnaire was designed mainly on two target enquiries, drivers and barriers to adoption of BIM in the Nigerian construction industry after determination of the respondent's demography. As it was set for a purpose, only those aware of BIM responses are accepted, thus the system accepts the only target audience.

Reliability test, descriptive statistics and Relative Importance Index (RII) were subsequently deployed for analysis of data. The reliability test was carried out to ascertain an internal consistency of scale of items used in the questionnaire as well as the reliability of questionnaire for further analysis. Descriptive statistics and RII are used the data analysis as to determine the most influential items and the interdependencies.

As for the respondents' profile, categorical data is generated while the main (enquiry) questions involved the use of five-point Likert rating scale with 5 as the highest rank and 1 the lowest.

Based on the five-point Likert rating scale, a standard method of ranking was used which is the RII.

RII is defined by the relationship as [54]:

$$\text{Relative Importance Index (RII)} = \frac{\Sigma W}{A \times N} \quad (0 \leq \text{index} \leq 1)$$

where:
W= weighting given to each element by the respondents.
i.e. between 1 and 5, where 1 is the least significant impact and 5 is the most significant impact;
A= highest weight; and
N= total number of respondents.
While the remaining are evaluated by simple descriptive statistics (in percentages).

4. Results

The reliability test result, respondents' demographic information, descriptive statistics on the barriers and the drivers as well as relative important index are evaluated and presented below.

4.1. Reliability test

As mentioned above, the reliability test was carried out to ascertain an internal consistency of scale of items used in the questionnaire as well as the reliability of questionnaire for further analysis. Thus, Cronbach's Alpha is adopted for the reliability analysis and the results are compared with George & Malley's [69] acceptability of any coefficient of

Cronbach's alpha greater than 0.6, as such all the items are within acceptable limit with Cronbach's Alpha coefficient of 0.95 (see table 3 and 4 below). All values >0.7 are considered acceptable [70], thus >0.9 indicated high level of internal consistency of items measurements and mean they are closely related.

Table 3. Reliability Test

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Availability of trained professionals to handle the tools	75.75	396.94	.68	.95
BIM Software affordability	76.09	396.80	.65	.95
Enabling environment within the industry	76.18	399.70	.69	.95
Clients interest in the use of BIM in their projects	76.15	391.14	.68	.95
Awareness of the technology among industry stakeholders	76.09	404.95	.59	.95
Cooperation and commitment of professional bodies to its implementation	76.16	397.78	.68	.95
Proof of cost savings by its adoption	75.94	406.62	.55	.95
Cultural change among industry stakeholders	76.54	402.52	.65	.95
Government support through legislation	76.51	389.18	.75	.95
Collaborative Procurement methods	76.46	394.25	.72	.95
Lack of expertise within the organisations	75.79	406.29	.52	.95
Lack of expertise within the project team	75.97	402.78	.58	.95
Lack of standardisation and protocols	76.04	397.71	.69	.95
Lack of collaboration among stakeholders	76.26	398.23	.70	.95
High Investment Cost	76.35	393.81	.71	.95
Legal issues around ownership, IP & PI insurance	76.69	397.38	.68	.95
Lack of client demand	76.21	398.20	.59	.95
Lack of infrastructure	76.40	394.21	.67	.95
Lack of government policy	76.24	391.41	.71	.95
Industry's Cultural resistance	76.31	401.95	.64	.95
Lack of additional project finance to support BIM	76.24	394.84	.72	.95
Resistance at operational level	76.62	405.82	.57	.95
Reluctance of team members to share information	76.26	398.74	.75	.95
Return on Investment (ROI) issue	76.60	401.86	.64	.95

Table 4. Reliability Alpha Value

Reliability Statistics	
Cronbach's Alpha	N of Items
.95	24

4.2. Demographic profile of respondents

The table 5 below presents the details of the respondents involved in the survey. The details include their location of practice in Nigeria, year of experience in the industry, size of their organisations, profession, specialisation and their highest qualifications.

Table 5. Analysis of socio-economic variables. *(Source: field survey, 2018.)*

Variable	Characteristics	Freq.	Percentage (%)	Total
Location of practice	North-Central	26	38.2	
	North-East	11	16.2	
	North-West	16	23.5	
	South-East	2	2.9	
	South-South	4	5.9	
	South-West	9	13.2	68
Years practice	< 5 years	14	20.6	
	5 - 10 years	27	39.7	
	11 - 15 years	15	22.1	
	> 15 years	12	17.6	68
Number of employees	< 10 personnel (Micro)	29	42.6	
	10 - 50 personnel (Small)	29	42.6	
	50 - 200 personnel (Medium)	7	10.3	
	> 200 personnel (Large)	3	4.4	68
Profession	Architecture	16	23.5	

	Building Engineering	1	1.5	
	Civil/Structural Engineering	30	44.1	
	Electrical Engineering	8	11.8	
	Mechanical Engineering	4	5.9	
	Construction Management	1	1.5	
	Quantity Surveying	7	10.3	
	Other:	1	1.5	68
Specialization	Contractor/Construction	19	27.9	
	Designer or Consultant	41	60.3	
	Client	4	5.9	
	Development Authority	4	5.9	68
Highest qualification	OND or HND	2	2.9	
	B.Sc./B.Tech./B Eng.	34	50.0	
	MSc/M.Eng.	25	36.8	
	PhD	7	10.3	68

There is considerably higher respondents from four out the six zones, this happened due to higher number of researchers' own network and considerable number of firms and construction works within North-Central and South-West specifically. The predominant respondents are having 5 to 15 years of experience in the industry and mostly (about 80%) came from micro (<10 personnel) and small (10 – 50 personnel) firms or organisations. In the case of their professions, specialties and educational qualifications, over 60% of them came from Architectural and Civil/Structural engineering backgrounds and working as designers/consultants and contractors (over 80%). And, more than 80% are first degree (B.Sc./B.Tech./B.Eng) and second degree (MSc/M.Eng.) holders.

5. Results

5.1. BIM awareness and usage

This aspect involves evaluation of proportion of those using BIM from those aware but not using the concept. Note that all the respondents are only those aware of BIM; whether the use it or not. Thus, the percentages reflect the only within targeted group (who are aware of BIM). A significant shift can be notice from the 2017 survey and this indicated substantial increase in the awareness and usage within the market (see fig. 1 below). The proportion of usage to awareness increased from 28%:72% to 54%:46% (fig. 2) based on those aware of BIM.

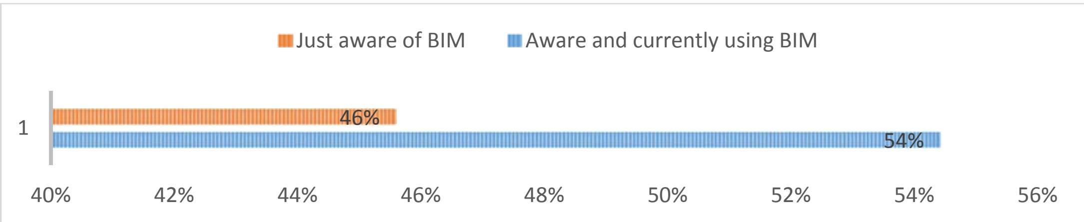

Fig. 1. BIM awareness and usage *(Source: field survey, 2018.)*

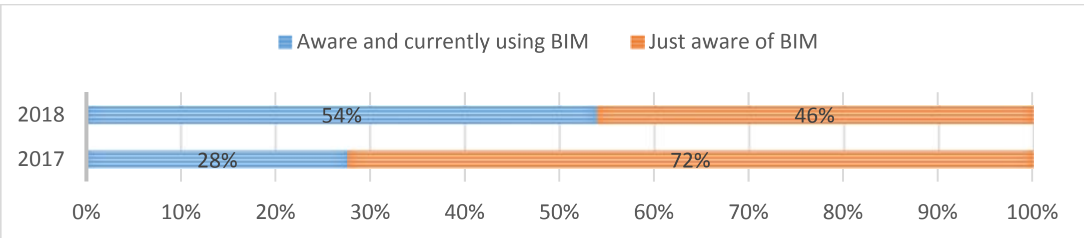

Fig. 2. BIM awareness and usage for 2017 and 2018

5.2. Barriers to BIM adoption in Nigeria

Subjecting the fourteen generated barriers to BIM adoption in Nigeria into RII (see table 6 below) using the scale of 1-5 (Likert scale), it was realised that, the 1st ninth ranked barriers are the most significant (RII ≥ 0.70) or mean ≥3.5 in a five-point Likert scale [71].

Table 6. RII and ranking of barriers against BIM adoption in Nigeria

Number of Rank *R* & Weighted value *W* impact	Weight 5	Weight 4	Weight 3	Weight 2	Weight 1	Total	∑ *W*	RII	Rank
Lack of expertise within the organisations	110	92	39	10	5	68	256	0.75	1
Lack of expertise within the project team	90	92	42	14	6	68	244	0.72	2
Lack of standardisation and protocols	85	76	63	8	7	68	239	0.70	3
Lack of client demand	95	60	42	22	9	68	228	0.67	4
Lack of government policy	85	80	27	24	10	68	226	0.66	5
Lack of additional project finance to support BIM	75	64	63	16	8	68	226	0.66	5
Lack of collaboration among stakeholders	55	88	51	24	6	68	224	0.66	5
Reluctance of team members to share information	40	100	57	22	5	68	224	0.66	5
Industry's Cultural resistance	50	80	60	26	5	68	221	0.65	9
High Investment Cost	80	44	60	26	8	68	218	0.64	10
Lack of infrastructure	60	84	42	16	13	68	215	0.63	11
Return on Investment (ROI) issue	40	48	75	30	8	68	201	0.59	12
Resistance at operational level	30	56	81	24	9	68	200	0.59	12
Legal issues around ownership, IP & PI insurance	50	36	63	36	10	68	195	0.57	14

The result in general indicated lack of expertise within the organisations, lack of expertise within the project team, lack of standardisation and protocols, and lack of client demand as the most influential barriers (1st to 4th) respectively; and ranked the following as 5th: lack of government policy, lack of additional project finance to support BIM, lack of collaboration among stakeholders and reluctance of team members to share information.

5.3. Drivers to BIM adoption in Nigeria

Subjecting the ten generated drivers to BIM adoption in Nigeria into RII (see table 7 below) using the scale of 1-5 (Likert scale), it was realised that, the 1st seventh ranked drivers are the most significant (RII ≥ 0.70) or mean ≥3.5 in a five-point Likert scale [71]. The result indicates availability of trained professionals to handle the tools, proof of cost savings by its adoption, BIM Software affordability and awareness of the technology among industry stakeholders as the most influential drivers (1st, 2nd, 3rd and 3rd) respectively; and ranked the following as 5th: clients interest in the use of BIM in their projects, cooperation and commitment of professional bodies to its implementation, and enabling environment within the industry.

Table 7. RII and ranking of drivers against BIM adoption in Nigeria

Number of Rank R & Weighted value W impact	Weight 5	Weight 4	Weight 3	Weight 2	Weight 1	Total	∑ W	RII	Rank
Availability of trained professionals to handle the tools	130	84	24	16	5	68	259	0.76	1
Proof of cost savings by its adoption	85	88	57	12	4	68	246	0.72	2
BIM Software affordability	90	84	36	18	8	68	236	0.69	3
Awareness of the technology among industry stakeholders	70	84	57	22	3	68	236	0.69	3
Clients interest in the use of BIM in their projects	115	48	45	12	12	68	232	0.68	5
Cooperation and commitment of professional bodies to its implementation	80	72	48	26	5	68	231	0.68	5
Enabling environment within the industry	60	92	48	26	4	68	230	0.68	5
Collaborative Procurement methods	45	84	54	16	12	68	211	0.62	8
Government support through legislation	65	64	42	22	14	68	207	0.61	9
Cultural change among industry stakeholders	20	92	54	32	7	68	205	0.60	10

6. Conclusions and Recommendations

The urgent need for BIM adoption in construction industry is providing huge opportunities in research and development. However, researches in barriers and drivers to its adoption didn't yield fetched universal adoption thus, that leaves a question of inadequacy or misrepresentations. There are several findings on barriers and drivers to adopt BIM from literatures, many of which having different influence over the other. Nigeria is among developing countries where BIM is becoming vibrant however, BIM adoption in Nigeria still remains in its infancy. This piece of research is aim at filling the gap of differentiating by order of importance, the common barriers vis-a-vis to drivers toward BIM adoption in Nigerian construction market. This study contributes to the knowledge body by providing an in-depth understanding of potential barriers and drivers, their strength of influence and interactive relationships among barriers affecting the Nigerian construction industry as single body. Fourteen barriers and ten drivers were identified from literature, five Likert scale was used for measuring the respondents' perceptions and RII was used to rank the perceptions. Findings of this study discovered that 1^{st} to 9^{th} ranked barriers are very important (highly influential) against the adoption and 1^{st} to 7^{th} drivers are significant (highly influential) to facilitate BIM adoption in Nigeria. It is then recommended that, further evaluation should be made to compare the perception of those adopted BIM and those that haven't so as to determine percentage disagreement between the two groups; then further recommendation shall be made.

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