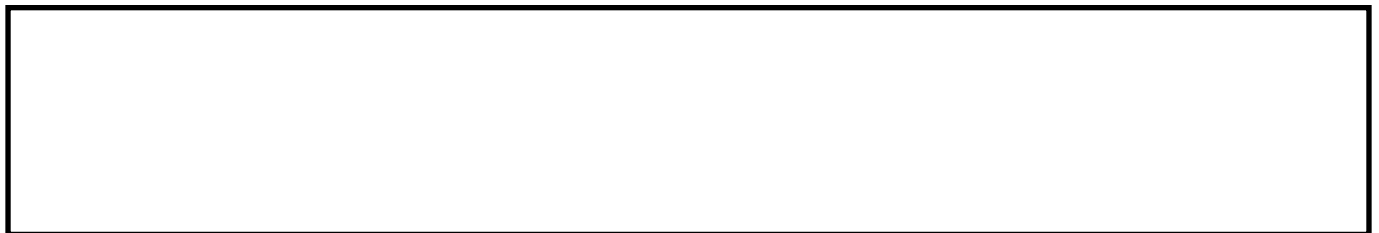


Analysis of barriers and drivers for BIM adoption.

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Analysis of Barriers and Drivers for BIM Adoption

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Abstract:

Research on 'digitalization and collaboration' in the construction industry has been gaining momentum in the recent academic engagements. Despite its existence in many industries (i.e. financial services, retailing, publishing and travelling) for over ten years, it is yet to catch up by the construction market; this is due to several challenges whose existence are more dynamic and contextual than generic to various countries. The problems are defined in many studies across borders, but their impacts varied with countries. This case is equally the same to drivers toward the adoption of BIM. This study analyses barriers and drivers to BIM adoption in the Nigerian construction industry from adopters and non-adopters perspectives as to allow an informed decision in developing a strategy for macro BIM adoption. Primary data fetched from professional stakeholders through an online questionnaire survey were analysed using SPSS software and Microsoft Excel. This investigation reveals the most significant barriers against BIM adoption as Lack of expertise, Lack of standardization and protocols to mention but a few. And, most influential drivers from both adopters and non-adopters as Availability of trained professionals to handle the tools, Proof of cost savings by its adoption, BIM Software affordability, and awareness of the technology among the industry stakeholders. The adopters and non-adopters groups have nearly equal Percentage Disagreement (PD) and Percentage Agreement (PA) for both the barriers and drivers to BIM adoption. Thus, this suggests that the adopters are still at the early stage of BIM adoption, so have nearly the same perceptions with the non-adopters. The study recommends proper consideration of the established barriers and drivers while developing any strategy for effective BIM adoption. Further face-to-face (interview) study is necessary to explore more and in-depth challenges to adoption of BIM in the industry; and as the industry is getting more aware of the BIM, periodic evaluation of the critical barriers and drivers is vital.

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

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1. Introduction:

Building Information Modelling (BIM) is a digital model representing physical and functional characteristics of building or infrastructure (BIM Industry Working Group 2011). Chartered Institute of Builder (CIOB) described the fundamental idea behind the BIM as to create and share the right information at the right time throughout the design, construction and operation of a building or facility to improve efficiency and decision making. This new paradigm shift in the construction industry is gaining high recognition both in the academic discuss (research) and the industry (application). However, its universal adoption is facing common 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 a similar trend with the barriers.

The BIM is similar to other technologies or innovations; it comes with challenges and barriers while adoption and implementation (McAdam, 2010). Barnes and Davies (2015) revealed the most perceived barriers against BIM adoption by organizations as an 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 (i.e. awareness driven) or technology and human resources readiness. The construction industry is widely known to be conventional and resistive to changes (Walasek and Barszcz, 2017); although, this new technological process has come to stay.

Eadie et al. (2014) worked on the identification of barriers to BIM adoption and their order of importance, this study reveals so much to the UK BIM adoption strategy and more importantly directing to the most significant barriers to allow adopters pay more attention to them. However, solving one or more barriers without considering the rest may not bring the end to the challenges on adoption (Lindblad, 2013). Studies on barriers and drivers to adoption of BIM revealed many barriers and drivers with differential significance by country (Walasek and Barszcz, 2017; Shaban et al., 2018; Ademci and Gundes, 2018; Elhendawi et al., 2019). A recent study undertaken by Elhendawi et al. (2019) on Kingdom of Saudi Arabian AEC sector where BIM adoption barriers were assessed considering six different categories (personal, technical, business, process, market and organisational barriers). The study holistically revealed personal challenges as the significant barriers to the deployment of BIM. These personal challenges are dominated by a lack of understanding of BIM and its benefits, resistance to change, and lack of BIM education and skills. Similarly, few studies from Nigeria revealed some barriers to BIM adoption (Wang, 2015; Onungwa et al., 2017), but not to common professionals or wide market (macro scale). It is therefore difficult to appraise (at market level) the challenges required to be resolved and drivers to persuade the BIM adoption in the Nigerian construction industry.

As an extended conference paper (Hamma-adama and Kouider, 2019), this study attempts to fill a gap of differentiating by order of importance, the common barriers and drivers toward BIM adoption from adopters and non-adopters perspectives within the Nigerian construction market. The investigation was set to be achieved through a critical review of literature where potential barriers and drivers for BIM adoption were identified; then ranked by order of significance, and evaluate the adopters and non-adopters perspectives (i.e. the percentage of disagreement). This will allow an informed decision in the development of a strategy to effective BIM adoption within the Nigerian construction market.

2. Literature review:

BIM is amongst the most discussed subjects in the Architecture Engineering and Construction (AEC) industry, and perhaps the most discussed area of development in the AEC process. There is a huge development in research and efforts to implement this new innovative process. Hjelseth (2017) compiled five years of publications (2013-2017) from Automation in Construction in the field of BIM; his statistics revealed high (>70%) concentration on interoperable technology perspective than collaborative processes. The study suggests more research on awareness of real understanding and how BIM influences AEC activities. On the other hand, some investigators believed that researchers had concentrated mostly on adoption and non-adopters, investigating the barriers and drivers, development of models and frameworks (Hosseini et al., 2016); albeit there is an irregularity in the adoption as well as the implementation across the globe and different disciplines.

There are several investigations and studies on BIM development and usage around the globe. McAuley et al. (2016) mapped the global overview of BIM adoption; Africa is the only continent who does not have representation. Remarkably, there are case studies to learn from at country levels, particularly the countries' BIM adoption trends. Several countries around the world have been striving to preserve the digital shift, for example, USA, UK, Australia, Singapore, South Korea, Denmark, Russia and Finland to mention but a few (McAuley et al., 2016). These countries happened to have bodies that survey the BIM adoption and provide Noteworthy BIM Publications (NBPs) to maintain guide and keep track of the BIM progress. Bodies like 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 examples of these bodies. For a global assessment of BIM adoption and its business value, McGraw Hill Construction remains the only source of NBPs (McAuley et al., 2016).

In the recent academic discussion, there are several investigations on the 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 of the BIM (Ademci and Gundes, 2018). Such efforts (by countries and organizations) played a significant role in

revolutionizing the BIM adoption process (Mustaffa et al., 2017). Subsequent studies on BIM adoption challenges revealed consistent trend, from Walasek and Barszcz (2017) to Ademci and Gundes (2018), Sun et al. (2017) and Tan et al. (2019). These studies brought about describing, categorizing, and ranking of barriers against the BIM adoption.

Wang (2015) study also compiled and ranked some challenges faced by Mechanical, Electrical and Plumber (MEP) firms in Nigeria. The study reveals that lack of technical expertise on BIM tools utilization, lack of awareness of BIM technology as well as high cost of investment on staff training, process change, software and hardware upgrade as the most critical barriers to BIM adoption. While Onungwa et al. (2017) revealed lack of skilled personnel, internet connectivity, the reluctance of other stakeholders to use BIM, lack BIM object libraries, and lack of awareness of the technology as the main barriers against BIM adoption. On common grounds, most studies cited and identified challenges in the lack of trained personnel. They are abreast of the latest development in technology also lamented the BIM knowledge gap where most Architects learn on the job, as no training is mostly offered to them.

In the NBS report (2018), barriers to BIM adoption were reported under two umbrellas, internal (i.e. lack of training, expertise and funds to invest), and external (i.e. lack of BIM demand by the client and lack of large projects that necessitate the BIM deployment). While, the most recent compiled barriers by Ademci and Gundes (2018) were grouped into five categories; these include personal, legal, management, cost, and technical for convenience while carrying out analysis (Sun et al. 2017). Sun et al. (2017) compiled a total of twenty-two BIM adoption barriers; however, that does not necessarily apply to the entire professional fields, organizations, and countries as common. For example, the UK reported 18 barriers in their continuous BIM assessment survey (NBS 2018, p. 35), and these barriers are not exactly as those extracted by Sun et al. (2017) or those by Wang (2015). Though, there are some similarities and common terms across the lists. For example, Khosrowshahi and Arayici (2012) reported many barriers to adopt BIM across the UK, and assert that those barriers are commonly on organizational readiness. Table 1 summarizes the compiled barriers to BIM adoption from across organizations and countries.

Table 1: Barriers to BIM adoption

S/No.	Barriers to BIM adoption	Reference
1	Lack of expertise within the organizations	Aouad et al., 2006; Yan and Damian, 2008; Arayici et al., 2009; Lindblad, 2013; Wang et al., 2015; Saleh, 2015; Ahmed et al., 2018; Jamal et al., 2019; Tan et al., 2019
2	Lack of expertise within the project team	Saleh, 2015; Wang et al., 2015; Jamal et al., 2019; Tan et al., 2019
3	Lack of standardization and protocols	BCIS, 2011; Wang et al., 2015; Ahmed et al., 2018; Jamal et al., 2019; Tan et al., 2019
4	Lack of collaboration among stakeholders	BCIS, 2011; Wang et al., 2015; Tan et al., 2019
5	High Investment Cost	Yan and Damian, 2008; Coates et al., 2010; Giel et al., 2010; Thompson and Miner, 2010; Azhar, 2011; Efficiency and Reform Group, 2011; Lee et al., 2012; Crotty, 2012
6	Legal issues around ownership, IP & PI insurance	Christensen et al., 2007; Furneaux and Kivvits, 2008; Arayici et al., 2009; Chao-Duivis, 2009; Azhar, 2011; Oluwole, 2011; UK BIM Industry Working Group, 2011; Udom, 2012; Race, 2012; Jamal et al., 2019;
7	Lack of client demand	BCIS 2011; Zuhairi et al. 2014; Saleh, 2015; Wang et al., 2015; Jamal et al., 2019
8	Lack of infrastructure	Wang et al., 2015
9	Lack of government policy	Wang et al., 2015; Elhendawi, A.I.N., 2018
10	Industry's Cultural resistance	Jordani, 2008; Mihindu and Arayici, 2008; Yan and Damian, 2008; Rowlinson et al, 2009; Watson, 2010; Arayici et al., 2011
11	Lack of additional project finance to support BIM	Arayici et al., 2009; Jamal et al., 2019
12	Resistance at the operational level	Jamal et al., 2019
13	The reluctance of team members to share information	Yan and Damian, 2008; Arayici et al., 2009; Wang et al., 2015
14	Return on Investment (ROI) issue	Coates et al., 2010; Arayici et al., 2011; Lee et al., 2012

The lack of expertise, training and cost of the tools are consistently remaining amongst the significant barriers to BIM adoption across some countries. Countries like the UK (NBS,

2018; NBS, 2017 NBS, 2013), Malaysia (Jamal et al., 2019) and Nigeria (Wang, 2015; Onungwa et al., 2017; Abubakar et al., 2014) are examples of that. In the UK, a lack of expertise is attributed to the low performance of the Higher Education Institutions (HEIs). Moreover, the low levels of engagement between the HEIs and the industry appear the major issue (Underwood et al., 2015). While in Nigeria, students are generally trained on ‘file-based collaboration’ – 2D and 3D CAD and HEIs are not technically ready to offer the BIM training at all (Hamma-adama et al., 2018).

The drivers to adopt innovation are merely the facilitators to adopt a new product or process (Saleh, 2015). The facilitators are the enablers as resolving the barriers ease the adoption of innovation; 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 circumstances, the motivator is achieved by removal of a barrier. For example, resolving the lack of experts or trained personnel on BIM means providing training on BIM. Table 2 below summarizes 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	McDonald, 2012; Kiani et al., 2015; Saleh, 2015; Badrinath et al., 2016
2	BIM Software affordability	Oladapo, 2007; Macdonald, 2012; Eadie et al., 2013
3	Enabling environment within the industry	Oladapo, 2007; Takim et al., 2013
4	Clients’ interest in the use of BIM in their projects	Liu et al., 2010; BCIS 2011; Eadie et al., 2013; Lee & Yu, 2013; Takim et al., 2013; Saleh, 2015
5	Awareness of the technology among industry stakeholders	Oladapo, 2007; Zikic, 2009; Saleh, 2015
6	Cooperation and commitment of professional bodies to its implementation	Oladapo, 2007; Becerik-Gerber et al., 2011
7	Proof of cost savings by its adoption	Newton & Chileshe, 2012; Eadie et al., 2013; Demirdoven, 2015; Saleh, 2015
8	Cultural change among industry stakeholders	Kiani et al., 2015; Saleh, 2015
9	Government support through legislation	Efficiency and Reform Group, 2011; buildingSMART Australasia, 2012; Eadie et al., 2013; Zuhairi et al., 2014; Kiani et al., 2015; Saleh, 2015; Natalija et al., 2019
10	Collaborative Procurement methods	Sinclair, 2012

3. Research Methodology:

A literature review was adopted in identifying potential barriers and drivers for BIM adoption. That serves as precedent and baseline to the study; primary data is also involved in this study and was collected within five months period. An online questionnaire survey was used as a tool for data collection. To determine the target population, interested parties were quite insignificant as the study subject awareness appears low (Hamma-adama et al., 2018b). A mixture of purposeful sampling and snowball method was adopted in the sampling and data collection procedure. The purposeful sampling 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 (Coyne, 1997); and snowball was utilized in generating substantial (in both quality and quantity) responses (Noy, 2008). The purposeful sampling is adopted because; only those who are aware of or have knowledge of BIM are of interest in this study.

A quantitative research approach is adopted. A quantitative research method is used in achieving a wide coverage of the survey with a considerable response rate, bias free-response and free from privacy issues (Naoum, 2012). 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 is set for a purpose, only those aware of BIM responses are accepted; thus, the system accepts the only target audience.

A reliability test, descriptive statistics and Relative Importance Index (RII) were subsequently deployed in the analysis of data. The reliability test was carried out in ascertaining the internal consistency of the scale of items used in the questionnaire. Descriptive statistics and RII were used in the determination of the most influential items for both adopters and non-adopters.

As for the respondents' profile, categorical data is generated while the main questions involved the use of a five-point Likert rating scale with five as the highest rank and one as the lowest. A five-point Likert rating scale is used with a standard method of ranking using Relative Importance Index (RII).

The relationship defines RII as:

$$\text{Relative Importance Index (RII)} = \frac{\sum W}{A \times N} \quad (0 \leq \text{index} \leq 1) \quad (\text{Eadie et al., 2013})$$

where:

W= element weighting by the respondents using a number between 1 and 5. Considering 1 as the least significant variable, and 5 as the most significant variable;

A= highest weight; and

N = total number of respondents.

Subsequently, the BIM barriers and BIM drivers ranked by the respondents are examined in terms of their interaction with the BIM concept. Some have already adopted the concept, while some are still at the awareness stage. A comparison was carried out using the Rank Agreement Factor (RAF) to determine adopters and non-adopters level of agreement or disagreement to the respective rankings by the group of adopters and non-adopters.

The following relationships define RAF:

And, maximum RAF (RAF_{max}) is then evaluated with:

Where;

$R_{i,1}$ is the rank of item i in group 1,

$R_{i,2}$ is the rank of item i in group 2,

N is the total number of items, which is the same for each group,

$R_{j,2}$ is the rank of item j in group 2, and;

$j = N - i + 1$.

Percentage Disagreement (PD) between the two groups is the ratio of RAF to RAF_{max}, as expressed below:

While the Percentage Agreement (PA) between the two ranked groups is the balance of percentage from the PD, which is:

$$PA = 100 - PD$$

A higher RAF value indicates a weaker agreement between the two groups. Thus, the RAF value of zero means a complete agreement between two subject groups. A spider diagram is plotted as in Fig. 3 and 4 to graphically illustrate the ranking variations by the two set groups.

4. Data collected, results and discussions:

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

4.1 Reliability test

The reliability test is carried out to ascertain an internal consistency of the scale of items used in the questionnaire as well as the reliability of the questionnaire for further analysis. Thus, Cronbach's Alpha is adopted for the reliability analysis, and the results are compared with George & Malley's (2003) acceptability. Any coefficient of Cronbach's alpha that is greater than 0.6 is considered acceptable, as such, all the items are within acceptable limit with Cronbach's Alpha coefficient of 0.95 (see Table 3 and 4). Moreover, all values >0.7 are considered acceptable according to Pallant (2013); thus, Cronbach's alpha >0.9

indicated a high level of internal consistency of the measured items and mean values 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	Cronbac h'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 organizations	75.79	406.29	.52	.95
Lack of expertise within the project team	75.97	402.78	.58	.95
Lack of standardization 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 the operational level	76.62	405.82	.57	.95
The 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

Table 5 presents the details of the respondents participated in the study or survey. The details include their location of practice in Nigeria, years of experience in the industry, size of their organizations, profession, specialization and their highest educational qualification.

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

Variable	Characteristics	Freq.	Percentage (%)	Total
Location of practice	North-Central	26	38.2	68
	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	
Years of practice	< 5 years	14	20.6	68
	5 - 10 years	27	39.7	
	11 - 15 years	15	22.1	
	> 15 years	12	17.6	
Number of employees	< 10 personnel (Micro)	29	42.6	68
	10 - 50 personnel (Small)	29	42.6	
	50 - 200 personnel (Medium)	7	10.3	
	> 200 personnel (Large)	3	4.4	
Profession	Architecture	16	23.5	68
	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	
Specialization	Contractor/Construction	19	27.9	68
	Designer or Consultant	41	60.3	
	Client	4	5.9	
	Development Authority	4	5.9	
Highest qualification	OND or HND	2	2.9	68
	B.Sc./B.Tech./B Eng.	34	50.0	
	MSc/M.Eng.	25	36.8	
	PhD	7	10.3	

There are considerably higher respondents from four out the six zones, this happened due to a higher number of researchers' network, and a 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. In the case of their professions, specialities and educational qualifications, over 60% of them came from Architectural and Civil/Structural engineering backgrounds and working as designers/consultants and contractors. In addition, more than 80% are first degree (B.Sc./B.Tech./B.Eng) and second-degree (MSc/M.Eng.) holders.

4.3 BIM awareness and usage

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

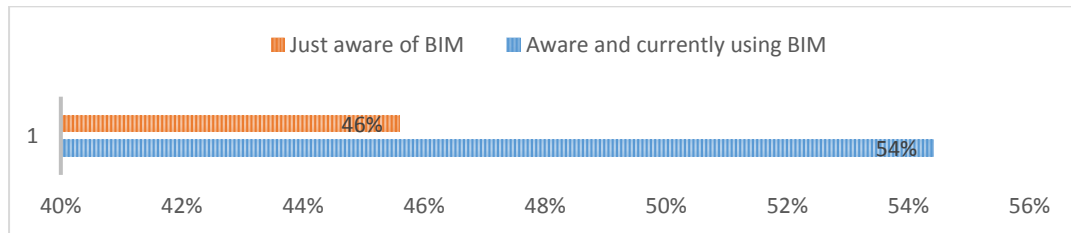


Fig. 1. BIM awareness and usage (Source: field survey, 2018.)

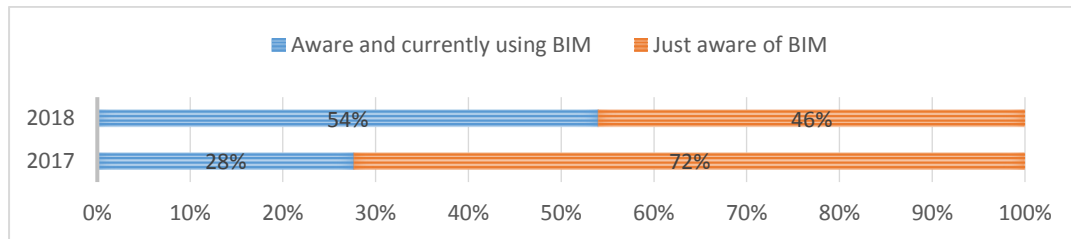


Fig. 2. BIM awareness and usage for 2017 and 2018

4.4 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 is realised that, the 1st ninth-ranked barriers are the most significant ($RII \geq 0.70$) or mean ≥ 3.5 in a five-point Likert scale (Badu et al., 2012).

The result, in general, indicated lack of expertise within the organizations, lack of expertise within the project team, lack of standardization and protocols, and lack of client

demand as the most influential barriers (1st to 4th) respectively. Moreover, 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.

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	ΣW	RII	Rank
Lack of expertise within the organizations	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 standardization 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
The 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 the 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

These barriers were analyzed further to balance the perceptions by the BIM adopters and the non-adopters. Table 7 presents the two group rankings. From the first glance on radar plot (Fig. 3), adopters ranking was quite simultaneous, indicating a higher level of reality and consistency. At the same time, non-adopters are a sort of zig-zag manner (ranking whether very high or very low). This pattern suggests that while adopting BIM, perception to barriers change as the realities unfold or became dominant. The barriers ranked 1st, 2nd, 3rd and 4th by non-adopters, were ranked 2nd, 6th, 9th and 1st by adopters with quite lower average index, as such what is perceived most influential barriers before adoption tend to change after adoption; such challenges may have been dealt with in the adoption process.

Table 7: Variation of barriers ranking among adopters and non-adopters

BARRIERS	Adopters		Non-adopters	
	RII	Rank	RII	Rank
Lack of standardization and protocols	0.74	1	0.66	4
Lack of expertise within the organizations	0.72	2	0.79	1
Industry's Cultural resistance	0.69	3	0.60	11
Lack of additional project finance to support BIM	0.69	3	0.64	9
Lack of client demand	0.68	5	0.66	4
Lack of expertise within the project team	0.67	6	0.77	2
Lack of government policy	0.67	6	0.66	4
Lack of collaboration among stakeholders	0.66	8	0.66	4
Resistance at the operational level	0.65	9	0.52	14
The reluctance of team members to share information	0.65	9	0.67	3
High Investment Cost	0.64	11	0.64	8
Lack of infrastructure	0.63	12	0.63	10
Return on Investment (ROI) issue	0.59	13	0.59	12
Legal issues around ownership, IP & PI insurance	0.57	14	0.58	13
Average RII	0.66		0.65	

On the other hand, they quite agreed over half of the barriers as to their significance or indexes. For instance, High Investment Cost, Lack of infrastructure, and Return on Investment (ROI) issue are scored the same magnitude although they were in different ranks. This situation leads to the determination of PD and PA to allow us to drive exclusive findings.

Table 8 presents the evaluation of the PD and PA. The result reveals 49.48% PD and 50.52% PA, means both groups have approximately 50:50 agreement to disagreement, in other words, they agreed on half (50%) of the ratings and disagreed on the other half (50%). Conclusively, this indicates that the adopters are still at the infancy stage as their PA is still high (50%). Higher PA does not go with the findings from (Eadie et al., 2014) that "...BIM adopters change their views on the most significant barriers to BIM after implementation by ranking them differently than those yet to adopt BIM" (Eadie et al., 2014 p. 92). Moreover, the average of 0.66 and 0.65 RII of adopters and non-adopters (respectively) indicated a small difference to their perception of BIM adoption barriers. Thus, confirmed that the country is at the early stage of BIM adoption...

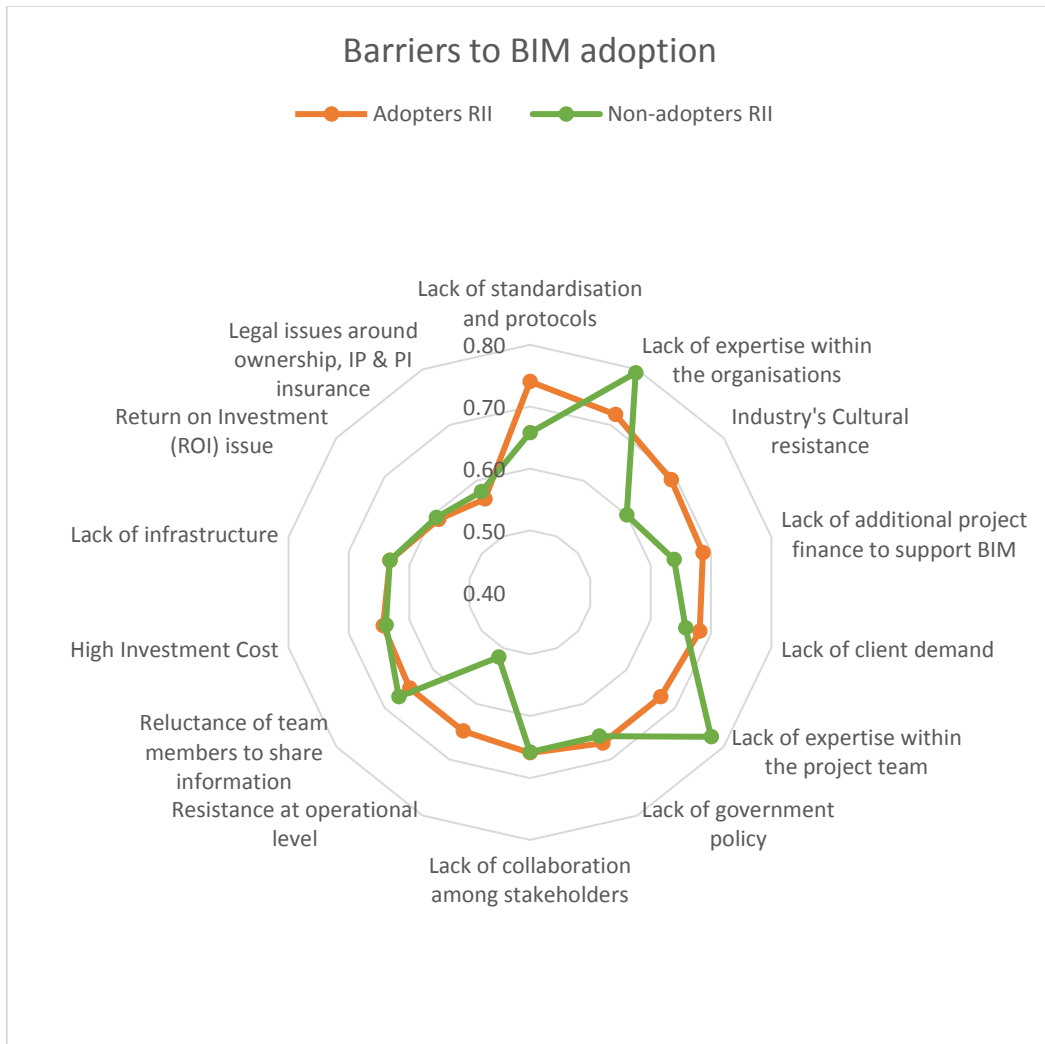


Fig. 3. Variation of barriers ranking among adopters and non-adopters (Source: field survey, 2018.)

Succinctly, nine of the fourteen barriers are significantly crucial to both the adopters and non-adopters; however, the remaining five appeared less important to both groups. These five barriers are resistance at the operational level, high investment cost, lack of infrastructure, return on investment (ROI) issue as well as legal issues around ownership, IP & PI insurance.

Table 8: RAF, PD and PA values for BIM barriers

BARRIERS	BIM Users	BIM Non-users					
	Rank (Ri1)	Rank (Ri2)	Ri1-Ri2	Absolute of Ri1-Ri2	Rj2 = Ri2 corresponds to (N-Ri1+1) from Ri1	Ri1-Rj2	Absolute of Ri1-Rj2
Lack of standardisation and protocols	1	4	-3	3	13	-12	12
Lack of expertise within the organisations	2	1	1	1	12	-10	10
Industry's Cultural resistance	3	11	-8	8	10	-7	7
Lack of additional project finance to support BIM	3	9	-6	6	10	-7	7
Lack of client demand	5	4	1	1	3	2	2
Lack of expertise within the project team	6	2	4	4	14	-8	8
Lack of government policy	6	4	2	2	14	-8	8
Lack of collaboration among stakeholders	8	4	4	4	4	4	4
Resistance at the operational level	9	14	-5	5	2	7	7
The reluctance of team members to share information	9	3	6	6	2	7	7
High Investment Cost	11	8	3	3	9	2	2
Lack of infrastructure	12	10	2	2	11	1	1
Return on Investment (ROI) issue	13	12	1	1	1	12	12
Legal issues around ownership, IP & PI insurance	14	13	1	2	4	10	10
			Absolute Sum	48		Absolute Sum	97
			RAF	3.43		RAF MAX	6.93
			PD	49.48%		PA	50.52%

4.5 Drivers to BIM adoption in Nigeria

Subjecting the ten generated drivers to BIM adoption in Nigeria into RII (see Table 8) using the scale of 1-5 (Likert scale), it was realized that, the 1st seventh-ranked drivers are the most significant ($RII \geq 0.70$) or mean ≥ 3.5 in a five-point Likert scale (Badu et al., 2012). The most influential drivers revealed as availability of trained professionals to handle the tools, proof of cost savings by its adoption, BIM Software affordability and awareness of the technology amongst industry stakeholders (in descending order). Moreover, 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 9: 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	ΣW	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

These drivers were analyzed further to balance the perceptions by both the adopters and non-adopters. Table 10 presents the two group rankings. From the first glance on radar plot (Fig. 4), the adopters ranking was simultaneous, indicating a higher level of reality and consistency. At the same time, the non-adopters are a sort of zigzag at some points (ranking very high and very low). This suggests that while adopting BIM, perception to driving the adoption changes. The drivers ranked 1st, 2nd, 3rd and 4th by the non-adopters are ranked 1st, 8th, 5th and 2nd by the adopters. Furthermore, with a tiny difference of average RII as such, what is perceived most influential drivers before adoption tend to change after the adoption.

On the other hand, the average RII of 0.68 and 0.67 for the adopters and the non-adopters respectively revealed that the adopters are still at an early stage, so they perceive the drivers' influence the same way with the non-adopters.

Table 10: Variation of drivers ranking among adopters and non-adopters

DRIVERS	Adopters		Non-adopters	
	RII	Rank	RII	Rank
Availability of trained professionals to handle the tools	0.76	1	0.77	1
Proof of cost savings by its adoption	0.74	2	0.70	4
Clients interest in the use of BIM in their projects	0.70	3	0.66	6
Enabling environment within the industry	0.69	4	0.66	6
Awareness of the technology among industry stakeholders	0.68	5	0.71	3
Cooperation and commitment of professional bodies to its implementation	0.68	5	0.68	5
Cultural change among industry stakeholders	0.66	7	0.54	10

BIM Software affordability	0.65	8	0.74	2
Collaborative Procurement methods	0.65	8	0.59	8
Government support through legislation	0.61	10	0.61	8
Average RII	0.68		0.67	

Notwithstanding, they nearly have the same average RII, the adopters disagree a bit more than they agree with the non-adopters in terms of individual drivers’ influence to adopt BIM (Table 10). To demonstrating this scenario, availability of trained professionals to handle the BIM tools, cooperation and commitment of professional bodies to BIM implementation and Government support through legislation are drivers that scored the same and rated the same to moving the adoption further by both the adopters and non-adopters. This finding suggests persistent investment on the drivers to drive the BIM adoption further.

Table 10 presents the evaluation of the PD and PA. The result reveals more justification of early adoption stage as shown by the study on the barriers. The PD is found to be 58.82%, and the PA is 41.18%. It means both groups have nearly 40:60 agreement to disagreement; in other words, they agreed on 4 out of 10 (40%) of the drivers' scoring and disagreed on the remaining 6 out of the 10 (60%) drivers' scoring.

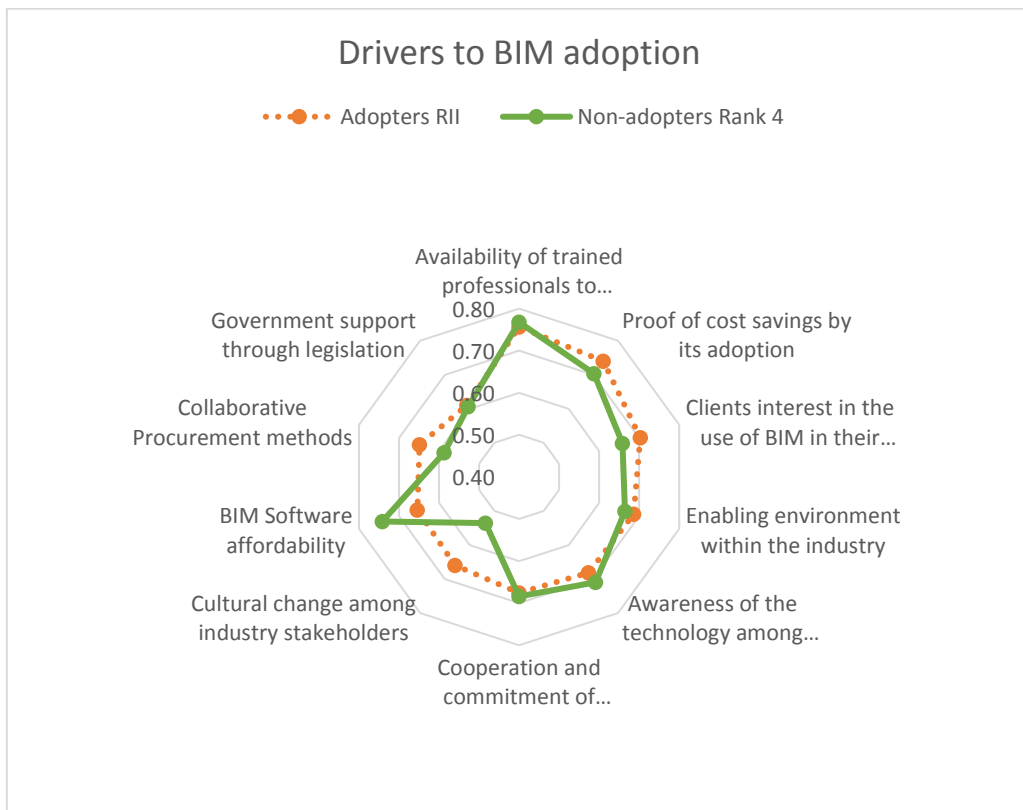


Fig. 4. Variation of drivers ranking among adopters and non-adopters (Source: field survey, 2018.)

Succinctly, all the drivers are of high importance to both the adopters and non-adopters in the exception of three who appear less compared to the rest. These three drivers are cultural change among industry stakeholders, collaborative procurement methods and government support through legislation.

Table 10: RAF, PD and PA values for BIM Drivers

DRIVERS	BIM Users	BIM Non-users					
	Rank (R1)	Rank (R2)	$Ri1-Ri2$	Absolute of $Ri1-Ri2$	$Rj2 = Ri2$ corresponds to (N- $Ri1+1$) from $Ri1$	$Ri1-Rj2$	Absolute of $Ri1-Rj2$
Availability of trained professionals to handle the tools	1	1	0	0	8	-7	7
Proof of cost savings by its adoption	2	4	-2	2	8	-6	6
Clients interest in the use of BIM in their projects	3	6	-3	3	2	1	1
Enabling environment within the industry	4	6	-2	2	10	-6	6
Awareness of the technology among industry stakeholders	5	3	2	2	5	0	0
Cooperation and commitment of professional bodies to its implementation	5	5	0	0	5	0	0
Cultural change among industry stakeholders	7	10	-3	3	6	1	1
BIM Software affordability	8	2	6	6	6	2	2
Collaborative Procurement methods	8	8	0	0	6	2	2
Government support through legislation	10	8	2	2	1	9	9
			Absolute Sum	20		Absolute Sum	34
			RAF	2.00		RAF MAX	3.40
			PD	58.82%		PA	41.18%

5. Conclusions:

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 did not yield fetched universal adoption thus, that leaves a question of inadequacy or misrepresentations. There are several findings on barriers and drivers to BIM adoption 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 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 the Nigerian construction market. Fourteen barriers and ten drivers were identified from literature, five Likert scale was used for measurement of respondents' perceptions and RII was used to rank the perceptions. The study revealed that barriers ranked from 1st to 9th are highly influential to the adoption of BIM in Nigeria, and the drivers ranked from 1st to 7th are significant to facilitate BIM adoption in Nigeria. Further evaluation was carried out in comparing the perception of those adopted BIM and those that have not. Ranking and scoring of barriers and drivers amongst adopters and non-adopters having nearly 50:50 PD to PA which suggests early adoption stage or low maturity stage. The common and most significant barriers and drivers were established from the two set groups. The common and significant barriers to adopters and non-adopters are: Lack of standardization and protocols, Lack of expertise within the organizations, Industry's Cultural resistance, Lack of additional project finance to support BIM, Lack of client demand, Lack of expertise within the project team, Lack of government policy, Lack of collaboration among stakeholders, and Reluctance of team members to share information. On the other hand, the common and most significant drivers to adopters and non-adopters are: Availability of trained professionals to handle the tools, Proof of cost savings by its adoption, Clients interest in the use of BIM in their projects, Enabling environment within the industry, Awareness of the technology among industry stakeholders, Cooperation and commitment of professional bodies to its implementation, and BIM Software affordability.

The study recommends that, to develop effective BIM adoption framework, the established barriers and drivers should be considered vital. The barriers should be resolved in totality, and drivers should be instigated, motivated and encouraged. Further face-to-face (interview) study is necessary to explore more and in-depth challenges of BIM adoption in the industry under study; and as the industry is getting more aware of the BIM, periodic evaluation of the critical barriers and drivers is vital. This study contributes to the body of knowledge in providing an in-depth understanding of barriers and drivers from adopters and non-adopters perspectives, their strengths of influence from the two groups and combined influence to adoption of BIM in the Nigerian construction industry.

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