Barriers to Building Information Modelling Adoption in Nigeria

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Abstract

Building Information Modeling (BIM) adoption is still evolving in Nigeria and there are no many examples of its usage for project execution by industry practitioners. There is a dearth of studies on how barriers to BIM adoption can be overcome. Following the identification of barriers to BIM adoption from literature, an online survey approach was used to investigate the perception of Nigerian construction industry professionals on the significant barriers to BIM adoption based on a five point Likert scale from 1 "not at all a barrier" to 5 "extreme barriers". Class means difference among professional group was used to identify barriers to BIM adoption and a discriminant analysis was used to established disagreement among the respondents. The result shows that, the various groups have equal mean discriminant function score on 16 barrier factors to BIM adoption, indicating agreement in the opinion of the groups on these factors. However, 5 items have the most significant predictive power in differentiating the professional groups from the standpoint of perceived barriers to BIM adoption. Implying that there is difference of opinion between the group on whether the 5 factors constitute barriers to BIM adoption or not. The factors in order of magnitude are: clients low level of awareness, lack of funding, poor power supply, legal uncertainty and lack of transparency. The barrier factors identified in this study will assist industry stakeholders in formulating appropriate strategies to overcome them in order to ensure successful BIM implementation. Findings from this study indicates the need for construction industry stakeholders to encourage practitioners to adopt BIM at various level for project execution.

Keywords

Barriers, building information modelling, Nigeria, practitioners, stakeholders.

1. Introduction

Construction industry is well known for fragmentation of workflow processes with temporary multi-organizations operating at the lower ends of the supply chain (Eastman, et al., 2011). Fragmentation in the industry involves two dimensions: process (construction process) and entities (firms). Fragmentation of process influences fragmentation of entities and this is described by as “over-the-wall” approach, where several project stakeholders work independently or in silos due to construction process separation (Anumba, et al., 1991; Anumba, et al., 2002). The consequences of this is inability to communicate, collaborate and share project related information with each other in a constructive way. Thus, information exchange is mostly constraint to paperwork, thereby enhancing the possibility of data loss, corruption and the use of incorrect or unreliable information (Baiden, et al., 2006).

Adoption and implementation of Building Information Modelling (BIM) could facilitate better integration of all construction stages and processes as well as enabling project team to collaborate and exchange project information electronically (Teo et al., 2006; Matipa, et al., 2010; Forgues, et al., 2012; Harison & Thurnell, 2015). Success story of BIM adoption on construction project have been widely reported in more industrialized world (Boon, et al., 2011). For instance, the study by (Eadie, et al., 2013) indicates that the highest positive financial benefits of BIM is collaboration, followed by process aspect, which according to Eadie *et al.,* (2013) suggests that management aspects of adopting BIM were more important than the technology in the software itself in terms of financial significance.This has led to many governments and authorities calling for the acceptance of BIM within the construction industry to provide the required information exchange between stakeholders (Succar, 2009; Cartlidge, 2011; Ashworth, et al., 2013). While government agencies in overseas countries like the USA, UK, Singapore and South Korea have already established plans for the mandatory use of BIM for public projects, and the government agencies of these countries pressurises construction industry to invest in and adopt BIM to win public sector contracts (Eadie, et al., 2013).

On the contrary, the case in developing countries seems to be different as changes in the construction processes and effective adoption of BIM is largely limited to developed countries (Abubakar, et al., 2014). This is because there is a big difference between ICT implementation and its use between developed and developing countries (Gichoya, 2005). Some of these developing countries are characterised by limited computer applications Tse, et al. (2005), inadequate infrastructure and shortage of skilled manpower (Ugwu, et al., 2007) . According to Oladapo (2007), there is large gap in access to electricity and other communication infrastructures between developed and developing countries. Kori & Kiviniemi, (2015) said that Nigeria is categorized as a developing country and the level of ICT adoption is generally developing. Consequently, studies on BIM implementation and case studies have been limited to these developed countries (Arayici, et al., 2009; Arayici, et al., 2012; Boon & Prigg, 2011), and there is a dearth of studies on what constitute barriers to BIM implementation in Nigeria. In addition, the implementation of BIM in Nigeria has not yet been documented in the form of publicly available reports such as best practice, implementation guide, or framework (Kori & Kiviniemi, 2015; Abdulahi, et al., 2016). The absence of these documents thus drives the need to identify the barriers to BIM adoption from the perspectives of industry practitioners. This will enable industry stakeholders to understand the critical barriers that must be overcome before implementation of BIM at industry level.

Therefore, the main objectives of this study are to identify barriers to BIM adoption and determine the level of agreement among industry practitioners on the barriers factors.

2. Barriers to Building Information Modelling Adoption

BIM is a methodology to integrate digital descriptions of all the building objects and their relationships to others in a precise manner, so that project participants can query, simulate and estimate activities and their effects on the construction process as a lifecycle entity (Arayici, et al., 2012). BIM also supports the concept of integrated project delivery, which is a novel project delivery approach to integrate people, systems, and business structures and practices into a collaborative process to reduce waste and optimize efficiency through all phases of the project life cycle (Glick and Guggemos 2009).

The construction industry has many contributing disciplines and construction professionals generating information to meet the various demands of a construction project, ranging from architects, quantity surveyors and engineers to contractors, fabricators, and owners (Egbu, 2006). Each of these professionals creates specific project deliverables that demand specific and sometime unique data inputs (Baiden, et al., 2006). This creates a complex environment of multiple exchanges of information between people, disciplines, and project phases. Meanwhile, a widely-publicized advantage of BIM is the increased collaboration amongst the project team, achievable using a centralized model (Sabol, 2008). Therefore, BIM requires multi-disciplinary project teams to collaborate using BIM software solutions to create, use, and share intelligent 3D digital model information, giving all stakeholders a clearer vision of the project and increasing their ability to make faster and more informed decisions (Eadie, et al., 2014).

However, a major barrier to the widespread use of BIM among practitioners according to Arayici et al., (2009) is the lack of guidance for the transition and the poor amount of studies rooted in reality to support firms in their adoption. Rogers, et al., (2015) explored BIM adoption from the perspectives of engineering consulting services firms in Malaysia. They used focus group interview and questionnaire survey for the study and found that engineering consulting services firms were prepared to adopt BIM where market demands, but the main barriers to BIM adoption is lack of well trained personnel, guidance and government support. Similarly, Arayici et al., (2009) conducted survey of 16 UK practitioners and academics and observed that the critical barriers to BIM adoption include unfamiliarity with BIM use, reluctance to initiate new workflows, inadequate opportunity for BIM implementation, the beliefs that benefits from BIM implementation do not outweigh the costs to implement it and that benefits are not tangible enough to warrant its use.

Eadie et al., (2013) identified lack of expertise within the project team and external organizations as the main reason for not adopting BIM on current projects in the UK. In another study, Eadie, et al., (2014) pointed out that there were differences between what constitutes barriers to BIM implementation from the perspectives of those already using BIM and those that have not implemented BIM, that the top most important barriers to the non-user of BIM include lack of supply chain buy-in, scale of culture change required, lack of technical expertise and cost of software. While the top three barriers by those that are already using BIM are lack of vision of benefits, scale of culture change required and cost of training.

Kori & Kiviniemi, (2015) used online survey to sample the opinion of respondents from Architectural firms in Nigeria and found that: BIM implementation in small and medium Architectural firms lacked leadership, motivation and improvement strategy to enhance performance; lack of policy rules, standard in use of digital tools and there was no focus on the contractual and regulatory aspect of BIM implementation and; BIM adoption in medium firm lay on individual championship and what was readily available. Oyediran & Odusami, (2005) adopted a survey methodology to examine the challenges faced by QS in the adoption of information technology in Nigeria. The authors found that 89% of QS surveyed were using computers for project cost management. However, Oyediran and Odusami identified educational problems as a leading factor group that affects effort to adopt ICT by the Nigerian Quantity Surveyors. The authors pointed out that Returns on Investment (ROI) was also considered as inhibiting factors. ROI was further explained as cost of software, cost of branded hardware, cost of infrastructure to support computerization and cost of support services by computer professionals in relation to earning capacity of QS firms.

Oladapo (2007) investigated the impediments to the use of ICT in Nigerian construction industry and identified top five constraints to the use of ICT as irregular power supply, high cost of ICT software and hardware, low job order for firms, fear of virus attacks and high rate of obsolescence of ICT software and hardware. This study has identified and combined previous studies on barriers BIM/ICT adoption. The rationale for this is that there is a dearth of studies on barriers to BIM adoption in the context of Nigeria practice and BIM is considered an extension of ICT in the construction industry.

3. Methodology

In order to achieve the objectives of this study, a total of 21 BIM barriers factors identified from previous studies were included in a questionnaires survey instrument that also addressed other factors on BIM implementation in Nigeria. The complete questionnaire comprised four sections: the first section request information about respondents' background, the second sections relates to questions on BIM awareness and the third sections ask questions about critical success factor to BIM adoption. The fourth section is barriers to BIM adoption". Snowballing sampling technique was adopted because BIM has not been widely used in Nigeria, and the questionnaire was administered to Architects, Engineers, Quantity Surveyors and Building Engineers, that either have been involved on projects that utilized BIM or have good knowledge of BIM use on construction project. This is to ensure that, respondents have the requisite knowledge to respond to the list of barriers factors to BIM adoption. This paper present the analysis of the survey on perceived barriers to BIM adoption in Nigeria.

The initial questionnaire was sent out to three practitioners for comments and the final questionnaire were sent out to 231 professionals in the Nigerian construction industry. A total of 63 useable questionnaires were returned. This represent 27% effective response rate. Of the respondents, 19 (30%) are architects, 15 (24%) are engineers, 22 (35%) quantity surveyors and the remaining 7 (11%) are builders. The small number of respondents may be associated with the fact that BIM have not been widely implemented at industry level in Nigerian. A discriminant analysis test was conducted to see how respondents were distinguished based on the 21 items used in measuring barriers to BIM adoption. The rationale for the use of discriminant analysis is that this study involves test of group mean differences among the professional groups (Architect, Engineer, Quantity Surveyor, Project managers and Builders) on perceptions towards barrier to BIM adoption in Nigeria. Discriminant analysis is an appropriate statistical technique for testing for equality of group means and building a predictive model of group membership based on a set of observed discriminating variable (Hair, et al., 1998). It is useful in determining whether a set of variables are effective in predicting group membership (Green et al., 2008). It is a linear combination of two or more discriminating variables (discriminant function) that discriminate best between groups. The relationship is expressed as the ratio of between-group to within-group variances. The linear combination is derived from equation 1.

$$Z = W1X1 + W2X2 + W3X \ldots\ldots + WnXn \qquad (1)$$

Where Z = the discriminant score, W = the discriminant weights (discriminant coefficients), X = the independent discriminating variables
Four group discriminant analysis was adopted to explore and test for possible differences on barriers to BIM adoption among the professional groups. The 21 items were measured on 5 point Likert scale ranging from 5 *extreme barriers* to 1 *not at all a barrier*. The aim is to determine if significant mean difference exists among the groups with respect to barriers to BIM adoption and on the other hand assess the discriminatory power of set of attribute items adopted.

4. Discussion of Results

The results in Table 1 show the class means score differences among the four professional groups based on 21 items used in measuring barriers to BIM adoption in Nigeria. The items recorded moderate class means ranging from 2.0 to 4.5 and standard deviation ranging from 0 to .7 as shown in Table 1. For the individual groups (architect), results show that 14 out of the 21 items have mean score >3 while the rest (7) scored <3. What this suggests therefore, is that the architect perceived these 14 items (BAR1, BAR5, BAR6, BAR7, BAR8, BAR10, BAR 11, BAR 12, BAR 13, BAR 14, BAR16, BAR19, BAR20 and BAR21) as barrier to BIM adoption in Nigeria. For the Engineers, all the 21 items have their mean score >3 which is an indication that they perceived all of them as barriers to BIM adoption in the country. However, for the quantity surveyors two items (BAR 18 and BAR 19) have their mean scores <3, which is an indication that they did not see them as barriers to BIM adoption. In other words, quantity surveyors do not see legal uncertainties and staff resistance as a major barrier to BIM adoption. Lastly, for the builders, four items (BAR 4, BAR 16, BAR17 and BAR 19) have mean scores <3. What this suggests is that they do not perceive lack of funding, poor power supply, lack of transparency and staff resistance as major barriers to BIM adoption in Nigeria. In general, it could be seen from the results, that 9 out the 21 items (BAR1, BAR5, BAR6, BAR7, BAR8, BAR10, BAR11, BAR20 and BAR 21) recorded mean scores >3 across all the groups.

Put differently, all the professional groups sampled in this study viewed lack of knowledge about BIM technology, collaborative initiatives from industry stakeholders, support from local institutions, absence of required standard to support BIM, insufficient ICT infrastructure, government support, resistance to change, cost of software and training as the barriers to BIM adoption. Based on the test of equality of group mean (Table 1), 18 items registered strong discriminatory power ($p<0.05$) and therefore contributed significantly in differentiating the four professional groups based on perception about barriers to BIM adoption in Nigeria. The items have Wilks' Lambda (λ) range from .755 to .978. Three items (BAR7 λ= .968, F=1.596, p>.05, BAR14 λ=.974, F=1.326, p>.05 and BAR18 λ=.958, F=2.164, p>.05) revealed a poor discriminatory power and thus did not significantly discriminate the professional groups. In other words, no significant differences were recorded among the groups for these three items.

4.1 Predicting Discriminant Function for Class Barriers to BIM Adoption

The objective here is to identify the significant predictive items that best differentiate among the four professional groups from the stand point of perceived barrier to BIM adoption in Nigeria. To achieve this, all the 21 items used in measuring barrier to BIM adoption were subjected to stepwise method to select the ones that maximizes the overall Wilks'L ambda at each step. The results in Table 2 show that at 10 iterations and at 0.05 significant level, only 5 out of the 21 items entered the model and emerged as the ones with the most significant predictive power in differentiating the professional groups from the stand point of perceived barriers to BIM adoption. The items in order of magnitude are: BAR2, BAR4, BAR16, BAR 18, and BAR17. What this result suggests therefore is that low level awareness of client on BIM, lack of funding, poor power supply in Nigeria legal uncertainties and lack of transparency appeared to be the major items that differentiate the professional groups because perceived barriers to BIM adoption in Nigeria.

Table 1- Class mean difference on barriers to BIM adoption

Code	Barriers to BIM adoption	Architect Mean (STD)	Engineer Mean (STD)	Quantity Surveyor Mean (STD)	Builders Mean (STD)	Test of Equality of class means		
						Wilks' Lambda (Λ)	*F	**Sig.
BAR1	Lack of knowledge about BIM technology	3.9130 (1.31125)	4.0732 (.90527)	4.7436 (.56834)	4.4444 (.52705)	.837	9.536	.000
BAR2	Client awareness is low	2.6522 (.83168)	3.6585 (1.06324)	4.0769 (.83385)	4.0000 (.00000)	.755	15.886	.000
BAR3	Fragmented nature of the construction industry	2.4348 (.50687)	3.3902 (.80244)	3.5256 (1.10164)	4.4444 (.52705)	.797	12.495	.000
BAR4	Lack of funding	2.6522 (.83168)	4.1463 (.85326)	3.6923 (1.12015)	2.5556 (.52705)	.768	14.841	.000
BAR5	Lack of collaborative initiatives from industry	3.7826 (.79524)	4.5366 (.71055)	4.4872 (.61883)	4.4444 (.52705)	.867	7.541	.000

Code	Barriers to BIM adoption	Architect Mean (STD)	Engineer Mean (STD)	Quantity Surveyor Mean (STD)	Builders Mean (STD)	Test of Equality of class means		
						Wilks' Lambda (Λ)	*F	**Sig.
	stakeholders							
BAR6	Lack of support from local institutions	3.3478 (.83168)	4.0000 (.74162)	3.6026 (.99792)	4.4444 (.52705)	.905	5.148	.002
BAR7	Absence of required standard to support collaboration in BIM	3.9130 (.90015)	4.2683 (1.11858)	3.9103 (1.09528)	4.4444 (.52705)	.968	1.596	.193
BAR8	Insufficient ICT infrastructure	3.5652 (1.07982)	4.5122 (.74572)	3.9744 (1.28906)	3.0000 (.00000)	.879	6.731	.000
BAR9	Over reliance on foreign initiatives	2.6522 (.83168)	3.4878 (.50606)	3.3974 (1.22039)	2.0000 (.00000)	.842	9.162	.000
BAR10	Lack of government	3.9130	3.8780	3.5385	4.4444	.948	2.690	.048

Code	Barriers to BIM adoption	Architect Mean (STD)	Engineer Mean (STD)	Quantity Surveyor Mean (STD)	Builders Mean (STD)	Test of Equality of class means		
						Wilks' Lambda (Λ)	*F	**Sig.
	support	(1.12464)	(.67805)	(1.23470)	(.52705)			
BAR11	Resistance to change	3.5652 (1.07982)	3.9024 (.86037)	3.6667 (.76730)	4.4444 (.52705)	.940	3.145	.027
BAR12	Unfamiliarity with BIM use	4.3478 (.48698)	3.7073 (.98092)	3.8590 (.59706)	4.0000 (.00000)	.918	4.377	.006
BAR13	Reluctance to initiate new workflows	3.2609 (.96377)	3.6585 (.88345)	4.0513 (.55590)	3.5556 (.52705)	.857	8.179	.000
BAR14	Inadequate opportunity for BIM implementati on	3.3913 (1.03305)	3.4634 (1.09767)	3.6795 (.91869)	4.0000 (.00000)	.974	1.326	.268
BAR15	Uncertainty about the benefits of BIM	2.7391 (.96377)	3.4146 (.99939)	3.7436 (1.21073)	3.4444 (.52705)	.906	5.090	.002

Code	Barriers to BIM adoption	Architect Mean (STD)	Engineer Mean (STD)	Quantity Surveyor Mean (STD)	Builders Mean (STD)	Test of Equality of class means		
						Wilks' Lambda (Λ)	*F	**Sig.
BAR16	Poor power supply	3.5217 (1.37740)	4.0244 (.79018)	3.3077 (1.28232)	2.0000 (.00000)	.850	8.653	.000
BAR17	Lack of transparency	2.6522 (.83168)	3.9268 1.05807	3.5385 1.12460	2.0000 (.00000)	.784	13.491	.000
BAR18	Legal uncertainties	2.9565 (1.46095)	3.4634 (.97718)	2.9359 (1.06099)	3.1111 (1.05409)	.958	2.164	.095
BAR19	Staff resistance	3.1304 (.75705)	3.0732 (1.12673)	2.9615 (1.16711)	2.0000 (.00000)	.947	2.763	.044
BAR20	Cost of software	3.1739 (.98406)	4.2195 (.41906)	3.7179 (.89584)	3.0000 (.00000)	.806	11.822	.000
BAR21	Cost of training	3.6087 (1.23359)	4.0732 (.46852)	3.6667 (.84771)	3.0000 (.00000)	.905	5.159	.002

Table 2 - Stepwise statistics for barriers to BIM adoption

CODE	Entered	Statistic	*Sig
BAR2	Client awareness is low	.755	.000
BAR4	Lack of funding	.510	.000
BAR 16	Poor power supply	.343	.000
BAR 18	Legal uncertainties	.252	.000
BAR 17	Lack of transparency	.195	.000

*Significant @ p-value <0.05)

4.2 Testing for Significance of the Model

The summary of canonical discriminant function n in Table 3 provides the basis for verifying the hypothesis that: the four professional groups have equal (same) mean discriminant function score on perceived barriers to BIM adoption. In other words, the four groups have the same discriminant function score U1=U2=U3=U4. The first discriminant function (DF1) has the highest eigenvalue (31.42) which means it bears the strongest power of discrimination on the four professional groups. Accordingly, DF1 accounts for 70.2% variance in the class means while DF2 has 9.8 eigenvalue, and accounted for only 21.9% variance in the class mean and DF3 3.5 eigenvalue (7.9% variance).

Looking at how the first Discriminant function (DF1) accounting for most variance (70.2%) in the model separates the professional groups, the following group centroid values were obtained: architect (-9.787), engineer (-3.251), quantity surveyor (3.301) and builder (11.213). Adopting a cut-off (mid-point), whereby a movement above zero signifies (+) and below (-), it could be said that architects and engineers do not necessarily perceive these five items as barriers to BIM adoption whereas quantity surveyors and builders with values lying above (+) are predicted as seeing the items as barrier to BIM adoption in Nigeria.

Table 3 - Summary of standardized canonical discriminant functions and variance

Professional Group	Functions at Group Centroids		
	Function		
	DF1	**DF2**	**DF3**
	Eigen value 31.415[a] (70.2% of variance)	Eigen value 9.801[a] (21.9% of variance)	Eigen value 3.526[a] (7.9% of variance)
Architect	-9.787	4.394	-1.185
Engineer	-3.251	-4.688	-.343
Quantity Surveyor	3.301	1.065	1.257
Builder	11.213	.893	-6.305

Unstandardized canonical discriminant functions evaluated at group means

Furthermore, the hypothesis of equal discriminant function among the groups was tested. The results in Table 4 provides the model Wilks' Lambda statistics for testing the discriminant function and verifying the hypothesis. The value of Wilks'Lambda (Table 4) for the test of DF1 through DF3 (λ = .001, X2 = 1013.09, $p < 0.05$), DF2 through DF3 (λ = .020, X2 = 534.79, $p < 0.05$) and DF3 (λ = .221, X2 = 207.59, $p < 0.05$).

Table 4 -Testing the hypothesis of equal discriminant functions

Wilks' Lambda				
Test of Function(s)	Wilks' Lambda (λ)	Chi-square	df	Sig.
1 through 3	0.001	1013.095	63	0.000
2 through 3	0.020	534.786	40	0.000
3	0.221	207.589	19	0.000

Thus, the hypothesis is rejected and the conclusion therefore, is that there is at least one significant function that separates the four professional groups on perceived barrier to BIM adoption. Classification Efficiency shows that the model and its function achieved classification accuracy of 100%. This suggests that the model has practical significance in differentiating the four professional groups on perceived barriers to BIM adoption.

5. Conclusions

As the literature reviewed suggest, BIM adoption in Nigerian construction industry is still developing and there is need for government to provide support to the industry to kick-start BIM implementation. This research investigated the barriers to BIM adoption from the perspectives of practitioners. The barriers factors were identified from previous studies relating to ICT and BIM adoption in the construction industries of both developed and developing countries. A class mean difference among practitioners has been used to identify significant barriers to BIM adoption. a discriminant analysis of all the 21 factors used in measuring barrier to BIM adoption in Nigeria was performed. The result shows that, of the 21 barrier factors, 5 items have the most significant predictive power in differentiating the professional groups from the standpoint of perceived barriers to BIM adoption. This means there is difference of opinion between the group on whether the 5 items constitute barriers to BIM adoption in Nigerian construction industry. The items in order of magnitude are: clients low level of awareness, lack of funding, poor power supply, legal uncertainty and lack of transparency. What this implies is that the four professional groups have equal mean discriminant function score on the remaining 16 barriers to BIM adoption, indicating agreement in the opinion of the groups. The barrier factors identified in this study will assist industry stakeholders in formulating appropriate strategies to overcome them to ensure successful BIM implementation.

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