Assessment of Some Key Issues that Affect the Acceptance of Building Information Modelling (BIM)

[1]N. Usman, [1]M. Abubakar and [1]M. A. Ibrahim

[1]Department of Building,
Abubakar Tafawa Balewa University Bauchi, Nigeria

Abstract

The study evaluated how technological integration affects Building Information Modelling (BIM) acceptance. Quantitative research design was used, whereby survey was employed using questionnaire as a means of data collection. A total of 190 questionnaires were distributed to the professionals in the Nigerian construction industry, 170 questionnaires were retrieved; SPSS software was employed for analysis with descriptive statistic and multiple regression as tools for the analysis. The finding shows that there is positive relationship between rapid change in technology, cost of integration, government policy and BIM acceptance. It means that rapid change in technology and cost of its integration in conjunction with lack of government enforcement affects BIM acceptance. Therefore, government should formulate and enforce policies that can control the adoption and implementation of a new or integrated technology.

Keywords: *Building Information Modelling; Integration; Technology*

Introduction

Building Information Modelling is defined by Woo (2007) as "an intelligent 3D virtual building model that can be constructed digitally by containing all aspects of building information into an intelligent format that can be used to develop optimized buildings solutions with reduced risk and increase value before committing to a design proposal". That is by using BIM, both the client and contractor would know exactly the scope of the work involved before the actual commencement of the site work. Zuppa, Raja, and Issa (2009) found that, "BIM was most frequently perceived as a tool for visualizing and coordinating Architecture, Engineering, and Construction (AEC) work and avoiding errors and omissions".

According to Joseph (2008), the utilization of BIM has not been empirically and clearly established to be beneficial to the overall outcome of a construction project. Owners are faced with the dilemma of making a decision of whether or not to utilize BIM based on speculated benefits. The largest barriers to BIM implementation and acceptance across the building industries are recognition and enforcement by owners and a balanced framework for implementation that considers both monetary and managerial outcomes (Succar, 2009).

Elvin (2007) explained Building Information Model could provide 2-D and 3D drawing with no graphical information including specifications, cost data, scope data, and schedules. Most importantly, it creates an object-oriented database, meaning that it is made up of intelligent objects, for example representation of doors, windows, and walls which are capable of storing both quantitative and qualitative information about the project. So, while a door represented in a 2D CAD drawing is just a collection of lines, in BIM it is an intelligent object containing information on its size, cost, manufacturer, schedule and more. BIM also goes further creating a relational database. This means that all information in the BIM is interconnected, and when a change is made to an object in the database, all other affected areas and objects are immediately updated. For example, if a wall is deleted, the doors and windows within the wall are also deleted, and all data on project scope, cost, and schedule are instantly adjusted.

BIM Integration

Building information modeling is an innovative approach to building design, construction, and management introduced by Autodesk in 2002. It has changed the way industry professionals world wide think about how technology can be applied to building design, construction, and management. It also supports the continuous and immediate availability of project design scope, schedule, and cost information that has high quality, reliable, integrated, and fully coordinated.

For each of the three major phases in the building lifecycle: design; construction; and Management, building information modeling offers access to the following critical information:

a In the design phase - design, schedule, and budget information

b. In the construction phase - quality,

schedule, and cost information

c. In the management phase performance, utilization, and financial information.

The ability to keep this information up to date and accessible in an integrated digital environment gives architects, engineers, builders, and owners a clear overall vision of their projects, as well as the ability to make better decisions faster that lead to raising the quality and increasing the profitability of projects (Autodesk, 2012).

As a construction project grows increasingly complex and involves numerous building elements, two-dimensional (2D) drawings are often unable to adequately express design ideas or resolve the conflicting problems that interfere with the construction. *n*D modelling project which aim to integrate an *n*th number of design dimensions into holistic model which would enable users to portray and visually project the building design over its complete lifecycle can provide solution to resolves these problems. Wang, Weng, Wang, and Chen (2013) have indicated that a four-dimensional (4D) model, which integrates 3D building components with time as the fourth dimension, can further facilitate construction management by discovering inappropriate schedule sequences, evaluating issues of constructability, and identifying potential time and space conflicts.

Adebayo, Balogun, and Kareem (2013) discovered that cost, funds, skills and training, management support and government support attitude are the main factors that affect BIM adoption in Nigeria.

Categories of BIM Environment

A. 3D in a BIM Environment

3D BIM consists of intelligent objects which are able to hold information which automatically can be updated and modified with the progress of a project (America Geological Society, 2007).

B. 4D in a BIM Environment

4D modeling is the fourth dimension, which means that it connects place and time. In 3D, an object can be determined by place, size and shape (x,y,z) but it cannot tell anything about *when* an object will be in a particular place. Therefore time is added in the fourth dimension, to be able to determine *when* an object will be in a particular place (x,y,z,t) (Geological Society of America, 2007 & Koo and Fisher, 2000).

C. 5D in a BIM Environment

5D modeling is the fifth dimension, which means that it connects place, time and total cost. In 4D, an object can be determined by shape, size, place and time (x,y,z,t), but this does not tell anything about how much it will cost to get a certain object to be at a certain place at a certain time. Therefore the cost is added, the fifth dimension, to be able to determine the (total) cost of getting a certain object to be present at a certain place at a certain time (x,y,z,t,$).

D. 6D in a BIM Environment

The sixth dimension is still under dispute whether it exists or not. For those that believe that the sixth dimension exists it is about lifecycle cost, facilities management, and environmental impact.

E. 7D in a BIM Environment

The 7th dimension is still under dispute whether it exists or not. For those that believe the seventh dimension exists it is about procurement solutions e.g. contracts, purchasing, suppliers, and environmental standards.

A survey conducted by Ayarici, Khosrowshahi, Ponting, and Mihindu (2009) in UK reported the primary barriers to the adoption of BIM by the UK construction companies as the unfamiliarity of firms with the use of BIM, reluctance to train staff or initiate new work flows, lack of opportunities to implement, and lack of proof for tangible benefits of BIM. The same survey also revealed that lack of training: cost of training and high cost of software are the barriers to BIM adoption by other respondents. This shows that BIM is still under scrutiny by many building professional across the globe questioning its potential benefit on their projects. Nigerian building professionals were not exceptional from this as can be seen from the work of Mu'awiya (2013) “The survey revealed that all the groups of Nigerian design firms are appreciably ready for the adoption of BIM technologies in their practice, with slight variations in their respective levels of readiness. 'Lack of awareness of BIM technology among professionals' and clients and 'lack of knowledgeable and experienced partners' was identified as the most important barriers of BIM adoption in Nigeria”.

Theoretical Framework

Technology has been changing rapidly, the changes affect its acceptance because the stakeholders did not really understand what the first technology is, a second evolved, based on this Christopher and Richard (2015) states that rapid change creates significant uncertainties that can blindside the most cautious project manager. Also, rapid changing information technology is increasing the complexity of IT management (John and Albert, 2010). Likewise, implementing BIM necessitates purchase of software, hardware, and constant update, in which the management are not supporting more additional cost burden (Robert, Henry, Bike, Clare, and Michael, 2014). Therefore, based on the aforementioned factors hindering IT adoption, this study aimed at assessing the effect of technological integration, cost of the integration, and lack of government policy on BIM acceptance, because they are among the major factors hindering the acceptance technology, with a view to sensitized professionals in relation to its impact as shown in figure 1 below.

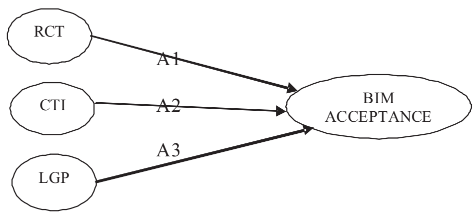

Fig. 1: Framework for BIM acceptance

The framework in figure 1 was tested based on the following hypothesis:

H_{a1} = Rapid change in technology (RCT) affect BIM acceptance.

H_{a2} = Cost of technology integration (CTI) affects BIM acceptance.

H_{a3} = Lack of government policy (LGP) affect BIM acceptance.

Methodology

The research design for this study is a quantitative method, and a field survey was adopted where questionnaires were used as instrument for data collection. 5 points likert rating scale closed ended multiple choice-questions was employed for this study and are targeted to measure the respondents (building construction stakeholders) BIM acceptance in relation to the certain factors that may influence it. The population of the respondents was derived from the directorate of building and construction services (2013) as 250 registered building construction companies, while the sample size was derived from Krejcie and Morgan (1970) table of determining sample size as 152. But with 80% expected response rate the sample size is 190. The 190 sample size met the criteria for Sekaran (2006) appropriate and effective size for a research. However, out of the 190 questionnaires produced and distributed to the professionals in the Federal Capital Territory (FCT) Abuja, only 170 questionnaires were retrieved. The data collected was analysed using SPSS version 21 for windows. The demography of the respondents was analysed using descriptive statistics. Reliability test was employed in this study to measure internal consistency of the instrument using Cronbach alpha, where values above 0.7 are considered acceptable (Pallant, 2011). The assumption made by Maiyaki and Mokhtar (2011) that a skewness which fall between $\pm$ 2.0 and Kurtosis of $\pm$ 10.0 can be described as reasonably normal was adopted in this study. In addition, standard multiple regression was employed to measure the nature of the relationship that exist between the three independent and one dependent variables. Where correlation coefficient, coefficient of determination (r^2), and beta values in relation to the significant level, were used to examine the effect of each independent variable on the dependent variable.

Results

A. Preliminary Analysis

The purpose of the whole preliminary analysis was to show the objectivity of the data collected for the study in terms of the nature of the organization, gender, rank of the respondent, level of education, and years of experience. It also shows whether the data collected is normal and reliable.

Table 1 presents the frequency and percentage for the respondent's types of organisation, consultants has 25.9%, contractors 47.6%, and those that are both consultants and contractors have 26.5%. This shows that among the respondents contractors participate more than the consultants.

TABLE 1: TYPE OF ORGANISATION

ORGANISATION	Frequency	Percentage
Consultancy	44	25.9
Contracting	81	47.6
Both	45	26.5
Total	170	100.0

Table 2 presents the frequency and percentage for the respondent's gender; male has 85.3% and female 14.7%. These depict the population of male are more than that of female due to the nature of construction activities.

TABLE 2: GENDER

Gender	Frequency	Percentage
Male	145	85.3
Female	25	14.7
Total	170	100.0

Table 3 presents the frequency and percentage for the respondent's position in the organisation, 16.5% are managing directors, 34.7% project managers, 22.4% supervisors and 26.5% resident engineers. This shows project managers has the highest percentage because they are the ones that handle issues of project from inception to completion, and they are also responsible for innovativeness like the adoption BIM.

TABLE 3: POSITION

Position	Frequency	Percentage
Managing Director	28	16.5
Project Manager	59	34.7
Supervisor	38	22.4
Resident Engoneer	45	26.5
Total	170	100.0

Table 4 presents the frequency and percentage for the respondent's educational level, where 1.8% are certificate/diploma holders, 58.2% Degree/HND, 36.5% Masters, and 3.5% are PhD holders. This proves that most of the respondents acquire degree so they are not ignorance of what BIM is all about.

TABLE 4: EDUCATIONAL LEVEL

Level of Education	Frequency	Percentage
Cert./Diploma	3	16.5
Bachelor/HND	99	34.7
Masters	62	22.4
Ph.D	6	26.5
Total	170	100.0

Table 5 presents the frequency and percentage for the respondent's years of experience, 11.2% has less than 5 years, 19.4% has between 6 & 10 years, 17.6% has between 11 & 15 years, 13.5% has between 16 & 20 years, and 38.2% has more than 20 years. This shows most of the participant has more than five years working experience which is enough to judge on BIM adoption.

TABLE 5: YEARS OF EXPERIENCE

	Frequency	Percentage
Less than 5 years	19	11.2
6 - 10	33	19.4
11 - 15	30	17.6
16 - 20	23	13.5
More than 20 years	65	38.2
Total	170	100.0

Preliminary analyses were performed to ensure that no violation of assumptions, in terms of objectivity, reliability, and normality in the data collected. After running the reliability test Table 6 presents the study constructs, number of items under each construct, and Cronbach alpha scores. The Cronbach alpha value for rapid change is 0.8, cost of integration has 0.7, government policy has 0.9, and BIM acceptance has 0.8. These show the reliability values are acceptable since the Cronbach alpha values fall between 0.7 and above. In addition, Table 7 presents normality test results that show the constructs studied, number of items under each construct, skewness and kurtosis under normality scores. All the values are considered normal based on the assumptions that skewness of ± 2.0 and kurtosis of ± 10.0 are reasonably normal. Also the normality plots for all the constructs shows a bell shape (Fig. 2 to 5), which means the data is normally distributed and it can be acceptable.

TABLE 6: RELIABILITY TEST RESULT

SN	Construct	Number of Items	Cronbach's Alpha
1	Rapid change	19	11.2
2	Cost of integration	33	19.4
3	Government policy	30	17.6
4	BIM acceptance	23	13.5

TABLE 7: NORMALITY TEST RESULT

SN	Construct	Number of Items	Normality	
			Skewness	Kurtosis
1	Rapid change	19	0.089	-0.326
2	Cost of integration	33	0.048	-0.309
3	Government policy	30	-0.197	-0.209
4	BIM acceptance	23	-1.116	1.911

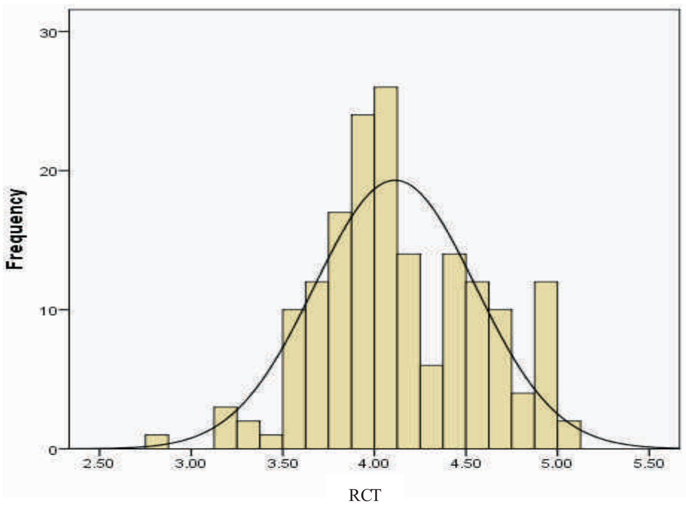

Fig. 2: Rapid Change in Technology (RCT) normality plot

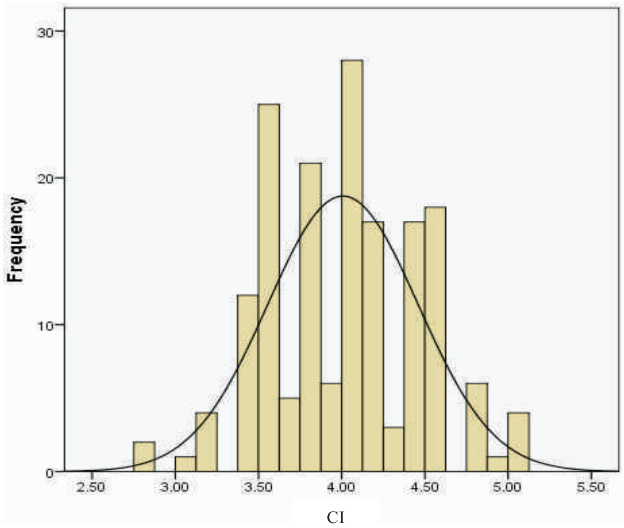

Fig. 3: Cost of Integration (CI) normality plot

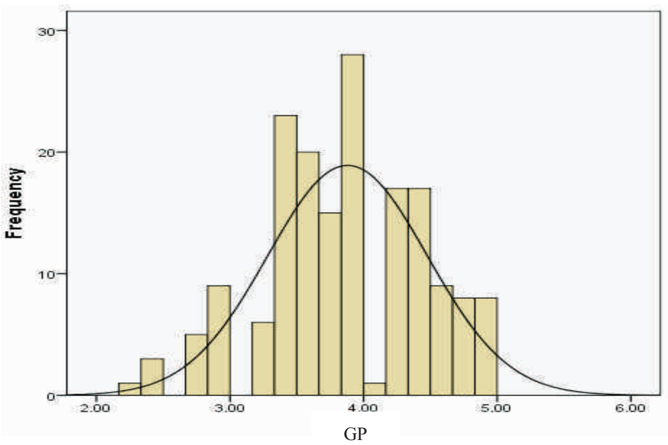

Fig. 4: Government Policy (GP) normality plot

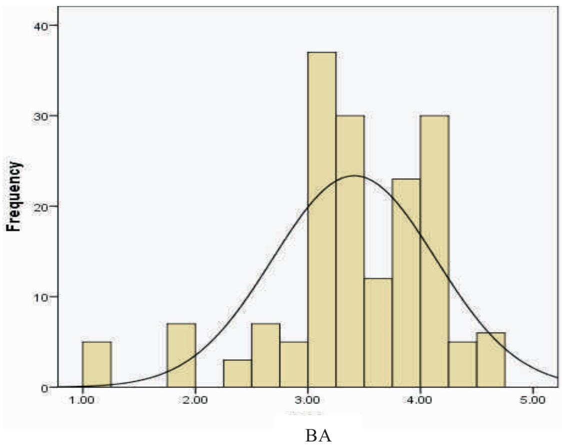

Fig. 5: BIM acceptance (BA) normality plot

B. Regression Analysis

Standard multiple regression was used to evaluate how the three (3) independent variable (Rapid change in Technology, Cost of its Integration and Lack of Government Policy), affect dependent variable (BIM acceptance).

Table 8 and Table 9 were interpreted based on Cohen (1988) guidelines, which show r between 0.10 and 0.29 having little relationship, 0.30 to 0.49 have Moderate relationship, and 0.50 to 1.0 have Strong relationship. Therefore, the table 8 shows there was a moderate positive correlation between rapid change in technology and BIM acceptance (r = 0.413, n = 170, Pvalue = 0.05) with moderate levels of effect on BIM acceptance. Also cost of integration shows a little positive correlation with BIM acceptance (r = 0.320, n = 170, Pvalue = 0.05) with little effect on BIM acceptance, while Government policy has strong positive correlation with BIM acceptance (r = 0.534, n = 170, Pvalue = 0.05) with high effect on BIM acceptance.

TABLE : 8 CORRELATION RESULT

		BA	RCT	CI	GP
Pearson Correlation	BA	1.000	.413	.320	.534
	RCT	.413	1.000	.396	.362
	CI	.320	.396	1.000	.241
	GP	.534	.362	.241	1.000
Sig. (1-tailed)	BA	.	.000	.000	.000
	RCT	.000	.	.000	.000
	CI	.000	.000	.	.001
	GP	.000	.000	.001	.
N	BA	170	170	170	170
	RCT	170	170	170	170
	CI	170	170	170	170
	GP	170	170	170	170

Table 9 presents the Rapid change in Technology, Cost of its Integration and Lack of Government Policy explained 35.6% of the variance in BIM acceptance with positive correlation coefficient of 0.596 (Cohen, 1988).

TABLE 9: MODEL SUMMARY RESULT

Model	R	R Square	Adjusted R Square
1	.596	.356	.344

Table 10 presents that the three independent variables beta value were statistically significant because the significant value (Pvalue) is less than 0.05 (Pallant, 2011), in which the government policy recorded a higher beta value (Beta = 0.427, Pvalue = 0.000) than rapid change in technology (Beta = 0.204, Pvalue = 0.005) and Cost of its Integration (Beta = 0.136, Pvalue = 0.048).

TABLE 10: COEFFICIENT RESULTS

Model	Unstandardized	Coefficients	Standardized Coefficients	Sig.
	B	Std. Error	Beta	
(Constant)	-.863	.511		.093
RTC	.338	.118	.204	.005
CI	.218	.110	.136	.048
GP	.518	.082	.427	.000

Discussion

The preliminary analysis results shows that the information obtained using the instrument is normal and reliable, which means that the instrument can be used in a similar situation and the result can be generalised. Also the demography of the respondent's shows those that participate in the study were educated (58.2% Degree/HND and 36.5% Master), Most of them are Project Managers and Engineer (34.7% and 22.4% respectively) operating as a contracting or consultancy (47.6% and 25.9%) with above 10 personnel's (69%), and more than 5 years working experience involving both males and females. The effect of these demographists on the findings is that, it would make the result to be referred to as an objective and reliable evidence for proving the effect of technological integration on BIM acceptance.

The standard multiple regression results shows that there is positive significant relationship between Rapid change in Technology, Cost of its Integration, Lack of Government Policy (independent variable) and BIM acceptance (dependent variable; all at P-value of 0.000), these means that any change in one variable can affect BIM acceptance, it also means all the alternative hypothesis (H_{A1}, H_{A2} and H_{A3}) are accepted. Furthermore, the correlation coefficient of 0.596 proof that strong relationship exist between the independent variables and the dependent variable. Likewise, 0.356 coefficients of determination means the independent variables can explain up to 35.6% of the variance in the dependent variable. Therefore, with strong relationship that exist between the variables and high value of shared variance also means any integration in one independent variable can affect the BIM acceptance.

Furthermore, with the high beta value (standardise coefficient) for Lack of Government Policy and Rapid change in Technology (0.427, and 0.204), and the least in Cost of its Integration (0.136), it means that Rapid change in Technology, and Lack of Government Policy made strong contribution in explaining BIM acceptance, while Cost of its Integration made less contribution. Consequently, it means all the independent variables affect BIM acceptance, but Lack of Government Policy and Rapid change in Technology have more effect than Cost of its Integration. These findings proof that alternative hypotheses can be accepted and null hypotheses can be rejected.

Conclusion

The study has shown that rapid change in technology, lack of government policy and cost of BIM integration affects BIM acceptance. Consequently, the implication of these results in the developed countries is that, the construction firms have to spend more funds on retraining of their personnel's all the time and governments also has to adjust their policy, so that enforcement can be regulated at reasonable cost of integration so that BIM adoption is maintained. While the developing and under developed countries may end up been frustrated and abandoned the BIM usage due to the rapid change in technology, Where 3D has not been understood 4D was invented, up to now 6D in which it might make the stakeholders to be so reluctant in adopting it, and some might say less wait for the last version, which is not healthy to the built environment development. These are in line with the views of Christopher and Richard (2015), John and Albert (2010), and Robert et al. (2014) that, rapid technological changes cause uncertainty and additional cost, which at the end affect its adoption. However, this study established empirical evidence on how these factors are affecting BIM acceptance. Finally, there is need to investigate whether the curriculum of Built Environment courses include training students on BIM, and whether enough enlightenment has been carried out to educate the project managers and the law enforcement agents on the benefit of BIM adoption.

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