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APPLICATION OF MULTIPLE REGRESSIONS ON THE IMPACT OF BUILDING INFORMATION MODELLING ADOPTION DRIVERS ON SUSTAINABLE CONSTRUCTION IN NIGERIA

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ABSTRACT
This study aims at determining the influence of BIM adoption drivers on attaining sustainable construction in Nigeria, with a view to fostering the adoption of BIM through the use of these drivers by the necessary authorities. Exploratory and survey research design approach was used for the study. 191 copies of structured questionnaire were administered on the respondents using random sampling method on the construction professionals in Akwa Ibom State, South-South, Nigeria. The research instrument's validity test was done by experts in the department of building, University of Uyo; and a reliability test was carried out on the collected data using Cronbach's alpha. The perceptions of the professionals on the adoption strategies were analysed using relative importance index (R.I.I) method; while the test on the impact of the strategies on sustainable buildings was done using multiple regression analysis. The professionals agreed that the most important strategies that will enhance the adoption of BIM for sustainable building projects in the study area, are organising professional workshops and training for stakeholders, the availability of well-trained professionals, and making the software packages affordable; from the multiple regression analysis, it was found that the strategies have a positive impact on attaining sustainable construction. The coefficient of determination (R^2) was 0.995 while the adjusted R^2 was 0.995 showing that 99.5% of the variation in achieving sustainable building projects in the study area was explained by combined changes in the predicting variables (Advanced Man-Power and Public Sector Led Strategies). The analysis also showed that the overall fit of the regression model was good given the ANOVA F-value of 13869.627 and significant at 0.05 critical level. The Durbin Watson showed 1.766, which was an indication that there was an autocorrelation among the successive values of the variables in the model since the value was greater than one. The study therefore establishes that in order to implement BIM for sustainable building projects, the use of advanced man-power training and the role of the public sector must be strongly adhered to.

Keywords: Building information modelling, Information technology, Sustainable buildings, and Building projects.

Introduction

The need for the adoption of the building information modelling (BIM) technology in the construction industry especially in developing countries like Nigeria has become very pertinent.

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Building Information Modelling (BIM) is an innovation in the global construction industry that poses a lot of benefits. BIM is the process of constructing a virtual 3D, 4D (time schedule), 5D (cost schedule) digital model before carrying out the real site activities in a construction project. It could be said to mean building twice – first by using software packages and then on site. BIM is a management method of developing a building model through collaboration for use by the project team and facility managers (Alliance for Construction Excellence, ACE, 2008). Coenders (2010) explained that BIM is an

integrated process of constructing, engineering, designing and sustaining a building using information models. This shows that a building information model serves as a working office for the project stakeholders, to access at any time in order to obtain necessary information. BIM has emerged as a tool with benefits like reduction in project cost, productivity and quality enhancement and decrease in project delivery time (Azhar, 2011). In situations where clashes in a project are detected on time using BIM, it helps to curtail costly errors and rework that may arise on site, thereby delivering safe, efficient and quality buildings and giving the clients value for their money. It was observed by Eastman, Teicholz, Sacks and Liston (2011) that in developed countries, the construction industry has derived a lot of benefits from the growing interest in using BIM, through its implementation. Arayici, Khosrowshahi, Ponting and Mihindu (2009) explained that the emergence of the BIM has led to the development in building design, management, maintenance and operations. The technology of BIM gave birth to a virtual model of a building called Building Information Model which is digitally constructed or developed to support and realize the various stages of a project (Azhar, 2011). Dim, Ezeabasili and Okoro (2015) explained that BIM emerged recently as a domineering tool for the design, construction and maintenance of building projects in order to promote collaboration and to integrate the design team which consists of the architect, structural and services engineers, quantity surveyor, and general contractor and tier suppliers.

Despite the enormous benefits that BIM has to offer, its adoption in the construction industry has been very slow. BIM's adoption in developed economies, that much is expected from, has not been as fast as expected because there are challenges or barriers to its adoption. It is because of this, that in the United States, the General Services Administration (GSA) made BIM to be compulsorily used in all public projects. However, in the United Kingdom, the adoption of BIM in projects has been slow because the government has not made enough polices to ensure its implementation (Alufohai, 2012; Daibi-Oruene, Ebiloma and Bumaa, 2017). This is to show that the government has a serious role to play in the adoption of BIM in construction projects, through policy making. Researchers have also discussed that a strategy to BIM's adoption is to increase the level of knowledge of stakeholders on the uses and benefits of BIM. In Nigeria, the adoption of BIM has been very slow in building project by the stakeholders (Ryal-Net and Kaduma, 2015; Ugochukwu, Akabogu, and Okolie, 2015; Abubakar, Ibrahim, Kado and Bala, 2015).

Alufohai (2012) outlined some strategies to the adoption of BIM in building projects; an increase in the knowledge of BIM, its software packages and their benefits, the need for professional bodies to organize workshops and training for the stakeholders, and the publicity of the benefits by analysts. In a study carried out by Ryal-Net and Kaduma (2015), strategies like the involvement of relevant professional bodies, the availability of the software packages, BIM's integration into academic curricula, availability of well trained professionals, and government support though legislation were highlighted; and it was seen that the place of professional bodies coming in to follow up is crucial and most important for BIM's adoption. The study by Abubakar, Ibrahim, Kado and Bala (2015) asserted that availability of trained professionals to handle the tools, availability/affordability of BIM software tools, enabling environment, and clients' interest in the use of BIM in their projects, are the major drivers to BIM implementation in the Nigerian construction industry. Oladokun, Ebiloma and Ikediashi (2017) in a study also indicated that the most important strategies to BIM adoption in the Nigerian construction industry for sustainable building projects are organising professional workshops and training for stakeholders, the availability of well-trained professionals, and making the software packages affordable.

In view of these research trends on BIM adoption drivers, it was seen that in order to foster the use of these strategies to BIM adoption in the Nigerian construction industry, a scientific inquiry on the effect of these drivers on sustainable construction is needed. Therefore, this study is aimed at determining the influence of BIM adoption drivers on attaining

sustainable construction in Nigeria, with a view to fostering the adoption of BIM through the use of these drivers by the necessary authorities.

Research Methodology

The area chosen for the study was one of Nigeria's oil-producing states – Akwa Ibom State, South-south, Nigeria. The survey design was used to obtain the perception of construction professionals on the adoption strategies of BIM for sustainable building projects. The population of the study was made up of Architects, Builders, Engineers, Quantity Surveyors, Estate Surveyors, Land Surveyors and Town Planners within Akwa Ibom State only. The population size was the number of registered professionals in the industry, obtained from the directories of professional bodies in Nigeria – 366. The Taro Yamane's formula was used to obtain the sample size of 191. The study adopted the random sampling method which is a method under the probability sampling techniques, and this was preferred so that every member of the sample size would have equal prospect or chances of been selected for the study. However, before this process of random sampling was carried out, the number of respondents to be allotted to each of the group of professionals in the construction industry was determined using the proportional stratified random sampling method. The data analysis was done using the multiple regression analysis but incorporating factor analysis to obtain the foremost drivers from the list of strategies obtained from the same study. The ranked list is shown on Table 3. Table 1 show that the copies of questionnaire that were properly filled and returned from the field were one hundred and forty-one (141), out of the one hundred and ninety-one (191) copies of questionnaire that were administered on the respondents. This represented a response rate of 74.2% which is far above the 30% rate, as an acceptable response rate in construction studies (cited in Ryal-Net and Kaduma, 2015). Hence, the total of one hundred and forty-one copies of questionnaire was used for the analysis.

Table 1: The response rate of the research instrument

Responses	Number	Percentage
Questionnaires properly filled and returned	141	74.2
Questionnaires not properly filled and returned	50	25.8
Total	191	100

(Source: Author's Survey, 2016)

Data Analysis and Discussion

Respondents' Socio-economic Characteristics

Table 2 shows the outcome of the respondents' characteristics which are obtained from the one hundred and forty-one (141) questionnaires used for the analysis. The characteristics are: sex, nationality, profession, years of experience, age, educational status, professional affiliation, and registration status.

Table 2: Outcome of respondents' characteristics

Characteristics	Frequency	Percentage
Sex		
Male	130	92.2
Female	11	7.8
Nationality		
Nigerian	141	100
Non-Nigerian	0	0
Profession		
Builder	12	8.5
Architect	22	15.6
Estate Manager	14	9.9
Quantity Surveyor	20	14.2
Land Surveyor	8	5.7

Town Planner	4	2.8
Engineer	61	43.3
Years of Experience		
1-5 years	28	19.9
6-10 years	52	36.9
11-15 years	12	8.5
16-20 years	11	7.8
21-25 years	17	12.1
Above 25 years	21	14.9
Respondents' Age		
21-30 years	10	7.1
31-40 years	64	45.4
41-50 years	28	19.9
51-60 years	33	23.4
Above 60 years	6	4.3
Educational Status		
OND	0	0
HND	3	2.1
B.Sc	43	30.5
M.Sc	62	44
Ph.D	29	20.6
Others	4	2.8
Professional Affiliation		
NIOB	12	8.5
NITP	4	2.8
NIESV	16	11.3
NIQS	20	14.2
NIA	22	15.6
NSE	61	43.3
NIS	6	4.3
Registration Status		
Student	0	0
Technician	0	0
Licentiate	0	0
Graduate	25	17.7
Corporate	108	76.6
Fellow	8	5.7
Honorary	0	0

(Source: Author's Survey, 2016)

From Table 2, the result for the sex distribution shows that 92.2% of the respondents were male, while 7.8% of them were female. This shows that the female gender's participation in the construction industry is far lower than the males' participation, which thus affects their usage of BIM. Perhaps, when more women are brought into the construction industry, it may influence the implementation of BIM in projects. The next characteristic on Table 2 is the nationality distribution of respondents. It reveals that 100% of the

respondents were Nigerian. This indicates that the result of the analysis will be adequate and satisfactory enough to conclude, since Nigerians who are aware of their environment are the ones giving the needed information and suggesting solutions.

The result on the profession distribution of the respondents shows that the engineers top the list with 43.3%, followed by architects with 15.6%, quantity surveyors with 14.2%, estate mangers with 9.9%, and builders with 8.5%. However, the land surveyors and town planners were the least set with 5.7% and 2.8% of the respondents, respectively. This means that the relevant professionals were represented in the survey.

As shown on Table 2, the result for the respondents' years of experience reveals that 19.9% of the respondents had experience between 1-5 years, 36.9% of them had experience between 6-10 years, 8.5% had experience between 11-15 years, 7.8% had experience between 16-20 years, 12.1% had experience between 21-25 years, and 14.9% of the respondents had above 25 years. This shows that the result of the study will be adequate based on the fact that BIM is an innovation in the Nigerian construction industry; this is so because 36.9% of the respondents had experience between 6-10 years, followed by the respondents with experience between 1-5 years, which are all recent periods.

Looking at Table 2, the age distribution of the respondents reflects that 7.1% of the respondents were between the age range of 21-30 years, 45.4% of them were between the range of 31-40 years, 19.9% were between 41-50 years, 23.4% were between 51-60 years, while 4.3% were above 60 years. This also reveals that the conclusion of the study will be satisfactory, since it is expected that the younger generation (on the average) will be more proficient in the use of BIM in construction projects. This is due to the outcome which reflected that 45.4% of the respondents were between the age ranges of 31-40 years.

The result on the educational status of the respondents shows that none of the respondents filled the ordinary national diploma (OND) status, 2.1% of them have attained the higher national diploma (HND) level, 30.5% have attained the bachelor of Science (B.Sc) degree, 44% had attained the master of science (M.Sc) degree, 20.6% had attained the doctor of philosophy (Ph.D) status, while 2.8% filled for other educational qualifications. This shows that the respondents are qualified through experience, expertise and training to give the relevant information needed for the study.

From Table 2, it is seen that all the respondents were affiliated to their respective professional bodies which are the Nigerian Institute of Building (NIOB), Nigerian Institute of Town Planners (NITP), Nigerian Institute of Estate surveyors and valuers (NIESV), Nigerian Institute of Quantity Surveyors (NIQS), Nigerian Institute of Architects (NIA), Nigerian Society of Engineers (NSE), and the Nigerian Institution for surveyors (NIS). This implies that all the respondents were professionals and not quacks who will seldom use the BIM tool; and which has its effects on the needed outcome.

The result on the registration status of respondents reveals that the corporate membership topped the list having 76.6% of the respondents, followed by graduate membership (17.7%), and lastly the fellow membership (5.7%); all other status were not represented. This indicates that 82.3% of the respondents were fully registered with both their professional and regulatory bodies, which indicates the authenticity and originality of this study. It was observed from the field that some of the graduate members were already at the final stage of their registration into the corporate status of these professional and regulatory bodies.

The Adoption Strategies of BIM in the Study Area

Table 3 presents the responses of the professionals with respect to the strategies that enhance the use of BIM for sustainable building projects in the study area. From Table 3, it can be seen that all the factors are very much relevant and important to be used as adoption strategies for BIM in order to attain sustainable building projects in the

Nigerian construction industry; this is because all the factors are above the 0.80 R.I.I score for very high level of importance. However, it can be seen by ranks that the use of professional workshops and training for stakeholders (Ranked 1st), availability of well-trained professionals (2nd), and affordability of software packages (3rd), are of foremost importance with respect to the strategies that will provoke the implementation of BIM in projects by professionals in the Nigerian construction industry.

Table 3: The adoption strategies of BIM in the study area

BIM Adoption Strategies	No. of Respondents in Ordinance Scale 1	2	3	4	5	Total	R.I.I*	Rank
Professional workshops and trainings for stakeholders	0	0	6	48	87	141	0.915	1
Availability of well-trained professionals	0	0	10	49	82	141	0.902	2
Affordability of software packages	0	0	11	48	82	141	0.901	3
Increasing the level of knowledge	0	0	4	66	71	141	0.895	4
Integration of BIM into academic curricula	0	2	16	41	82	141	0.888	5
Cooperation and commitment of professional bodies to its implementation	0	0	17	67	57	141	0.857	6
Publicity and proof of its benefits to stakeholders	0	8	9	60	64	141	0.855	7
Policy making by government	0	11	6	63	61	141	0.847	8
Change of mentality by stakeholders	0	3	15	74	49	141	0.839	9
Collaborative procurement methods	0	6	23	75	37	141	0.803	10

*Relative Importance Index
(Source: Author's Survey, 2016)

The Impact of the BIM Adoption Drivers on Sustainable Construction

The Multiple Regression Analysis was adopted for this test but in order to extract few and notable factors that can replace other variables in this test, factor analysis was employed. The results of the rotated factor analysis are outlined in Table 4.

Table 4: Rotated factor matrix to determine BIM strategies for sustainable building projects

Cases	Strategies	Factor Loadings F1	F2	Communalities
1.	Professional workshops and trainings for stakeholders	.865	.164	.669
2.	Integration of BIM into academic curricula	.839	.198	.774
3.	Increasing the level of knowledge	.827	.189	.592
4.	Availability of well-trained professionals	.769	.245	.743
5.	Availability of software packages	.766		.652
6.	Change of mentality by stakeholders	.594	.482	.627
7.	Publicity and proof of its benefits to stakeholders	.417	.310	.689

8.	Policy making by government	-.101	.811	.585
9.	Collaborative procurement methods	.404	.725	.270
10.	Cooperation and commitment of professional bodies to its implementation	.477	.632	.720
	Eigen Value	4.243	2.080	
	Percentage Variance	42.432	20.800	
	Cumulative %	42.432	63.232	

(Source: Author's Survey, 2016)

From Table 4, it can be seen that the factor analysis procedure with Varimax Rotation applied to the data yielded a two-dimensional solution. The communalities, which can be regarded as indicators of the importance of the variables in the analysis are generally high (above 50%) across all the data set apart from "collaborative procurement methods" which recorded a communality score of 0.270. Hence, the variables selected for this study are appropriate and relevant.

The two factors extracted from the analysis altogether accounted for 63.2% of total variance in the ten variables, hence, may be regarded as composite indicators defining the major BIM strategies in the study area. Factor one accounted for 42.4% of the total variance and is without doubt the most important factor of the 10 variables in the analysis. Seven strategies loaded positively and significantly on this factor which are case 1, 2, 3, 4, 5, 6, and 10 respectively. They included variables usually associated with Educational/Man-Power Training which enables professionals gain more advanced knowledge towards achieving sustainable building projects. This factor can be named Advanced Man-Power Training Factor. Factor two loaded positively on case 6, 8, 9, and 10. Hence, it accounted for 20.80% of the total variation. Because factor two was predominantly dominated by case 8, 9, and 10 which has to do with public and private collaboration and partnership, it was named Public Sector led Factor. The relative importance of the BIM strategies are shown by their Eigen values, which indicated that F1 (Advanced Man-Power Training Factor) is the most important strategy; followed by F2 (Public Sector led Factor).

The results of the inferential test using the multiple regression analysis on the two most important and extracted strategies are shown in Table 5. It showed that $p<0.01$for Advanced Man-Power and Public Sector Led Strategies on overall sustainable building Project were significant at 0.05 level of significance. Hence, the null hypothesis was rejected. This therefore means that both Advanced Man-Power and Public Sector Led Strategies significantly influence the outcome of the observed sustainable building projects in the study area. The coefficient of determination (R^2) was 0.995 while the adjusted R^2 was 0.995 showing that 99.5% of the variation in achieving sustainable building projects in the study area was explained by combined changes in the predicting variables (Advanced Man-Power and Public Sector Led Strategies). The analysis also showed that the overall fit of the regression model was good given the ANOVA F-value of 13869.627 and significant at 0.05 critical level. The Durbin Watson showed 1.766, which was an indication that there was an autocorrelation among the successive values of the variables in the model since the value was greater than one. Hence, linear relationship exists between the dependent and the independent variables.

Table 5: Summary of multiple regression analysis of advanced man-power and public sector led strategies on overall sustainable building projects

Variable	Beta Estimate	T	Remark
Sig. (.000)			Accept H_1
Advanced Man Power Training Strategies	.806	134.495	
Public Sector led Strategies	.588	98.237	
R	.998		
R^2	.995		
Adjusted R^2	.995		
Standard Error	.34035		
D-Watson	1.766		
F Value	13869.627		

(Source: Author's Survey, 2016)

To determine the contribution of each independent variable on the overall sustainable building projects in order to decide whether to accept or reject the earlier hypothesis through evaluation of each independent variable, the absolute value of the Beta estimate (β) was used. Table 5 shows that both independent variables were good predictors of sustainable building projects in the study area. At 0.05 level of significance, Advanced Man-Power Training Strategies (β = 0.806; t = 134.495) made the highest significant contribution (80.6%) towards predicting sustainable building projects in the study area. This is followed by Public-sector led Strategies (58.8%) with (β = 0.588; t = 98.237) respectively. This means that given one standard deviation increase in Advanced Man-Power Training Strategies, sustainable buildings will increase by 0.806 standard deviation, and given one standard deviation increase in Public-sector led Strategies, sustainable building projects will increase by 0.588 standard deviation.

Discussion of Major Findings

It was observed from this study that the most important set of strategies to be employed in BIM adoption for sustainable buildings in Nigeria are organising professional workshops and training for stakeholders, the availability of well-trained professionals, and making the software packages affordable. This study aligns with the studies by Ryal-Net and Kaduma (2015) and Alufohai (2012), where strategies like the used of Professional bodies, the availability of software packages, the support of government, and the availability of well-trained professionals, among others were outlined. This study also agrees with the study by Abubakar, Ibrahim, Kado and Bala (2014) which outlined these strategies as the drivers to BIM implementation in the Nigerian construction industry.

The result on the impact of BIM adoption strategies on sustainable building projects in the study area revealed that the null hypothesis was rejected while the alternative hypothesis was accepted meaning that there is a significant impact of the BIM adoption strategies in attaining sustainable building projects in the Nigerian construction industry. It meant that both Advanced Man-Power and Public Sector Led Strategies significantly influence the outcome of the observed sustainable building projects in the study area. In order to attain sustainable building projects, all the determined strategies must be employed so that every professional's view of adopting this new technology will be covered. It reflects the importance of these strategies which will aid in ensuring BIM's full implementation and for sustainable building projects in the construction industry. The findings of this research aligns with a study by Ezeokoli, Okoye and Nkeleme (2016) which reflected the importance of these strategies for BIM adoption, especially the need for education and training programme for project stakeholders in the construction industry.

Conclusion and Implications of the Study

The study concluded that the BIM adoption drivers which are the use of professional workshops and training for stakeholders, the availability of well-trained professionals, and the affordability of software packages among others, have positive impact on attaining sustainable construction in the Nigerian construction industry. This means that there is no doubt that if the necessary authorities make use of the BIM adoption drivers, sustainable construction is achievable in the Nigerian construction industry.

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