Contractors Perception of the Factors Affecting Building Information Modelling (BIM) Adoption in the Nigerian Construction Industry

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ABSTRACT

Building Information Modelling (BIM) is one of the most visible aspects of a deep and fundamental change that is rapidly transforming the global construction industry. It is the platform that brings about collaboration between project stakeholders and improvement of project outcomes. The growing worldwide adoption and implementation of BIM for its powerful data-based modeling, visualization, analysis and simulation capabilities represents a paradigm shift to an integrated digital information infrastructure that will ultimately revolutionize almost all aspects of the construction industry. Many developed economies of the world have recorded impressive outcomes by implementing BIM in their construction practices, and this necessitates the need for an investigation into the level of its awareness and factors affecting its adoption in the Nigerian Construction Industry. The study was undertaken through a survey of Nigerian Building construction firms. The central issues addressed were the awareness of the respondents on BIM, and their perception on the drivers and barriers to its adoption in the Nigerian construction industry. Structured questionnaires and semi-formal interviews were used for data collection. The study highlighted areas requiring attention by researchers, government and other stakeholders towards a country wide implementation of BIM technologies and has set a scene for developing a framework for BIM adoption in the Nigerian construction industry. This will make the industry equipped to operate in line with the global best practices and deliver projects successfully and more efficiently and also be a good market for foreign firms to benefit.

BACKGROUND

The construction industry has faced so many criticisms across the globe for its inefficiency and lack of productivity, which have been attributed to its fragmented nature of project delivery. (Khalfan and Anumba, 2000). The industry has therefore

experienced a paradigm shift to increase productivity, infrastructure value, quality and sustainability, and reduce lifecycle costs, lead times and duplications through effective collaboration and communication between all stakeholders in construction projects. (Nour, 2007). Several initiatives were introduced in the industry in order to achieve the much desired need for continuous improvement in the way the industry operates. These range from new contractual/procurement arrangements like partnering, concurrent engineering (Malik *et al*, 2000), and integrated project delivery, (Kim and Dossic, 2011) to technological innovations in design and construction processes such as 3D CAD and modeling (Isikdag and Underwood, 2010; Olatunji, *et al*, 2010).

Building information Modelling (BIM) is one of such innovative processes that promises to bring about the continuous improvement and desired change in the construction industry and revolutionize the processes of its operation to achieve better collaboration between project parties and ensure successful project delivery. BIM stimulates the construction activities in a virtual environment. With BIM technology, an accurate virtual model of a building known as *Building Information Model* is digitally constructed and used to support the design, procurement, fabrication and physical site construction activities required to realize the structure. The model is also used for the maintenance and facility management of the building after completion. (Azhar, 2011). BIM has also been defined as the digital representation of the physical and functional characteristics of a facility, which serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward (Building Smart, 2010).

According to Becerik-Gerber and Rice (2010), BIM is seen as an enabler that can help the building industry to improve its productivity by ensuring effective communication and collaboration between all project stakeholders from inception to completion of projects. Several BIM-related studies have been reported, especially those that have to do with its success stories and inherent benefits. There are numerous case studies (Khanzode et al, 2008; Eastman et al, 2011) that provide evidences to support the fact that the use of BIM makes the building process more efficient and effective. According to Succar (2005), BIM has now solidified its position as a promising approach towards addressing the AEC's numerous inefficiencies.

Previous studies have reported the adoption of BIM technologies in many developed nations of the world such as USA, UK, Australia, Netherlands, Singapore, Hong Kong Finland, Norway, Denmark, Hong Kong (Yan and Damian, 2010; Isikdag and Underwood, 2010; Nederveen et al, 2010; Wong et al, 2010; Sebastian and Berlo, 2011) with impressive outcomes, despite some challenges. Considering the reported benefits, Olatunji, *et al:* (2010) stressed the need for the full adoption of BIM technologies across all disciplines and geographical boundaries. This makes it imperative for the Nigerian construction industry, which has been described as a 'sleeping giant' and having no capacity to deliver due to inefficiency and poor service delivery among other problems (Kolo and Ibrahim, 2010), to exploit the widely acclaimed benefits of BIM technologies in order to perform in line with the global best practices and achieve the continuous improvement needed by its players. This

will also make the Nigerian construction professionals equipped to practice all over the world since the construction industry, especially considering the global nature of today's construction projects, requires teams that are geographically dispersed and working across multiple time zones and numerous organizational boundaries in a variety of cultures. Further, the global construction companies practicing in the country will have an enabling environment to use their collaborative expertise and benefit from the numerous construction wealth in the country.

Based on this premise, this research attempts to explore the factors likely to affect the adoption of BIM technologies in the Nigerian Construction industry with a view to finding ways of addressing the challenges while drawing the attention of the global construction researchers and practitioners to the level of readiness of the industry in order to work collaboratively towards addressing the concerns and achieving benefits of global BIM adoption.

1.0 BIM and the construction industry

The need for continuous improvement in the conventional design and construction in the industry has been well documented in the literature. Several studies and government reports have enunciated the desire for the construction industry to improve and change the way it performs its primary activities. (Kagioglou et al; 1999; Ibrahim and Price, 2006; Ibrahim, 2008). Yan and Damian (2008) observed that design of buildings has been done in the traditional way with the use of simple tools such as pen, paper and ruler, until the advancement of mathematics and building material science in the mid nineteenth century when engineers began to use computers to produce 2D CAD drawings. Paper based communication was used between all project stakeholders on the construction industry with no basis for collaboration and clear visualization of design. This has resulted to poor documentation and information management and has fuelled the fragmentation in the activities of the construction industry. It has further resulted to a lot of errors and waste, poor performance, low productivity and inefficiency in the construction industry. The many problems reported include design errors, estimate deficiencies, conflicts between design and construction and fragmented platforms which limit information flow throughout project lifecycle. Olatunji et al; (2010), Building SMART (2010)

The advent of Building Information Modeling (BIM) has shown a lot of potentials for the improvement of efficiency in design, construction and maintenance of buildings. Yan and Damian (2008) described BIM as a powerful set of design management tools that have significant advantages over the entire building lifecycle, particularly design, but also construction and facility management. It is the platform that brings about collaboration between project stakeholders and improvement of project outcomes. Over the years, the issue of BIM has attained widespread popularity among all stakeholders in the construction industry the world over. BIM is seen as a driver for the building industry to improve its productivity by ensuring effective communication and collaboration between all project stakeholders from inception to completion of building projects. Haron et al (2010) observed that many design and construction organizations in different parts of the world are moving towards BIM adoption in their practices. Ayarici et al; (2009) reported that in a recent past, many pilots and

live projects have been completed and documented in Finland, Sweden, Norway, Germany, France, Singapore, UK and Australia, which demonstrated the capability of using BIM within the construction process. Though, Yan and Damian (2008) argued that not all companies are interested in its adoption, but still the future of BIM technologies in the industry looks bright with increasing efforts by researchers and industry stakeholders.

Several benefits of BIM were claimed by its proponents to include changing the process of design and build to better, integration of building plans, sections, graphics and details in ways not possible in 2D CAD, providing concurrent information on performance and economic aspects of construction among others.

This new technology that was introduced in the early 80s (Thorpe, 2009) has now proves its potentials in sanitizing the construction industry from its traditional and fragmented ways of operation with improved efficiencies and collaboration capabilities. Aranda-mena et al, (2008).

2.0 Nigerian Construction Industry

Estimates as at the fourth quarter of 2011 revealed that the Nigerian construction sector contributes 1.99% to the national Gross Domestic Product (GDP). The figure below shows that despite the fact that the sector has experienced significant growth in terms of Compound Annual Growth Rate (CAGR), its contribution to national GDP has remained statically low. The construction industry report, 2011 revealed that in 1981, the construction sector accounted for 5.8% of the national GDP and in the last 3 decades, Nigeria's total GDP has raised to approximately 495 times its size. On the contrary, construction sector GDP has only grown to 125 times its size in 1981. As it has always been, the key drivers of the nation's GDP over the last 3 decades still remain the same-Agriculture, crude oil production and Trade. In comparison to other sectors, the construction industry in Nigeria even as it produces nearly 70% of the nation's fixed capital formation (Idrus and Sodangi 2007), is yet to realize its potentials in spite of the country's huge infrastructural deficit.

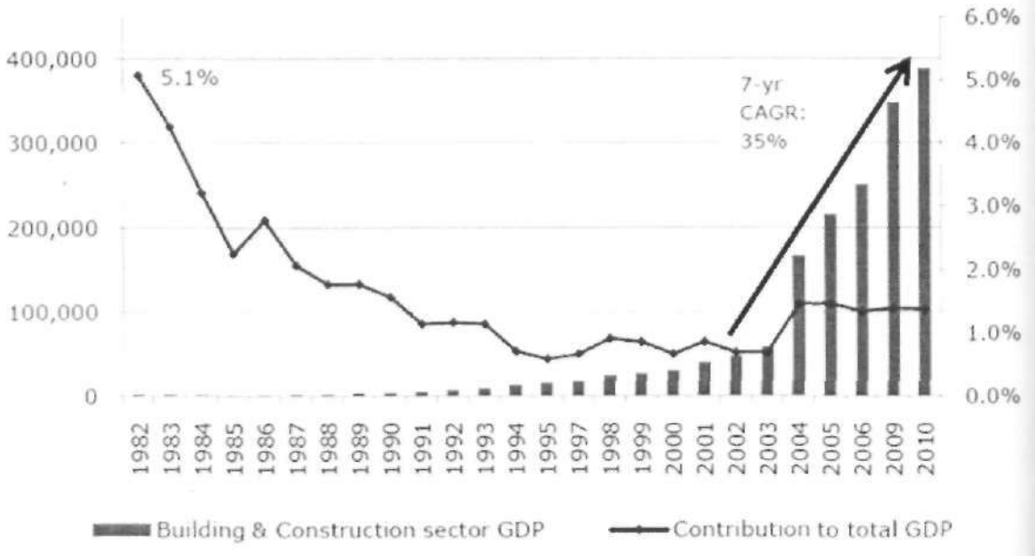


Fig 1: Nigeria Construction GDP. Source: National accounts, Vetiva Research.

A review of the last 3 decades showed that Agriculture, crude oil production and wholesale and retail trade recorded a 27 year CAGR of 28%, 29% and 26% respectively while the construction sector GDP on the other hand grew at a CAGR 21% over the same period (construction industry report, 2011).

In comparison to other oil producing countries, similar less diversified oil producers like the Saudi Arabia and the United Arab Emirate (UAE) and more diversified oil producers like Russia witnessed considerable boom in construction taking full advantage of the presence of crude oil in the regions in the last three decades. In UAE for instance, the oil boom in early 1970's sky-rocketed the construction sector of the UAE and managed to sustain its infrastructural development even amidst falling oil price in the 1980's. Oil fuelled economic growth, favorable demographic fundamentals, growing commercial activities and tourism have caused substantial construction boom in these countries (Construction Industry Report, 2011)

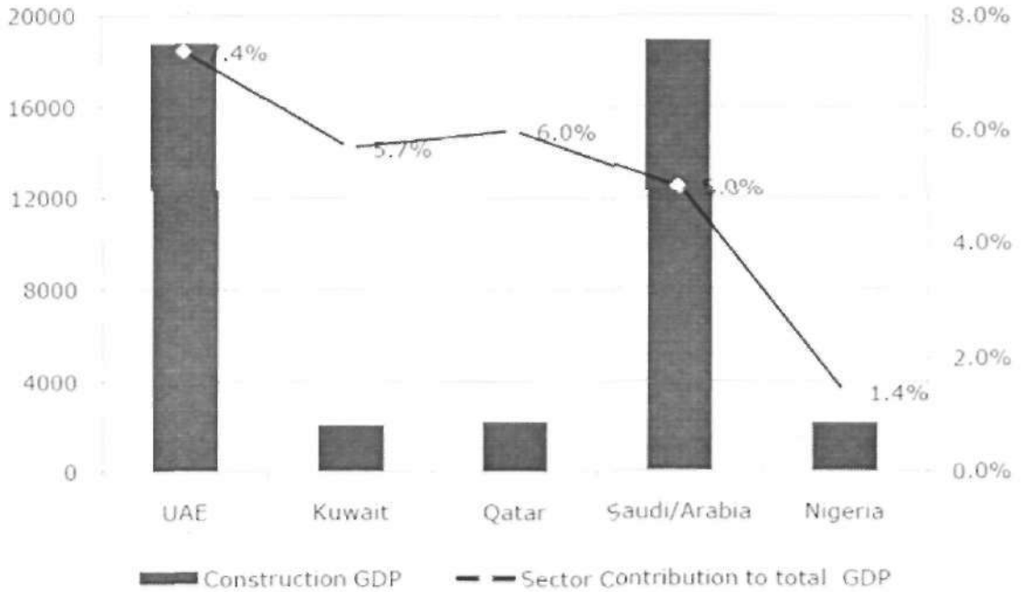


Fig25: Construction GDPs compared. Source: National accounts, Vetiva Research.

By 2009, UAE's construction sector has grown very rapidly with construction accounting for almost 11% of its GDP. They saw the need to take advantage of the rising oil prices in the world market to sustain their infrastructure which the construction sector has tremendously benefitted from. The figure below shows some oil producing countries and their construction sector's GDP.

In contrast to oil producing economies, as a net importer of crude oil, china's construction industry is not attributed to oil wealth rather than by the rapid industrialization and an export driven economy. In its first two decade of the reform

(1978-1999), china's construction GDP grew from 3.8% to 6.6% and in the last decade however, china witnessed a tremendous construction output for it accounted for 13% of GDP in 2010.

Other problems bedeviling the Nigerian construction industry are time and cost overruns inadequate planning and budgetary provisions, contract sums inflation, inefficient and poor service delivery (Kuroshi and Okoli, 2010; Ameh, 2011; Ogwueleka 2011, Kolo and Ibrahim, 2010; Mohammed, 2012). Hence Aibinu and Jagboro (2002) and Oyewobi et al., (2011) emphasized the need for improved performance and efficiency, if the industry is to deliver value for money and effectively satisfy the needs of its clients.

BIM is seen as a solution to some or even most of these problems, as it serves as a platform for effective collaboration and communication between all parties to a building project and has the capability of bringing sanity in the design and construction processes thereby improving the general performance of the construction industry.

3.0 Factors affecting BIM adoption in the Nigerian Construction Industry

The introduction and adoption of any new technology such as BIM usually requires that the factors that may positively or negatively affect the adoption by the relevant stakeholders be identified and addressed for the successful take up of the innovations and subsequent benefits to be derived thereof. Numerous potential barriers and drivers for BIM adoption were documented in the literature. These barriers are of different categories as defined by different experts. Fox and Hietanen (2006) put it that some of these barriers are specific to building information modeling, while others are general to the diffusion of innovation. Eastman et al; (2011) posited that the barriers to BIM adoption fall into two categories: process barriers to the business including legal and organizational issues that prevent the adoption; and technology barriers related to readiness and implementation. Autodesk (2004) on the other hand view the barriers to BIM adoption in three aspects as transactional business process evolution, computability of digital information, and meaningful data interoperability. On critical observation, it can be seen that all the aspects of barriers can conveniently fit into the first categorization by Eastman et al, (2011) i.e. the process and the technology barriers.

Some of them include the lack of highly skilled cross trained staff with both construction and IT skills which could hinder the realization of BIM benefits, Fox and Hietanen (2006). A survey conducted UK reported the primary barriers to the adoption of BIM by the UK construction companies are 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 using 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. Ayarici et al, (2009).

Similarly, another survey by RICS (2011) revealed the following as the potential barriers of BIM adoption amongst quantity surveyors, building surveyors, and project managers in UK: lack of clients demand for BIM in their projects, lack of standards

to guide implementation, lack of government lead/direction, lack of IT infrastructure, lack of new or amended conditions of contract; and lack of education and training.

Further, a survey by some professional groups in Texas identified the following as the barriers of adopting BIM by construction stakeholders: lack of knowledgeable and experienced partners; legal and contractual constraints; lack of industry standards; it takes too much time to learn; and high cost of implementation (TCUF 2009). The pilot study also identified the frequent power failure and poor internet connectivity as barriers in the case of Nigeria.

On the other hand, the drivers of BIM adoption in the construction industry were identified as government support through legislation, clients' interest, software availability, cooperation and commitment of professional bodies, and collaborative procurement methods. All these have to be in place to enable successful transition of the industry to BIM working.

4.0 Research Methods

A review of literature was carried out for the purpose of articulating issues regarding the concept of BIM in the construction industry with particular emphasis on the Nigerian Construction Industry. The review also aimed at identifying the potential barriers and drivers of BIM adoption in the construction industry.

The research involved the use structured questionnaire as a tool of data collection distributed to building construction firms in Abuja, the federal capital, and Lagos, the industrial hub of the country. A total of 100 questionnaires were self-administered by the researchers and 49 were retrieved and used for analysis, based on the assertion of Moser and Kalton (1971), that the result of a survey could be considered significant if the response rate not lower than 30-40% is obtained.

The questionnaire meant to obtain information on the company's perception of the factors affecting the BIM adoption in the Nigerian construction industry. The factors identified from literature were of two categories: drivers/facilitators of the adoption and the barriers to the adoption which was also divided into two subcategories by Eastman et al (2011) as process barriers and technology barriers. The two tables were provided with statements on the two categories to be assessed by the respondents on a five point Likert scale.

The relative importance index method (RII) was used to determine the firm's perception of the significant factors affecting BIM adoption in the construction industry. This calculation puts the factors in rank order and indicates how much the top ranked is more important than the next and so on (Kometa *et al.*, 2007). The RII was computed as:

Relative importance index (RII) $= \Sigma w / (A \times N)$ - - - , $(0 \leq index \leq 1)$

Where: w = weighting given to each factor by the respondents and ranges from 1 to 5 where 1 is not significant and 5 is extremely significant, A = highest weight (i.e. 5 in this case), and N = total number of respondents (i.e. in this case 49).

5.0 Results and Discussion

a. Drivers of BIM adoption in the Nigerian Construction Industry

Table 1 shows respondents' view of the most important drivers of BIM adoption in the Nigerian construction industry.

Table 1: Drivers of BIM Adoption in the Nigerian Construction Industry

S/N	Drivers of BIM Adoption	RII	Rank
1	Availability of trained professionals to handle the tools	0.795	1
2	BIM Software availability and affordability	0.775	2
3	Enabling environment	0.755	3
4	Clients' interest in the use of BIM in their projects	0.751	4
5	Awareness of the technology among industry stakeholders	0.746	5
6	Cooperation and commitment of professional bodies to its implementation	0.746	5
7	Proof of cost savings by its adoption	0.726	6
8	Cultural change among industry stakeholders	0.718	7
9	Government support through legislation	0.702	8
10	Collaborative Procurement methods	0.673	9

Source: Field survey (2013)

Among the drivers identified from literature, 'availability of trained professionals to handle BIM tools' (RII 0.795), 'software availability and affordability' (RII 0.775), and 'enabling environment' (RII 0.755) were found to be the most significant drivers of BIM adoption in the Nigerian Construction Industry, followed by 'clients interest in the use of BIM in their projects' (RII 0.751) and the 'awareness of the technology among industry stakeholders' (RII 0.745). While 'government support through legislation' (RII 0.702), and the existence of 'collaborative procurement methods' (RII 0.673), were found to be the least significant facilitators of BIM adoption in the Nigerian Construction Industry. This shows that the respondents collectively emphasized the issues of education and training, software availability and enabling environment, with informed clients who have interest in the use of BIM on their projects as the most important factors that will aid the adoption of BIM technology in Nigeria. These findings are in line with those of a similar study by Abubakar, et al, (2012) which investigated the designers' perception of the same factors in Nigeria, similarly, the findings of a survey presented at the Texas College and University Facilities Conference (TCUF) 2008 on the state wide BIM adoption. It also reflects the idea propagated in the Rethinking Construction document of the United Kingdom in 2008 about education and training for the transformation of the construction industry.

b. Barriers to the adoption of BIM in the Nigerian Construction Industry

Table 2 shows the respondents' view on the most important barriers to BIM adoption in the Nigerian construction industry, with 'social and habitual resistance to change'

(RII 0.824) having the highest rank of most significant barrier, followed by 'legal and contractual constraints' and 'high cost of integrated software' for all professionals with relative importance of (RII 0.783) and (RII 0.791) respectively. 'Lack of enabling environment' In form of policies and legislations of government towards the adoption was ranked fourth with a relative importance index of (0.697) and then lack of trained professionals to handle the tools coming fifth on the significance list. Another issue of importance is the fact that clients do not require the use of BIM technologies in their construction projects and this serves a significant hindrance to the adoption of BIM in the Nigerian construction industry, since clients are the drivers of change and innovations in projects, and so far they are not ready to invest in BIM, then the technology may face a serious hindrances of implementation in the industry.

Table 2: Barriers to the adoption of BIM in the Nigerian Construction Industry.

S/N	Barriers	RII	Rank
1	Social and Habitual Resistance to Change	0.824	1
2	Legal and Contractual Constraints	0.791	2
3	High Cost of Training	0.783	3
4	Lack of Enabling Environment (Government policies and legislations)	0.697	4
5	Lack of Trained Professionals to handle the tools	0.665	5
6	Clients not requesting the use of BIM on projects	0.657	6
7	No proof of financial benefits	0.648	7
8	High Cost of Integrated software/Models for all professionals	0.640	8
9	Lack of Standards to Guide Implementation	0.579	9
10	Poor Internet Connectivity	0.555	10
11	Frequent Power Failure	0.477	11
12	Lack of Awareness of the technology among industry stakeholders	0.408	12

Source: Field survey (2013)

The results show that 'lack of awareness of the technology among industry stakeholders', frequent power failure and poor internet connectivity, (which are still challenging issues in Nigeria) as least significant factors hindering the adoption of BIM technologies in the country. Even though, these were found in other studies by Kigbu (2012) and Abubakar (2012) as part of the significant challenges facing the adoption of ICT and BIM in the Nigerian construction industry.

6.0 Conclusion and Recommendations

The study assessed the perception of the Nigerian Building Contractors on the factors affecting the adoption of Building Information modeling technologies in the Nigerian construction industry. The findings revealed that 'availability of trained professionals to handle BIM tools' (RII 0.795), 'software availability and affordability' (RII 0.775), and 'enabling environment' (RII 0.755) were found to be the most significant drivers of BIM adoption in the Nigerian Construction Industry, followed by 'clients interest in the use of BIM in their projects' (RII 0.751) and the 'awareness of the technology among industry stakeholders' (RII 0.745). On the other hand, the potential barriers to BIM adoption in the Nigerian construction Industry are the 'social and habitual resistance to change' (RII 0.824) having the highest rank of most significant barrier, followed by 'legal and contractual constraints' and 'high cost of integrated software' for all professionals with relative importance of (RII 0.783) and (RII 0.791) respectively. 'Lack of enabling environment' In form of policies and legislations of government towards the adoption was ranked fourth with a relative importance index of (0.697) and then lack of trained professionals to handle the tools coming fifth on the significance list. These findings are in line with some previous works on the subject matter such as Kigbu (2012) on BIM awareness in the Nigerian construction industry, another survey on state-wide BIM adoption (2008) in Texas by the groups of professionals, and another one in Finland as reported in Fox and Haetanen (2006).

The study has set a scene for further research and development in the area of BIM adoption in Nigerian construction industry, and has provided an insight for international researchers and practitioners who may be interested in the developments of BIM adoption in the Nigerian Construction Industry. It therefore recommends that further research should focus on developing a framework for the full adoption of BIM in the Nigerian construction industry.

Education and training were identified as important parts of BIM implementation due to the process and technological changes it brings in an organization. Ayarici et al; (2009). This research also recommends that further studies be centered towards ensuring providing ways of incorporating BIM training in the curriculum of tertiary institutions offering any building construction related programs. Awareness enhancing programs should also be initiated by professional bodies and relevant government agencies to carry all stakeholders along, and do away with the resistance to change and encourage project parties to uphold BIM processes in practice.

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