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A principal component analysis of Organisational BIM Implementation

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ABSTRACT
BIM implementation by organisations is a bit challenging for many organisations. It has become an essential yardstick for project execution in the construction industry. However, many organisations struggle to achieve its implementation as they are still in the chaotic stage due to the BIM introduction. The knowledge of the inherent value and usefulness resulting from BIM implementation can help them transform from the status quo to a new status quo. The study adopted purposive sampling through a quantitative approach to identify the merits of organisational BIM adoption. Data was collected using a structured questionnaire from thirty BIM aligned construction organisations. The study identified the critical BIM benefits to construction organisations. In addition, the structure among the factors was identified through principal cluster analysis and three clusters were identified; these are achieving competitive advantage through BIM adoption, effective organisational process and enhanced work output and achieving project outcome. The results of this study provide insight, and it is instructive to stakeholders in the construction industry to aid BIM diffusion.

KEYWORDS
BIM, construction industry, developing country, implementation, Nigeria, organisational benefits

INTRODUCTION
The construction industry is impacted by the adoption of emerging technologies. The diffusion of Building information modelling (BIM) is a critical discussion in the construction industry due to its potential of changing the construction industry process, people, and technology. Consequently, it has experienced different research efforts to achieve its adoption and diffusion. These include research efforts include studies on barriers to adoption (Adekunle et al., 2020; Oraee et al., 2019), benefits of BIM implementation (Babatunde et al., 2018; Ullah et al., 2019) and adoption of BIM for various aspects of the construction lifecycle (Elagiry et al., 2019; Joblot et al., 2019). Other studies include BIM awareness level (Acquah et al., 2018; Adekunle, et al., 2021), adoption at macro and micro levels (Kassem & Succar, 2017; Troiani et al., 2020), BIM roles evolution (Akintola et al., 2017; Bosch-Sijtsema & Gluch, 2019, Adekunle et al., 2022) amongst others.
Most of these studies focus mostly on the industry-wide adoption of BIM. However, it is vital that organisations are also studied in terms of BIM diffusion. Pre-BIM adoption, construction organisations are considered to be in a state of harmony. This is regarded as the status quo, but the

introduction of a foreign element causes chaos (this is according to Satir's model (Cameron & Green, 2009)). In this case, the foreign element is BIM; this introduction requires the integration and continuous practice for the organisation to achieve transformation and a new status quo. However, critical to this transformation for organisations is understanding the benefits inherent in BIM, and the value BIM will add to the organisations. This is coined as the perceived usefulness of BIM as a critical factor for BIM adoption (Acquah et al., 2018). This study articulates the merits of BIM implementation by construction organisations. Understanding the BIM benefits will help organisations with a clearer perspective of the inherent value in BIM implementation thus helping them in its adoption.

Previous study has observed that the BIM adoption rate in Nigeria is low (Adekunle et al., 2020; Hamma-Adama et al., 2018). Also, the usage level in the Nigerian construction industry has been studied (Olugboyega & Aina, 2018). Onungwa & Uduma-Olugu, (2017) identified some of the benefits of BIM in the Nigerian construction industry, these are conflict resolution, construction programming, satisfaction of clients and quality of drwings among others. It has also been identified to improve facility management operations (Oluleye et al., 2021). In an industry wide study, the following benefits were identified: improved project design, clash detection, improved coordination, reduction in rework and better synchronization among others (Okereke et al., 2021).

METHODS

The study aim at unearthing the benefits of BIM implementation by organisations in the construction industry. to achieve this, an objectivist philosophical standpoint was adopted. The objectivist stance seeks to uncover "the truths" through a quantifiable and measurable approach from which generalisations emerge (Saunders et al., 2019). The facts are considered to be external to the actors (in this study, construction organisations). Consequently, a quantitative approach was adopted through the adoption of questionnaires to gather data (Akinradewo et al., 2022; Creswell, 2014). A structured questionnaire was distributed to selected organisations that are digitally inclined and are adopting some dimensions of BIM in their organisations. Thus the study adopted a purposive sampling approach. Purposive sampling is adopted in quantitative research when little is known about the phenomenon under study or when the study can only get the required data from a selected few (Kumar, 2011). The questionnaires were distributed online to the construction organisations in Lagos, Abuja, Rivers, Delta and Ogun states. To determine the reliability of the research instrument, the Cronbach alpha was determined, and it was found to be 0.941. This value is considered adequate and also means that the data retrieved using the instrument is reliable.

RESULTS AND DISCUSSION

Background information of respondents

Table 1 shows the results of the analysis of respondent demographic information. The majority of the respondent organisations are based in Lagos, followed by Abuja. This is not surprising due to the commercial city status of Lagos state, and Abuja is the federal capital territory. It is also observed that most are medium-scale organisations with 11 to 20 employees, followed by small organisations with between 1 to 10 employees and large organisations with above 20 employees.

Table 1. Respondent background information

Location	%	Scale	%	BIM dimension	%	Organisation type	%	Organisation existence	%

		Small						
Abuja	10	scale	33.3	2D/3D	96.7	Contractor	36.7	less than 5years	3.3
Lagos	76.4	Medium	36.7	5D	3.3	Consultant	43.3	5-10years	13.3
Delta	3.3	Large	30			Government	3.3	11-15years	13.3
						Private			
Rivers	3.3					clients	13.3	16-20years	20
Ekiti	3.3					Builder	3.3	Above 20years	50
Ogun	3.3								

The organisations are mostly consulting organisations; this is followed by contracting organisations and private clients. These organisations mostly have been in existence for more than 20 years, and this is followed by organisations that have been in existence for between 16-20 years. Thus most of them have been able to transform with the times and are receptive to technology adoption.

Benefits of BIM implementation to construction organisations

The collected data were subjected to different analyses to articulate the merits of BIM implementation to construction organisations. Respondents were presented with factors to be ranked in respect of the study aim. As shown in Table 2, the MIS was analysed and indicated for each organisational merit. This is to understand the respondents level of agreement and thus provide a ranking for the benefits. It should, however, be noted that on the 5 point Likert scale presented to the respondents, strongly agree was represented by 1 and strongly disagree was represented by 5. Eighteen BIM merits were presented to respondents to be ranked (Table 2). Overall, all the presented factors are shown to have been agreed to be organizational BIM benefits by the respondents.

Table 2. Merits of Organisational implementation of BIM

S/N	Merits	Mean	Std. Deviation
1	Increased job productivity	1.43	0.626
2	Opportunity to work on international projects outside the country	1.53	0.730
3	Improved job satisfaction	1.53	0.730
4	Improved job outputs	1.63	0.850
5	Efficient work process	1.63	0.718
6	Enhanced information management	1.63	0.718
7	Ease of communication	1.70	0.750
8	Achieving client satisfaction	1.73	0.868
9	Ease of professionals fitting into BIM process	1.83	0.747
10	Risk reduction/management	1.83	0.791
11	It is easy to achieve project outcomes with BIM	1.87	0.937
12	Effective cost saving	1.90	0.845
13	A total facelift of the work process	1.93	0.868
14	Seamless project execution process	1.93	1.015
15	It is easy to incorporate into existing workflow	1.97	0.890
16	The BIM process is convenient	1.97	0.928
17	Learning the BIM process is easy	2.23	0.971
18	Provides huge ROI	2.50	1.106

Furthermore, the study conducted a factor analysis using the principal component analysis. This is intended to help understand the structure and pattern inherent within the benefits. To determine the sampling adequacy, the Kaiser–Meyer–Olkin Measure of Sampling Adequacy was determined, and a value of 0.747 was achieved; this is greater than the threshold accepted, 0.6 (Pallant, 2010). Bartlett's Test of Sphericity was observed to be 0.000 to reveal statistical significance. Figure 1, Table 3 and Table 4 presents the results of the principal component analysis of the data collected. It is observed that three components explain the 18 factors giving rise to three clusters.

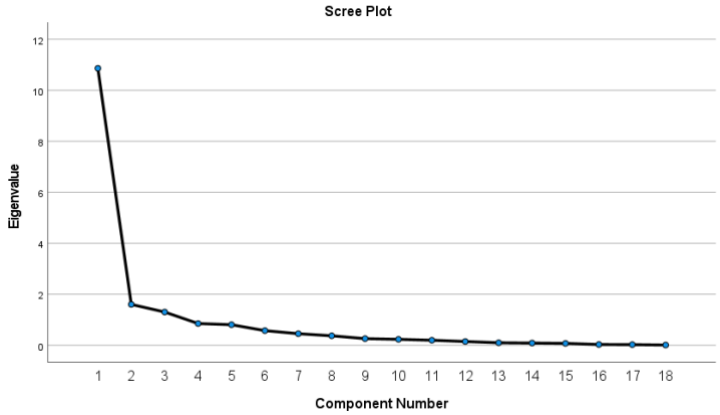

Figure 1. Scree plot

These three clusters explain 76.50% of the factors.

Table 2. Total variance explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.863	60.351	60.351	10.863	60.351	60.351	5.043	28.018	28.018
2	1.603	8.906	69.257	1.603	8.906	69.257	4.498	24.988	53.006
3	1.304	7.247	76.504	1.304	7.247	76.504	4.230	23.497	76.504
4	.853	4.739	81.242						
5	.807	4.483	85.725						
6	.575	3.193	88.917						
7	.454	2.524	91.442						
8	.372	2.068	93.510						
9	.261	1.449	94.959						
10	.234	1.297	96.257						
11	.198	1.100	97.356						
12	.148	.823	98.179						
13	.099	.551	98.731						
14	.088	.487	99.218						
15	.074	.412	99.630						
16	.031	.173	99.804						
17	.025	.141	99.945						
18	.010	.055	100.000						

Extraction Method: Principal Component Analysis.

Cluster one contains seven benefits these are "ease of communication" (85%), "enhanced information management" (83.7%), "Opportunity to work on international projects outside the

country" (82.5%), "Efficient work process" (76.8%), "Learning the BIM process is easy" (69.3%), "Effective cost-saving" (63.2%), and "A total facelift of the work process" (57.8%). Considering the component benefits in this cluster, they relate to achieving competitive advantage through BIM adoption. The organisations achieve the dynamic capability to be strategically agile. According to Teece, (2019), it enables firms to do tasks faster and cheaper. Consequently, they achieve a competitive advantage over their competitors. It also helps organisations be part of international conglomerate and dynamic project teams without necessarily leaving their geographical location.

Table 3. Components

Rotated Component Matrix[a]

	Component		
	1	2	3
Ease of communication	0.850		
Enhanced information management	0.837		
Opportunity to work on international projects outside the country	0.825		
Efficient work process	0.768		
Learning the BIM process is easy	0.693		
Effective cost saving	0.632		
A total facelift of the work process	0.578		
It is easy to incorporate into existing workflow		0.866	
Provides huge ROI		0.741	
Ease of professionals fitting into BIM process		0.722	
Seamless project execution process		0.705	
Risk reduction/management		0.550	
Improved job satisfaction			0.835
increased job productivity			0.807
Improved job outputs			0.785
Achieving client satisfaction			0.690
It is easy to achieve project outcomes with BIM			0.630
The BIM process is convenient			0.496

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

Cluster two contains five benefits these are "It is easy to incorporate into existing workflow" (86.6%), "Provides huge ROI" (74.10%), "Ease of professionals fitting into BIM process" (72.2%), "Seamless project execution process" (70.5%) and "Risk reduction/management" (55%). This cluster is termed the effective organisational process. Achieving this involves the development of people, teams, tools and processes to be BIM process aligned. This aligns with Aghimien et al., (2021) for construction organisations' ability to adapt to external commercial environment changes while managing their business environment to achieve dynamic capability. Implementing BIM will enable construction organisations to effectively respond to the latest external commercial requirements while achieving efficient business environment management. This also aligns with the position of (McGraw Hill, 2012) regarding the positive ROI on BIM investment.

Cluster three consists of six benefits they are "Improved job satisfaction" (83.5%), "increased job productivity" (80.7%), "Improved job outputs" (78.5%), "Achieving client satisfaction" (69%), "It

is easy to achieve project outcomes with BIM" (63%) and "The BIM process is convenient" (49.6%). Cluster three is named enhanced work output and achieving project outcomes. Through the implementation of BIM, organisations achieve a more efficient work process and product. This is similar to the findings by Akintola et al., (2016) on the experiences of BIM implementation in three companies in the South African construction industry. BIM implementation impacts positively on productivity, efficiency, overall project outcomes and achieving project outcomes.

CONCLUSION

This study unearths the BIM merits of organisation implementation in construction organisations in Nigeria. The study identified the benefits of BIM implementation in construction organisations through a questionnaire survey. A purposive sampling approach was adopted to achieve the study aims. The study identified the top-ranked benefits; these are job productivity, opportunity to work on international projects outside the country, improved job satisfaction, improved job outputs and efficient work process. Also, through the principal component analysis, the clusters of the benefits were identified. Three clusters were produced; these are achieving competitive advantage through BIM adoption, effective organisational process and enhanced work output and achieving project outcome. The benefits of organisational BIM implementation will help inform and assist organisations with BIM implementation. Understanding the organisational benefits of BIM implementation is vital to construction organisational and other stakeholders. The paper achieved the identification and classification of the benefit. The study implication includes influencing the organizational level BIM implementation. Other studies can research on the impact of BIM on organizational workflow and cultures in the Nigerian construction industry. Also, the adoption of a qualitative approach or mixed method might provide a different or more insight into the research area.

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