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Assessment of Barriers Influencing the Adoption of Building Information Modeling in the Construction Industry in, Lagos State, Nigeria

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ABSTRACT

The implementation of building information modelling (BIM) has been slow in recent years and this is due to some prominent barriers that hinder its adoption. In this regard, this study aims to examine the significant barriers that influence the adoption of BIM in the Lagos State construction industry. Data were gathered through a questionnaire survey with 332 construction professionals in the study area. Three online structured interviews were conducted to support and validate the findings of the quantitative analysis. The results revealed six themes as major barriers namely; finance, industry, interest, leadership, legal and professional barriers. These themes revealed lack of interest, and awareness and understanding of BIM; absence of in-house BIM competent professionals; unavailability of these professionals in the labour market; and lack of policies and regulations on copyright ownership and enforcement from government agencies and industry leadership as barriers. Other barriers are people's inability or refusal to learn new technologies and processes, perception of BIM as a waste of time and human resources, and lack of clarity of professional roles in BIM. Thus, there is a need for the government to design and implement policies (regulatory, economic and information management) to promote financial schemes to support construction firms and professionals and to reduce financial barriers. It is also important for government to lay down rules and regulations that must be enforced among the construction professionals and firms in the Lagos State construction industry.

Keywords:
Building Information Modelling; Construction Industry; BIM Adoption Characteristics; Lagos State; Nigeria

INTRODUCTION

Construction projects, specifically large construction projects (buildings and infrastructure) are getting very complex and difficult to manage (Bryde *et al*., 2013). To meet up with the high complexity and difficulty of construction projects, building information modelling (BIM) has been developing at a fast rate and becoming greatly utilized (Qinghua *et al*., 2016). BIM advantages in the various types of construction projects are numerous and acknowledged by the parties involved (Eastman *et al*., 2011; Gu & London, 2010). Regardless of its enormous technical benefits and value potential, the use of BIM worldwide still falls short of its potentials as some construction projects disregard BIM because of the numerous barriers affecting its adoption (Cao *et al*., 2014). BIM is one of the main promising developments in the architecture, engineering, and construction (AEC) industry and it is defined as the digital visualization of the physical and functional characteristics of a project, and a method to foster collaboration among construction professionals at different phases of the life cycle of a facility (NIST, 2007).

In the past few years, the construction industry has been applying BIM methodology so as to increase productivity, and achieve more efficient design and construction performance throughout the building's lifecycle (Pärn *et al*., 2017, Zhang *et al*., 2017). With the introduction and incorporation of web-based networks and information technology (IT) into construction processes (Hosseini & Chileshe, 2013), the nature of collaboration among construction professionals has gone through an advanced change over the past years (Walker *et al*., 2017). It is therefore not surprising that in the past decade, BIM has been the answer to fragmentation, poor project coordination and information-management issues in the construction industry (Panagiotidou, *et al*., 2022).

Still, the wide benefits, such as ease in working digitally, reduced rework, ensuring quality and optimization of resources, and improved productivity, are yet to fully show in the Nigerian construction industry. This eventually led to the objectives of this paper, which aims to assess the barriers that influence the adoption of BIM in Lagos State Nigeria. The specific objectives of this study are firstly to identify and examine the barriers to the adoption of BIM in the Lagos State construction industry and secondly to analyze the effect of BIM adoption barriers on adoption characteristics in the Lagos state construction industry.

LITERATURE REVIEW

Building information modelling barriers in the construction industry

BIM has not been totally accepted by most AEC firms, especially in developing countries. Thus, some barriers to the adoption of BIM as noticed by previous studies are briefly identified and discussed. Finance barriers are the cost factors mentioned in literature and they include cost of purchasing BIM software and hardware, the software service charges, and training costs (Sun *et al*., 2017; Memon *et al*., 2014; Young *et al*., 2008; Barak *et al*. 2009). Technological and client barriers are the BIM tool-related factors restraining the application of BIM, such as lack of standards/protocols, frameworks and guidelines, insufficient technology to support wholesale BIM adoption, and lack of scalability, interoperability, and support for remote collaboration (Post 2008; Barak *et al*., 2009; Ezeokoli *et al*., 2016; Zhang, 2010). The industry barriers are referred to as the management factors which are the lack of existing successful cases and management standards for reference, the fragmented nature of the construction industry, the inappropriate business models, and the lack of cooperation from other construction industry firms (Zahrizan *et al*., 2013; Hergunsel, 2011; Obiegbu and Ezeokoli 2014).

Professional barriers represents the personnel factors such as lack of experienced professionals who are familiar with BIM operations, learning curve, lack of skilled professionals, refusal to learn new technologies and processes, and low level of BIM technical know-how and awareness (Liu *et al*., 2015; Babatunde *et al*., 2021; Hosseini and Chileshe, 2013; Kori and Arto, 2015). Legal barriers mentioned in past studies refers to copyright issues, lack of legal/contractual agreements, inadequate support from the government for BIM implementation and general regulation (Méndez, 2006; McAdam, 2010;

McAuley *et al*., 2012). Finally, interest barriers are recognized as the reluctance of other stakeholders (such as architects, engineers, and contractors) to adopt BIM, lack of their understanding of the application and the perception of its deployment as a waste of time and human resources (Abubakar *et al*., 2014; Gardezi *et al*., 2014; Memon *et al*., 2014).

Building information modelling adoption characteristics

The diffusion of innovation (DOI) theory has been in existence and incorporated since the 1960s in diverse disciplines stretching from agriculture to the diffusion of organizational innovation (Wijekoon, 2019). While previous theories explain the complications behind individual's technology adoption decisions, DOI centers on characteristics limiting the sharing and dissemination of a technology. Different to other theories, DOI acknowledged that even the innovations with distinct uses experience difficulty in dissemination which is the case of building information modelling. DOI covers characteristics of an innovation, the innovation decision process and the adopter's characteristics (Taherdoost, 2018). Rogers (2003) described innovation as "an idea, practice or object that is perceived as new". The word 'newness' is very germane.

Therefore, even if the idea or object has been invented for a while but since it is new to an individual in terms of awareness or not having a perception towards it (such as adopting or rejecting), it is an innovation to the supposed individual or organization. Thus, building information modelling is an innovation to construction professionals in developing countries because the majority of them are yet to adopt it. Characteristics of an innovation that will drive its adoption as identified by Rogers (2003) are its relative advantage, compatibility, complexity, trialability and observability. Around the 90's and 2000's, research in sociological psychology focused on adoption and acceptance of technology with several models called technology adoption models (Collan & Tétard, 2011). These theories brought forth (among other things) characteristics of an innovation that leads to technology selection: perceived usefulness, perceived ease of use, technical and economical aspects of the technology (Hochscheid & Halin, 2019). Some of the characteristics deal with the perception that potential users have of the innovation while others deals with the intrinsic characteristics of the innovation.

RESEARCH DESIGN AND METHODOLOGY

The study is based on a sequential exploratory mixed methods design with the aid of questionnaire administration and interviews. The respondents included the construction professionals in the registered construction firms as compiled by the Nigerian guide website in 2023. From these firms, the construction professionals were divided into seven sub groups ranging from architects, builders, civil/structural engineers, electrical engineers, mechanical engineers, and quantity surveyors to BIM mangers/project managers to answer questions relating to building information modeling adoption characteristics and barriers. A total of 332 copies of questionnaire were found useful for further analysis. For this research, BIM adoption characteristics and BIM adoption barriers were reflectively modelled. Both the predictors and the outcome were latent variables measured on a 5-point Likert scale (where 1 is strongly disagree and 5 is strongly agree). An online structured interview was conducted to support and validate the findings on the quantity analysis. The interview participants were part of the questionnaire survey respondents. Fourteen respondents included their email addresses as additional information in the questionnaire and only three of them responded to the email sent for information about the interview, thus making a total of three online structured interviews. For a qualitative research on validating quantitative findings, a sample size of two to three participants suffices (Paul *et al*., 2014). The transcription of the recorded interview was done using the "oTranscribe" tool and the interview transcripts were analyzed using the Nvivo 14 QSR software which categorized them into codes and themes.

Measurement model

This study has two latent variables. The first is building information modelling adoption

characteristics (bBIM_CH) which are the outcome variables with 26 items or indicators. The bBIM_CH's indicator can be categorized into eight sub-constructs: technical aspects of adoption characteristics (bITA with 4 indicators), economic aspects (bIEA with 4 indicators), availability (bIAV with three indicators), observability (bIOB with three indicators), compatibility (bPCM with three indicators), relative advantages (bPRA with three indicators), complexity (bPCX with three indicators), and usefulness (bPUS with three indicators). The second is the independent latent variable named as barriers to BIM adoption (cBBIM) which has 24 indicators and are grouped into six sub-constructs: Interest barriers to BIM adoption (cBBIM_INT with 4 indicators), leadership and finance (cBBIM_LEDFIN with five indicators), professional (cBBIM_PRO with three indicators), Legal (cBBIM_LEG with three indicators), Industry barriers (cBBIM_IND with four indicators), and Technology and Client (cBBIM_TEC_CLT with five indicators). The reflective measurement model was conducted for the quality assessment of the variables and it involves describing the results of internal consistency reliability (Cronbach's alpha and composite reliability); convergent validity (average variance extracted, AVE), and the discriminant validity (Cross-loading, HTMT ratio and Fornell-Larcker criterion). These results can be found on Table 1 to Table 4.

Table 1: Construct reliability and validity for Barriers to BIM and Adoption Characteristics

	Cronbach's alpha (CA)	**Composite reliability (CR)**	**Average variance extracted (AVE)**
bIAV	0.868	0.918	0.790
bIEA	0.807	0.867	0.627
bIOB	0.858	0.909	0.770
bITA	0.847	0.897	0.685
bPCM	0.844	0.900	0.752
bPCX	0.626	0.799	0.570
bPRA	0.723	0.758	0.533
bPUS	0.738	0.853	0.661
cBBIM_IND	0.786	0.859	0.605
cBBIM_INT	0.855	0.902	0.697
cBBIM_LEDFIN	0.798	0.869	0.625
cBBIM_LEG	0.660	0.815	0.595
cBBIM_PRO	0.854	0.911	0.774
cBBIM_TEC_CLT	0.755	0.834	0.513

The results show that all the quality criteria were established. The construct reliability and validity with Cronbach's Alpha (CA) were above the recommended value of 0.7 but only Complexity characteristics (bPCX) and legal barrier were very close with CA value of 0.626 and 0.660 respectively. The variables are all reflective because their indicators are highly correlated and are largely interchangeable (Hair *et al*., 2022). The AVE values ranged from 0.513 to 0.790 for the constructs, which is considered satisfactory as they are all above the threshold value of 0.5. The study further conducted an assessment of discriminant validity, to ascertain the extent to which each construct is distinct from others by empirical standards, thus affirming the uniqueness of each individual construct within the model. Firstly, the Cross-loadings criteria dictated that each indicator's outer loading on its associated construct should exceed any cross-loading on other constructs within the model. The findings confirmed that this criterion was met, demonstrating the distinctiveness of each construct (Adepoju and Adeniji, 2020). Then the Fornell–Larcker criterion was employed to compare the square root of each construct's Average Variance Extracted to its highest correlation with any other construct. As indicated

Table 2: Cross loadings for Barriers to BIM and Adoption Characteristics

	bIAV	bIEA	bIOB	bITA	bPCM	bPCX	bPRA	bPUS	cBBIM_IND	cBBIM_INT	cBBIM_LEDFIN	cBBIM_LEG	cBBIM_PRO	cBBIM_TEC_CLT
bIAV1	0.895	0.148	0.189	0.051	0.058	-0.034	0.029	-0.096	-0.011	-0.023	0.051	0.041	0.050	-0.106
bIAV2	0.939	0.111	0.231	0.026	0.048	-0.010	0.001	-0.048	0.038	-0.017	0.093	0.138	0.082	-0.028
bIAV3	0.829	0.169	0.369	0.044	0.149	-0.003	0.026	-0.088	-0.021	0.084	0.107	0.000	0.046	-0.079
bIEA1	0.159	0.556	0.149	0.365	0.072	0.069	0.110	-0.035	-0.059	0.069	0.015	-0.063	0.068	-0.021
bIEA2	0.108	0.817	0.222	0.351	0.177	0.055	0.065	0.088	0.011	0.057	0.148	0.026	0.148	0.065
bIEA3	0.167	0.923	0.284	0.421	0.153	0.046	0.062	0.021	0.049	0.155	0.249	0.051	0.198	0.082
bIEA4	0.079	0.823	0.251	0.333	0.113	0.038	0.011	0.013	0.067	0.060	0.119	0.012	0.151	0.091
bIOB1	0.248	0.291	0.914	0.113	0.457	0.094	0.032	0.092	0.046	0.111	0.200	0.049	0.126	-0.031
bIOB2	0.267	0.210	0.854	0.016	0.415	0.077	-0.001	0.168	0.000	0.008	0.079	0.040	0.132	0.017
bIOB3	0.232	0.258	0.862	0.065	0.499	0.105	0.066	0.116	0.038	0.070	0.127	0.028	0.096	0.021
bITA1	0.062	0.370	0.085	0.824	0.106	0.172	0.127	-0.038	0.013	0.136	0.063	0.096	0.136	0.066
bITA2	0.036	0.369	0.091	0.819	0.046	0.069	0.015	-0.044	0.069	0.159	0.137	0.151	0.146	0.127
bITA3	-0.012	0.372	0.049	0.805	0.065	0.152	0.003	-0.008	0.146	0.065	0.155	0.148	0.157	0.109
bITA4	0.054	0.378	0.055	0.862	0.046	0.177	0.084	-0.033	0.071	0.177	0.170	0.129	0.155	0.060
bPCM1	0.111	0.121	0.468	0.046	0.716	0.162	0.180	0.124	0.017	0.099	0.061	0.068	-0.007	0.011
bPCM2	0.061	0.170	0.460	0.103	0.936	0.171	0.144	0.190	0.085	0.152	0.136	0.107	0.136	0.132
bPCM3	0.082	0.145	0.472	0.039	0.931	0.159	0.115	0.214	0.086	0.066	0.082	0.142	0.087	0.148
bPCX1	0.024	0.122	0.124	0.173	0.219	0.727	0.287	0.275	0.101	0.161	0.144	0.146	0.072	0.134
bPCX2	-0.029	-0.018	0.057	0.075	0.103	0.746	0.188	0.171	0.004	0.143	0.127	0.101	0.038	0.045
bPCX3	-0.042	0.012	0.049	0.122	0.080	0.791	0.331	0.232	0.052	0.177	0.046	0.118	-0.001	0.052
bPRA1	0.014	0.077	0.060	0.064	0.167	0.339	0.985	0.200	-0.081	0.138	0.059	-0.017	-0.022	0.026
bPRA2	-0.007	-0.041	-0.146	-0.018	-0.070	0.229	0.471	0.208	0.017	0.009	-0.018	0.029	0.033	0.013
bPRA3	0.033	-0.014	-0.075	0.053	0.031	0.301	0.636	0.346	0.041	0.051	-0.008	0.093	0.077	0.062
bPUS1	0.001	0.025	0.125	-0.079	0.159	0.192	0.224	0.707	0.131	0.097	0.116	0.206	0.048	0.110
bPUS2	-0.124	0.039	0.090	-0.007	0.167	0.313	0.165	0.852	0.194	0.083	0.160	0.180	0.131	0.062
bPUS3	-0.071	0.026	0.112	-0.010	0.186	0.229	0.214	0.871	0.175	0.035	0.081	0.164	0.127	0.139
cBBIM10	0.110	0.143	0.130	0.149	0.082	0.019	0.003	0.132	0.043	0.065	0.341	0.142	0.867	0.080
cBBIM11	0.019	0.171	0.088	0.148	0.120	0.089	-0.003	0.129	0.147	0.071	0.339	0.146	0.889	0.201
cBBIM12	0.054	0.194	0.136	0.176	0.073	0.025	-0.010	0.076	0.136	0.121	0.368	0.106	0.883	0.126
cBBIM13	0.053	0.002	0.022	0.128	0.148	0.146	-0.017	0.132	0.322	0.148	0.246	0.788	0.194	0.271
cBBIM14	0.016	0.004	0.086	0.100	0.098	0.133	0.003	0.162	0.165	-0.029	0.071	0.740	0.090	0.109
cBBIM15	0.106	0.057	0.004	0.139	0.051	0.102	0.020	0.224	0.406	0.108	0.202	0.785	0.065	0.144
cBBIM16	-0.047	0.073	-0.012	0.129	0.047	0.052	-0.076	0.157	0.745	0.160	0.179	0.434	0.104	0.262
cBBIM17	0.011	-0.011	-0.036	0.022	0.044	0.033	-0.001	0.122	0.755	0.106	0.124	0.341	0.014	0.240
cBBIM18	0.023	0.039	0.077	0.073	0.085	0.096	-0.042	0.181	0.827	0.132	0.245	0.209	0.101	0.263
cBBIM19	0.040	0.000	0.053	0.029	0.073	0.031	-0.059	0.165	0.781	0.125	0.173	0.264	0.136	0.329
cBBIM20	-0.090	0.062	-0.030	0.055	0.098	0.052	0.031	-0.008	0.205	0.086	0.047	0.032	0.020	0.404
cBBBIM21	-0.016	0.093	0.018	0.072	0.130	0.128	0.036	0.176	0.324	0.073	0.126	0.202	0.147	0.792
cBBIM22	-0.080	0.068	-0.013	0.097	0.084	0.100	0.024	0.101	0.270	0.023	0.063	0.186	0.098	0.846
cBBIM23	-0.059	0.017	-0.033	0.081	0.072	0.015	0.028	0.037	0.165	0.051	0.052	0.194	0.138	0.732
cBBIM24	-0.051	0.018	0.028	0.096	0.060	0.014	-0.003	0.052	0.226	0.035	0.034	0.167	0.140	0.725
cBBIM1	0.026	0.100	0.078	0.090	0.101	0.207	0.142	0.084	0.095	0.840	0.321	0.001	0.034	0.050
cBBIM2	-0.027	0.006	0.006	0.111	0.078	0.129	0.131	0.065	0.050	0.821	0.274	0.023	0.028	0.011
cBBIM3	0.003	0.084	0.094	0.175	0.108	0.194	0.092	0.081	0.179	0.902	0.413	0.128	0.116	0.033
cBBIM4	0.010	0.170	0.078	0.167	0.115	0.167	0.086	0.063	0.216	0.771	0.558	0.162	0.128	0.139
cBBIM5	0.042	0.147	0.112	0.131	0.128	0.149	0.084	0.077	0.231	0.585	0.709	0.157	0.144	0.148
cBBIM6	0.087	0.161	0.086	0.167	0.034	0.090	0.044	0.106	0.167	0.386	0.844	0.178	0.280	0.055
cBBIM7	0.092	0.167	0.192	0.116	0.088	0.104	0.010	0.127	0.202	0.330	0.837	0.170	0.372	0.042
cBBIM8	0.068	0.161	0.131	0.099	0.109	0.103	0.027	0.154	0.165	0.233	0.765	0.214	0.447	0.081

Table 3: Fornell-Larcker criterion for Barriers to BIM and Adoption Characteristics

	bIAV	bIEA	bIOB	bITA	bPCM	bPCX	bPRA	bPUS	cBBIM_IND	cBBIM_INT	cBBIM_LEDFIN	cBBIM_LEG	cBBIM_PRO	cBBIM_TEC_CLT
bIAV	0.889													
bIEA	0.154	0.792												
bIOB	0.281	0.295	0.877											
bITA	0.043	0.449	0.085	0.828										
bPCM	0.086	0.170	0.519	0.077	0.867									
bPCX	-0.018	0.058	0.105	0.169	0.184	0.755								
bPRA	0.019	0.065	0.038	0.067	0.155	0.361	0.730							
bPUS	-0.083	0.038	0.133	-0.038	0.210	0.305	0.246	0.813						
cBBIM_IND	0.007	0.040	0.036	0.090	0.083	0.074	-0.063	0.207	0.778					
cBBIM_INT	0.007	0.117	0.083	0.166	0.123	0.214	0.133	0.088	0.172	0.835				
cBBIM_LEDFIN	0.092	0.202	0.168	0.161	0.115	0.142	0.051	0.148	0.243	0.483	0.791			
cBBIM_LEG	0.078	0.029	0.046	0.160	0.127	0.164	0.003	0.226	0.392	0.102	0.228	0.771		
cBBIM_PRO	0.069	0.193	0.134	0.180	0.104	0.050	-0.004	0.127	0.124	0.098	0.397	0.149	0.880	
cBBIM_TEC_CLT	-0.075	0.084	-0.005	0.110	0.131	0.107	0.035	0.126	0.353	0.075	0.102	0.227	0.154	0.717

Table 4: HTMT for Barriers to BIM Adoption and Adoption Characteristics

	bIAV	bIEA	bIOB	bITA	bPCM	bPCX	bPRA	bPUS	cBBIM_IND	cBBIM_INT	cBBIM_LEDFIN	cBBIM_LEG	cBBIM_PRO	cBBIM_TEC_CLT
bIAV														
bIEA	0.200													
bIOB	0.344	0.332												
bITA	0.069	0.561	0.087											
bPCM	0.124	0.200	0.627	0.099										
bPCX	0.059	0.139	0.137	0.228	0.248									
bPRA	0.050	0.108	0.138	0.088	0.159	0.531								
bPUS	0.114	0.085	0.180	0.060	0.256	0.443	0.430							
cBBIM_IND	0.050	0.088	0.070	0.109	0.092	0.110	0.085	0.262						
cBBIM_INT	0.060	0.133	0.083	0.189	0.138	0.284	0.116	0.110	0.193					
cBBIM_LEDFIN	0.117	0.214	0.182	0.195	0.129	0.198	0.075	0.190	0.291	0.571				
cBBIM_LEG	0.119	0.075	0.071	0.211	0.165	0.252	0.100	0.322	0.544	0.180	0.309			
cBBIM_PRO	0.088	0.214	0.156	0.211	0.103	0.080	0.070	0.159	0.141	0.109	0.476	0.201		
cBBIM_TEC_CLT	0.112	0.117	0.083	0.142	0.167	0.135	0.106	0.175	0.431	0.107	0.124	0.318	0.202	

in Table 3, this criterion was satisfied, reinforcing the distinctiveness of the constructs. The HTMT ratio, considered a superior method for discriminant validity assessment, was also utilized. This ratio represents the between-trait correlations of the constructs. Based on the threshold values proposed by Henseler *et al*. (2015), values above 0.90 suggest a lack of discriminant validity. However, a more conservative threshold of 0.85 or lower is recommended for constructs that are conceptually more distinct. Table 4 showed the HTMT results, indicating that none of the construct values exceeded 0.90, thereby meeting the quality criteria for outer measurements and first order in the model. The results of HTMT conclude the quality criteria for outer measurements.

The Qualitative Data Analysis Process

Thematic analysis was carried out following an induction approach according to the procedures outlined by Braun and Clarke (2012). The coding strategy used is the description focused coding which simply means using phrases to describe the significant information found in the interview transcript. The research question was experiential and exploratory in nature and having this in mind significant information was identified from the participants' transcripts. Based on the significant information identified, a label was developed (known as codes) to represent the significant information. A total of twelve (12) codes were developed and then categorized and reviewed to develop potential themes. A total of six (6) themes were developed in the study.

FINDINGS OF STRUCTURAL MODEL

The structural model was assessed to determine the results of the objectives of the study. The process involved examining the inner VIF; the value of coefficient of determination (R^2), and the importance and performance matrix (IPMA). Table 5, 6, 7 and Figure 1 present the structure analysis results. The assessment of collinearity as depicted in Table 5 demonstrated the absence of issues with the variance inflation factors (VIF) for latent variables all falling below 3, aligning with the recommendations by Hair *et al* (2024). Moving to Table 6 and Figure 1, the structural path analysis uncovered positive and statistically

Table 5: VIF of Barriers and BIM adoption Characteristics

	bBIM_CH	VIF
cBBIM_IND		1.329
cBBIM_INT		1.339
cBBIM_LEDFIN		1.629
cBBIM_LEG		1.219
cBBIM_PRO		1.231
cBBIM_TEC_CLT		1.173

Table 6: Path Coefficient of Barriers and BIM adoption Characteristics

	Beta	**STD**	**T statistics**	**P values**
cBBIM_IND -> bBIM_CH	0.042	0.055	0.770	0.442
cBBIM_INT -> bBIM_CH	0.136	0.057	2.400	0.016
cBBIM_LEDFIN -> bBIM_CH	0.093	0.067	1.399	0.162
cBBIM_LEG -> bBIM_CH	0.178	0.060	2.965	0.003
cBBIM_PRO -> bBIM_CH	0.142	0.059	2.430	0.015
cBBIM_TEC_CLT -> bBIM_CH	0.083	0.056	1.472	0.141

Table 7: R-Square of BIM adoption Characteristics

	R-square	**R-square adjusted**
bBIM_CH	0.162	0.147

significant connections with three major barriers: Legal barrier (cBBIM_LEG -> bBIM_CH, Beta = 0.178, T Statistics = 2.965), Professional Barrier (cBBIM_PRO -> bBIM_CH, Beta=0.142, T statistics = 2.430), and Interest barrier (cBBIM_INT -> bBIM_CH, Beta = 0.136, T statistics = 2.400). These results signify that these barriers play a significant role in influencing BIM adoption characteristics in the construction sector. The study found the coefficient of determination of the model to be 0.147 (R- square adjusted). This indicates that our model (the predictors, cBBIM) explains 14.7 percent of the variance in the endogenous construct (bBIM_CH). The R-square of 0.162 is described to be moderate based on the criteria proposed by Cohen (1992) and echoed in Tehseen *et al*. (2019) and Adepoju *et al*. (2023), where R-Square values of 0.26, 0.13, and 0.02 are deemed substantial, moderate, and weak, respectively. Figures 2 and 3 showed the

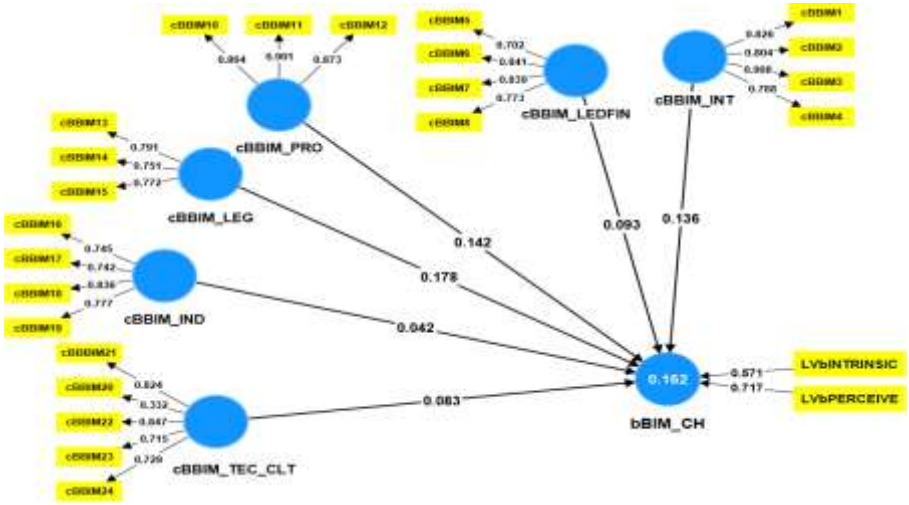

Figure 1: Framework and structural analysis of the study (Algorithm of Barriers and BIM adoption Characteristics)

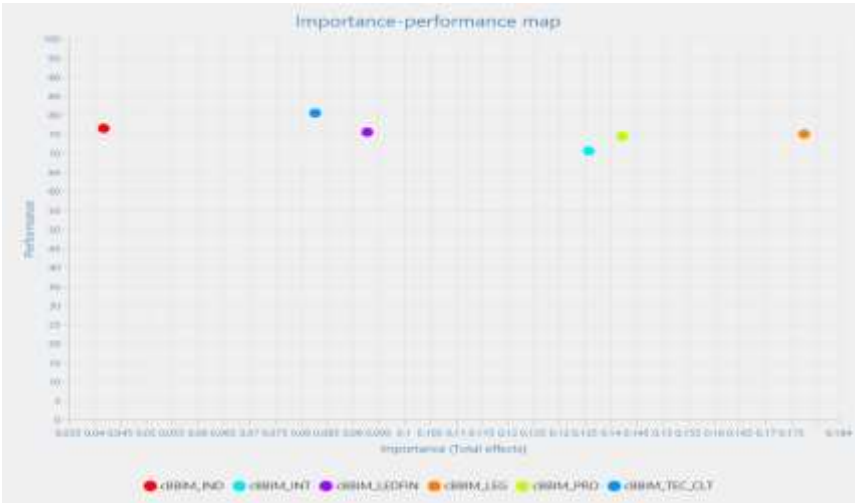

Figure 2: IPMA Barriers of BIM subconstructs and BIM adoption Characteristics

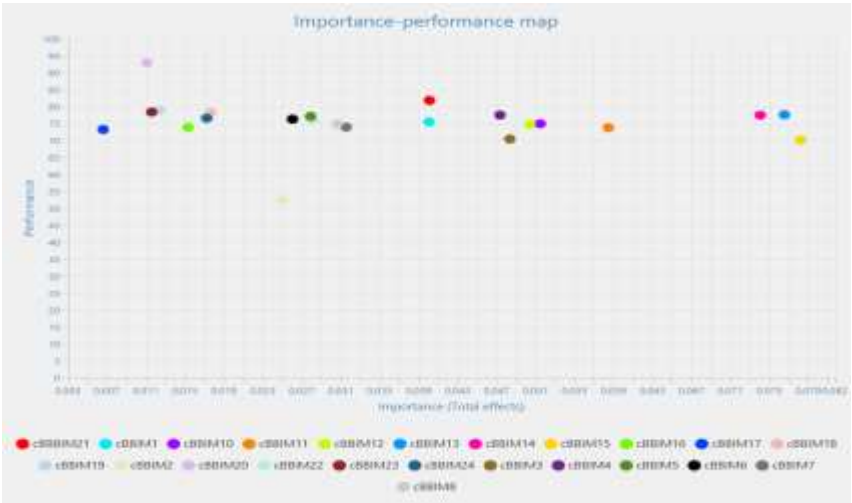

Figure 3: IPMA Barriers of BIM indicators and BIM adoption Characteristics

importance performance map (IPMA) of constructs and indicators related to barriers in BIM adoption. Figure 2 highlighted that the legal barrier emerged as the most crucial and highest-performing construct in the context of BIM adoption within the construction sector in Lagos State. Figure 3 shows the specific indicators, identifying cBBIM15 (Lack of enforcement from industry leaderships), cBBIM13 (Lack of policies and regulations on copyright ownership), and cBBIM14 (Lack of enforcement from government agencies) as the most important and highest performing barriers. Remarkably, cBBIM15 stood out as the most impactful barrier on building information modeling adoption characteristics in the construction sector in Lagos State. In summary, the IPMA analysis further emphasizes the paramount importance of the legal barrier and specific indicators, providing actionable insights for stakeholders in the construction sector in Lagos State seeking to navigate and enhance BIM adoption practices.

Barriers to BIM Adoption (BBIMA) and BIM Adoption Characteristics (BIMAC)

Six final themes were generated namely: finance barriers, industry barriers, interest barriers, leadership barriers, legal barriers and professional barriers.

Finance barriers

This explains the capital restraint that limits the adoption of building information modelling. The theme also went further to explain that some of these BIM software are not readily available for construction professionals in Nigeria and that even with access, getting a legitimate license to operate them is expensive. The theme has two codes with five significant information connected to the codes. Figure 4 delineated the two participants connected to the theme. P3, who is an architect and uses several BIM software shared that:

> *"This software is quite expensive if you are going to get their legitimate license and most professionals don't want to spend money"*

This is also related to the opinion of P1 who is also an architect and uses Revit software:

> *"Some of these software are not readily available and it is expensive to put everything together maybe that's why it's not being adopted."*

Industry barriers

This theme focuses on the lack of cooperation and trust among the construction professionals in the construction industry. It is interesting to know that some of the older generations in the construction industry are unwilling to learn how to use BIM software from the younger generation which makes them to be intimidated and shun off any idea about using BIM software by young professionals in the construction industry. Figure 5 illustrates the participant connected to this theme. According to P2 who works in an organization with about 50 employees shared his experience that:

> *"There is a lot of power tussle between the older and the younger generations. When it comes to construction work and the older generation, they don't want to believe that technology wise, things can be done more efficiently. Most of them do not want to relearn from the younger generation and for you to now change, to now come in and change oh no don't let us do it this way, let's do it this other way round. You are going to have a lot of issues, they will see you as you are just trying to shun them off, you are just trying to take them off the market, and so by that they will start fighting you."*

Interest barriers

This theme talks about the lack of awareness, understanding and seriousness of some construction professionals in adopting BIM in the construction industry. The theme further explains that some organizations lack competent professionals and would rather employ few professionals that adopt BIM on a contract basis than to employ them full-time because of their lack of interest in adopting BIM. This theme is one of the dominant themes as it explains a larger part of the research question. It has two codes and all the participants gave their opinion on the theme. Figure 6 illustrates the participants connected to this theme. According to P1 who is a senior staff with five years of experience reiterates that:

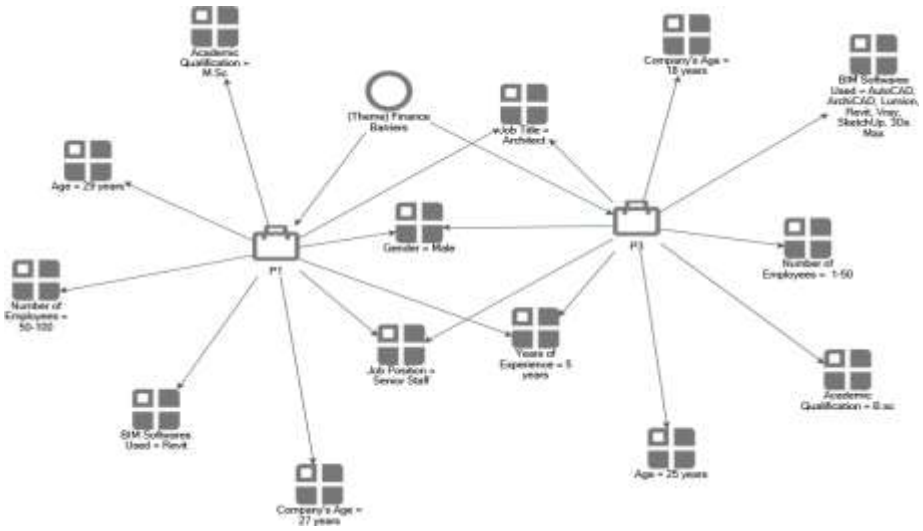

Figure 4: Project Map of Participants connected to Finance Barriers

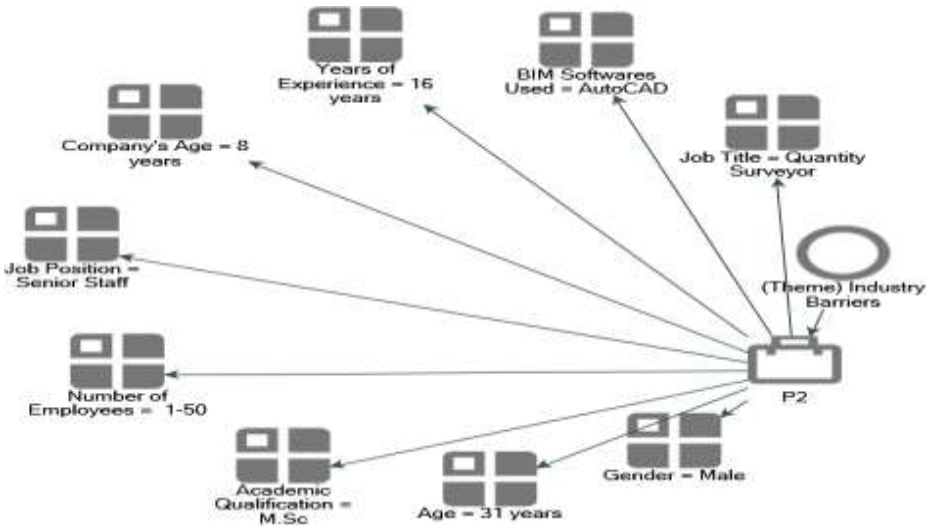

Figure 5: Project Map of Participants connected to Industry Barriers

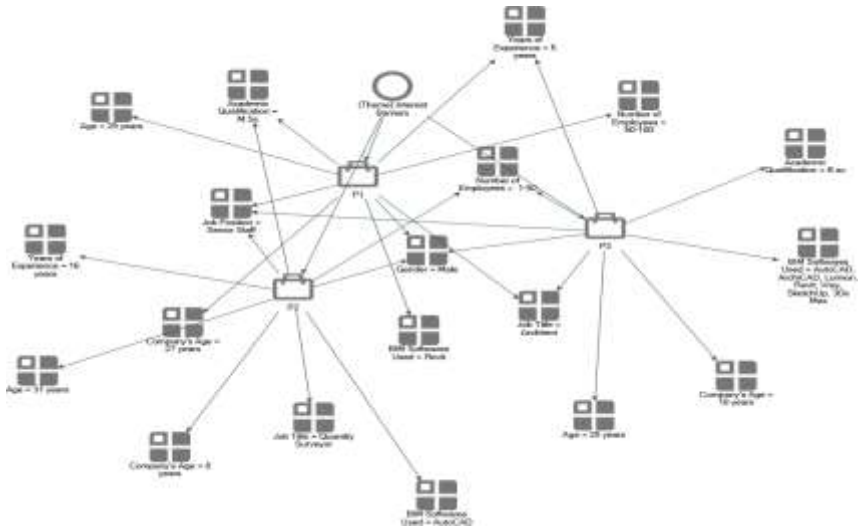

Figure 6: Project Map of Participants connected to Interest Barriers

> *"Let's say thirty percent (30%) of the construction industry now are the people who are fully into the adoption of this BIM because some people don't take it seriously like that. In some companies they have only the architect and without the QS (Quantity Surveyor) whereby they will just invite the QS as a contract staff and maybe for the engineers too."*

P2 who is also a senior staff with sixteen years of experience supports the claim that some professionals do not take BIM adoption seriously:

> *"The older generation, they don't have interest in it"*

The third participant P3 who is a senior staff with five years of experience also corroborates the claim:

> *"They don't want to evolve; there is no willingness and interest in it."*

Leadership barriers

This theme explained that some construction professionals are reluctant to follow proper standards. The theme also shared that in the Lagos State construction industry, some professionals would rather prefer to design and construct to not meet proper standards and get paid than to follow proper procedures. A single code was developed under this theme. Figure 7 shows the participant connected to this theme. As explained by P1 who is an architect:

> "*In this part of the Country and world we are in, we don't follow standards, we just feel let me just design, let me just do it and just throw it outside there so that I can be paid without following the correct standard. Lagos State especially needs to design and construct to standard because let's say the past years where they experienced building collapses and all that if the designs are followed strictly with laid down rules and regulations and are also incorporated into the BIM software and process it's going to reduce all that."*

Legal barriers

This refers to the lack of enforcement from government agencies and lack of policies and regulations from the construction industry leaders and government. This theme also gave an insight into how some construction professionals cut corners to avoid following BIM laid down rules. Two codes were developed under this theme. Figure 8 shows the participants connection to the theme. As explained by P2 who is a quantity surveyor:

> *"We have issue of government policies in Nigeria because everybody wants to pass through shortcuts and have their way. People who are supposed to enforce it, to enforce the use of BIM, once they just tip them off, they are off it, they don't care anymore"*

P3 who is an architect also supports the assertion of P2 and disclosed that:

> *"There is no actual policy and that the enforcement is just up to a certain level"*

Professional barriers

This theme refers to how most professionals do not have an adequate knowledge of BIM, the rigorous learning process that goes into learning BIM software, difficulties in switching to new methods by construction professionals and professionals claiming BIM is a waste of time and human resources. The theme further explains that some of the older generation of construction professionals still prefers to draw by hand instead of using BIM software because they lack the technical knowledge needed to operate the application. This theme is the dominant theme as it explains a large part of the research question and has four codes and all the participants gave their opinion on the theme. Figure 9 illustrates the participants connected to this theme. According to P1 who is a senior staff with five years of experience:

> *"I still have a lot of people that still prefer to sketch with hand and it is somehow hard for someone who has been using, let's say for an architect who has been used to designing with AutoCAD or hand so it's going to be hard for such person to easily switch. Also the training and the learning process sometimes is usually hard."*

P2 who is also a senior staff with sixteen years of experience shared that:

> *"Some of the older generation, they don't want to give room for let me say modern technology so to say, instead of them to*

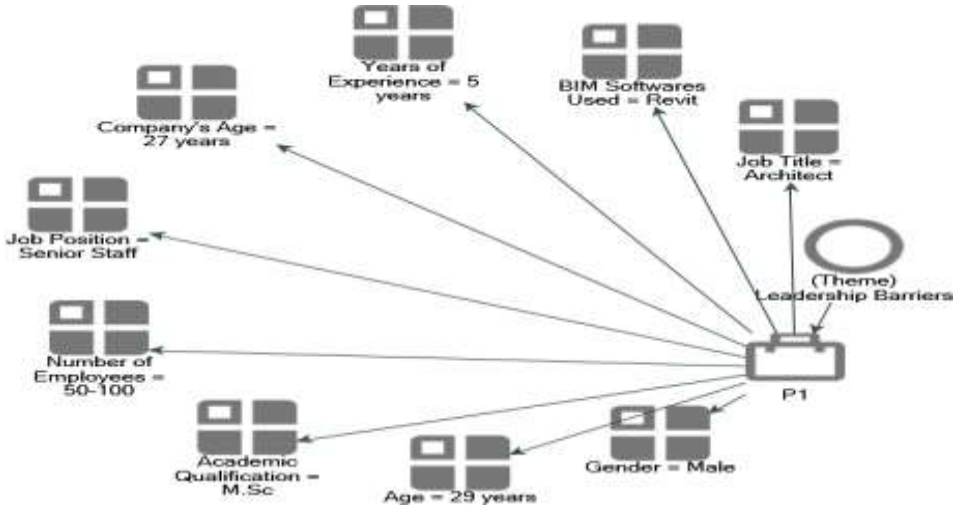

Figure 7: Project Map of Participants connected to Leadership Barriers

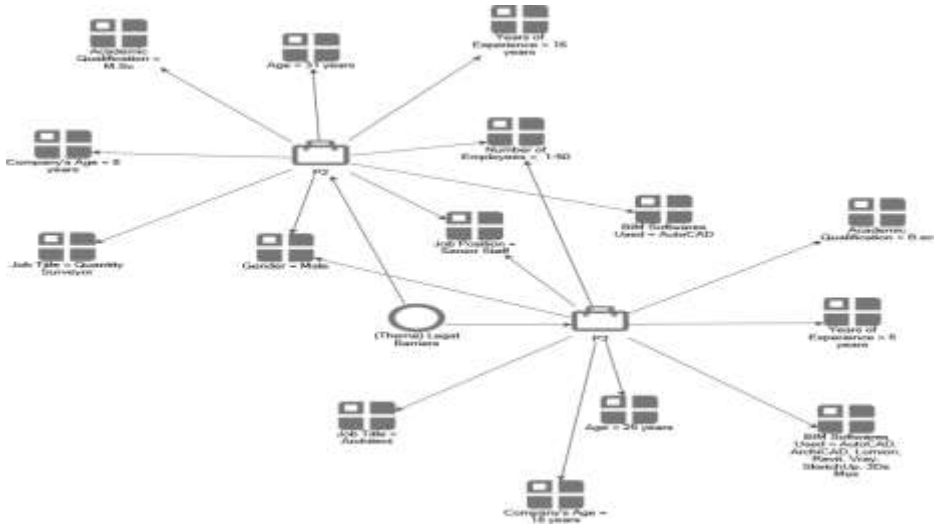

Figure 8: Project Map of Participants connected to Legal Barriers

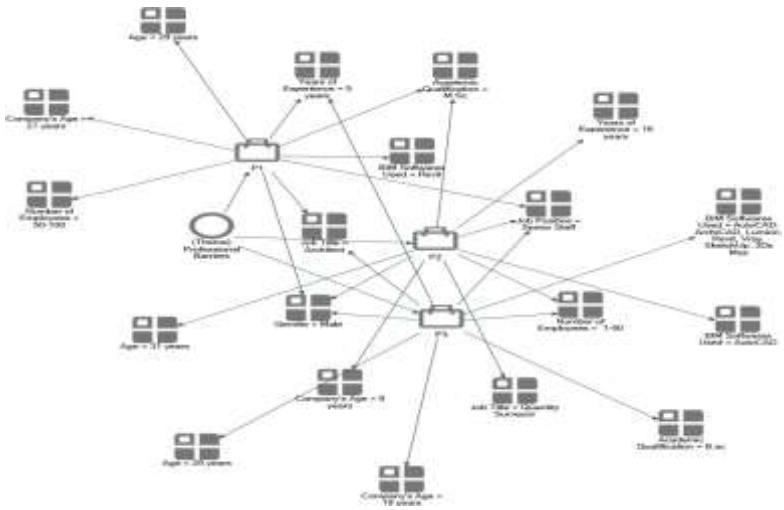

Figure 9: Project Map of Participants connected to Professional Barriers

adopt the modern technology and learn, they don't want to. These older generation based on my experience with them, they don't want to unlearn what they've learnt not to talk of relearning because they believe, most of them they are let me say are lagging behind in some areas and once you now bring up okay sir I have this, let's work with this automatically you are pushing them to the side because BIM will not encourage or allow you to bring someone who is not needed into the construction world"

The third participant P3 who is a senior staff with five years of experience explained that:

"They don't want to be stressed to learn new skills and there are professionals who consider this as a waste of time. It's also complex because you need some technical knowledge; you need some basic skills before you can actually use the BIM"

Table 8 and 9 shows the codes and themes categorization for all the themes in the study while the matrix coding query shows the number of significant information connected to the themes and participants respectively.

In addition, Figures 10, 11 and 12 illustrate the framework matrix showing the significant information connected to both the themes and the participants, matrix coding query chart depicting the participants, themes, number of counts by the number of times significant information was dropped into the theme and the word cloud portrays the participants' kind of words and frequency used while answering questions.

Table 8: Codes and Themes Categorizations for Research Question Three

Cluster 1: Interest Barriers	Cluster 2: Professional Barriers	Cluster 3: Finance Barriers	Cluster 4: Legal Barriers	Cluster 5: Industry Barriers	Cluster 6: Leadership Barriers
• Lack of interest of professionals • Absence of substantial competent professionals	• Rigorous training and learning process • Difficulties in switching to new methods • Inadequate knowledge of BIM • Waste in time and human resources	• High cost of purchase • Unavailability of BIM software	• Lack of enforcement from government agencies • Lack of policies and regulations	• Lack of cooperation among professionals	• Reluctance of professionals to follow proper standards

Table 9: Matrix Coding Query for Research Question Three

Participants	Finance Barriers	Industry Barriers	Interest Barriers	Leadership Barriers	Legal Barriers	Professional Barriers
P3	2	0	2	0	2	4
P2	0	4	1	0	4	4
P1	3	0	3	2	0	3

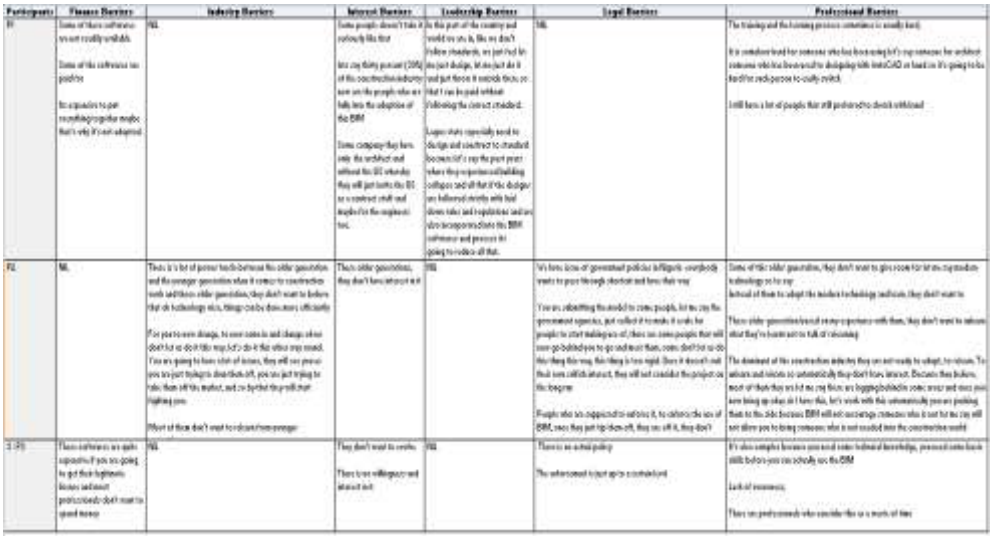

Figure 10: Framework Matrix for study

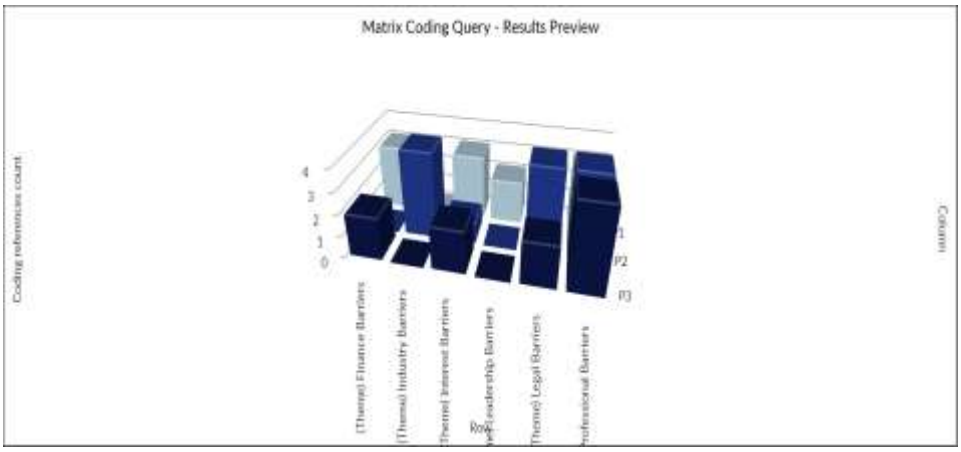

Figure 11: Matrix Coding Query Chart for the study

Figure 12: Word Cloud for study

DISCUSSION

The study evaluated the effects of barriers of adopting building information modelling on BIM adoption characteristics and found that legal barriers observed a significant association with complexity, perceived usefulness and technical aspects of BIM adoption characteristics. A recent report by Olugboyega (2020) on the nexus between building information modelling implementation strategies, adoption and levels of construction supply chain integration in South Africa showed that lack of enforcement from the government is one of the major barriers against preliminary BIM adoption in the South African construction industry. Similarly, the result shows that professional barrier has a significant relationship with economic and technical aspects of BIM adoption characteristics. This view is also supported by the assertion of Sun *et al*. (2017) that the lack of experienced professionals who are familiar with BIM and have experience using it is a prominent limiting factor affecting its adoption (Sun *et al*., 2017). The findings of Shang and Oraee (2022) explained that 'resistance to change by professionals' was identified as the number one influential factor in BIM adoption in the construction industry. This means that, 'resistance to change' by construction professionals was considered the most significant barrier to BIM adoption in the construction industry. In addition to support this result as discussed in the studies of Arayici *et al*. (2011) and Meža *et al*. (2015), resistance to change from the traditional project delivery approach to digitalization by construction professionals and also the conservative nature of the industry were identified as significant barriers to BIM adoption. However, the technology and client related barrier has no significant relationship with any of the sub constructs of BIM adoption characteristics. Legal barrier demonstrated a statistically significant relationship with perceived characteristics while professional barriers exhibited a significant relationship, albeit with intrinsic characteristics. The findings also revealed professional, legal and interest barriers to have the most significant role in influencing BIM adoption characteristics in the construction sector. Furthermore, this result supports the findings of Kori and Arto (2015) that opined that the interest of construction professionals to change from an existing process to a new one poses more problems than acquiring the skills. This is because the traditional method of procurement has been used long enough that it is extremely difficult to embrace a new process. Zahrizan *et al*. (2013) argued that professionals at the corporate level have been identified as a key factor that bring about incessant incorporation of changes to innovation. Sun *et al*. (2017) revealed that interest barriers such as participants' attitudes toward BIM applications, the lack of existing successful cases, the fragmented nature of the construction industry, the inappropriate business models, and the lack of cooperation from other industry partners have significant relationship on the adoption of BIM. Six final themes were generated from the thematic analysis namely: finance barriers, industry barriers, interest barriers, leadership barriers, legal barriers and professional barriers. The finance barrier theme explained that some of the BIM software is not readily available for construction professionals in Nigeria because getting a legitimate license to operate them is expensive. This theme is in line with a 2008 McGraw-Hill survey which revealed costs and training issues to be the greatest barriers to the application of BIM (Young *et al*. 2008). The themes also shared that some older generations of professionals in the construction industry are unwilling to learn how to use BIM software from the younger generation professionals which makes them to be intimidated and shun off any idea about using BIM softwares by young professionals in the construction industry. This is in line with the findings of Post (2008) which revealed that changes in everything from file management, to client billing, to deliverables, to coordination meetings are multifarious and complicated, and organizations and professionals lack trust and cooperation to adapt to these changes. The themes further explains that some organizations lack competent professionals and would rather employ few professionals that adopt BIM on a contract basis than to employ them full time because of their lack of interest in adopting BIM. The themes also shared that in the Lagos state construction

industry, some professionals would rather prefer to design and construct to not meet proper standards and get paid than to follow proper procedures. The theme is strongly backed by Sun *et al*. (2017) which revealed that leadership barriers such as reluctance to follow standards, the lack of existing successful cases, fragmented nature of the construction industry, the inappropriate business models, and the lack of cooperation from other industry partners have significant relationship on the adoption of BIM. The themes explained that there are no actual policies regulating BIM adoption in Lagos State and that construction professionals would rather cut through corners to avoid following BIM laid down rules because its enforcement by industry leaders and government agencies is just up to a certain level. Finally, the themes explained how most professionals don't have an adequate knowledge of BIM, the rigorous learning and process that goes into learning how to use BIM software, difficulties in switching to new methods by construction professionals and professionals claiming BIM is a waste of time and human resource. The theme supports the findings of Shang and Oraee (2022) who explained that 'resistance to change by professionals' was identified as the number one influential factor in the adoption of BIM in the construction industry.

CONCLUSION

The study has examined the major barriers relevant to building information modelling adoption characteristics in the Lagos State construction industry. It is evident that there is a huge effect of these barriers on building information modeling adoption characteristics. To affirm this, the study employed structural equation modelling to examine the effects of exogenous constructs (Barriers to building information modeling adoption) on an endogenous construct (building information modeling adoption characteristics). This is important to establish the construct and indicator with high relevance to predict BIM adoption characteristics. Additionally, based on the six themes developed in this study it seems reasonable to conclude that the themes gave a clear explanation of the relationship between barriers to BIM adoption and BIM adoption characteristics and recommends that construction managers and industry leaders should create an atmosphere where professionals can freely share BIM knowledge, as well as be able to trust their colleagues thereby limiting industry barriers in the Lagos State construction industry. Also, Professional bodies should incorporate policies and rules that will serve as requirements that must be met before construction professionals can get their practicing license as this will reduce interest barriers limiting the professionals in adopting BIM which will further increase in-house BIM competent professionals in construction firms. Also, policy makers should design and implement policies (regulatory, economic and information) to promote financial schemes to support construction firms and professionals and to reduce finance barriers. Finally, policy makers should lay down rules and regulations that must be enforced among the construction professionals and firms in the Lagos State construction industry. Thus, despite reaching the objectives, the study has limitations. The study conducted 3 interviews to support and validate the findings of the qualitative analysis. Further studies should include increased number of participants for the interview across the different group of professionals in the construction industry.

References

Abubakar, M., Ibrahim, Y. M., Kado, D., & Bala, K. (2014). Contractors perception of the factors affecting building information modeling adoption in the Nigerian construction industry, *Computing in Civil and Building Engineering.* doi.org/10.1061/978078441361602 2

Adepoju, A. and Adeniji, A. (2020). Technology acceptance of e-banking services in an unnatural environment, SEISENSE *Journal of Management*, 3(3), 34–50

Adepoju, A., Ekundayo, K., & Oladiipo, A. (2023). Household energy conservation behaviour: A socioeconomic perspective. *Journal of Digital Food, Energy & Water Systems*, *4*(1), 1 - 24

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C. & O'reilly, K. (2011). Technology adoption in the BIM implementation for lean architectural practice. *Automation in Construction, 20*, 189-195.

Babatunde, S. O, Udeaja, C. E., & Adekunle, A.O. (2021). Barriers to BIM implementation and ways

forward to improve its adoption in the Nigerian AEC firms. *International Journal of Building Pathology and Adaptation*, 1-28

Barak, R., Jeong, Y. S., Sacks, R., Eastman, C. M. (2009). Unique requirements of building information modeling for cast-in-place reinforced concrete. *Journal of Computing in Civil Engineering*, *23* (2), 64–74.

Bryde, D., Broquetas, M., & Volm, J.M. (2013). The project benefits of building information modelling (BIM). *International Journal of Project Management*, *31*(7), 971–980

Cao, D., Li, H., & Wang, G. (2014). Impacts of isomorphic pressures on BIM adoption in construction projects. *Journal of Construction Engineering and Management*. *140* (12). 1-10

Collan, M., & Tétard, F. (2011). Lazy User Model: solution selection and discussion about switching costs. *Scandinavian Conference on Information Systems*. doi.10.1109/HICSS.2009.289

Cohen, J. Y. (1992). Statistics and Data with R: An applied approach through examples. John Wiley & Sons. New York

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors. John Wiley & Sons, New York.

Ezeokoli, F. O., Okoye, P. U., & Nkeleme, E. (2016), "Factors affecting the adaptability of building information modeling for construction projects in Anambra state Nigeria. *Journal of Scientific Research & Reports*, *11* (5), 1-10

Gardezi, S. S., Shafiq, N., Faris, M., & Khamidi, B. (2014), "Prospects of building information modeling in Malaysian construction industry as conflict resolution tool". *Journal of Energy Technologies and Policy*, *3* (11), 346–350

Gu, N., & London, K. (2010). Understanding and facilitating BIM adoption in the AEC industry. *Automation in Construction*, *19* (8), 988–999.

Hair, J. F., Hult, T., Ringle, C. M. and Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). Thousand Oaks: Sage. Oaks.

Hair, J. F., Sarstedt, M., Ringle, C. M. and Gudergan, S. P., (2024), Advanced issues in Partial Least Squares Structural Equation Modeling (PLS-SEM), Sage Publication.

Henseler, J., Ringle, C. M. and Sarstedt, M., (2016). Testing measurement invariance of composites using partial least squares, *International Marketing Review*, 33 (3), 405-431.

Hergunsel, M. F. (2011). Benefits Of Building Information Modeling for Construction Managers and Bim Based Scheduling. Worcester Polytechnic Institute.1-95

Hochscheid, H., & Halin, G. (2019). A framework for studying the factors that influence the BIM adoption process. *CIB W78 – Information Technology for Construction*, Sep. 2019, Newcastle, United Kingdom

Hosseini, M. R., & Chileshe, N. (2013). Global Virtual Engineering Teams (GVETs): A fertile ground for research in Australian construction projects context. *International Journal of Project Management, 31*, 1101-1117.

Kori, S. I., & Kiviniemi, A. (2015). Toward adoption of BIM in the Nigerian AEC industry; context framing, data collecting and paradigm for interpretation. 9th BIM Academic Symposium & Job Task Academic Review, NIBS-Washington DC, USA, 7-8 April, 2015

Liu, S., Xie, B., Tivendal, L., & Liu, C. (2015), Critical barriers to BIM implementation in the AEC industry". *International Journal of Marketing Studies*, *7* (6), 162-171

McAdam, B. (2010). Building information modeling: the UK legal context. *International Journal of Law in the Built Environment, 2* (3), 246–259.

McAuley, B., Hore, A. V., West, R. (2012). Implementing of building information modelling in public works projects, in Proceedings of the 9th European Conference on Product and Process Modelling, 25–27

Memon, A. H., Rahman, I. A., Memon, I., & Azman, N. A. (2014). "BIM in Malaysian construction industry: status, advantages, barriers and strategies to enhance the implementation level". *Research Journal of Applied Sciences, Engineering and Technology*, *8* (5), 606-614

Méndez, R. O. (2006). The building information model in facilities management: Master's thesis. Worcester Polytechnic Institute

Meža, S., Turk, Ž. & Dolenc, M. (2015). Measuring the potential of augmented reality in civil engineering. *Advances in Engineering Software*, 90, 1-10.

NIST (2007). National Building Information Modeling Standard Version 1 - Part 1: Overview, Principles, and Methodologies, Washington, DC 20005, *National Institute of Building Science*.

Obiegbu, M. E, & Ezeokoli, F. O. (2014), Building information modeling, a panacea for timely project delivery, being a paper delivered at River State quantity surveyor's week holding at

The Arena Event Centre, Tombia Street, Port Harcourt, Nigeria.

Olugboyega, O. (2020). The Nexus between Building Information Modelling Implementation Strategies, Adoption, and Levels of Construction Supply Chain Integration in South Africa. Doctoral Thesis submitted to the Faculty of Engineering and the Built Environment, Department of Construction Economics and Management, University of Cape Town

Panagiotidou, N., Pitt, M., & Lu, Q. (2022). Building information modelling execution plans: a global review. *Smart Infrastructure and Construction*, 176 (3), 126 - 147

Pärn, E. A., Edwards, D. J. & Sing, M. C. P. (2017). The Building Information Modeling trajectory in facilities management: A review. *Automation in Construction, 75*, 45-55

Paul D., Leedy, Ormrod, J. E., & Johnson, L. R. (2014). *Practical research: Planning and design* p.360 Pearson Education.

Post, N. M. (2008). Building Information Modeling snags don't dampen spirits. *Engineering News Record*, 261 (17), 30–32.

Qinghua, H., Wang, G., Lan, L., Qian, S., Jianxun, X., & Xianhai, M. (2016). Mapping the managerial areas of building information modeling (BIM) using scientometric analysis. *International Journal of Project Management, 35*, 670–685.

Rogers, E. M. (2003). Diffusion of innovations. (5th ed.). New York: Free Press.

Shang, G., & Oraee, M. (2022). An integrated model of factors and barriers influencing BIM and lean construction adoption. *Geography and Tourism* 2022, 80-101

Sun, C., Jiang, S., Skibniewski, M. J., Qingpeng Man, Q., & Shen, L. (2017). A literature review of the factors limiting the application of BIM in the construction industry. *Technological and Economic Development of Economy, 23* (5) 764–779.

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories". *Procedia Manufacturing, 22*, 960 –967

Tehseen, S., Qureshi, Z. H., Johara, F., & Ramayah, T. H. U. R. A. S. A. M. Y. (2020). Assessing dimensions of entrepreneurial competencies: a type II (reflective-formative) measurement approach using PLS-SEM. *Journal of Sustainability Science and Management*, 15(2), 108 - 145

Walker, D. H. T., Davis, P. R., & Stevenson, A. (2017). Coping with uncertainty and ambiguity through team collaboration in infrastructure projects. *International Journal of Project Management, 35*, 180-190

Wijekoon, K. A. N. (2019). Optimising the adoption of Building Information Modelling (BIM) in Facilities Management (FM): a model for value enhancement. 1-260

Young, N. W., Jones, S. A., & Bernstein, H. M. (2008). Transforming design and construction to achieve greater industry productivity: SmartMarket report on building information modeling (BIM). McGraw-Hill

Zhang, J., Liu, Q., Hu, Z., Lin, J., & Yu, F. (2017). A multi-server information-sharing environment for cross-party collaboration on a private cloud. *Automation in Construction, 81*, 180-195.

Zahrizan Z., Ali, N. M., Haron, A. T., Marshall-Ponting, A. & Hamid Z. A. (2013). Exploring the adoption of building information modeling in the Malaysian construction industry: a qualitative approach. *International Journal of Research in Engineering and Technology, 2* (8), 384–39.