Barriers to BIM for Facilities Management adoption in Nigeria: a multivariate analysis

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Abstract

Purpose - Building Information Modelling (BIM) has been established in the literature as a successful platform that creates an intelligent virtual model for processing data from conceptual design through construction to operational stage of a facility. However, its adoption for facilities management provision in Nigeria has been slow due to inherent barriers. The aim of this paper is to (1) assess and categorise using factor analysis BIM for facilities management barriers and (2) model the barriers using stakeholders' personal/professional attributes.

Design/methodology/approach-Anchored on quantitative research design, 205 copies of structured questionnaire were distributed to key stakeholders and facilities managers in Nigeria's three strategic cities while 135 valid responses were received giving a response rate of 65.8%. Data collected were analysed using descriptive statistics while multiple regression analysis was used to model the barriers. Kruskal Wallis test was used to test the only hypothesis postulated for the study.

Findings - The study established lack of awareness of BIM for FM, poor supporting infrastructure for internet services, and lack of education and training as the top three rated barriers militating against adoption of BIM for FM in Nigeria while corruption, widespread mistakes and errors and cultural issues were established as the three least rated barriers. Besides, findings also established eight underlying factors that explained twenty-three barrier factors used for the study which were subsequently used to develop eight regression models. In effect, *gender, professional affiliation, organisation, experience, education, expertise, BIM for FM project type, and location* were found to statistically predict the 8 extracted factors driving perceived barriers of BIM for FM adoption in Nigeria.

Practical implication - The study has provided a framework of barrier factors to help stakeholders identify specific barriers for which appropriate measures can be taken to ameliorate consequences of the perceived barriers. Meanwhile, an improved and rejuvenated advocacy on inherent benefits of BIM for facilities management by frontline stakeholders could potentially steer up interests and increased participation of stakeholders on BIM for FM.

Originality/value – The unique study developed the first ever regression model that links BIM for FM barriers to professional attributes of facilities management stakeholders in Nigeria.

Key words: Building information modelling (BIM), Facilities Management (FM), inhibiting factors, factor analysis, regression model, Nigeria
Paper type Research paper

1. INTRODUCTION

The coming of the Fourth Industrial Revolution age alongside the advancement in Information and Communication Technology (ICT) has led to the growth of technologies that improve efficiency and address the complexity of the construction process (Alemayehu et al., 2021). Building Information Modelling (BIM) as one of such technologies has tremendously impacted the construction industry. According to Naghshbandi (2017), it is a virtual base of a building's information that enables various stakeholders to effectively communicate and collaborate with one another. In other words, BIM models facilitate the process of project delivery by creating an intelligent virtual platform that processes data from design through the construction stage to the operational stage of a building or facility (facilities management). BIM has several useful purposes which include programming at inception of a project up to its demolition (BIM, 2018), as well as code reviews, estimation, construction scheduling, clash detections and facilities management (Azhar, 2011).

Facilities management has over the years developed from the traditional view of being mere maintenance unit of organisations to what Atkin and Brooks (2009) describe as an integrated approach at strategic levels of organisations to operating, maintaining, improving and adapting buildings and infrastructure of an organisation in order to create an environment that strongly supports the primary objectives of that organisation. According to Becerik-Gerber et al. (2011), BIM data is mostly useful at the operational stage for commissioning, space management, locating building components, quality control, energy management, security management and maintenance and repairs. Furthermore, information and data about a facility, including its construction, materials and maintenance schedules can be stored, accessed and exchanged through BIM, thus acting as a reliable shared knowledge resource that can assist the decision-making process for facility managers throughout the life cycle of a building (Stanley and Thurnell, 2014).

Despite the numerous potentials of BIM enunciated by researchers in past studies, substantial organisational and process barriers have tended to hinder its effective adoption for construction process generally and facilities management in particular. Studies on these barriers have been explored in several countries of US, Europe, Asia and Africa including Nigeria, (Ku and Taiebat, 2011; Onungwa et al., 2017; Onungwa and Uduma-Olugu, 2017; Asiedu, 2017; Hamma.adama and akaouider, 2019; Stride et al., 2020; Babatunde et al., 2020; Alemayehu et al. (2021)). While these studies have extensively explored BIM adoption barriers, relatively lesser studies have been carried out on BIM for FM barriers. BIM for facilities management remains largely unexplored. This had earlier been substantiated by the Smart Market Report by Dodge Data and Analytics (Jones, 2015), which showed that over 86 per cent of building owners require BIM data from general contractors, while only 17 per cent use it for facilities management. What is therefore the source of this hindrance? This study intends to answer the research question. Meanwhile, although Alemayehu et al. (2021) modelled the relationship between individuals' personal attributes and perception of adoption of BIM barriers, some gaps exist which the present study intends to fill. For instance, the study was conducted in the Ethiopian construction industry with 35 sample units all within the country's capital Addis Ababa. This study extends that body of knowledge by exploring the current state of BIM for facilities management adoption in three strategic cities of Nigeria and develops a regression model that links the barriers to the professional attributes of stakeholders.

Given the background above, the primary objectives of this research are to (1) assess and categorise the BIM for facilities management barriers; and (2) model the barriers using professional attributes of respondents. It is expected that this will help to prioritise the barriers that are deemed critical in Nigeria's facilities management sector and link the importance of these barriers to the characteristics of the stakeholders under investigation.

2. LITERATURE REVIEW

The concept of BIM

The evolution of what is today described as BIM started in the 1960s as simple computing applications (Chiu and Lai, 2020). This has steadily progressed with improvements in solid modelling programmes in the 1970s resulting in its multidimensional nature of allowing for integration of an almost indefinite number of dimensions (Smith, 2014) from 3D (object model), to 4D (time), 5D (cost), 6D (operation), 7D (sustainability) to 8D (Safety) (Alemayehu et al., 2021). Over the years, researchers have developed different definitions of BIM in line with their chosen areas of specialisation. In one of such, BIM model was described as a digital representation of the physical and functional characteristics of a facility, which serves as a shared knowledge of resource to the needs of various users and supports collaboration between different stakeholders at different phases of the life cycle (NIBS, 2007). It is also viewed by Autodesk (2010) as an integrated model which greatly improves understanding of the project processes with a view towards predicting a successful outcome. Central to these definitions is the conclusion that BIM encompasses a broad expense of common key features and capabilities which include virtual modelling, information management, coordination/collaboration, standards support and ease to use (Ahmad, 2012).

According to Baldwin (2012), BIM functions can be categorised into *design* (existing conditions modelling, spatial programming, design coordination); *analysis* (structural/energy/lighting analysis, model auditing, code checking); *construction* (site utilisation, construction sequencing, cost estimation); *operation* (asset and space management, maintenance scheduling) and *data management* (managing metadata, linking database, interoperability and file exchange). While it is evident from the functions enumerated above that BIM has the capability to address inefficiencies bedevilling the Architectural, Engineering, Construction and Operation (AECO) sector, the impracticability and interoperability of these functions have continued to pose a big challenge.

BIM for facilities management (FM)

Since its formation, FM is said to have transformed from mere janitorial services to becoming an integral part of the boardroom management (Ikediashi and Ekanem, 2015). It is a multidisciplinary profession that ensures functionality of the workplace through people, place, process and technology (Arayici et al. 2012). Its functional areas include emergencies preparedness, communication, business continuity, human factors, leadership environmental stewardship and sustainability, finance and business, strategy, project management, quality, real estate and property management and technology (IFMA, 2016). This growing popularity of FM is corroborated by a recent survey credited to ResearchAndMarkets.com by Businesswire (2021) in which the FM global market, amid the COVID-19 crisis is expected to grow from US$1.4 trillion in 2020 to $3 trillion in 2027. Many researchers have affirmed the importance of BIM for FM roles. For instance, Kassem et al. (2015) argues that BIM in FM improves the handover process from construction phase to operation phase of a facility. According to Stride et al. (2020), the very vital information to support the operation of a facility, such as product data sheets, operational and maintenance schedules, warranties, compliance data and equipment lists, is typically handed over manually in paper format and is often inaccurate and incomplete. The authors argue that “As-built” BIM models, which are models of a constructed facility, usually contain the manufacturer’s information and specifications within the facilities’ digital objects and elements, thus reducing the need to transfer information into a FM system. This way, facilities managers are able to maintain an inventory of equipment and other assets which can be relied upon for creation of scheduled maintenance programmes for maintenance management purposes (Pittard and Sell, 2016).

However, it is apparent that despite these benefits, challenges and barriers hindering the adoption of BIM for FM especially from the perspective of developing economies like Nigeria existed and still persist. The next section reviews some of the inherent barriers.

Empirical review of BIM for FM barriers

An extensive body of literature exist on plethora of barriers hindering the adoption of BIM, most of which also affect its use for facilities management. In one of such, Ku and Taiebat (2011) empirically examined barriers to BIM implementation using 31 construction firms in the United States. The study identified six barriers which include (1) learning curve and lack of skilled personnel, (2) high implementation cost, (3) stakeholders’ (e.g. architect, engineer, and contractor etc.) reluctance to adopt BIM, (4) lack of collaborative processes and modelling standards, (5) interoperability and (6) lack of legal/contractual agreements. In yet another, Mehran (2016) examined BIM adoption barriers in UAE and revealed three critical barriers in BIM implementation to include lack of BIM standards, lack of BIM awareness, and resistance to change.

Azhar et al. (2008) and Eastman et al. (2011) had in separate studies categorised the barriers into technical and non-technical. The technical challenges hindering BIM adoption include; data interoperability across different software, computability of design data and information exchange and maintenance among the BIM components (Rogers et al., 2015; Volk et al., 2014; Zhao et al., 2018; Chiu and Lai, 2020). Some other technical barriers include poor library, low running speed of the system, lack of table customisation, lack of standards to guide for implementation, inaccurate data and information (Azhar et al., 2008; Volk et al., 2014; Chiu and Lai, 2020). The non-technical barriers were classified into four categories namely cost, management, personnel and legal. The cost category contains factors such as high software service charge and training cost (Chan, 2014; Sun et al., 2017). Alemayehu et al. (2021) modelled the relationship between 7 individuals’ personal attributes and perception of 5 barriers components extracted from 20 identified BIM barriers from the literature using principal component analysis. The study found all the personal attributes to have positive effect on the 5 factors driving the perceived barriers to BIM adoption. In Nigeria, Babatunde et al. (2020) conducted empirical survey of architectural, engineering and construction firms in Lagos only and used factor analysis to categorise 20 BIM adoption barriers into (1) weak top management support, (2) cost of BIM software and training, and (3) incompatibility, legal, contractual and culture related issues. It however felt short of linking the perceived barriers with professional characteristics of the respondents. This study extends that body of knowledge.

BIM-enabled FM are known to improve both the operations of a facility and the functions, roles and responsibilities of the facilities managers (Stride et al., 2020). However, many challenges have impeded its full implementation. Dixit et al. (2019) investigated factors impeding the integration of FM into BIM and categorised them into BIM-execution and information-management, technological, cost-based and legal and contractual issues. The results of the survey which involved FM professionals reveal that the single most important issue is the lack of FM involvement in project phases when BIM is evolving.

These studies on BIM for FM barriers have been complemented in the literature by the following; cultural behaviours, combined lack of BIM skills by FM professionals and lack of awareness by clients inhibit the adoption of BIM in FM (Kaseem et al., 2015; Becerik-Gerber et al., 2012); legal hurdles to defining model ownership, necessary involvement of software developers, integration with other FM technologies due to data libraries' lack of standardisation and insufficient collaboration between stakeholders and other disciplines (Kaseem et al., 2015; Becerik-Gerber et al., 2012; Edirisinghe et al., 2017).

While these studies have extensively explored BIM adoption barriers with relatively lesser studies on BIM for FM barriers from different countries' perspectives, an investigation of the relationship between BIM for FM barriers and specific professional attributes of stakeholders has largely been unexplored. This study extends that body of knowledge by exploring the current state of BIM for FM adoption in three strategic cities of Nigeria and develops a regression model that links the barriers to the professional attributes of stakeholders. Nigeria's FM industry has grown over the years on account of the impact of oil revenue on the nation's economy while the use of BIM enabled FM has also steadily improved although with some scepticism.

3. METHODOLOGY

Data for this study were collected through a structured questionnaire and involved a survey of FM professionals drawn from the registrar of International Facilities Management Association (IFMA) chapters in three strategic cities of **Port Harcourt** in the south- south geopolitical zone of Nigeria and home of major oil multinationals in the country, **Lagos** in the south-west and former capital of Nigeria and commercial hub of the country, and **Abuja**, the current capital and construction hub of the country (Ikediashi and Ogwueleka, 2016). The questionnaire was sent through dedicated email invitation and links to 205 identified respondents within the chapters. These included FM consultants, contractors, vendors and suppliers, as well as BIM specialists who may or may not have been involved in BIM related projects; but have requisite knowledge about BIM. They were purposively selected from the chapters with knowledge of the use of BIM for facilities management as the major criterion for selection. The questionnaire was first pilot-tested to verify validity of the constructs and gauge likely feedbacks from respondents. During the pilot study, copies of the first draft were administered to five academic experts while a group discussion section was organised with a team of five industrial practitioners to scrutinise contents of the questionnaire. Based on the outcome, the barriers were reduced from initial 40 variables to 30 factors while some were modified to situate the research problem. Specifically, the ten factors removed as suggested by the experts included those who have close similarity with the factors used for the survey, and those who are very generic BIM barriers. Data screening procedure was also carried out for missing data and Multicollinearity using MCAR and item-to-total correlation respectively. Seven (7) additional variables were removed during data screening which gave rise to 23 final variables used for the study. The study questionnaire was in two parts. Part one solicited background information from respondents while part two solicited responses from participants on barriers hindering BIM for FM adoption in Nigeria. The questions were rated on 1 to 5 point Likert scale (1 = strongly disagree 2= disagree 3= agree 4 = slightly agree 5 = strongly agree). A total of 143 out of 205 copies distributed were received. However, 8 were excluded due to missing data bringing the total of valid responses to 135. This gave an overall response rate of 65.8%.

In order to achieve the stated objectives that reflect the research problem, two constructs were used. The first set included 8 variables of the respondent's demographics which ranged from designation, through years of experience, educational background, area of expertise, to location in Nigeria. The second set included 23 factors/barriers from original 40 factors from extant literature (Azhar et al., 2008; Volk et al., 2014; Rogers et al., 2015; Volk et al., 2014; Zhao et al., 2018; Chiu and Lai, 2020) but validated and prone down through a rigorous pilot study and data screening exercise. Full list of the barriers and measurement scale is shown in Appendix 1.

Data collected were analysed using IBM SPSS Statistics version 22 in three main steps. *First*, demographics of respondents were analysed using basic descriptive statistics such as frequency counts and percentages. *Second*, mean score (MS) of items' ratings for each group of respondents (consultants, contractors, FM vendors, suppliers etc.) was computed and ranked to identify major barriers. The same approach was adopted by Chileshe and Kikwasi (2014), Ikediashi and Ogwueleka (2016) and Alemayehu et al. (2021). *Thirdly*, exploratory factory analysis (EFA) using principal component analysis was performed to reduce the 23 barriers to a smaller structure of latent factors and extract latent structure among the variables before multiple regression analysis was performed to model the extracted factors/barriers (dependent variables) using 8 personal attributes of respondents (independent variables). The personal attributes include gender, experience, BIM for FM project type, and education. Others include organisation, profession and location in Nigeria.

Brief description of multiple regression analysis (MRA)

Multiple linear regression analysis is used to predict values of a dependent variable Y, given a set of explanatory independent variables, X_1, X_2, X_3…..Xn. The relationship between the dependent variable and the independent variables is represented by a mathematical equation called regression equation.

The regression equation is expressed as:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_n X_{ni} + e_i \qquad \text{Equation 1}$$

Where Y = dependent variable (barriers to BIM for FM adoption);

X_1 to X_n = set of independent variables for 1 to N (respondents' characteristics);

$\beta_{1\text{ to }}\beta_n$ = regression coefficients relating the n variables to the variables of interest;

β_0 = the intercept; and

e = residual value which is the difference between actual and predicted values of the dependent variable.

Three most important tables of outcome used to interpret MRA results from SPSS Statistics are Model Summary, ANOVA and Coefficient tables. Besides these, relevant scatterplots and partial regression plots, histogram (with superimposed normal curve), Normal P-P Plot and Normal Q-Q Plot, correlation coefficients and Tolerance/VIF values, casewise diagnostics and deleted residuals are used to check that assumptions for MRA are not violated.

Prior to data analysis, Cronbach's alpha was used to examine internal consistency of the 23 factors. Alpha values greater than 0.7 are regarded as sufficient (Pallant, 2010). The results of the consistency test gave **0.873** for the 23 factors providing evidence that all factors have high internal consistency and therefore are reliable. They were also checked for potential outlier and normality. Normality of all the 23 attributes was checked by significance test for skewness and kurtosis. According to Chan et al. (2001), the observed values of skewness and kurtosis should be tested against null hypothesis of zero because values of skewness and kurtosis are zero when a distribution is normal while any values between -3 to +3 is acceptable threshold (Arnan et al., 2103). The standardised score was within ±2.94 @ $p < 0.01$ indicating that no case of univariate outlier was found while the skewness and kurtosis values were reasonably acceptable.

4. RESULTS AND DISCUSSION

4.1 Respondents' characteristics

The result on the analysis of respondents' attributes is presented in Table 1. The result indicates that majority of respondents who participated in the survey work in client/consultant organisations (50.4%) while 31.1% were from contractor firms. It is worth pointing out that respondents in these two categories majored in Building and Civil Engineering works in addition to facilities management services. However, 6.7% are full time facilities management vendors and BIM specialists each while 5.2% are facilities management suppliers.

Position of table 1

In terms of professional affiliation, 31.1% were Builders, 21.5% were Engineers, followed by Quantity Surveyors at 20%, Architects at 14.8%, and Estate Surveyors and Valuers at 12.6%. The result from table 1 also shows that in terms of areas of expertise, 40% specialise in Building and Civil Engineering works, while 57.8% of the respondents were experts in facilities management related services such as facilities management, property management, real estate and building services. The BIM for facilities management projects for which respondents had been involved ranged from railways and bridges (1.5% each) to commercial buildings at 45.2%. All respondents were said to possess measurable years of experience while more than 90% had Bachelor degree or its equivalent and above. This is in addition to the fact that more than 25% of respondents were female and almost 75 % male. It is however safe to conclude from this finding that the pedigree of respondents are well grounded to provide reliable and credible information about BIM for facilities management.

4.2 BIM for facilities management barriers

In order to assess key barriers hindering full adoption of BIM for FM in Nigeria, a taxonomy of 23 factors derived from the extant literature were subjected to the views of 135 respondents spread across three strategic cities in the country. They were asked to rate the factors using a 5 point Likert scale of 1 = strongly disagree, 2= disagree, 3 = slightly agree, 4 = agree, and 5 = strongly agree. The result of analysis is presented in Table 2.

Position of table 2.

The result shows that the top three rated barriers by *all groups* were "lack of awareness of BIM for FM" (MS=4.0667), "poor supporting infrastructure for internet services" (MS=3.8000), and "lack of education and training" (MS=3.7926) while the three least rated factors were "corruption"

(MS=3.2963), “widespread mistakes and errors” (MS=3.2741) and “cultural issues” (MS=2.9852). However, the top rated factor by *client/consultants* was “poor supporting infrastructure for internet services” (MS=4.0294), followed by “lack of awareness of BIM for FM” (MS=3.8529) and “lack of government lead/direction” (MS=3.8235) in that order. Besides, the top rated barrier by *contractors* was “lack of awareness of BIM for FM” at MS=3.8333, while the top rated by *FM vendors* was “difficulty in integration with FM technologies” at MS=4.3333. In another development, “lack of standards to guide implementation” was the top rated by *FM suppliers* at MS=4.4286, while “frequent changes in operations during facilities operations” was the top rated by *BIM specialists* at MS=4.3333. It is also important to observe that “cultural issues” was the least rated barrier in all the groups.

A benchmark of 3 which is median of five point Likert scale [(1+2+3+4+5)/5] was used as threshold to identify significant barriers. The decision rule as suggested by Ikediashi et al. (2012) and Chileshe and Kikwasi (2014) is that all factors above three point threshold are significant while those below are deemed not significant. On that note, all the factors are recognised as significant barriers militating against BIM for FM adoption according to the respondents.

A null hypothesis was postulated to test if there is any significant difference in the perception of respondents (based on their organisational roles) on barriers to BIM for FM in Nigeria. Kruskal Wallis test was adopted. It is a non-parametric technique used to test difference between several independent groups in distributions which are not normally distributed (Pallant, 2010). Based on chi-square distribution, the decision rule for Kruskal Wallis test statistic is that the null hypothesis is accepted if the significant level presented as asymptotic significance is greater than 0.05 (5% level of significant difference), otherwise the null hypothesis is rejected and alternate hypothesis is accepted. The result of the analysis is shown in Table 3.

Position of table 3

The results indicates that the p value is 0.004 which is less than 0.5. The hypothesis is therefore rejected and the alternate hypothesis accepted which states that there is significant difference in the perception of the respondents.

4.3 Multivariate analysis of BIM for FM barriers in Nigeria

4.3.1 Exploratory factor analysis

The essence of this section is to reduce the 23 identified barriers into smaller number of factors using exploratory factor analysis (EFA), and then model the extracted factors using respondents' characteristics and their perception about BIM for FM barriers. This is with a view towards using the characteristics to predict specific barriers so that strategies can be put in place to mitigate them. The EFA was performed using Varimax orthogonal rotation to accurately interpret the factors (barriers) so as to simplify the loadings of each factor. The same procedure was used by Alemayehu et al. (2021).

Position of table 4

The result of the Bartlett's test and Kaiser-Meyer-Olkin (KMO) is presented in Table 4. It shows that Bartlett's test of sphericity is 837.458 while the associated significance is 0.000 meaning that the population correlation matrix is an identity matrix. Meanwhile, the value of Kaiser-Mayer-Olkin measure of sampling adequacy is 0.662, above the 0.5 threshold (Ferguson and Cox, 1993) thereby indicating that the criterion was met for factor analysis. The result of analysis for total variance explained by the 23 factors is shown in Table 5.

Position of table 5.

It indicates that 8 components accounting for over 64% of total variance explained were extracted while both Kaiser's criterion (Eigen value > 1) and % of total variance explained > 5% (King, 1969) were met meaning that a model with 8 factors is considered adequate to represent the data. Meanwhile, the 8 component are further confirmed by the scree plot in Figure 1 with three most prominent components are conspicuously shown. Results of factor rotation showing factor loadings, and the rotated components are presented in Table 6.

Position of figure 1.

Position of table 6

The *first component* exclusively measures attributes perceived to be related to cost of BIM for FM functions, while the *second component* measures related to stakeholders' contractual obligation to BIM for FM including legal constraints. Perceived difficulty in the operability of BIM for FM and other maintenance issues are measured by the *third component*, while perception of general lack of training is measured by the *fourth component*. The *fifth component* measures perceived of infrastructure for BIM for FM adoption and concern about accessibility of its benefits, while the sixth component measures perceived difficulty in integration of BIM with FM models. The *seventh component* measures perceived lack of standards, risks insurance and complicated nature of BIM for FM, while the *eighth component* measures cultural issues and concerns about mistakes and errors. These eight extracted factors formed the dependent variables for the modelling exercise explained in the next section.

4.3.2 Modelling of BIM for FM barriers as a function of respondents' characteristics

Multiple regression analysis was used to link BIM for FM barriers with respondents' attributes. In it, the 8 extracted factors served as dependent variables while the 8 attributes of respondents (please see table 1) served as the independent variables. However, data transformation procedure was first performed on the underlying factors and factor loadings on each of them before regression analysis. Eight (8) regression models and 38 regression parameters were produced as shown in Table 7.

Position of table 7.

Accordingly, 8 regression equations were produced as:

Barrier1 = 2.760 + 0.250Gender + 0.062Profession – 0.51Organisation + 0.153Experience – 0.060Education – 0.050Expertise + 0.055BIM for FM project type + 0.066Location.

Barrier2 = 3.479 + 0.151Gender + 0.087Profession – 0.105Organisation + 0.100Experience – 0.099Education + 0.001Expertise - 0.109BIM for FM project type + 0.020Location.

Barrier3 = 2.830 + 0.243Gender + 0.091Profession – 0.069Organisation + 0.056Experience + 0.037Education – 0.040Expertise + 0.020BIM for FM project type + 0.068Location.

Barrier4 = 3.358 + 0.229Gender + 0.122Profession – 0.044Organisation + 0.032Experience – 0.123Education – 0.058Expertise + 0.093BIM for FM project type - 0.001Location.

Barrier5 = 3.570 + 0.142Gender + 0.106Profession + 0.055Organisation + 0.027Experience + 0.195Education – 0.048Expertise - 0.015BIM for FM project type - 0.074Location.

Barrier6 = 3.785 + 0.252Gender + 0.022Profession + 0.144Organisation + 0.102Experience + 0.259Education + 0.085Expertise - 0.043BIM for FM project type - 0.152Location.

Barrier7 = 3.152 - 0.210Gender - 0.095Profession – 0.035Organisation - 0.075Experience – 0.045Education – 0.061Expertise + 0.005BIM for FM project type + 0.000Location.

Barrier8 = 3.276 + 0.027Gender - 0.149Profession – 0.134Organisation + 0.077Experience – 0.231Education – 0.080Expertise - 0.035BIM for FM project type + 0.068Location.

Tables of Model summary and ANOVA are found in the Appendix 2. The values of R, which is the multiple correlation coefficient for each of the models indicated a good level of prediction, while values of R^2, also called the coefficient of determination indicated that the independent variables explained a good measure of variability of the dependent variables. Full detail of the models is explained in the next section.

4.4 Discussion of findings

The result that lack of awareness of BIM for FM, poor supporting infrastructure for internet services, and lack of education and training are the top three rated barriers militating against adoption of BIM for FM in Nigeria is consistent with previous findings of Zahrizan et al. (2013), Akerele and Etiene (2016), Olapade and Ekemode (2018) and Babatunde et al. (2020). More precisely, it corroborates the assertion by Olapade and Ekemode (2018) that the perceived unpopularity of BIM in the construction industry and facilities management industry in particular can be traced to the relatively inadequate level of awareness of BIM. This is particularly evident in Nigeria where the concept of BIM though not relatively new, its benefits to facilities management have not been fully accessed by majority of stakeholders. Poor infrastructure backing for internet facilities as the second most rated barriers by respondents has also been cited in the literature (Belay et al., 2021). It is a true reflection of the frustration stakeholders are facing in developing countries about the perennial problem of infrastructure deficit. This had evidently led to high cost of doing business which has invariably discouraged would-be investor-stakeholders willing to invest on BIM for FM. It is worth noting that lack of education and training on BIM for FM rated third by respondents is a confirmation from previous studies (Aibinu and Venkatesh, 2014; Maina, 2018) that deliberate incremental education from beginner level to advance level at the higher institutions levels coupled with vocational training could bolster the interest on BIM for facilities management by stakeholders. Meanwhile, in contrast to Becerik-Gerber et al. (2012), corruption, widespread mistakes and errors and cultural issues were the least rated barriers by respondents. This may be attributed to the observation that majority of Nigerian FM stakeholders do not see the issue of corruption as relevant because government has not fully established its presence and leadership in the concept of BIM. It is however difficult to understand why issue of culture was not among the top rated even when previous research have established the fact that FM industry had entrenched cultural issues and industry resistance due to lack of willingness to learn and invest in new innovations like BIM. Be that as it may, the three factors had a mean score above 3, an indication that they are significant barriers militating against smooth adoption of BIM for FM in Nigeria.

A cursory look at results from the study also highlights different distribution of perception about the barriers among the organisations. For instance, in client/consultant firms, poor supporting infrastructure for internet, lack of awareness for BIM for FM, and lack of government lead/direction were the top three rated barriers, while among respondents for contractor firms, lack of awareness for BIM for FM, lack of skilled personnel, and lack of education and training were the top three rated barriers. The top three rated barriers among FM vendors were difficulty in integration with FM technologies, lack of standards to guide implementation, and frequent changes in operations during facilities operations, while the top three rated barriers by FM suppliers were lack of standards to guide implementation, compatibility of design data and information problem, and lack of education and training. The respondents for BIM specialist organisations rated frequent changes in purpose during facilities operations, difficulty in integration with FM technologies, and poor supporting infrastructure for internet as the three most significant barriers to smooth adoption of BIM for FM. The fairly similar trend in the ranking of the top three rated factors by client/consultant and contractor firms may have stemmed from the fact that majority of them are basically architects, builders and engineers who are mostly engaged in the pre and construction stages of projects and must have held similar perceptions about the major barriers confronting full adoption of BIM for FM. Moreover, the trend is also seen in the rankings of the three top rated barriers by firms with affiliation to facilities management, though with marked divergent perception from consultants and contractors. This may be the reason why the null hypothesis postulated was rejected. Invariably, there is significant difference in the perception of the five group of respondents on barriers affecting the adoption of BIM for FM in Nigeria.

With the help of multiple regression analysis, 8 conceptual models were developed to link perceived BIM for FM barriers to personal attributes of stakeholders in FM sector. The *first model* suggests that gender, professional affiliation, experience, BIM for FM project type and location all have positive effect on cost of BIM for FM hindering its adoption. The implication is that these groups of respondents perceive high cost of tools, software, maintenance and training as major barrier hindering the successful adoption of BIM for FM in Nigeria. For instance, professionals such as Builders, Engineers, and Facilities managers who have superior knowledge about what BIM entails (cost implications) are strongly convinced that issue of cost is a major barrier. The negative impact of education and expertise, tends to suggest that as educational level of professionals associated with facilities management as an area of expertise increases, it offers them the privilege of properly assessing cost implication of BIM for FM functions. Consequently, they perceive cost hindrance to the adoption of BIM for FM as less important. This also followed similar trend in the second and fourth models where the regression coefficient for education was observed to negatively impact on stakeholders' contractual obligation including legal constraints and lack of training in BIM for FM. What this implies is that as stakeholders become more educated and enlightened at various educational levels, issues of BIM for FM contractual obligations as well as training no longer pose as challenges.

The negative impact of organisation on *second barrier component* which measures contractual obligations including legal hurdles, and *third barrier component* which measures general lack of training implies that personnel in these organisations with their levels of experience and who must have had technical training on BIM and facilities management might not perceived contractual obligations and training as key barriers to BIM for FM adoption in Nigeria. The result also indicates from the fifth and sixth models that, while respondents' characteristics such as gender, profession, and experience positively impact *fifth barrier component* measuring infrastructure challenge for BIM for FM, and *sixth barrier component* measuring perceived difficulty in integration of BIM with FM models, BIM for FM project type as well as location negatively impact the fifth and sixth components respectively. It is worth reiterating that in this study, "experience" measured how long respondents have been in facilities management practice which ranged from less than 5 years to over 20 years (please see table 1), while "profession" measured nature of respondents' professional calling such as Building, Engineering, Quantity Surveying, Estate Management, Architecture etc. Therefore, given their relative novelty in FM models (note that facilities management is an inter-disciplinary profession) and level of infrastructure challenge facing developing countries like Nigeria, they are likely to perceive general lack of infrastructure sufficient to back up integration of FM models into BIM as leading barrier to adoption of BIM for FM in the country.

From the seventh and eighth models, it is clear that gender, profession, organisation and experience, all negatively impact perceived lack of standards, risk insurance and complicated nature of BIM for FM (*seventh barrier component*), and cultural issues and concerns about mistakes and errors (*eighth barrier component*). It can be inferred that given the widely held view that BIM and FM are still evolving in Nigeria, the issues of cultural norm and concerns about mistakes and errors will not necessarily be at the forefront of challenges hindering the adoption of BIM for FM in Nigeria. This is clearly inconsistent with findings from research conducted in developed countries of Europe and USA (Becerik-Gerber et al., 2012; Hamada-adama and Kouider, 2019; Stride et al., 2020) where these concepts have developed tremendously. As such, respondents across the four attributes perceive these factors to be less important barriers. What is however not clear is why the barrier component measuring perceived lack of standards and risk insurance cover for FM was negatively impacted by the attributes. The reason may not be unconnected with the earlier proposition that BIM for FM is still evolving in Nigeria.

5. CONCLUSION AND RECOMMENDATIONS

Based on a questionnaire survey of 135 professionals, this study assessed perceived barriers hindering full adoption of BIM for FM in Nigeria and examined how the perceived barriers can be linked to respondents' professional attributes. Data collected were analysed using descriptive statistics while multiple regression analysis was used to model the barriers. Kruskal Wallis test was used to test the only hypothesis postulated for the study.

The study established lack of awareness of BIM for FM, poor supporting infrastructure for internet services, and lack of education and training as the top three rated barriers militating against adoption of BIM for FM in Nigeria. However, corruption, widespread mistakes and errors and cultural issues were established as the three least rated barriers. The practical implication of this finding is that an improved and rejuvenated advocacy on inherent benefits of BIM for facilities management by frontline stakeholders could potentially steer up interests and increased participation of stakeholders who for now are sitting on the fence, and ultimately bolster facility management service delivery. Besides, the outcome has reiterated the need for government to make deliberate efforts aimed at improving the state of infrastructure to support heavy data needed for BIM for FM. The study has also provided insight on the need to provide proper trainings at both educational and vocational levels through review of curriculum to accommodate digital construction and facilities management. It is gladdening to however understand that the Nigerian Institute of Building (NIOB) and other professional bodies in collaboration with Nigeria's National University Commission (NUC) are working very hard to make it a reality. The study also established eight underlying factors that explained twenty-three barrier factors used for the study which were subsequently used to develop eight regression models. In effect, *gender, professional affiliation, organisation, experience, education, expertise, BIM for FM project type, and location* were found to statistically predict the 8 extracted factors driving perceived barriers of BIM for FM adoption in Nigeria. This has profound theoretical and practical implications. Theoretically and in line with previous studies, the study has confirmed the existence of positive relationship between professional attributes of individuals and antecedents of barriers to BIM adoption in the construction industry. In practice, the study has provided a framework of barrier factors to help stakeholder identify specific barriers for which appropriate measures can be taken to ameliorate consequences of the perceived barriers. Meanwhile, the successful adoption of BIM for FM would require the establishment of appropriate strategies to address uncertainties about cost implications for BIM for FM run models as well as infrastructure needs for BIM for FM in Nigeria.

Based on findings of the study, it is recommended that sustained efforts be made to continue to sensitise stakeholders in the Built Environment about inherent benefits of BIM generally and facilities management in particular. This could be through workshops, seminars and webinars and could be championed by professional bodies such as International Facilities Management Association (IFMA) and NIOB. Besides, there is need for professional bodies to collaborate with government agencies regulating education in the country to work on the school curriculum by incorporating digital technology to drive the fourth industrial revolution in the country. Additionally, construction and facilities management companies could encourage their staff to go for BIM training and make such as criteria for promotion. Meanwhile, this study has one obvious limitation. It relied on responses based on perceptions rather than actual practices and hard data. A case study research involving collection of hard archival data could be conducted to triangulate findings from the study.

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APPENDIX 1: Variables used for the study

Table 8: Variables used for the study

Code	Barriers/Inhibiting factors	Measurement scale
RC01	Gender	Nominal
RC02	Professional affiliation	Nominal
RC03	Organisation	Nominal
RC04	Experience	Interval
RC05	Education	Nominal
RC06	Expertise	Nominal
RC07	BIM for FM project type	Nominal
RC08	Location in Nigeria	Nominal
BF01	Data interoperability with FM software	Ordinal
BF02	Compatibility of design data and information	Ordinal
BF03	Maintenance among BIM components such as CAFM	Ordinal
BF04	High maintenance cost	Ordinal
BF08	Lack of standards to guide implementation	Ordinal
BF11	High cost of BIM for FM hardware and tools	Ordinal
BF12	High cost of training	Ordinal
BF13	Lack of customised collaborative system	Ordinal
BF16	Lack of skilled personnel	Ordinal
BF17	Lack of education and training	Ordinal
BF19	Legal and contractual constraints	Ordinal
BF20	Lack of government lead/direction	Ordinal
BF21	Corruption	Ordinal
BF23	Cultural issues	Ordinal
BF25	Widespread of mistakes and errors	Ordinal
BF28	New and complicated nature of BIM for FM	Ordinal
BF29	Frequent changes in purpose during facilities operations	Ordinal
BF32	Lack of awareness of BIM for facilities management	Ordinal
BF34	Difficulty in integration with FM technologies	Ordinal
BF35	Lack of BIM risk insurances for FM	Ordinal
BF37	BIM for FM benefits not accessed among stakeholders	Ordinal
BF38	No physical infrastructure to run BIM for FM models	Ordinal
BF40	Poor supporting data infrastructure for internet	Ordinal

APPENDIX 2: Regression outputs from SPSS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.299[a]	.090	.032	.72232

a. Predictors: (Constant), Location in Nigeria, Experience, profession, BIMforFM projects, Gender, Expertise, Education, Organisation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.469	8	.809	1.550	.047[b]
	Residual	65.740	126	.522		
	Total	72.208	134			

a. Dependent Variable: Bar1

b. Predictors: (Constant), Location in Nigeria, Experience, Profession, BIMforFM projects, Gender, Expertise, Education, Organisation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.307[a]	.094	.036	.73805

a. Predictors: (Constant), Location in Nigeria, Experience, profession, BIMforFM projects, Gender, Expertise, Education, Organisation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.122	8	.890	1.634	.021[b]
	Residual	68.635	126	.545		
	Total	75.756	134			

a. Dependent Variable: Bar2

b. Predictors: (Constant), Location in Nigeria, Experience, Profession, BIMforFM projects, Gender, Expertise, Education, Organisation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.245[a]	.060	.001	.72766

a. Predictors: (Constant), Location in Nigeria, Experience, profession, BIMforFM projects, Gender, Expertise, Education, Organisation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.276	8	.535	1.009	.032[b]
	Residual	66.716	126	.529		
	Total	70.993	134			

a. Dependent Variable: Bar3

b. Predictors: (Constant), Location in Nigeria, Experience, Profession, BIMforFM projects, Gender, Expertise, Education, Organisation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.304[a]	.092	.035	.72147

a. Predictors: (Constant), Location in Nigeria, Experience, profession, BIMforFM projects, Gender, Expertise, Education, Organisation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.683	8	.835	1.605	.030[b]
	Residual	65.585	126	.521		
	Total	72.268	134			

a. Dependent Variable: Bar4

b. Predictors: (Constant), Location in Nigeria, Experience, Profession, BIMforFM projects, Gender, Expertise, Education, Organisation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.279[a]	.078	.019	.75155

a. Predictors: (Constant), Location in Nigeria, Experience, profession, BIMforFM projects, Gender, Expertise, Education, Organisation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.990	8	.749	1.326	.037[b]
	Residual	71.169	126	.565		
	Total	77.159	134			

a. Dependent Variable: Bar5

b. Predictors: (Constant), Location in Nigeria, Experience, Profession, BIMforFM projects, Gender, Expertise, Education, Organisation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.351[a]	.123	.067	.89988

a. Predictors: (Constant), Location in Nigeria, Experience, profession, BIMforFM projects, Gender, Expertise, Education, Organisation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.293	8	1.787	2.206	.031[b]
	Residual	102.033	126	.810		
	Total	116.326	134			

a. Dependent Variable: Bar6

b. Predictors: (Constant), Location in Nigeria, Experience, Profession, BIMforFM projects, Gender, Expertise, Education, Organisation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.274[a]	.075	.016	.60486

a. Predictors: (Constant), Location in Nigeria, Experience, profession, BIMforFM projects, Gender, Expertise, Education, Organisation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.741	8	.468	1.278	.001[b]
	Residual	46.098	126	.366		
	Total	49.839	134			

a. Dependent Variable: Bar7

b. Predictors: (Constant), Location in Nigeria, Experience, Profession, BIMforFM projects, Gender, Expertise, Education, Organisation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.263[a]	.069	.010	.91561

a. Predictors: (Constant), Location in Nigeria, Experience, profession, BIMforFM projects, Gender, Expertise, Education, Organisation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.850	8	.981	1.170	.022[b]
	Residual	105.632	126	.838		
	Total	113.481	134			

a. Dependent Variable: Bar8

b. Predictors: (Constant), Location in Nigeria, Experience, Profession, BIMforFM projects, Gender, Expertise, Education, Organisation

Table 1: Respondents' attributes

Characteristics	Frequency	Percentage (%)
Gender		
Male	101	74.8
Female	34	25.2
Total	**135**	**100**
Educational qualification		
NCE/OND	4	3.0
HND/B.SC/B.ENG	77	57.0
M.SC/M.ENG	41	30.4
PhD	13	9.6
Total	**135**	**100**
Years of experience		
< 5 years	9	6.7
6-10 years	58	43.0
11-15 years	40	29.6
16-20 years	17	12.6
> 20 years	11	8.1
Total	**135**	**100**
Organisational role		
Client/consultant	68	50.4
Contractor	42	31.1
FM vendor	9	6.7
FM supplier	7	5.2
BIM specialist	9	6.7
Total	**135**	**100**
Profession		
Builder	42	31.1
Engineer	29	21.5
Architect	20	14.8
Quantity surveyor	27	20.0
Estate surveyor	17	12.6
Total	**135**	**100**
Area of expertise		
Building & C.Eng. works	54	40.0
Facilities management	34	25.2
Property management	21	15.6
Real estate	17	12.6
M&E works	6	4.4
Electrical Engineering works	3	2.2
Total	**135**	**100**
BIM for FM projects		
Residential buildings	43	31.9
Commercial buildings	61	45.2
Industrial buildings	16	11.9
Institutional buildings	6	4.4
Roads	5	3.7
Bridges	2	1.5
Railways	2	1.5
Total	**135**	**100**
Location in Nigeria		
Lagos	46	34.1
Abuja	34	25.2
Port Harcourt	55	40.7
Total	**135**	**100**

Table 2: Mean score (MS) and rankings of the 23 barriers in groups

Code	BIM for FM Barriers	Client/Consultants (N = 68)		Contractors (N = 42)		FM Vendors (N = 9)		FM Suppliers (N = 7)		BIM Specialists (N = 9)		All groups (overall) (N = 135)	
		MS	Rank	MS	Rank	MS	Rank	MS	Rank	MS	Rank	MS	Rank
BF01	Data interoperability with FM software	3.7353	5	3.1190	20	2.8885	21	3.8966	10	3.4421	17	3.4815	14
BF02	Compatibility of design data and information	3.7353	6	3.2143	18	2.7774	23	4.2857	2	2.8889	21	3.4444	18
BF03	Maintenance among FM components such as CAFM, CMMS etc.	3.4705	20	3.2619	16	4.2122	4	4.1421	5	3.9154	6	3.5259	12
BF04	High maintenance cost	3.5441	13	3.2857	15	3.6661	10	3.8571	11	3.4429	16	3.4815	15
BF08	Lack of standards to guide implementation	3.7353	4	3.4048	12	4.3333	2	4.4286	1	3.4429	15	3.6889	6
BF11	High cost of BIM for FM hardware and tools	3.5294	15	3.6429	5	3.1101	18	3.8571	12	2.7778	22	3.6000	9
BF12	High cost of training	3.4706	19	3.2143	19	3.5556	11	3.5711	17	3.4431	14	3.3333	20
BF13	Lack of customised collaborative systems	3.5735	12	3.4286	11	3.0000	19	4.1426	4	3.4434	13	3.5111	13
BF16	Lack of skilled personnel	3.6765	8	3.6905	2	3.4424	14	3.7143	13	3.8089	8	3.7630	4
BF17	Lack of education and training	3.7059	7	3.6667	3	4.0000	5	4.1429	3	4.0000	5	3.7926	3
BF19	Legal and contractual constraints	3.6765	9	3.3095	14	3.2222	16	3.5714	16	2.8889	20	3.4741	16
BF20	Lack of government lead/direction	3.8235	3	3.2143	17	3.8788	8	3.5714	15	4.0000	4	3.6370	8
BF21	Corruption	3.5147	16	2.7619	22	3.9889	6	3.1429	23	3.6667	11	3.2963	21
BF23	Cultural issues	3.2794	23	2.5952	23	2.7778	22	3.3321	22	2.4444	23	2.9852	23
BF25	Widespread of mistakes and errors	3.3235	22	3.0238	21	3.4444	13	3.9884	9	3.3333	18	3.2741	22
BF28	New and complicated nature of BIM for FM	3.4853	18	3.6667	4	3.8889	7	3.5702	18	3.6667	10	3.5852	11
BF29	Frequent changes in purpose during facilities operations	3.6618	10	3.5952	7	4.2222	3	3.4119	21	4.3333	1	3.7111	5
BF32	Lack of awareness of BIM for FM	3.8529	2	3.8333	1	3.1111	17	3.9965	8	3.8889	7	4.0667	1
BF34	Difficulty in integration with FM technologies	3.5294	14	3.6190	6	4.3333	1	3.4221	20	4.3330	2	3.6593	7
BF35	Lack of efficient BIM risk insurance for FM	3.4559	21	3.4286	10	2.8889	20	3.7142	14	3.4444	12	3.4222	19
BF37	BIM for FM benefits not accessible among stakeholders	3.6029	11	3.5000	8	3.3333	15	3.9996	7	3.7778	9	3.5852	10
BF38	No physical infrastructure to run BIM for FM models	3.5147	17	3.3095	13	3.6667	9	4.0000	6	3.2222	19	3.4667	17
BF40	Poor supporting infrastructure for internet	4.0294	1	3.4524	9	3.5556	12	3.4286	19	4.2222	3	3.8000	2

Note: MS = mean score; N = number of respondents

Table 3: Kruskal Wallis test result for BIM for FM barriers

	BIM for FM barriers
Number of variables	23
Mean rank for client/consultants	77.16
Mean rank for contractors	54.30
Mean rank for FM vendors	48.56
Mean rank for FM suppliers	87.36
Mean rank for BIM specialists	67.11
Chi-square	15.317
Df	4
P-value	0.004
Significant level	0.05
Decision	Reject

Table 4: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.662
Bartlett's Test of Sphericity	Approx. Chi-Square	837.458
	df	253
	Sig.	.000

Table 5: Result output of total variance explained by the 23 factors

	Initial Eigenvalues			**Extraction sums of square loadings**			**Rotation sums of square loadings**		
Component	**Total**	**% of Var.**	**Cum. %**	**Total**	**% of Var.**	**Cum. %**	**Total**	**% of Var.**	**Cum. %**
1	4.564	19.843	19.843	4.564	19.843	19.843	2.406	10.462	10.462
2	2.193	9.533	29.377	2.193	9.533	29.377	2.005	8.717	19.179
3	1.821	7.918	37.295	1.821	7.918	37.295	1.982	8.620	27.799
4	1.506	6.546	43.841	1.506	6.546	43.841	1.929	8.388	36.187
5	1.360	5.912	49.752	1.360	5.912	49.752	1.670	7.262	43.450
6	1.265	5.501	55.253	1.265	5.501	55.253	1.658	7.211	50.660
7	1.116	4.852	60.106	1.116	4.852	60.106	1.604	6.974	57.634
8	1.033	4.490	64.595	1.033	4.490	64.595	1.601	6.961	64.595
9	.971	4.222	68.818						
10	.909	3.953	72.771						
11	.842	3.661	76.431						
12	.729	3.168	79.599						
13	.659	2.863	82.462						
14	.617	2.684	85.146						
15	.563	2.447	87.594						
16	.473	2.058	89.652						
17	.451	1.963	91.615						
18	.430	1.869	93.484						
19	.398	1.732	95.216						
20	.345	1.501	96.716						
21	.323	1.405	98.121						
22	.243	1.056	99.177						
23	.189	.823	100.000						

Extraction Method: Principal Component Analysis

Table 6: Result of rotated component matrix from principal component analysis

Code	Bar1	Bar2	Bar3	Bar4	Bar5	Bar6	Bar7	Bar8
BF11	.792							
BF04	.671							
BF12	.660							
BF32	.602							
BF20		.822						
BF19		.722						
BF21		.601						
BF13		.593						
BF01			.803					
BF02			.640					
BF03			.572					
BF29			.554					
BF16				.745				
BF17				.533				
BF38					.735			
BF37					.561			
BF40					.603			
BF34						.838		
BF08							.627	
BF35							-.567	
BF28							.698	
BF25								.808
BF23								.607

Extraction Method: Principal Component Analysis

Rotation Method: Varimax with Kaiser Normalization

a. Rotation converged in 14 iterations.

Bar stands for Barrier

Table 7: SPSS result output for unstandardized regression coefficients for the eight models

	Bar1	Bar2	Bar3	Bar4	Bar5	Bar6	Bar7	Bar8
Intercept	2.760	3.479	2.830	3.358	3.570	3.785	3.152	3.276
Gender	0.250	0.151	0.243	0.229	0.142	0.252	-0.210	0.027
Professional affiliation	0.062	0.087	0.091	0.122	0.106	0.022	-0.095	-0.149
Organisation	-0.51	-0.105	-0.069	-0.044	0.055	0.144	-0.035	-0.134
Experience	0.153	0.100	0.056	0.032	0.027	0.102	-0.075	0.077
Education	-0.060	-0.099	0.037	-0.123	0.195	0.259	-0.045	-0.231
Expertise	-0.050	0.001	-0.040	-0.058	0.048	0.085	-0.061	-0.080
BIM for FM project type	0.055	-0.109	0.020	0.093	-0.015	-0.043	0.005	-0.035
Location in Nigeria	0.066	0.020	0.068	-0.001	-0.074	-0.152	0.000	-0.068

Bar stands for Barrier

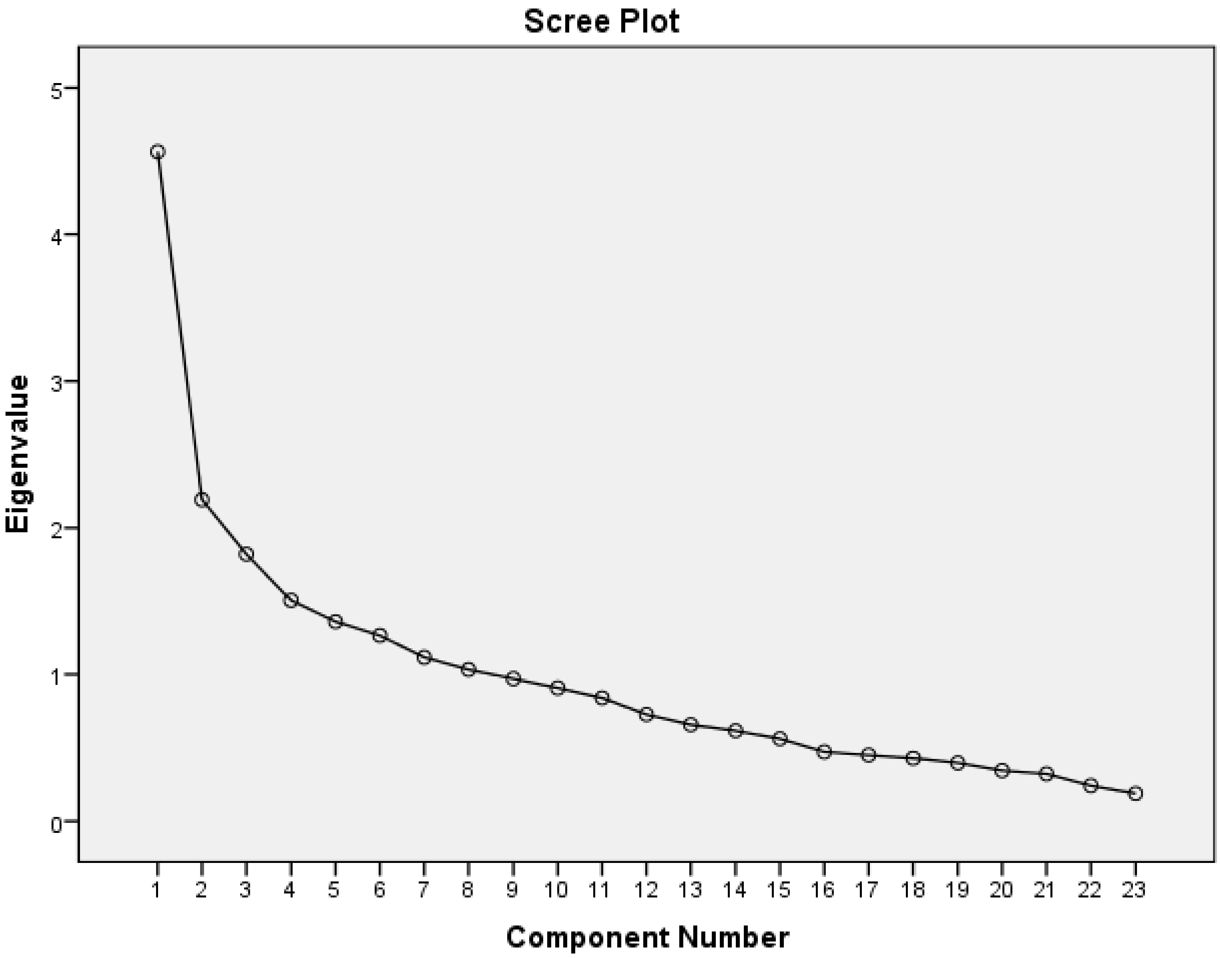

Figure 1: Scree plot diagram showing 8 extracted factors on 23 barriers to BIM for FM adoption