buildings

Article

Barriers to Building Information Modelling Adoption in Small and Medium Enterprises: Nigerian Construction Industry Perspectives

Olusayo Ayobami Bamgbose, Babatunde Fatai Ogunbayo * and Clinton Ohis Aigbavboa

CIDB–Centre of Excellence & Sustainable Human Settlement and Construction Research Centre, Department of Construction Management & Quantity Surveying, Faculty of Engineering and the Built Environment, University of Johannesburg, Johannesburg 2006, South Africa; olusayobamgbose@aol.com (O.A.B.); caigbavboa@uj.ac.za (C.O.A.)

* Correspondence: babatundeo@uj.ac.za

Abstract: The widespread adoption of building information modelling in the construction industry faces significant obstacles, particularly among small and medium-sized construction enterprises. This research accessed barriers to building information modelling adoption among small and medium enterprises in the Nigerian construction industry. The study obtained quantitative data from 182 participants out of the 200 questionnaires that were distributed. A combination of descriptive and exploratory factor analysis was performed using IBM SPSS version 26, and the Kaiser–Meyer–Olkin (KMO) test and Bartlett's sphericity test were conducted to check data adequacy and reliability. The study findings clustered five factors from the 25 identified barriers to BIM adoption in SMEs in the Nigerian construction industry. They are functionality and compatibility, risk and the unavailability of BIM resources, inadequate awareness of BIM, inadequate clients' demands and support, and stakeholders' skills gaps. The study recommends training opportunities for construction professionals, government facilitation through incentives, and safeguarding intellectual property linked to BIM-oriented projects. Collaboration among construction stakeholders would also increase client awareness and knowledge sharing on modern technology, such as BIM adoption in SMEs in the construction industry.

Keywords: building information modelling; construction industry; construction professionals; small and medium-sized enterprises; technology

Citation: Bamgbose, O.A.; Ogunbayo, B.F.; Aigbavboa, C.O. Barriers to Building Information Modelling Adoption in Small and Medium Enterprises: Nigerian Construction Industry Perspectives. *Buildings* **2024**, *14*, 538. https://doi.org/10.3390/buildings14020538

Academic Editor: Rodrigo F. Herrera

Received: 19 November 2023
Revised: 28 January 2024
Accepted: 12 February 2024
Published: 17 February 2024

1. Introduction

The evolution of project conceptualisation, from the initial design phase to the efficient management of construction facilities, has been accelerated by integrating modern technology within the construction industry [1,2]. Modern technology in the construction industry, like BIM, has brought about transformative changes, enhancing various project development and management aspects, including design precision, collaboration efficiency, resource optimisation, and overall project performance [3]. Through the strategic incorporation of modern tools and digital solutions, the construction industry has experienced a paradigm shift, resulting in streamlined processes, improved decision-making, and the realisation of more successful and sustainable construction projects [3]. Despite the advancements in modern technology used in construction operations, many construction professionals continue to rely predominantly on traditional methods, such as paper-based working drawings and the manual extraction of building quantities, to execute various construction projects [4,5]. This often results in gross errors in the form of wrong interpretation during estimating and at the construction stage [5]. Sometimes, the client's intention is wrongly interpreted, leading to dissatisfaction at the end of the project [4].

However, continuous research and development in solving construction challenges from the design stage to the property management level brought the need to adopt construction technology such as BIM into construction operations and processes [6]. Building information modelling technology is strategically developed to tackle significant issues prevalent in the construction industry [7,8]. These include deficiencies in effectively conveying clients' intentions, the potential for contractors to misconstrue intricate working drawings, recurrent rework due to discrepancies, and inaccuracies in project cost estimations, among others in the construction industry [9]. However, the seamless integration of BIM technology into construction operations has many barriers preventing its adoption to construction operations [10]. This is particularly pronounced among the construction SMEs, which significantly populate the construction industry landscape [11]. These barriers are notably magnified owing to the dominance of these SMEs within the construction industry, necessitating careful consideration of strategies to foster the successful adoption and utilisation of BIM technology [11].

However, in addressing numerous barriers associated with BIM adoption within construction SMEs in the construction industry, this study explicitly focuses on examining barriers to BIM adoption among construction SMEs. The motivation for this study was based on a similar study on barriers to BIM adoption in construction SMEs in developing countries [12]. However, the study by [12] only focused on selected expert panellists and used an interpretive structural modelling approach. Hence, this present study addresses this gap by assessing barriers to BIM adoption in construction SMEs among construction professionals using different professional bodies in the construction industry in Lagos toward a better understanding of barriers to BIM adoption in SMEs in the Nigerian construction industry. This study also uses exploratory factor analysis (EFA) to gather information and explore the interrelationships among a set of variables in research [13].

This study will contribute an additional theoretical base to the body of knowledge for future studies on BIM adoption among construction SMEs in the Nigerian construction industry. The practical implications of this study's findings intend to assist construction stakeholders, government policymakers, and professional institutions in understanding strategies to overcome barriers to BIM software (Revit architecture, ArchiCAD, Naviswork manager, Protastructure, QS CAD, Revit MEP and others) functionality and compatibility, risk and the unavailability of BIM resources, inadequate awareness of BIM, inadequate client demands and support, and stakeholders' skills gaps that significantly affect BIM adoption by construction SMEs in the Nigerian construction industry.

2. Literature Review

2.1. Small and Medium Construction Enterprises in the Construction Industry

The role of small and medium-sized enterprises in global development cannot be underscored in terms of economic growth, innovation, job creation, and contribution to environmental stability [1,14,15]. According to Ward [16], SMEs are businesses categorised by their revenues, assets, and number of employees, all falling below a specific threshold set by each country's SME classification. SMEs are adept at innovating and creating new products or services, making them highly adaptable to dynamic market demands [17]. Their pivotal role in shaping a country's economy underscores them as an attractive and extensive innovative system. According to Endris and Kassegn [18], SMEs hold the potential to significantly impact the achievement of numerous sustainable development goals, surpassing the expectations set by their size. Fiseha and Oyelana [19] also note that SMEs play a pivotal role in tackling the challenges of poverty, inequality, and job creation in rural areas, and they serve as significant sources of employment, especially for women, low-skilled workers, and the youth. Similarly, the role of SMEs in the construction industry is of utmost importance, serving as vital materials suppliers to construction works, independent project contractors, and essential sub-contractors supporting larger projects and construction companies [20]. Construction SMEs are the lifeblood of the construction industry, serving as catalysts for generating social value, fostering innovation, and propelling product development [19].

Construction SMEs have become a driving force of sustainability in the construction industry [21]. Sustainable development in construction SMEs involves the conscientious integration of environmentally and socially responsible practices throughout the lifecycle to minimise negative impacts and promote long-term viability [22]. Adopting BIM technology is pivotal in advancing this goal [22]. The adoption of BIM by construction SMEs contributes to sustainable growth by minimising resource wastage, reducing carbon footprints, enhancing project efficiency, and creating aesthetically and functionally superior buildings that are more environmentally and socially responsible [23]. According to Lévy and Ouellette [24], BIM's data-rich environment allows for effective monitoring and analysing the building's energy consumption, water usage, and overall environmental performance. This data-driven approach empowers construction SMEs to identify opportunities for energy savings, operational efficiency, and improved indoor air quality, leading to more environmentally friendly and economically viable structures [23].

2.2. Construction Technology

Jones [25] described construction technology as integrating innovative tools, methods, and processes into construction operations to improve various aspects of project planning, design, execution, and management. Practically, all construction aspects are innovating with cutting-edge technology, a new dimension to projects and construction execution in the construction field [7]. It involves a wide range of digital solutions, software applications, devices, and advanced techniques, which contribute to improving construction projects' efficiency, accuracy, safety, and sustainability [26]. Modern construction technologies can be likened to BIM, drones and unmanned aerial vehicles (UAV), augmented reality (AR), modular construction, 3D printing, construction management software, smart sensors, internet of things (IoT), robotics, green and sustainable technologies, artificial intelligence (AI), blockchain technology, site management, and safety tools, which are used simultaneously at different stages of construction to achieve quality and a functional project output [27–30]. Construction technology such as BIM improves project efficiency, reduces costs, enhances collaboration, reduces environmental impact, and ensures safer working conditions [31]. As technology advances, the construction industry evolves, benefiting from innovative solutions that shape how buildings and infrastructure are planned, constructed, and managed [31,32].

2.3. Building Information Modelling

Building information modelling is a digital process revolutionising how construction projects are planned, designed, built, and managed [33]. It presents a comprehensive landscape for improved construction practices by incorporating a high coordination and management level from the initial construction stage to the end-user level [34]. BIM involves creating a 3D digital model of a building or infrastructure project that encompasses its physical and functional attributes [35]. The robust data in BIM encourages collaboration among various stakeholders, such as architects, engineers, contractors, and facility managers [35]. All relevant parties can access and work on the same model simultaneously, leading to better coordination and communication throughout the project lifecycle [36]. This is a central repository of information, encompassing everything from the building's geometry and structural components to the materials used and operational data [37]. It gives project sponsors a platform to communicate their intentions appropriately and contribute at all construction stages [37]. Furthermore, incorporating BIM into the construction processes could enhance the process of preparing maintenance budgets, leading to more effective maintenance practices within the construction industry [38]. BIM improves project delivery timelines and cost-effectiveness by enhancing collaboration, reducing errors, and streamlining processes [39]. In addition, BIM data can be used during the operational phase of a building to support facility management tasks, such as maintenance scheduling, asset tracking, and energy performance analysis [40]. This data-driven approach ensures that buildings operate efficiently and sustainably. Summarily, BIM has the potential to transform the construction industry by fostering a more integrated and data-driven approach to project management, resulting in improved construction practices, better building production, and enhanced user experiences [41]. Despite the huge benefits BIM is associated with, developing countries are lagging in its adoption, especially construction SMEs in the Nigerian construction industry [42].

2.4. Barriers to Building Information Modelling Adoption in SMEs in the Nigerian Construction Industry

James [5] notes that the lack of progress in overall efficiency and productivity in construction SMEs is primarily due to the continued reliance on manual labour and outdated business models. This, in turn, has resulted in stagnation and hesitance to fully embrace technological advancements like BIM [5]. Fragmentation and outdated business models further exacerbate this problem, as they often prioritise familiarity and comfort rather than embracing innovative solutions such as BIM, thus hindering progress and growth [43]. Aigbavboa [44] noted that some of the stumbling blocks to growth in SMEs can be traced to poor managerial skills, planning, and inadequate skills, among others. The inability of construction SMEs to recognise BIM as a digital innovation that will transform the construction industry often makes them reluctant to use BIM technology for their construction operations and processes [22]. Although BIM offers numerous advantages, such as enhanced collaboration, streamlined project management, and reduced errors, the lack of willingness to fully embrace BIM technology hampers its widespread adoption. As a result, the construction industry loses out on the potential improvements in efficiency and productivity that BIM can provide [45].

While the trend towards adopting BIM is gaining traction and becoming standard practice within the construction industry, there remain uncertainties about the capacity of the current legal framework to support BIM adoption effectively [46]. Conventional construction contracts, designed without consideration for BIM's collaborative nature, are ill-equipped to address their unique approach to executing construction projects successfully [47]. This mismatch can lead to contractual disputes in many construction projects [46]. Team collaboration in BIM raises several concerns, including a deficiency in trust, ambiguities surrounding ownership, intellectual property rights, breakdowns in communication, and disparities in cultural perspectives, among other factors [48]. Furthermore, supplementary barriers to BIM adoption may emerge concerning the generated data, encompassing potential data loss, inconsistencies in data, errors, and accountability for inaccurate or incomplete data [49]. These collective challenges mutually impede the widespread adoption of BIM by construction SMEs operating within the Nigerian construction sector [49].

Saka and Chan [12] attributed the barriers to BIM adoption in developing countries, particularly construction SMEs in Nigeria, to complex sociotechnical systems with the external environment, internal environment, and technology context. According to ref. [50], construction SMEs face major barriers to adopting BIM technology due to its high cost. This cost encompasses the investment in BIM software and hardware, training existing staff or hiring new experts, and meeting certification and licensing requirements [49]. As a result, construction SMEs perceive BIM as an expensive technology to implement in their operations [50]. Likewise, the lack of clear benefits, insufficient incentives for adoption, the absence of risk insurance, and the absence of established BIM standards create difficulties for construction SMEs in adopting BIM within the construction industry [51]. Furthermore, construction SMEs lack sufficient support and encouragement from the government regarding policies and documentation procedures for adopting BIM [52]. Puolitaival and Fotsythe [53] asserted that the government does not prioritise the development of digital construction by providing the necessary infrastructure and conducive environment that could promote BIM adoption among construction SMEs. Criminale and Langer [54] also concluded that the main challenges in BIM implementation are predominantly at the organisational level, indicating higher resistance to change than project-level challenges. The significant barriers include employee training, lack of national BIM standards, data management, and software interoperability [55]. Developed countries are rapidly embracing BIM adoption, but the same cannot be said for developing countries, particularly the Nigerian construction industry, due to the poor state of infrastructure [53].

Adopting BIM in developing countries, particularly Nigeria, faces multiple obstacles, such as limited government and contractors' support, inadequate training, and retraining of professionals on BIM usage [55]. In addition, lack of initiative and education, difficulty in modifying existing work practices, and a lack of understanding regarding the roles and benefits of implementing a BIM approach make BIM difficult to adopt by SMEs in the construction industry [45]. Fadason et al. [52] admitted that lack of BIM education, information on BIM, investment in BIM technology, government support through legislation, and standard guide to implementation are the major barriers to BIM adoption in SMEs in the Nigerian construction industry. Furthermore, the lack of awareness among construction SMEs regarding BIM and its advantages can be attributed to the nonchalant attitude construction SMEs exhibit towards adopting BIM technology to their operations [56]. This slow adoption can be further explained by the poor state of electricity in Nigeria and interoperability risks between BIM-related software, which pose a barrier to BIM uptake in construction SMEs in the Nigerian construction industry [57]. Ref. [58] admitted that the most significant barriers in terms of technological, governmental, resource and cultural categories are lack of client demand, BIM adoption is majorly slow due to the absence of the government's mandate for BIM usage at the project level and the high cost of BIM software and licenses.

Without a strong push from clients for BIM adoption, construction SMEs in the Nigerian construction industry might be reluctant to explore and integrate BIM technology into their workflows [11]. They may see BIM as an additional expense without immediate returns and thus opt for the traditional methods that they are already familiar with [55]. The reluctance to transition from traditional paper-based methods and the lack of effective collaboration among project stakeholders are significant barriers to adopting BIM in SMEs in the Nigerian construction industry [58]. These factors hinder the widespread integration of BIM technology, which could otherwise enhance efficiency and project quality in the construction sector [58]. According to ref. [58,59], variations in partners' work values, inadequate regulatory frameworks, undefined objectives, cultural clashes among partners, economic viability concerns, operational limitations, and conflicts of interest undermine collaboration among construction professionals in the construction industry. However, ref. [60,61] observed that the lack of skilled personnel and the poor state of infrastructure are significant setbacks for BIM adoption in construction SMEs. When clients and industry stakeholders begin to see BIM's value and demand, construction SMEs will likely be more motivated to embrace BIM technology and make it an integral part of their construction processes [56]. Table 1 below summarises the barriers to BIM adoption in SMEs in the Nigerian construction industry.

Table 1. Barriers to BIM adoption in construction SMEs in construction SMEs in the Nigerian construction industry.

S/N	Barriers to BIM Adoption in SMEs in the Nigerian Construction Industry	Source(s)
1	High cost of BIM implementation	[12,47,48]
2	Cost of Training	[12,47,50,54,55]
3	Lack of clear benefits	[22,45,47,48]
4	Insufficient incentives for adoption	[51]
5	Absence of risk insurance	[51]
6	Unavailability of BIM standard	[47,52,54]
7	Insufficient government support	[52,53,55]
8	Resistance to change	[4,5,52,54,56,60]
9	Lack of initiative and education	[43,45,55,56]
10	Lack of BIM role and benefits	[23,45,55]
11	Inadequate BIM awareness	[56]

Table 1. *Cont.*

S/N	Barriers to BIM Adoption in SMEs in the Nigerian Construction Industry	Source(s)
12	Poor state of infrastructure	[53,57,60]
13	Interoperability risks between BIM-related software	[54,57,58]
14	Lack of skilled personnel	[44,59]
15	Lack of Demand from Clients	[11]
16	Unwillingness to change from traditional paper-based practices	[22,48,55,59]
17	Lack of Collaborative Procurement Systems to support BIM	[47,48,59]
18	Contractual uncertainty	[12,46]
19	The complexity of BIM tools	[48]
20	Lack of BIM evaluation	[48]
21	Limited knowledge of usage	[12,55,60,61]
22	Legal disputes and uncertainties in policies	[46,49,56]
23	Patent right protection	[47,48]
24	Software incompatibility	[54,61]
25	BIM data insecurity	[49,54,61]

Source: Researcher's review (2023).

3. Research Methodology

This research adopted a quantitative method to evaluate the barriers to BIM adoption in SMEs in the Nigerian construction industry. The study explores BIM through an extant literature review on modern technology in the construction industry. In addition, opinions of construction professionals such as architects, builders, engineers, quantity surveyors, estate surveyors, and land surveyors, among others, were sampled for data collection. The participants were selected based on their ample experience in construction activities in the Nigerian construction industry and members of various construction professional bodies in Nigeria. Lagos, Nigeria, was selected as the study area based on the number of ongoing BIM-related construction projects. According to ref. [62–64], Lagos, Nigeria, has been a commercial hub for several construction activities in recent times, ranging from the Lagos Island International Airport, Eko Atlantic City, Lekki free trade zone, Lekki Deep Sea Port and Dangote Petroleum refinery, and other real estate buildings. Hence, a quantitative structured survey questionnaire was designed on a Likert scale based on the research objective. This comprises a sample size that fairly represents construction professionals in the Nigerian construction industry to improve the generalisation of study findings in the study area. The structured questionnaire was designed on a Likert scale based on the research objective. Respondents were asked to indicate their level of agreement with the barriers to BIM adoption in construction SMEs in the Nigerian construction industry using: 5 = Strongly agree (SA), 4 = Agree (A), 3 = Neutral (N), 2 = Disagree (D), 1 = Strongly disagree (SD). Using the purposive quota sampling technique, two hundred (200) questionnaires were administered, and one hundred and eighty-two (182) responses were retrieved for the survey, representing 91% of the total questionnaires administered. The 182 responses retrieved out of 200 agree with Kothari's recommendations [65]. Descriptive and principal component analysis (percentage, frequency, and standard deviation) were performed on the retrieved data using IBM SPSS statistics version 26. The study data adequacy for exploratory factor analysis (EFA) was determined through Kaiser–Meyer–Olkin (KMO) and Bartlett's sphericity test. EFA reduces larger datasets into small components by establishing their level of relationship. Also, Cronbach's alpha test helps to determine data reliability and the interrelatedness of the variables in each component [66]. Tavakol and Dennick [66] posited that Cronbach's alpha test explores the scale reliability of data through their internal consistency. The reliability of the data collection instrument returned $0.839 > 0.6$ value of the coefficient of Cronbach's alpha scale recommended by Eiselen, Uys, and Potgiete [67]. This justifies the reliability of the data collection instrument and the responses obtained from the field survey. The results of the analysis were presented in tables.

4. Results and Discussion

4.1. Respondents' Years of Working Experience

Figure 1 shows the respondents' years of working experience. It comprises 2% (4) of respondents with less than one year of working experience, 25% (45) of respondents with 1–5 years of working experience, 20% (36) of respondents with 6–10 years of working experience, 19% (34) with 11–15 years of working experience, 14% (26) with 16–20 years of working experience, 13% (24) with 21–25 years of working experience and 7% (13) above 25 years of working experience from the 182 respondents who participated in the survey.

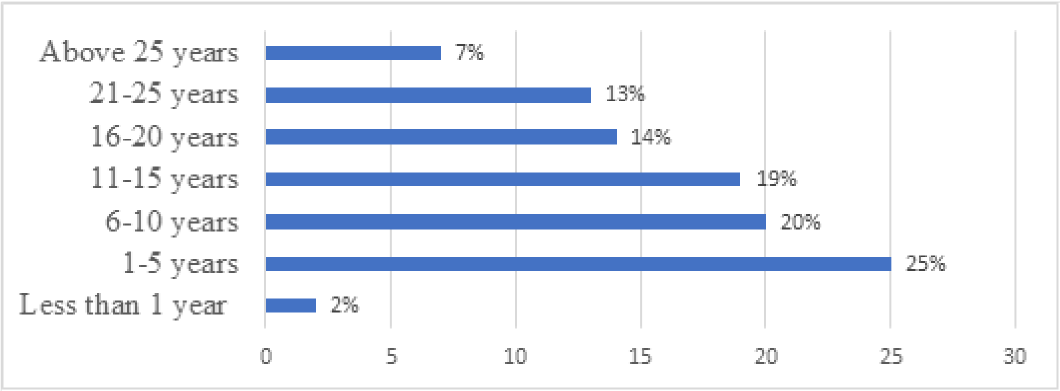

Figure 1. Respondents' years of experience.

4.2. Respondents' Professional Designation

Figure 2 shows the respondents' professional designation. It was revealed that builders were the most common profession with 40% (73), in second place was architects with 22% (40), and the third was quantity surveyors with 10% (18). It also involved 7% (13) project managers, 7% (13) engineers, 5% (9) quality control coordinators, 5% (9) contractors, 3% (5) consultants and 1% (2) others.

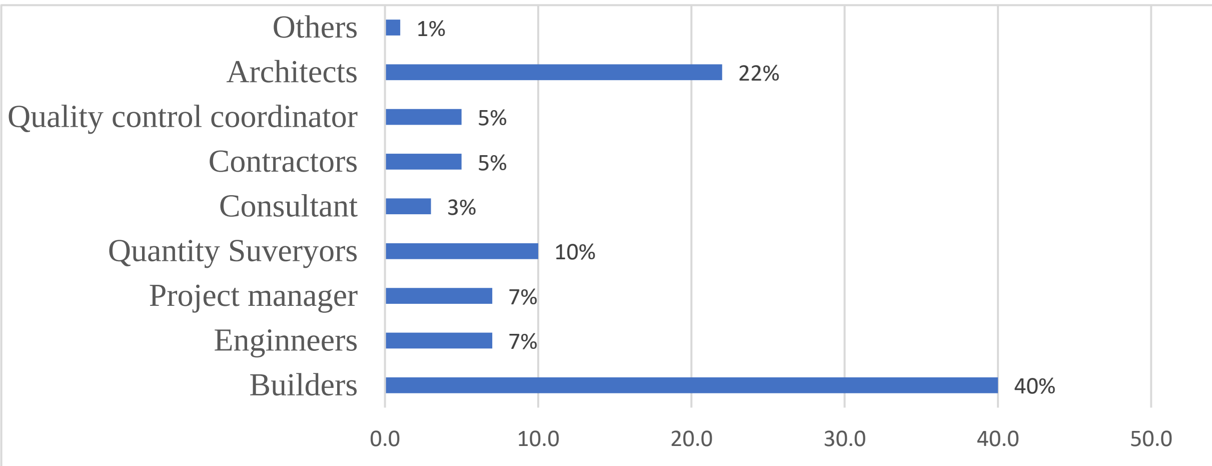

Figure 2. Respondents' professional designation.

4.3. Respondents' Professional Affiliations

Figure 3 shows the respondents' professional affiliations. 48% (87) of the respondents are affiliated with the Nigerian Institute of Building (NIOB), 21% (38) are affiliated with the Nigeria Society of Engineers (NSE), 10% (18) are affiliated with the Nigerian Institute of

Architects (NIA), 8% (14) are affiliated with the Nigerian Institute of Quantity Surveyors (NIQS), 6% (11) are affiliated with the Nigerian Institution of Estate Surveyors and Valuers (NIESV), and the last 9% (16) are other professional affiliations such as Project Management Professional (PMP) and Nigerian Institute of Town Planners (NITP), among others.

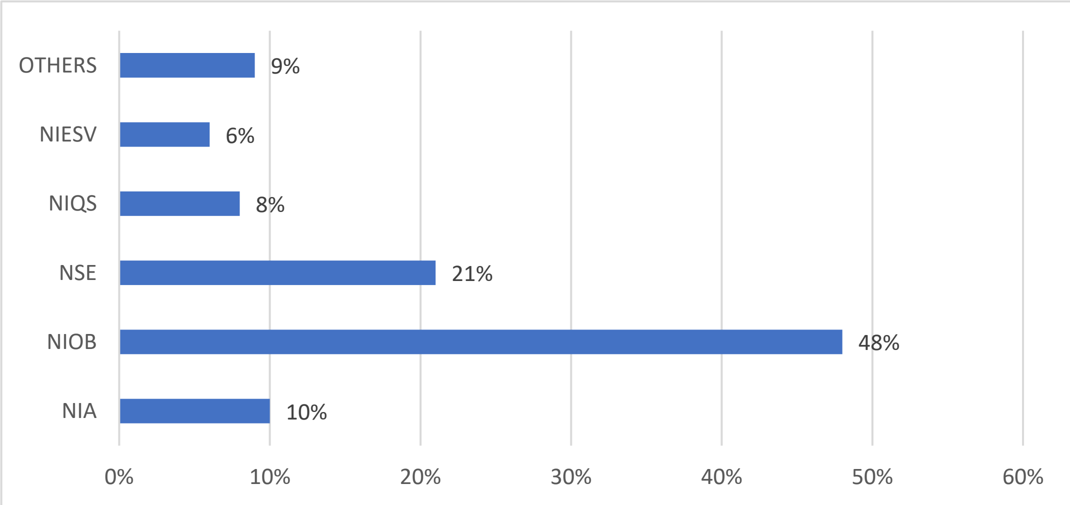

Figure 3. Respondents' professional affiliations.

Table 2 ranked respondents' level of agreement on the 5-point Likert scale: 1 = Strongly disagree (SD); 2 = Disagree (D); 3 = Neutral (N); 4 = Agree (A); 5 = Strongly agree (SA) on the twenty-five identified barriers to BIM adoption among small and medium-sized enterprises in the Nigerian construction industry using the mean item scores (MIS) and standard deviation (σ). As recommended by Opawole and Jagboro [68], an MIS value of 3.50 indicates the importance of the identified barriers to BIM adoption, while an MIS value < 3.50 is an insignificant barrier to BIM adoption. According to the respondents ranking of barriers to BIM adoption in small and medium-sized enterprises, limited knowledge of usage was ranked first (MIS = 3.92; σ = 1.08), high cost of implementation emerged second (MIS = 3.90; σ = 1.046), poor collaboration among professions ranked third (MIS = 3.88; σ = 1.140), high cost of training was ranked fourth (MIS = 3.87; σ = 1.143), lack of professional training (MIS = 3.87; σ = 1.57) and limited resources for BIM adoption (MIS = 3.86; σ = 1.098) emerged fifth. Likewise, poor financial resources ranked seventh (MIS = 3.78; σ = 1.185), poor client demand emerged eighth (MIS = 3.70; σ = 1.122), lack of BIM evaluation ranked ninth (MIS = 3.65; σ = 1.038), resistance to change from professionals ranked tenth (MIS = 3.62; σ = 1.165). Poor awareness emerged as the eleventh-ranked barrier to adopting BIM in small and medium-sized enterprises. The complexity of BIM tools ranked twelfth (MIS = 3.62; σ = 1.165), lack of risk insurance protection ranked thirteenth (MIS = 3.49; σ = 1.131), and no incentives for the adoption also ranked thirteenth (MIS = 3.49; σ = 1.169). Patent right protection (MIS = 3.48 σ = 1.126) and unsustainable for small construction projects (MIS = 3.48; σ = 1.206) were ranked fifteenth. No implementation guide ranked seventeenth (MIS = 3.44; σ = 1.191), contractual uncertainty ranked eighteenth (MIS = 3.73; σ = 1.077), and unclear financial benefit ranked nineteenth (MIS = 3.42; σ = 1.143). Legal disputes and uncertainties in policies (MIS = 3.38; σ = 1.219) and BIM data insecurity (MIS = 3.38; σ = 1.105) ranked twentieth. High risk in implementation ranked twenty-second (MIS = 3.38; σ = 1.105), software incompatibility ranked twenty-third (MIS = 3.36; σ = 1.217), poor compatibility with construction projects ranked twenty-fourth, and no tangible benefits ranked twenty-fifth (MIS = 2.89; σ = 1.131) as barriers often faced with in BIM adoption among small and medium-sized construction enterprises.

Table 2. Barriers to building information modelling adoption in small and medium-sized construction enterprises.

Barriers to BIM Adoption	Mean	Standard Dev.	Rank
Limited knowledge of usage	3.92	1.080	1
High cost of implementation	3.90	1.046	2
Poor collaboration among professionals	3.88	1.140	3
High cost of training	3.87	1.043	4
Lack of professional training	3.86	1.157	5
Limited resources for BIM adoption	3.86	1.098	5
Poor financial resources	3.78	1.085	7
Poor client demand	3.70	1.122	8
Lack of BIM evaluation	3.65	1.038	9
Resistance to change from professionals	3.62	1.115	10
Poor awareness of BIM	3.60	1.165	11
The complexity of BIM tools	3.55	1.120	12
Lack of risk insurance protection	3.49	1.131	13
No incentives for adoption	3.49	1.169	13
Patent right protection	3.48	1.126	15
Unsustainable for small construction project	3.48	1.206	15
No implementation guide	3.44	1.191	17
Contractual uncertainty	3.43	1.153	18
Unclear financial benefit	3.42	1.143	19
Legal disputes and uncertainties in policies	3.38	1.219	20
BIM Data Insecurity	3.38	1.105	20
High risk in implementation	3.37	1.177	22
Software incompatibility	3.36	1.217	23
Poor compatibility with construction projects	3.29	1.219	24
No tangible benefits	2.89	1.313	25

The exploratory analysis of the twenty-five identified barriers to BIM adoption in small and medium-sized enterprises in the Nigerian construction industry was subjected to exploratory factor analysis (EFA) using the IBM SPSS statistics version 26. The exploratory factors analysis used a principal component to check data appropriateness for factor analysis. The value of the KMO test of 0.836 for sample adequacy from the result obtained in Table 3 shows that the value is higher than the recommended value of 0.6 for the exploratory factor analysis [69,70]. The significant value of Bartlett's test of sphericity (represented by "Sig") shows a measure of the multivariate normality of the dataset distributions. The data returned a 0.000 significance value, indicating the acceptance of the data for factor analysis. According to George and Mallery [71], a significant value less than 0.05 represents the research data that could be accepted for factor EFA because the data does not generate an identity matrix. Therefore, a correlation coefficient of >0.3 supported the KMO and Bartlett's test for the factorability of the datasets.

Table 3. KMO and Bartlett's test for the barriers to BIM adoption in construction SME enterprises.

KMO and Bartlett's Test		
Kaiser–Meyer–Olkin Measure of Sampling Adequacy.		0.836
Bartlett's Test of Sphericity	Approx. Chi-Square	2565.207
	Df	300
	Sig.	0.000

Table 4 shows that the extraction values obtained are >0.3, which means that the identified variables for barriers to BIM adoption in small and medium-sized enterprises in the Nigerian construction industry fit well in their factors without any sign of variance. Thus, the factor grouping is reliable because none of the identified variables has a low extraction value.

Table 4. Communalities table.

Challenges Faced in BIM Adoption	Initial	Extraction
Limited resources for BM adoption	1.000	0.476
Poor collaboration among professionals	1.000	0.753
BIM data insecurity	1.000	0.852
Limited knowledge of usage	1.000	0.829
High cost of training	1.000	0.813
High cost of implementation	1.000	0.736
Unclear financial benefit	1.000	0.495
No incentives for adoption	1.000	0.644
Lack of professional training	1.000	0.730
Lack of BIM evaluation	1.000	0.717
Lack of risk insurance protection	1.000	0.820
Poor financial resources	1.000	0.842
Resistance to change from professionals	1.000	0.641
High risk in implementation	1.000	0.580
The complexity of BIM tools	1.000	0.525
Poor compatibility with construction projects	1.000	0.609
Poor client demand	1.000	0.543
No tangible benefits	1.000	0.483
Poor awareness of BIM	1.000	0.474
No implementation guide	1.000	0.630
Software incompatibility	1.000	0.659
Patent right protection	1.000	0.614
Unsustainable for small construction project	1.000	0.605
Contractual uncertainty	1.000	0.601
Legal disputes and uncertainties in policies	1.000	0.624
Extraction method: principal component analysis.		

4.4. Total Variance Explained

Table 5 shows that the latent root or Kaiser's criterion retains factors with >1.0 eigenvalues for the total variance explained by the barriers to BIM adoption in SME enterprises in the Nigerian construction industry (Figure 4). Five factors with eigenvalues > 1.0 were explored as 6.113, 4.576, 2.504, 1.402, and 1.294, which explains 20.077%, 18.302, 10.017, 5.610, and 5.177%. Thus, the five factors explained a cumulative percentage of 65.183 of the variance, highlighting the significance of the variables in the five factors.

4.5. Scree Plot

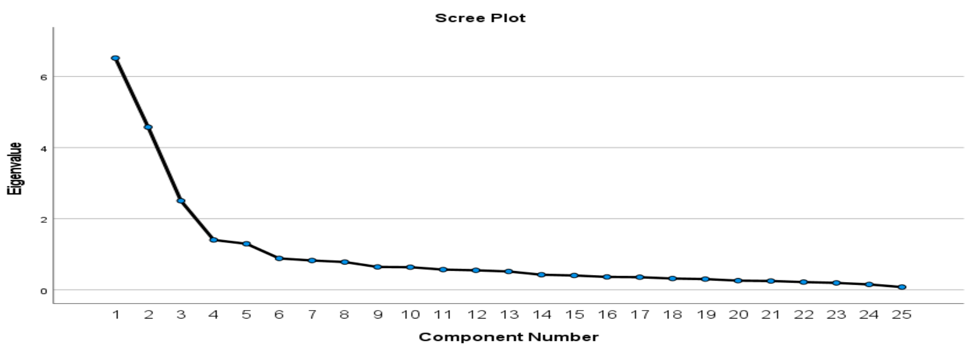

Figure 4. Scree plot of the barriers to BIM adoption in small and medium-sized enterprises.

4.6. Exploratory Factor Report

Table 6 shows the pattern matrix for the twenty-five identified barriers to BIM adoption in SME enterprises in the Nigerian construction industry. The twenty-five variables are clustered into five factors. Thus, the factors are interpreted based on the inherent relationship between the variables under each factor before assigning a familiar name to the factors. Therefore, Factor 1 is named *Functionality and Compatibility*; Factor 2 is named *Risk and Unavailability of BIM Resources*; Factor 3 is named *Inadequate Awareness of BIM*; Factor 4 is named *Inadequate Clients' Demands and Support*; Factor 5 is named *Stakeholders Skills Gaps*. Yong and Pearce [72] posited a 0.40 loading cut-off is considered a significant variable in exploratory factors components based on pragmatic reasons. Thus, the study retained underlying variables with loadings of more than 0.4.

Table 5. Total variance explained.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings [a]
	Total	**% of Vari**	**Cum %**	**Total**	**% of Vari**	**Cum %**	**Total**
1	6.519	26.077	26.077	6.519	26.077	26.077	6.113
2	4.576	18.302	44.379	4.576	18.302	44.379	4.202
3	2.504	10.017	54.396	2.504	10.017	54.396	2.640
4	1.402	5.610	60.006	1.402	5.610	60.006	2.936
5	1.294	5.177	65.183	1.294	5.177	65.183	3.774
6	0.883	3.532	68.714				
7	0.825	3.298	72.012				
8	0.781	3.123	75.136				
9	0.643	2.572	77.708				
10	0.636	2.544	80.252				
11	0.569	2.275	82.527				
12	0.548	2.192	84.719				
13	0.516	2.063	86.781				
14	0.424	1.695	88.476				
15	0.403	1.610	90.086				
16	0.362	1.448	91.534				
17	0.355	1.419	92.953				
18	0.317	1.269	94.221				
19	0.301	1.204	95.426				
20	0.258	1.030	96.456				
21	0.248	0.991	97.446				
22	0.217	0.868	98.315				
23	0.194	0.775	99.090				
24	0.151	0.603	99.693				
25	0.077	0.307	100.000				

Extraction method: principal component analysis. [a] When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 6. Pattern matrix [(a)].

	Component				
	1	**2**	**3**	**4**	**5**
Legal disputes and uncertainties in policies	0.820				
Software incompatibility	0.817				
No implementation guide	0.816				
Contractual uncertainty	0.757				
Patent right protection	0.748				
No tangible benefits	0.730				
Poor compatibility with construction projects	0.716				
Unsustainable for small construction project	0.578				
Poor awareness of BIM	0.525				
Unclear financial benefit	0.432				
Lack of risk insurance protection		0.963			
Poor financial resources		0.944			
Resistance to change from professionals		0.748			
The complexity of BIM tools		0.626			
High risk in implementation		0.618			

Table 6. *Cont.*

	Component				
	1	**2**	**3**	**4**	**5**
Limited resources for BIM adoption		0.570			
Limited knowledge on usage			0.911		
BIM Data Insecurity			0.907		
Poor collaboration among professionals			0.856		
Poor client demand				0.857	
Lack of BIM evaluation				0.801	
No incentives for adoption				0.735	
High cost of training					−0.947
High cost of implementation					−0.819
Lack of professional training					−0.534

Extraction method: principal component analysis. Rotation method: Oblimin with Kaiser normalization. [(a)] Rotation converged in 8 iterations.

4.6.1. Factor 1: Software Functionality and Compatibility

Factor 1 clustered ten variables: legal disputes and uncertainties in policies 82%, software incompatibility 82%, non-implementation guide 82%, contractual uncertainty 76%, right patent protection 75%, no tangible benefits 73%, poor compatibility with construction and projects 72%, unsustainable for small construction project 59%, poor awareness of BIM 53%, and unclear financial benefits 43%. The factor variables clustered a cumulative percentage of 20.077 variances. The ten variables clustered into Factor 1 are significant because they amount to 20.077% of the cumulative variances. The variables loaded in the factor include legal disputes and uncertainties in policies, software incompatibility, non-implementation guide, contractual uncertainty, right patent protection, no tangible benefits, poor compatibility with construction and projects, unsustainable for small construction projects, poor awareness of BIM, and unclear financial benefits. This factor provided the construction stakeholders and the industry with possible barriers to BIM adoption in the study area's small and medium construction enterprises. The study findings aligned with Azhar [57,73], which emphasised BIM copyright laws and other legal provisions to protect intellectual property as barriers preventing its adoption among construction stakeholders. The study findings show various barriers preventing BIM adoption in Nigeria's small and medium construction enterprises. In line with the findings of ref. [11,74], BIM adoption is affected by unclarified data ownership and the incompatibility of BIM software because of the size and capacity of the project that can be handled by small and medium construction enterprises in Nigeria. These barriers in factor 1 can be resolved by identifying the ownership of the intellectual property in all parts of the BIM project and ensuring software companies produce inter-related programmes that will make BIM operatable on different software packages to facilitate easy adoption of BIM by SMEs in the Nigerian construction industry.

4.6.2. Factor 2: Risk and Unavailability of BIM Resources

Factor 2 clustered four variables: lack of risk insurance protection 96%, poor financial resources 94%, resistance to change from professionals 75%, high risk in implementation, and the complexity of BIM adoption 57%. The factor variables clustered a cumulative percentage of 18.302 variances. The four variables clustered into Factor 2 are significant because they amount to 18.302% of the cumulative variances. The variables loaded into this factor include lack of risk insurance protection, poor financial resources, resistance to change from professionals, high risk in implementation, and the complexity of BIM adoption. The factor is named risk and unavailability of BIM resources to the small and medium construction enterprises in Nigeria to incorporate BIM adoption into the construction processes. BIM adoption in Nigeria's small and medium construction enterprises starts from stakeholder' willingness to transition from a conventional approach to a technology-based construction method. In collaboration with Maki and Kerosuo [12,75], the study findings established that BIM adoption requires transitioning from the traditional approach to construction execution to a technology-based workplace environment. Stakeholders' resistance to change, high risk in implementation, and the complexity of BIM processes due to the lack of mobile devices and the understanding of BIM tools restrict the practical use of BIM to a few tasks, places, and operations on construction sites [75]. Since BIM adoption allows collaboration among stakeholders in construction processes, the study finding aligns with Abanda et al. [32], who noted that property identification information, intellectual property rights, and multiple protocols are parts of the barriers affecting BIM adoption in construction practices among small and medium construction enterprises in the Nigerian construction industry. Also, the study findings emphasised that Nigeria's small and medium construction enterprises often lack the basic infrastructure to facilitate BIM adoption, such as electricity and internet connectivity [59]. The challenges identified in Factor 2 can be mitigated by providing insurance for all BIM-based projects. This will provide confidence for construction SMEs to adopt BIM in their operations as the security of their investment is guaranteed.

4.6.3. Factor 3: Inadequate Awareness of BIM

Factor 3 clustered three variables: limited knowledge of usage 91%, BIM data insecurity 91%, and poor collaboration among professionals 86%. The factor variables clustered a cumulative percentage of 10.017 variances. The third factor clustered three significant variables, amounting to 10.017% of the cumulative variances. The variables loaded into this factor include limited knowledge of BIM usage, BIM data insecurity, and poor collaboration among professionals. The variables loaded into this factor show the low awareness of BIM adoption among small and medium construction enterprises in Nigeria. The findings aligned with Arayici [76] that a low level of awareness and acceptance among stakeholders limits collaboration and maintaining an effective team to determine the method of operation and data exchange among the project team. The factor also indicates inadequate awareness of BIM among stakeholders in Nigeria's construction SME enterprises. This collaborates with the findings of Hamma-Adama [11] that construction professionals' unwillingness to form alliances toward BIM implementation hinders its adoption. However, the collaboration of construction professionals in modern construction practice could improve BIM knowledge and usage in all construction operations, thus improving BIM adoption in the construction industry.

4.6.4. Factor 4: Inadequate Client Demands and Support

Factor 4 clustered three variables: poor client demand 86%, lack of BIM evaluation 80%, and no incentive for adoption 74%. The factor variables clustered a cumulative percentage of 5.610 variances. The fourth factor clustered three significant variables, amounting to 5.610% of the cumulative variances. The variables loaded into this factor include poor client demand, lack of BIM evaluation, and no incentive for adoption. Because of cost and time constraints, the factors explained inadequate client demand and support to incorporate BIM tools in construction processes. The finding is consistent with the Hamma-Adama [11] study, which noted that poor client demand and a lack of government policy for BIM affect BIM usage in small and medium construction enterprises in developing countries, especially Nigeria. Improving BIM awareness and evaluating BIM importance at all stages of the construction process could facilitate clients' interest in BIM project implementation, including other stakeholders in the construction industry.

4.6.5. Stakeholders' Skills Gaps

Factor 5 clustered three variables: high cost of training 95%, high cost of implementation 82%, and lack of professional training 53%. The factor variables clustered a cumulative percentage of 20.077 variances. The factor variables clustered a cumulative percentage of 5.177 variances. The fifth factor clustered three variables with a total of 5.177% of the cumulative variances. The variables loaded in the factor include the high cost of training, high cost of implementation, and lack of professional training. The factor explains stakeholders' skills gaps in integrating BIM adoption into construction processes in small and medium construction enterprises in developing countries, especially Nigeria. This finding aligns with the Kassem [77] study, which posited that the high cost of hardware, practical training, and supportive infrastructures like office space and electricity are significant retardants to the usage of BIM in the construction industry, especially among construction in Nigeria. The unwillingness of construction professionals to adapt to a new construction method is due to knowledge gaps and inadequate training [77]. The variables loaded in the fifth factor explain the need for the construction stakeholders to attend continuous development training for the effective take-up of BIM among small and medium construction enterprises in developing countries, especially Nigeria. This study's finding agrees with Usman and Alaezi [78], positing that construction SMEs' barriers to adopting BIM include persistent industry fragmentation, inadequate collaborations with suppliers and contractors, difficulties recruiting a talented workforce, and insufficient knowledge transfer from project to project. Thus, government incentives through training and subsidising BIM implementation costs, especially on government projects, can reduce these adoption barriers.

4.7. Component Correlation Matrix

A positive relationship exists between the variables clustered in the factor correlation matrix in Table 7. The values of the relationship between the component variables are around 0.30.

Table 7. Component correlation matrix.

Factor	1	2	3	4	5
1	1.000	−0.087	−0.021	0.024	−0.456
2	−0.087	1.000	0.176	0.381	0.007
3	−0.021	0.176	1.000	−0.044	−0.050
4	0.024	0.381	−0.044	1.000	−0.087
5	−0.456	0.007	−0.050	−0.087	1.000

Extraction method: principal component analysis. Rotation method: Oblimin with Kaiser normalization.

4.8. Reliability of Cluster Factors

Table 8 shows the reliability test of the variables clustered in each factor; it revealed that the variables measured are valid for each factor. Table 8 shows that the Cronbach's alpha value for each factor for barriers to BIM adoption in small and medium-sized enterprises in the Nigerian construction industry ranges between 0.766 and 0.908.

Table 8. Reliability of cluster factors.

Factor	Cronbach's Alpha Coefficient
1 Functionality and Compatibility	0.908
2 Risk and Unavailability of Resources	0.869
3 Inadequate Awareness of BIM	0.880
4 Inadequate Clients Demands and Support	0.787
5 Stakeholders' Skills Gaps	0.766

5. Conclusions and Recommendation

Despite the advantages BIM offers, many factors affect the adoption process in the construction industry. The objective's findings established the barriers confronting BIM adoption in Nigeria's small and medium construction enterprises. This study's findings revealed that the barriers to BIM adoption in SMEs in the Nigerian construction industry include software functionality and compatibility, risk, unavailability of BIM resources, inadequate awareness of BIM, inadequate client demands and support, and stakeholders' skills gaps. BIM adoption is expected to improve construction projects through collaborative input from stakeholders to enhance project quality, delivery, and performance. However, it is noteworthy that construction firms, stakeholders, and the government contributed to the barriers to adopting BIM in SMEs in the Nigerian construction industry.

This study explores the barriers to BIM adoption in construction SMEs in the Nigerian construction industry. The empirical findings from the survey conform with the theoretical review. The major barrier to BIM adoption in small and medium-sized enterprises is the lack of BIM data ownership. The descriptive analysis ranked the top ten barriers in Nigeria's small and medium-sized construction enterprises as follows: inadequate knowledge of usage, high cost of implementation, poor collaboration among professions, high cost of training, lack of professional training, limited resources for BIM adoption, poor financial resources, poor client demand, lack of BIM evaluation, and resistance to change from professionals. Thus, understanding the barriers to BIM adoption in small and medium-sized construction enterprises in developing countries, especially Nigeria, will further increase the knowledge of BIM adoption in the construction industry.

Likewise, as indicated in the five factors obtained from the exploratory factor analysis, BIM functionality and compatibility, risk and unavailability of BIM resources, inadequate awareness of BIM, inadequate clients' demands and support, and stakeholders' skills gaps significantly affect BIM adoption among construction SMEs in the Nigerian construction industry. Consequently, the conclusions drawn from this study's findings provide:

i. An understanding of the need for copyright laws and other legal provisions to protect users' intellectual property, enabling full BIM adoption among construction stakeholders.
ii. Provision of government incentives through training and subsidising BIM implementation costs, especially on government projects, to reduce BIM adoption barriers.
iii. Mitigating BIM adoption via insurance for all BIM-based projects will provide confidence for construction SMEs in adopting BIM in their operations as the security of their investment is guaranteed.

The study recommends that identifying intellectual property ownership and breaking software interoperability barriers can improve BIM adoption among construction SMEs in the Nigerian construction industry. Collaboration among construction professionals can also improve knowledge sharing in modern digital construction and the provision of incentives by the government through training and subsiding BIM implementation costs on public projects. The present study was conducted in Lagos state, a southwestern state of Nigeria, which suggests that the study's limitation and scope should be expanded. However, the findings are similar to those of the construction industry in other geographical contexts. Thus, further research could be designed, a sample frame could be drawn across Nigeria's six geopolitical zones, or research could be conducted in other developing countries to further explore the barriers to BIM adoption in construction SMEs to improve BIM adoption in the Nigerian construction industry.

Author Contributions: Conceptualization, O.A.B. and B.F.O.; methodology, O.A.B., B.F.O. and C.O.A.; software, O.A.B. and B.F.O.; validation, O.A.B., B.F.O. and C.O.A.; formal analysis, B.F.O.; investigation, O.A.B. and B.F.O.; resources, O.A.B. and B.F.O.; data curation, O.A.B. and B.F.O.; writing—original draft preparation, O.A.B.; writing—review and editing, B.F.O. and C.O.A.; visualization, O.A.B. and B.F.O.; supervision, B.F.O. and C.O.A.; project administration, O.A.B., B.F.O. and C.O.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data are contained within the article.

Acknowledgments: The authors want to acknowledge the Sustainable Human Settlement and Construction Research Centre, Faculty of Engineering and the Built Environment, University of Johannesburg (cidb Centre of Excellence).

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Ogunbayo, B.F.; Aigbavboa, C.; Thwala, W. *A Maintenance Management Framework for Municipal Buildings in Developing Economies*, 1st ed.; Routledge: London, UK, 2023; p. 372. [CrossRef]
2. Gambatese, J.A.; Hallowell, M. Factors that influence the development and diffusion of technical innovations in the construction industry. *Constr. Manag. Econ.* **2011**, *29*, 507–517. [CrossRef]
3. Wong, K.; Fan, Q. Building information modelling (BIM) for sustainable building design. *Facilities* **2013**, *31*, 138–157. [CrossRef]
4. Gerrish, T.; Ruikar, K.; Cook, M.; Johnson, M.; Phillip, M.; Lowry, C. BIM application to building energy performance visualisation and management: Challenges and potential. *Energy Build.* **2017**, *144*, 218–228. [CrossRef]
5. James, H. Why Construction Sector Still Lags Behind in Digital Transformation. People Daily. Available online: https://www.pd.co.ke/business/why-construction-sector-still-lags-behind-in-digital-transformation-93901/ (accessed on 10 July 2023).
6. Baduge, S.K.; Thilakarathna, S.; Perera, J.S.; Arashpour, M.; Sharafi, P.; Teodosio, B.; Mendis, P. Artificial intelligence and smart vision for building and construction 4.0: Machine and deep learning methods and applications. *Auto. Constr.* **2022**, *141*, 104440. [CrossRef]
7. Amusan, L.; Adewumi, D.; Ajao, A.M.; Ogundipe, K.E. Adoption, Implementation Information and Communication Technology Platform Application in the Built Environment Professional Practice. In *Advances in Artificial Intelligence, Software and Systems Engineering: Proceedings of the AHFE 2021 Virtual Conferences on Human Factors in Software and Systems, July 25–29, 2021, USA*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 446–455.
8. Walasek, D.; Barszcz, A. Analysis of the adoption rate of building information modeling [BIM] and its return on investment. *Procedia Eng.* **2017**, *172*, 1227–1234. [CrossRef]
9. Abbasnejad, B.; Nepal, M.; Drogemuller, R. Key enablers for effective management of BIM implementation in construction firms. In *Proceedings of the CIB World Building Congress 2016: Volume I—Creating Built Environments of New Opportunities*; Tampere University of Technology: Tampere, Finland, 2016; Volume 1, pp. 622–633.
10. Parsamehr, M.; Perera, U.S.; Dodanwala, T.C.; Perera, P.; Ruparathna, R. A review of construction management challenges and BIM-based solutions: Perspectives from the schedule, cost, quality, and safety management. *Asian J. Civ. Eng.* **2023**, *24*, 353–389. [CrossRef]
11. Hamma-Adama, M.; Kouider, T. What are the barriers and drivers toward BIM adoption in Nigeria. In Proceedings of the Creative Construction Conference 2019, Budapest, Hungary, 29 June–2 July 2019; pp. 529–538. [CrossRef]
12. Saka, A.B.; Chan, D.W. Profound barriers to building information modelling (BIM) adoption in construction small and medium-sized enterprises (SMEs) An interpretive structural modelling approach. *Constr. Innov.* **2020**, *20*, 261–284. [CrossRef]
13. Pallant, J. *SPSS Survival Manual: A Step-by-Step Guide to Data Analysis Using SPSS*, 3rd ed.; Open University Press, McGraw-Hill Education: Maidenhead, UK, 2011.
14. Afolabi, A.O.; Odunola, M.; Ogundipe, K.E.; Ajao, A.M.; Ogunbayo, B.F. Sustainable locally sourced materials for small-scale paint production. *J. Phys. Conf. Ser.* **2019**, *1299*, 012124. [CrossRef]
15. Malik, K.; Jasińska-Biliczak, A. Innovations and other processes as identifiers of contemporary trends in the sustainable development of SMEs: The case of emerging regional economies. *Sustainability* **2018**, *10*, 1361. [CrossRef]
16. Ward, S. What Are SMEs? The Balance. Available online: https://www.thebalancemoney.com/sme-small-to-medium-enterprise-definition-2947962 (accessed on 12 July 2023).
17. Hsieh, Y.H.; Chou, Y.H. Modelling the impact of service innovation for small and medium enterprises: A system dynamics approach. *Simul. Model. Pract. Theory* **2018**, *82*, 84–102. [CrossRef]
18. Endris, E.; Kassegn, A. The role of micro, small and medium enterprises (MSMEs) to the sustainable development of sub-Saharan Africa and its challenges: A systematic review of evidence from Ethiopia. *J. Innov. Entrep.* **2022**, *11*, 20. [CrossRef]
19. Fiseha, G.G.; Oyelana, A.A. An assessment of the roles of small and medium enterprises (SMEs) in the local economic development (LED) in South Africa. *J. Econ.* **2015**, *6*, 280–290. [CrossRef]
20. Madiba. Growing SMEs through Key Construction Partnerships. Engineering News. Available online: https://www.engineeringnews.co.za/article/growing-smes-through-key-construction-partnerships-2023-03-14#:~:text=Small%20and%20medium%20enterprises%E2%80%99%20(SMEs,larger%20projects%20and%20construction%20companies (accessed on 13 July 2023).
21. Rezgui, Y.; Miles, J. Exploring the potential of SME alliances in the construction sector. *J. Constr. Eng. Manag.* **2010**, *136*, 558–567. [CrossRef]
22. Saka, A.B.; Chan, D.W.; Siu, F.M. Drivers of sustainable adoption of building information modelling (BIM) in the Nigerian construction small and medium-sized enterprises (SMEs). *Sustainability* **2020**, *12*, 3710. [CrossRef]
23. Ogunmakinde, O.E.; Egbelakin, T.; Sher, W. Contributions of the circular economy to the UN sustainable development goals through sustainable construction. *Resour. Conserv. Recycl.* **2022**, *178*, 106023. [CrossRef]
24. Lévy, F.; Ouellette, J.W. *BIM for Design Firms: Data Rich Architecture at Small and Medium Scales*; John Wiley & Sons: Hoboken, NJ, USA, 2019; pp. 175–196.
25. Jones, K. Construction Technology Is Reshaping the Industry. Constructconnect. 2020. Available online: https://www.constructconnect.com/blog/technology-reshaping-construction-industry (accessed on 20 July 2023).
26. Sepasgozar, S.M.; Davis, S. Digital construction technology and job-site equipment demonstration: Modelling relationship strategies for technology adoption. *Buildings* **2019**, *9*, 158. [CrossRef]

27. Mourão, J.M.P. Blockchain Technology-Potential Application in The Portuguese Construction Industry. Ph.D. Thesis, Faculty of Engineering—University of Porto, Porto, Portugal, June 2022.
28. Gundaraniya, N. Construction Technology. Types of Construction Technology You Will Use in the Future. CivilJungle. Available online: https://civiljungle.com/construction-technology/ (accessed on 20 July 2023).
29. Vincent, R.A.; Ecker, M. *Light Detection and Ranging (LiDAR) Technology Evaluation (No. OR11-007)*; Missouri Department of Transportation: Jefferson City, MI, USA, 2010.
30. Pan, Y.; Zhang, L. Roles of artificial intelligence in construction engineering and management: A critical review and future trends. *Autom. Constr.* **2021**, *122*, 103517. [CrossRef]
31. Akinradewo, O.; Aigbavboa, C.; Aghimien, D.; Oke, A.; Ogunbayo, B. Modular method of construction in developing countries: The underlying challenges. *Int. J. Constr. Manag.* **2023**, *23*, 1344–1354. [CrossRef]
32. Ogundipe, K.E.; Olaniran, H.F.; Ajao, A.M.; Ogunbayo, B.F. Assessing the Impact of Quality Supervision on Construction Operatives Project Delivery in Nigeria. *Int. J. Civ. Eng. Technol.* **2018**, *9*, 426–439.
33. Abanda, F.H.; Vidalakis, C.; Oti, A.H.; Tah, J.H. A critical analysis of Building Information Modelling systems used in construction projects. *Adv. Eng. Soft.* **2015**, *90*, 183–201. [CrossRef]
34. Wu, W.; Issa, R.R. BIM execution planning in green building projects: LEED as a use case. *J. Manag.* **2015**, *31*, A4014007. [CrossRef]
35. Zhang, S.; Hou, D.; Wang, C.; Pan, F.; Yan, L. Integrating and managing BIM in 3D web-based GIS for hydraulic and hydropower engineering projects. *Auto. Constr.* **2020**, *112*, 103114. [CrossRef]
36. Del-Giudice, M.; Osello, A. BIM for cultural heritage. *Inter. Arch. Photo. Rem. Sens. Spat. Info. Sci.* **2013**, *40*, 225–229. [CrossRef]
37. Svalestuen, F.; Knotten, V.; Lædre, O.; Drevland, F.; Lohne, J. Using building information model (BIM) devices to improve information flow and collaboration on construction sites. *J. Inf. Technol. Constr.* **2017**, *22*, 204–219.
38. Ogunbayo, B.F.; Aigbavboa, C.; Thwala, W.D.; Akinradewo, O.I. Assessing maintenance budget elements for building maintenance management in Nigerian built environment: A Delphi study. *Built Env. Proj. Asset Manag.* **2022**, *12*, 649–666. [CrossRef]
39. Wu, W.; Issa, R.R. BIM-enabled building commissioning and handover. In *Computing in Civil Engineering*; ASCE: Reston, VA, USA, 2012; pp. 237–244. [CrossRef]
40. Ogunbayo, B.F.; Aigbavboa, C.O.; Thwala, W.; Akinradewo, O.; Ikuabe, M.; Adekunle, S.A. Review of culture in maintenance management of public buildings in developing countries. *Buildings* **2022**, *12*, 677. [CrossRef]
41. Mêda, P.; Calvetti, D.; Hjelseth, E.; Sousa, H. Incremental digital twin conceptualisations targeting data-driven circular construction. *Buildings* **2021**, *11*, 554. [CrossRef]
42. Almuntaser, T.; Sanni-Anibire, M.O.; Hassanain, M.A. Adoption and implementation of BIM—Case study of a Saudi Arabian AEC firm. *Int. J. Manag. Proj. Bus.* **2018**, *11*, 608–624. [CrossRef]
43. Nagy, O.; Papp, I.; Szabó, R.Z. Construction 4.0 organisational level challenges and solutions. *Sustainability* **2021**, *13*, 12321. [CrossRef]
44. Aigbavboa, C.O. Challenges Facing Black Owned Small and Medium Construction Companies: A Case Study of Nelspruit-Mbombela Municipality, South Africa. *J. Econ. Behav. Stud.* **2014**, *6*, 771–778. [CrossRef]
45. Saka, A.B.; Chan, D.W. Adoption and implementation of building information modelling (BIM) in small and medium-sized enterprises (SMEs): A review and conceptualisation. *Eng. Constr. Arch. Manag.* **2021**, *28*, 1829–1862. [CrossRef]
46. Ragab, M.A.; Marzouk, M. BIM adoption in construction contracts: Content analysis approach. *J. Constr. Eng. Manag.* **2021**, *147*, 04021094. [CrossRef]
47. Ford, A.; Gillich, A. *Sustainability through Collaboration and Skills Development. Sustainable Futures in the Built Environment to 2050: A Foresight Approach to Construction and Development*; Wiley: Hoboken, NJ, USA, 2018; pp. 249–269. [CrossRef]
48. Alreshidi, E.; Mourshed, M.; Rezgui, Y. Factors for effective BIM governance. *J. Build. Eng.* **2017**, *10*, 89–101. [CrossRef]
49. Mutis, I.; Mehraj, I. Cloud BIM governance framework for implementation in construction firms. *Pract. Period. Struct. Des. Constr.* **2022**, *27*, 04021074. [CrossRef]
50. Ismail, N.A.A.; Zulkifli, M.Z.A.; Baharuddin, H.E.A.; Ismail, W.N.W.; Mustapha, A.A. Challenges of Adopting Building Information Modelling (BIM) Technology amongst SME's Contractors in Malaysia. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *1067*, 012047. [CrossRef]
51. Saka, A.; Chan, D.; Siu, F. Adoption of building information modelling in small and medium-sized enterprises in developing countries: A system dynamics approach. In Proceedings of the 21st CIB World Building Congress, Honk Kong, China, 17–21 June 2019.
52. Fadason, R.T.; Danladi, C.Z.; Akut, K.L. Challenges of Building Information Modelling Implementation in Africa A Case of Nigerian Construction Industry. In Proceedings of the FIG Congress, Istanbul, Turkey, 6–11 May 2018; Volume 2, pp. 1–6.
53. Puolitaival, T.; Forsythe, P. Practical challenges of BIM education. *Struct. Surv.* **2016**, *34*, 351–366. [CrossRef]
54. Criminale, A.; Langar, S. Challenges with BIM implementation: A review of literature. In Proceedings of the 53rd ASC Annual International Conference, Seattle, WA, USA, 5–8 April 2017; pp. 329–335.
55. Aka, A.; Iji, J.; Isa, R.B.; Bamgbade, A.A. Assessing the relationships between underlying strategies for effective building information modeling (BIM) implementation in Nigeria construction industry. *Arch. Eng. Des. Manag.* **2021**, *17*, 434–446. [CrossRef]
56. Babatunde, S.O.; Perera, S.; Ekundayo, D.; Adeleke, D.S. An investigation into BIM uptake among contracting firms: An empirical study in Nigeria. *J. Financ. Manag. Prop. Constr.* **2021**, *26*, 23–48. [CrossRef]

57. Oyewole, E.O.; Dada, J.O. Training gaps in the adoption of building information modelling by Nigerian construction professionals. *Built Env. Proj. Asset Manag.* **2019**, *9*, 399–411. [CrossRef]
58. Hall, A.T.; Durdyev, S.; Koc, K.; Ekmekcioglu, O.; Tupenaite, L. Multi-criteria analysis of barriers to building information modeling (BIM) adoption for SMEs in New Zealand construction industry. *Eng. Constr. Archit. Manag.* **2022**, *30*, 3798–3816. [CrossRef]
59. Olanrewaju, O.I.; Chileshe, N.; Babarinde, S.A.; Sandanayake, M. Investigating the barriers to building information modelling (BIM) implementation within the Nigerian construction industry. *Eng. Constr. Archit. Manag.* **2020**, *27*, 2931–2958. [CrossRef]
60. Seiso, M.P.; Ogunbayo, B.F.; Aigbavboa, C.O. Joint Ventures in the South African Construction Industry: Factors Militating against Success. *Buildings* **2023**, *13*, 1299. [CrossRef]
61. Onungwa, I.O.; Uduma-Olugu, N. Building information modelling and collaboration in the Nigerian construction industry. *J. Constr. Bus. Manag.* **2017**, *1*, 1–10. [CrossRef]
62. Osotimehin, K.O.; Jegede, C.A.; Akinlabi, B.H.; Olajide, O.T. An evaluation of the challenges and prospects of micro and small-scale enterprises development in Nigeria. *Am. Int. J. Contemp. Res.* **2012**, *2*, 174–185.
63. Ogunde, A.O.; Dafe, O.E.; Akinola, G.A.; Ogundipe, K.E.; Oloke, O.C.; Ademola, S.A.; Olaniran, H.F. Factors Militating Against Prompt Delivery of Construction Projects in Lagos MegaCity, Nigeria Contractors' Perspective. *Med. J. Soc. Sci.* **2017**, *8*, 1–10. [CrossRef]
64. Ogundipe, K.E.; Ogunde, A.O.; Olaniran, H.F.; Ajao, A.M.; Ogunbayo, B.F.; Ogundipe, J.A. Missing gaps in safety education and practices: Academia perspectives. *Int. J. Civ. Eng. Tech.* **2018**, *9*, 273–289.
65. Kothari, C.R. *Research Methodology: Method and Techniques*, 2nd ed.; New Age International Publishers: New Delhi, India, 2004.
66. Tavakol, M.; Dennick, R. Making sense of Cronbach's alpha. *Int. J. Med. Educ.* **2011**, *2*, 53–55. [CrossRef]
67. Eiselen, R.; Uys, T.; Potgieter, T. *Analysing Survey Data Using SPSS13*; University of Johannesburg: Johannesburg, South Africa, 2007.
68. Opawole, A.; Jagboro, G.O. Benchmarking parties' obligations in the execution of concession-based PPP projects in Nigeria. *J. Place Manag. Dev.* **2016**, *9*, 27–46. [CrossRef]
69. Hair, J.F.; Black, W.C.; Babin, B.J.; Anderson, R.E.; Tatham, R.L. *Multivariate Data Analysis*; Pearson University Press: Upper Saddle, NJ, USA, 2006.
70. Tabachnick, B.G.; Fidell, L.S. *Using Multivariate Statistics*, 5th ed.; Pearson Education Inc.: Kuala Lumpur, Malaysia, 2007.
71. George, D.; Mallery, M. *Using SPSS for Windows Step by Step: A Simple Guide and Reference*; Allyn & Bacon: Kuala Lumpur, Malaysia, 2003.
72. Yong, A.G.; Pearce, S. A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutor. Quant. Methods Psychol.* **2013**, *9*, 79–94. [CrossRef]
73. Azhar, S. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Lead. Manag. Eng.* **2011**, *11*, 241–252. [CrossRef]
74. Sahil, A.Q. Adoption of Building Information Modeling in Developing Countries: A Phenomenological Perspective. Ph.D. Thesis, Colorado State University, Colorado Springs, CO, USA, 2016.
75. Mäki, T.; Kerosuo, H. Site managers' daily work and the uses of building information modelling in construction site management. *Constr. Manag. Econ.* **2015**, *33*, 163–175. [CrossRef]
76. Arayici, Y. *Building Information Modeling*, 1st ed.; eBooks and Textbooks, Bookboon Publisher: Copenhagen, Denmark; London, UK, 2015. Available online: http://thuvienso.bvu.edu.vn/handle/TVDHBRVT/15384 (accessed on 12 July 2023).
77. Kassem, M.; Brogden, T.; Dawood, N. BIM and 4D planning: A holistic study of the barriers and drivers to widespread adoption. *J. Constr. Eng. Proj. Manag.* **2012**, *2*, 1–10. [CrossRef]
78. Usman, N.D.; Alaezi, J. The role of construction small and medium enterprises (SMEs) in economic development. In Proceedings of the 46th National Conference/Annual General Meeting of the Nigerian Institute of Building, Benin, Nigeria, 8–12 August 2016.