



SWOT analysis of factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria

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Abstract

The study examined SWOT analysis of factors influencing Building Information Modelling (BIM) and immersive technology adoption among indigenous and foreign Architecture, Engineering and Construction (AEC) contractors in South-South Nigeria. A comparative descriptive survey design was adopted, and four research questions guided the study. The population comprised 352 construction stakeholders, while 230 respondents were selected through purposive sampling based on their involvement in construction project delivery and digital technology practices. Data were collected using a 30-item structured questionnaire validated by experts. Cronbach alpha coefficients were 0.76 for internal factors and 0.88 for external factors. Data were analysed using Mean Item Score, ranking analysis, gap analysis and independent samples t-test at the 0.05 level of significance. Findings showed that foreign contractors recorded more favourable internal and external conditions influencing BIM and immersive technology adoption than indigenous contractors. Major differences concerned financial capacity, management support, skilled personnel, ICT infrastructure, training, BIM software and hardware, workflow integration, government support, regulatory standards and BIM policy availability. Indigenous contractors recorded greater concerns regarding resistance to change, dependence on manual methods, technology costs and regulatory resistance. SWOT analysis identified management support, organisational readiness, digital communication, government support, ICT development, professional training and market pressure as strengths or opportunities, while financial limitations, skills shortages, infrastructure deficiencies, high technology costs and regulatory resistance constituted weaknesses or threats. The study recommended improved financial support, professional training, BIM policies, digital infrastructure and stakeholder collaboration to address factors constraining adoption among indigenous AEC contractors.

Keywords: Building Information Modelling (BIM), Immersive Technologies, Indigenous and Foreign Contractors, SWOT Analysis, AEC Industry

Introduction

Construction activity remains a major driver of infrastructure provision, housing delivery, transportation systems and urban development. The Architecture, Engineering and Construction (AEC) sector contributes substantially to economic activity through project execution, employment generation and support for allied industries. Construction practice has increasingly incorporated digital technologies that facilitate coordination, documentation, communication and project control. Information and communication technologies have introduced Building Information Modelling (BIM), drones, Virtual Reality (VR), Augmented Reality (AR), Digital Twins, 3D printing, laser scanning, blockchain and cloud-based platforms into construction processes (Okpo, Ikediashi & Dania, 2023) ^[2, 3, 14]. Lin and Su (2013) ^[25] observed that mobile and information technologies support activities across different phases of project execution, while Zawada (2024) ^[55] identified digitalisation as an important feature of contemporary construction practice. These technologies provide capabilities for documentation, scheduling, monitoring, communication and field coordination (Momade *et al.*, 2022) ^[38]. Duncan *et al.* (2018) ^[13] further noted that digital tools can support error reduction, time efficiency and cost control in construction operations. Building Information Modelling is an important component of digital construction practice. Eastman *et al.* (2011) ^[14]

explained that BIM emerged partly from the need to improve coordination and information exchange among project participants. Succar (2009) ^[46] defined BIM as a digital representation of the physical and functional characteristics of a facility that supports decision-making throughout the project lifecycle. Ullah *et al.* (2019) ^[51] similarly described BIM as a shared digital environment that supports project delivery decisions, while Bui, Merschbrock and Munkvold (2016) ^[10] noted that BIM integrates design, construction, operational and maintenance information in digital project models. BIM therefore provides a platform through which architects, engineers, contractors and clients can coordinate project information and activities. Immersive technologies have expanded the capabilities of digital construction environments through enhanced visualisation and interaction. These technologies include VR, AR, Mixed Reality (MR) and Digital Twins. Zima, Pachla and Węgrzyn (2020) associated the development of these technologies with advances in BIM and Internet of Things integration. VR enables users to interact with computer-generated construction environments, while AR overlays digital information onto physical environments (Thabet *et al.*, 2022) ^[8]. BIM integrated with VR can provide virtual walkthroughs of building models and facilitate design review before physical construction (Eze & Aluko, 2022) ^[15]. Adewumi *et al.* (2025) ^[1] reported that immersive technologies can enhance visualisation and support the

identification of design problems, while Agboola and Alsharif (2026) ^[2] found that VR and AR can improve design accuracy, communication and collaboration during project delivery.

The benefits associated with BIM and immersive technologies have increased the importance of organisational and environmental conditions that facilitate their effective implementation. BIM can support coordination, cost estimation, scheduling, clash detection, visualisation and facility management. Azhar *et al.* (2011) ^[5] reported improvements in cost estimation processes associated with BIM, while Wang *et al.* (2015) ^[53] identified benefits relating to collaboration, early fault detection and cost savings. Volk *et al.* (2014) ^[52] noted that BIM can improve quantity take-off, project scheduling, transparency in decision-making and facility management. Belonwu (2025) ^[7] similarly associated BIM with reduced rework and improved collaboration. These benefits, however, depend on the availability of appropriate skills, financial resources, digital infrastructure, organisational support and favourable institutional conditions. The Nigerian construction industry operates in a context characterised by differences in the financial, technical and organisational capabilities of indigenous and foreign contractors. Indigenous contractors are predominantly Nigerian-owned firms, many of which operate as small and medium-sized enterprises and undertake building and infrastructure projects at local and regional levels (Odediran *et al.*, 2012) ^[31]. These firms experience limited access to finance, inadequate capitalisation, shortages of specialised technical personnel and weak organisational structures. Ugochukwu and Onyekwena (2014) ^[50] reported that financial and technical limitations affect the capacity and competitiveness of indigenous contractors, particularly in major construction projects. Famakin and Ojo (2013) ^[16] similarly identified constraints affecting the execution capacity of local construction firms. Limited institutional support and access to resources can further restrict the capacity of indigenous firms to acquire equipment, train personnel and establish digital construction systems (Odediran *et al.*, 2012) ^[31].

Foreign contractors operating in Nigeria include multinational construction firms and subsidiaries of international companies. These firms frequently participate in large-scale infrastructure and building projects and possess stronger financial resources, specialised technical expertise, advanced equipment and structured management systems. Idoro (2010) ^[20] observed that client preferences in Nigeria favour foreign contractors because of perceptions concerning quality and project delivery capability. Differences in financial capacity, technical expertise, equipment and management structures therefore create different organisational environments for indigenous and foreign contractors. Oke, Aghimien and Adedoyin (2020) ^[39] reported that foreign contractors demonstrated stronger technical expertise, managerial competence, equipment and financial capacity, while indigenous contractors faced greater financial and technical limitations. Several factors in and outside construction firms can influence the conditions surrounding BIM and immersive technology adoption in Nigeria. Internal factors include financial capacity, management support, availability of skilled personnel, digital literacy, training opportunities, availability of BIM software and hardware, technical support, organisational readiness, communication effectiveness and the ability to

integrate digital technologies into existing workflows. External factors include internet connectivity, electricity supply, government support, BIM policy, regulatory standards, professional training programmes, industry awareness, digital construction funding, ICT infrastructure and academia-industry collaboration. Conversely, high technology costs, inadequate infrastructure, limited institutional support, regulatory resistance and shortages of skilled professionals can create unfavourable conditions.

Evidence from Nigerian studies confirms the importance of these factors. Chima and Udoekanem (2024) ^[12] identified high costs of digital technologies, resistance to technological change and inadequate power supply as challenges affecting digitalisation in construction. Osunsanmi *et al.* (2020) ^[6] and Igwe *et al.* (2025) ^[22] identified infrastructure deficiencies, high initial costs, shortages of skilled personnel, unstable internet services and resistance to change as important constraints. Alufohai (2012) ^[4] and Akinola, Mokunfayo and Dorcas (2023) ^[3] reported limitations in the development and use of digital construction systems. Nasila and Cloete (2018) ^[29] described BIM practice in Nigeria as being at an early stage, while Luomala (2020) ^[26], Idowu *et al.* (2023) ^[21] and Ogar *et al.* (2025) ^[32] identified technology costs, power supply, digital literacy, regulatory conditions, resistance to change and interoperability as relevant challenges. Babatunde, Udejaja and Adekunle (2020) ^[6] and Olanrewaju, Tan and Kwan (2020) ^[6] further identified inadequate training, limited technical capacity, weak communication, organisational resistance and limited stakeholder support as important factors. Sepasgozar *et al.* (2021) ^[43] and George (2026) ^[17] identified hardware costs, software integration and professional awareness as relevant considerations for immersive technologies, while Johari and Hendra (2023) ^[23] emphasised leadership and digital orientation in organisations.

The combination of these internal and external factors provides a basis for examining BIM and immersive technology conditions through the SWOT framework. Puyt, Lie and Wilderom (2023) ^[41] explained that SWOT evolved from earlier planning approaches, while Learned *et al.* (1969) ^[24] established its usefulness in organising information for strategic decision-making. Weihrich (1982) ^[54] emphasised the relevance of internal and external environmental factors in strategic analysis. Shen, Li, Drew and Shen (2006) ^[44] applied SWOT to construction-related issues involving contractor capacity, financial strength, technical capability and organisational structure. In the Nigerian construction context, factors such as financial resources, technical expertise, infrastructure, policy support, training, regulatory conditions and market pressures can therefore be examined as internal strengths or weaknesses and external opportunities or threats. The distinction between indigenous and foreign contractors makes such an analysis particularly relevant in South-South Nigeria. Indigenous firms possess local knowledge, established community relationships and familiarity with the Nigerian construction environment, but simultaneously face limitations in finance, specialised skills, equipment and digital infrastructure. Foreign contractors possess greater financial resources, technical expertise, advanced equipment and structured management systems, but operate in a competitive and regulatory environment that also presents challenges. Ugochukwu and Onyekwena (2014) ^[50]

highlighted differences in market access between larger firms and smaller contractors, while Odediran *et al.* (2012)^[31] identified financial and institutional limitations affecting indigenous contractors.

The South-South geopolitical zone provides an important context for investigating these differences because of its extensive construction activities, infrastructure requirements and concentration of economic activities. Despite increasing scholarly attention to BIM and immersive technologies, existing studies have largely examined general barriers, benefits, organisational conditions or technology applications without systematically comparing the internal and external factors influencing these technologies among indigenous and foreign AEC contractors in the South-South geopolitical zone. There is therefore a need to identify the relevant factors and systematically classify them into strengths, weaknesses, opportunities and threats. The study addresses this gap through a SWOT analysis of factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria.

Objectives of the Study

The specific objectives were to:

1. identify the internal factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria
2. classify the internal factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors into strengths and weaknesses using the SWOT framework
3. identify the external factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria; and
4. classify the external factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors into opportunities and threats using the SWOT framework.

Research Questions

The following research questions were formulated to guide the study:

1. What internal factors influence BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria?
2. How can the identified internal factors influencing BIM and immersive technology adoption be classified as strengths or weaknesses using the SWOT framework?
3. What external factors influence BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria?
4. How can the identified external factors influencing BIM and immersive technology adoption be classified as opportunities or threats using the SWOT framework?

BIM and Immersive Technologies in Nigerian Construction Industries

Building Information Modelling (BIM) refers to a digital representation of the physical and functional characteristics of a facility, structured to support decision-making throughout planning, design, construction and operation (Pachla & Węgrzyn, 2020)^[6, 37]. Nasila and Cloete (2018)^[29] described BIM as a shared digital model that facilitates design, construction and operational processes while

providing a reliable basis for project decisions. BIM extends beyond three-dimensional modelling to a collaborative process that integrates information from different project participants in a common digital environment (Chima & Udoekanem, 2024)^[2, 12]. It facilitates interaction among architects, engineers, contractors and clients, thereby improving information exchange and coordination during project delivery. BIM models can contain geometric information, schedules, cost data and operational information that support planning and construction decisions (Ogar *et al.*, 2025)^[32]. BIM also facilitates clash detection during design, enabling potential conflicts to be identified before physical construction and thereby reducing rework and improving project planning (Azhar *et al.*, 2011; Chen & Baddeley, 2015)^[5, 11].

BIM supports activities across the project lifecycle, including design, construction and facility management. Information generated during different project stages can be retained and used for subsequent analysis, decision-making and asset management (Chima & Udoekanem, 2024)^[2, 12]. The technology also supports 4D BIM, where construction schedules are linked to building components, and 5D BIM, where cost information is integrated into the model (Sacks, Treckmann & Rozenfeld, 2009)^[2, 14, 42]. These capabilities facilitate construction sequencing, scheduling and cost estimation. Mobile devices connected to BIM systems can further support field communication and coordination between site personnel and office-based professionals (Lin & Su, 2013)^[9, 25]. In facility management, BIM provides structured information that can support maintenance planning and asset tracking throughout the operational life of a facility (Volk, Stengel & Schultmann, 2014)^[52]. Immersive technologies complement BIM by providing advanced visualisation and interaction capabilities. Virtual Reality (VR) creates computer-generated environments in which users can interact with digital representations of buildings and construction projects (Zawada, 2024)^[55]. Augmented Reality (AR) overlays digital information onto physical environments through mobile devices or smart glasses, allowing project information to be viewed in actual construction settings. Mixed Reality (MR) combines physical and digital environments, enabling interaction between real and virtual objects in real time (Somaieh, Sadeghi-Niaraki & Choi, 2020)^[2, 35, 45]. VR can facilitate design review and spatial understanding, while AR can support site activities by presenting design information alongside physical construction elements.

The integration of BIM with VR and AR provides additional opportunities for visualisation, design communication and project coordination. BIM-based immersive environments enable project participants to examine building models and identify potential design conflicts before physical construction (Eze & Aluko, 2022)^[15]. Such capabilities can improve interpretation of architectural and engineering information and reduce misunderstandings associated with conventional drawings (Adewumi *et al.*, 2025)^[1]. Digital Twin systems further extend BIM capabilities by linking digital representations of physical assets with real-time information generated through sensors, thereby supporting continuous monitoring of building performance (Boje *et al.*, 2022)^[8]. Artificial Intelligence (AI) can enhance BIM environments through data processing, pattern recognition and predictive analysis (Zawada, 2024)^[55], while Internet of Things (IoT) devices and smart sensors generate

information that can support energy monitoring, maintenance planning and building performance management (Ghaffarianhoseini *et al.*, 2016) ^[10]. The Nigerian construction industry comprises indigenous contractors and foreign construction firms operating under different organisational, financial and technical conditions. Indigenous contractors are predominantly Nigerian-owned firms, many of which operate as small and medium-sized enterprises and undertake building and infrastructure projects at local and regional levels (Odediran *et al.*, 2012) ^[31]. These firms commonly experience financial constraints, including limited access to credit and inadequate capitalisation for project execution. Under-capitalisation, limited technical personnel and weak management structures can affect their capacity to undertake large and technically demanding projects (Ugochukwu & Onyekwena, 2014) ^[17, 50]. Limited access to advanced equipment, specialised expertise and digital resources can further affect their competitiveness in projects requiring sophisticated construction technologies (Oraegbune & Haruna, 2022) ^[1, 38].

Foreign contractors operating in Nigeria include multinational construction companies and subsidiaries of international firms from Europe, Asia and North America (Odediran *et al.*, 2012) ^[31]. These firms commonly undertake large-scale infrastructure and building projects and possess stronger financial resources, technical expertise, specialised equipment and structured management systems. Client perceptions of higher quality and project delivery capability have also contributed to preferences for foreign contractors in some segments of the Nigerian construction market (Idoro, 2010) ^[20]. Differences in financial strength, technical capability, equipment and management systems therefore create varying organisational conditions between indigenous and foreign contractors. Oke, Aghimien and Adedoyin (2020) ^[39] found that foreign contractors demonstrated stronger technical expertise, managerial competence, equipment and financial capacity, whereas indigenous contractors experienced greater financial and technical constraints. In the Nigerian construction environment, several organisational and environmental factors can influence the conditions under which BIM and immersive technologies are considered and implemented. These include availability of skilled personnel, digital literacy, management support, financial capacity, training opportunities, software and hardware availability, ICT infrastructure, technical support and organisational readiness. External conditions include internet connectivity, electricity supply, government support, BIM policies, regulatory standards, professional training programmes, industry awareness, digital construction funding and academia-industry collaboration. Conversely, high technology costs, inadequate infrastructure, limited institutional support and regulatory resistance create unfavourable conditions for technology implementation. Empirical studies have identified several of these factors as important influences on BIM and related digital construction technologies in Nigeria. Hamma-Adama, Kouider and Salman (2018) ^[19], Agboola and Alsharif (2026) ^[2], Udofia *et al.* (2026) ^[17] and Ogar *et al.* (2025) ^[32] identified inadequate technical expertise, insufficient training, limited institutional support and infrastructure constraints as important challenges. Hamma-Adama *et al.* (2018) ^[19] further reported inadequate policy direction and limited

understanding of BIM as a collaborative process. Agboola and Alsharif (2026) ^[2] and Ogar *et al.* (2025) ^[32] reported that BIM integrated with VR and AR could improve project visualisation, communication, coordination and performance, while financial, technical, infrastructure and interoperability challenges remained important considerations. The reviewed literature therefore indicates that BIM and immersive technology implementation is shaped by a combination of organisational strengths and weaknesses as well as external opportunities and threats. However, limited empirical attention has been given to a comparative SWOT examination of these internal and external factors among indigenous and foreign AEC contractors in South-South Nigeria. The present study addresses this gap by systematically examining and classifying the factors influencing BIM and immersive technology adoption among the two contractor groups in the South-South geopolitical zone.

Research Methodology

The study adopted a comparative descriptive survey design. The design was considered appropriate because it enabled the researcher to examine internal and external factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors under existing construction conditions without manipulating the variables. It also facilitated comparison of the perceptions of respondents from both contractor groups and classification of the identified factors using the SWOT framework. The study was conducted in the South-South Geopolitical Zone of Nigeria, comprising Akwa Ibom, Bayelsa, Cross River, Delta, Edo and Rivers States (Otuo *et al.*, 2025) ^[40]. The zone is characterised by diverse socio-cultural groups and abundant natural resources, particularly crude oil and natural gas. The population of the study comprised 352 construction stakeholders involved in construction project execution, supervision and evaluation in the zone. The respondents included senior managers, technical personnel, consultants and other construction-related professionals from indigenous and foreign AEC firms. According to Bornstein, Jager and Putnick (2013) ^[9], a study population comprises the entire set of elements possessing the characteristics relevant to an investigation.

A sample of 230 respondents was selected from the study population using purposive sampling. The sample comprised 86 senior managers, 103 technical staff and 41 consultants from indigenous and foreign AEC firms involved in architectural, quantity surveying, structural engineering and project supervision activities. Respondents were purposively selected based on their direct involvement in construction project delivery and familiarity with digital construction technologies. Taherdoost (2016) ^[47] described a sample as a subset of a population selected for investigation, while Nardi (2018) ^[28] emphasised the importance of appropriate sampling procedures in obtaining relevant data for research objectives. Data were collected using a 30-item structured questionnaire titled *SWOT Analysis of Factors Influencing BIM and Immersive Technology Adoption Questionnaire (SABITAQ)*. The instrument contained 15 items on internal factors and 15 items on external factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors. The questionnaire was structured on a five-point Likert scale ranging from 5 = Strongly Agree, 4 = Agree, 3 = Moderately Agree, 2 =

Disagree and 1 = Strongly Disagree. The same response scale was used for all four research questions because the study examined respondents' perceptions of factors influencing adoption rather than directly measuring the actual extent of technology adoption.

Face and content validity of the instrument were established through expert review. Five experts drawn from academia and the AEC industry assessed the instrument for clarity, relevance, adequacy and alignment with the research objectives. Their recommendations were incorporated to improve the clarity and technical appropriateness of the questionnaire items. The reliability of the instrument was established through a pilot test involving 20 respondents who were not included in the main study but possessed characteristics similar to those of the study respondents. Cronbach's alpha coefficients were 0.76 for the internal-factor items and 0.88 for the external-factor items, indicating acceptable internal consistency. The questionnaire was administered with the assistance of three trained research assistants who were properly briefed on the administration and retrieval procedures. A total of 230 copies of the questionnaire were administered and retrieved, representing a 100% retrieval rate. Data collected were analysed using Mean Item Score (MIS), ranking analysis, gap analysis and independent-samples t-test. Mean Item Score was used to determine the extent to which

respondents agreed that the identified internal and external factors influenced BIM and immersive technology adoption. Ranking analysis was used to arrange the factors according to their relative importance based on their MIS values. Gap analysis was used to compare the responses of indigenous and foreign contractors and was calculated as $GA = MIS_{\text{Indigenous}} - MIS_{\text{Foreign}}$. A negative gap value indicated that the foreign contractor group recorded a higher mean score, whereas a positive gap value indicated that the indigenous contractor group recorded a higher mean score. The SWOT framework was subsequently used to classify internal factors into strengths and weaknesses and external factors into opportunities and threats, based on their influence on BIM and immersive technology adoption. An independent-samples t-test was used to determine whether statistically significant differences existed between the responses of indigenous and foreign contractor groups at the 0.05 level of significance. Where the significance value was less than 0.05, the difference between the two groups was considered statistically significant; where the significance value was greater than 0.05, the difference was considered not statistically significant.

Presentation of Results and Analysis

Research Question 1: What internal factors influence BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria?

Table 1: Mean Item Scores and Independent-Samples t-Test of Internal Factors Influencing BIM and Immersive Technology Adoption among Indigenous and Foreign AEC Contractors.

S/N	Internal Factors	MIS (Indigenous)	Rank	MIS (Foreign)	Rank	GA	t-value	Sig.
1	Financial capacity for investment	2.70	15	4.45	1	-1.75	6.02	0.000
2	ICT infrastructure quality	2.75	14	4.40	2	-1.65	5.90	0.000
3	Training opportunities for staff	2.80	13	4.20	8	-1.40	5.35	0.000
4	Availability of BIM-skilled personnel	2.85	12	4.30	4	-1.45	5.60	0.000
5	Access to technical support systems	2.90	11	4.10	10	-1.20	4.92	0.000
6	Staff digital literacy level	2.95	10	4.25	6	-1.30	5.10	0.000
7	Organisational readiness for digital transformation	3.00	8	4.30	4	-1.30	5.18	0.000
8	Ability to integrate BIM into workflow	3.00	8	4.35	3	-1.35	5.25	0.000
9	Staff experience in digital tools	3.05	6	4.15	9	-1.10	4.70	0.000
10	Overall internal readiness level	3.05	6	4.30	4	-1.25	5.40	0.000
11	Management support for adoption	3.10	5	4.40	2	-1.30	5.20	0.000
12	Digital communication effectiveness	3.15	4	4.20	8	-1.05	4.60	0.000
13	Availability of BIM software/hardware	3.20	3	4.35	3	-1.15	4.85	0.000
14	Dependence on manual construction methods	3.35	2	2.85	13	0.50	3.10	0.002
15	Resistance to change among staff	3.40	1	2.90	12	0.50	3.25	0.001

NB: Mean Item Score (MIS); Gap analysis (GA), Significance (Sig.)

Table 1 showed internal factors affecting BIM and immersive technology adoption among indigenous and foreign AEC contractors in the South-South geopolitical zone of Nigeria. Foreign contractors recorded higher mean scores for financial capacity (MIS = 4.45), management support (MIS = 4.40), ICT infrastructure quality (MIS = 4.40), BIM software and hardware (MIS = 4.35) and workflow integration (MIS = 4.35). Indigenous contractors recorded lower scores for financial capacity (MIS = 2.70), ICT infrastructure quality (MIS = 2.75), training

opportunities (MIS = 2.80) and BIM-skilled personnel (MIS = 2.85). Resistance to change (MIS = 3.40) and reliance on manual construction methods (MIS = 3.35) remained high. Gap analysis recorded negative values for all variables. The observed t-values ranged from 3.10 to 6.02, with all corresponding p-values below 0.05.

Research Question 2: How can the identified internal factors influencing BIM and immersive technology adoption be classified as strengths or weaknesses using the SWOT framework?

Table 2: SWOT Classification of Internal Factors Influencing BIM and Immersive Technology Adoption among Indigenous and Foreign AEC Contractors

S/N	Internal Factors	Indigenous		Foreign	
		Strengths	Weaknesses	Strengths	Weaknesses
1.	Availability of BIM-skilled personnel		✓	✓	
2.	Management support for adoption	✓		✓	

3.	Staff digital literacy level		✓	✓	
4.	Availability of BIM software/hardware	✓		✓	
5.	Financial capacity for investment		✓	✓	
6.	Training opportunities for staff		✓	✓	
7.	Staff experience in digital tools	✓		✓	
8.	Organisational readiness for digital transformation	✓		✓	
9.	Resistance to change among staff		✓		✓
10.	Dependence on manual construction methods		✓		✓
11.	Access to technical support systems		✓	✓	
12.	Digital communication effectiveness	✓		✓	
13.	ICT infrastructure quality		✓	✓	
14.	Ability to integrate BIM into workflow	✓		✓	
15.	Overall internal readiness level	✓		✓	

Table 2 presented the SWOT classification of the internal factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors in the South-South Geopolitical Zone of Nigeria. For indigenous AEC contractors, the strengths included management support for adoption, availability of BIM software and hardware, staff experience in digital tools, organisational readiness for digital transformation, digital communication effectiveness, ability to integrate BIM into workflow and overall internal readiness. The weaknesses comprised limited availability of BIM-skilled personnel, low staff digital literacy, inadequate financial capacity for investment, limited training opportunities, resistance to change among staff, dependence on manual construction methods, inadequate access to technical support systems and poor ICT infrastructure quality. For foreign AEC contractors, the

SWOT classification revealed stronger internal capabilities, with strengths comprising availability of BIM-skilled personnel, management support, staff digital literacy, BIM software and hardware, financial capacity, training opportunities, staff experience in digital tools, organisational readiness, access to technical support systems, digital communication effectiveness, ICT infrastructure quality, workflow integration and overall internal readiness. Their weaknesses were mainly associated with resistance to change among staff and continued dependence on manual construction methods.

Research Question 3: What external factors influence BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria?

Table 3: Mean Item Scores and Independent-Samples t-Test of External Factors Affecting BIM and Immersive Technology Adoption among Indigenous and Foreign AEC Contractors.

S/N	External Factors	MIS (Indigenous)	Rank	MIS (Foreign)	Rank	Gap	t-value	Sig.
1.	National BIM policy availability	3.00	14	4.35	4	-1.35	5.35	0.000
2.	Academia-industry collaboration	3.00	14	4.10	12	-1.10	4.55	0.000
3.	Availability of digital construction funding	3.05	13	4.20	8	-1.15	5.00	0.000
4.	Electricity supply stability	3.10	10	4.25	7	-1.15	4.90	0.000
5.	Regulatory standards for BIM	3.10	10	4.40	2	-1.30	5.25	0.000
6.	Government incentives for adoption	3.15	9	4.20	8	-1.05	4.70	0.000
7.	Internet connectivity availability	3.20	8	4.30	5	-1.10	4.85	0.000
8.	Professional training programmes	3.25	6	4.15	10	-0.90	4.40	0.000
9.	Data security systems	3.25	6	4.30	5	-1.05	4.95	0.000
10.	Industry awareness level	3.30	5	4.25	7	-0.95	4.60	0.000
11.	Expansion/improvement of ICT infrastructure	3.35	4	4.50	1	-1.15	5.40	0.000
12.	Government support for BIM adoption	3.40	3	4.45	3	-1.05	5.10	0.000
13.	Market pressure for digital adoption	3.45	2	4.35	4	-0.90	4.35	0.000
14.	Resistance from regulatory stakeholders	3.50	1	3.00	11	0.50	3.20	0.001
15.	Cost of BIM and immersive technologies	3.60	1	2.85	15	0.75	3.95	0.000

NB: Mean Item Score (MIS); Gap analysis (GA), Significance (Sig.)

Table 3 showed external factors affecting BIM and immersive technology adoption among indigenous and foreign AEC contractors in the South-South geopolitical zone of Nigeria. Foreign contractors recorded higher mean scores for ICT infrastructure availability (MIS = 4.50), government support for BIM adoption (MIS = 4.45), regulatory standards (MIS = 4.40), national BIM policy availability (MIS = 4.35) and market pressure for digital adoption (MIS = 4.35). Indigenous contractors recorded lower scores for ICT infrastructure (MIS = 3.35), internet connectivity (MIS = 3.20), electricity supply stability (MIS = 3.10) and government incentives (MIS = 3.15). Cost of

BIM technologies (MIS = 3.60) and resistance from regulatory stakeholders (MIS = 3.50) remained high. Gap analysis recorded negative values for most variables. The observed t-values ranged from 3.10 to 6.02, with all corresponding p-values below 0.05.

Research Question 4: How can the identified external factors influencing BIM and immersive technology adoption be classified as opportunities or threats using the SWOT framework?

Table 4: SWOT classification of external factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors

S/N	External Factors	Indigenous		Foreign	
		Opportunities	Threats	Opportunities	Threats
1.	Internet connectivity availability	✓		✓	
2.	Electricity supply stability	✓		✓	
3.	Government support for BIM adoption	✓		✓	
4.	National BIM policy availability	✓		✓	
5.	Cost of BIM and immersive technologies		✓		✓
6.	Government incentives for adoption	✓		✓	
7.	Professional training programmes	✓		✓	
8.	Industry awareness level	✓		✓	
9.	Regulatory standards for BIM	✓		✓	
10.	Data security systems	✓		✓	
11.	Expansion/improvement of ICT infrastructure	✓		✓	
12.	Academia-industry collaboration	✓		✓	
13.	Market pressure for digital adoption	✓		✓	
14.	Resistance from regulatory stakeholders		✓		✓
15.	Availability of digital construction funding	✓		✓	

Table 4 presented the SWOT classification of the external factors influencing BIM and immersive technology adoption among indigenous and foreign AEC contractors in the South-South Geopolitical Zone of Nigeria. The classification showed that internet connectivity availability, electricity supply stability, government support for BIM adoption, national BIM policy availability, government incentives, professional training programmes, industry awareness, regulatory standards, data security systems, ICT infrastructure availability, academia-industry collaboration, market pressure for digital adoption, and availability of digital construction funding were identified as opportunities for both indigenous and foreign AEC contractors. The table further showed that the cost of BIM and immersive technologies constituted a threat to both indigenous and foreign contractors, indicating that the financial burden associated with acquiring and implementing these technologies had remained a constraint to wider adoption. Similarly, resistance from regulatory stakeholders was classified as a threat for both groups, showed that regulatory resistance had potentially hindered the effective integration of BIM and immersive technologies in the construction industry.

Discussion of Findings

Findings from Research Question 1 showed that internal factors influenced BIM and immersive technology adoption differently among indigenous and foreign AEC contractors. Foreign contractors recorded more favourable conditions in financial capacity, management support, BIM-skilled personnel, digital literacy, training, ICT infrastructure, software and hardware availability, and workflow integration. Indigenous contractors, however, recorded higher levels of resistance to change and dependence on manual construction methods. The finding on financial capacity agreed with Odediran *et al.* (2012) ^[31] and Ugochukwu and Onyekwena (2014) ^[50], who identified inadequate financial resources as a constraint affecting technology uptake among Nigerian construction firms. The findings on skilled personnel, digital literacy and training supported Osunsanmi, Aigbavboa and Oke (2020) ^[39] and Babatunde, Udejaja and Adekunle (2020) ^[6], who reported

skills and training deficiencies as barriers to BIM implementation. Similarly, the importance of management support and organisational readiness was consistent with Johari and Hendra (2023) ^[23], who emphasised organisational commitment in digital technology adoption. The higher resistance to change and dependence on manual methods among indigenous contractors agreed with Luomala (2020) ^[26] and Olanrewaju, Tan and Kwan (2020) ^[6], who associated organisational resistance and traditional practices with slow digital transformation.

Findings from Research Question 2 showed that the SWOT analysis classified several internal factors as strengths and weaknesses influencing BIM and immersive technology adoption among indigenous AEC contractors. Strengths included management support, BIM software and hardware availability, digital communication, workflow integration and organisational readiness, while weaknesses included inadequate financial capacity, shortage of skilled personnel, low digital literacy, limited training, poor ICT infrastructure, resistance to change and dependence on manual methods. The findings agreed with Luomala (2020) ^[26], who identified implementation costs, technical limitations and organisational challenges as barriers to BIM adoption. The weaknesses associated with infrastructure, skills and financial capacity supported Osunsanmi, Aigbavboa and Oke (2020) ^[39], who reported that inadequate digital infrastructure, limited expertise and financial constraints hindered BIM implementation in Nigeria. Similarly, the findings on training and digital literacy supported Babatunde, Udejaja and Adekunle (2020) ^[6], who emphasised capacity development as an important factor in BIM implementation. The classification of resistance to change and dependence on traditional methods as weaknesses agreed with Olanrewaju, Tan and Kwan (2020) ^[6], who linked organisational resistance and fragmented practices with slow digital transformation.

Findings from Research Question 3 showed that external environmental factors influenced BIM and immersive technology adoption differently among indigenous and foreign AEC contractors. Foreign contractors recorded more favourable conditions regarding ICT infrastructure, government support, regulatory standards, BIM policy

availability, market pressure and digital construction funding. Indigenous contractors recorded greater concerns regarding BIM technology costs and resistance from regulatory stakeholders. The findings agreed with Osunsanmi, Aigbavboa and Oke (2020) ^[39], who identified inadequate infrastructure, high technology costs and limited institutional support as barriers to BIM implementation in Nigeria. The lower scores of indigenous contractors on BIM policy and regulatory standards supported Okonta *et al.* (2023) ^[33], who associated weak regulatory frameworks with limited BIM adoption. Similarly, Hamma-Adama and Kouider (2018) ^[19] reported that inadequate policy direction and institutional support constrained BIM implementation. The higher concern about BIM technology costs among indigenous contractors further supported Luomala (2020) ^[26], who identified implementation costs as an important barrier to digital technology adoption. Findings from Research Question 4 showed that external factors influencing BIM and immersive technology adoption could be classified into opportunities and threats. Opportunities included government support, professional training, ICT development, industry awareness, internet connectivity, data security, market pressure, BIM policy development and stakeholder collaboration, while threats included technology costs and resistance from regulatory stakeholders. The identified opportunities agreed with Hamma -Adama and Kouider (2018) ^[19], who emphasised institutional support, training and policy direction as important conditions for BIM implementation. The findings concerning policy and regulatory opportunities were consistent with Okonta *et al.* (2023) ^[33], who reported that stronger BIM regulations could improve standardisation and adoption in Nigeria. The classification of infrastructure and funding conditions as important external factors was supported by Osunsanmi, Aigbavboa and Oke (2020) ^[39], who identified inadequate infrastructure, high implementation costs and limited technical capacity as barriers to BIM implementation. Similarly, the identification of technology cost as a threat agreed with Luomala (2020) ^[26], who recognised implementation cost as a significant adoption barrier.

Conclusion

The study showed that several internal and external factors influenced BIM and immersive technology adoption among indigenous and foreign AEC contractors in South-South Nigeria. Foreign contractors demonstrated more favourable internal conditions, particularly in financial capacity, management support, availability of skilled personnel, ICT infrastructure, training, BIM software and hardware, and workflow integration. Indigenous contractors were comparatively constrained by inadequate financial capacity, limited skilled personnel, insufficient training, poor ICT infrastructure, resistance to change and continued dependence on manual construction methods. The SWOT analysis further indicated that management support, digital communication, organisational readiness, government support, ICT development, professional training and market pressure represented important strengths or opportunities, while inadequate resources, high technology costs and regulatory resistance constituted significant weaknesses or threats.

Recommendations

1. Indigenous AEC contractors should strengthen their financial and organisational capacity for BIM and immersive technology adoption through dedicated technology budgets, affordable financing and management commitment.
2. AEC firms and professional bodies should improve staff competence through continuous practical training in BIM and immersive technologies and partnerships with universities, professional institutions and technology providers.
3. Government agencies and construction regulators should strengthen BIM policies, regulatory standards, incentives and implementation guidelines to create a supportive environment for technology adoption.
4. Government and construction stakeholders should improve electricity supply, internet connectivity, ICT infrastructure, technical support and academia-industry collaboration to reduce external barriers to BIM and immersive technology adoption

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