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FACTORS INFLUENCING THE ADOPTION OF EMERGING TECHNOLOGIES BY INDIGENOUS CONSTRUCTION AND REAL ESTATE DEVELOPMENT COMPANIES IN ABUJA, NIGERIA

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ABSTRACT

The aim of this paper is to assess the adoption of emerging technologies (ET) by indigenous construction and real estate development companies (CRED) in Abuja, Nigeria with a view to identifying the key driving factors. The study adopted a combination of descriptive and exploratory research designs. Data were collected through structured questionnaire administered to thirty - eight indigenous CRED companies in the study area via purposive sampling technique. Data obtained for the study were analysed through descriptive and inferential statistical techniques. The study found that drone technology is the most commonly used form of ET by indigenous CRED companies in Abuja with 26% of the total occurrence observed. This is followed by BIM (23%) and virtual reality (19%) respectively. It also found that location of the project, labour factor, government policy and technical nature of the project are the crucial factors that influence the adoption of ET by indigenous CRED companies in the study area. The study concludes that there are prospects of greater usage of ET by indigenous CRED companies for their operations in the city in the nearest future. In the light of the findings, it recommends the establishment of a robust regulatory framework by policy makers in the construction industry to clearly provide the technical and ethical standards required for the use of ET in the industry and the penalties for non-compliance especially concerning geographical coverage, data privacy and data security.

Keywords: Emerging Technologies, Indigenous Construction Companies, Construction Industry, Abuja, Nigeria

1. INTRODUCTION

Nowadays, technology is generally regarded as a means of effecting positive change in the construction industry as well as the national economy at large. The transition from legacy segregated technology to a data-driven and analytical digital strategy has helped the industry to advance (Tunji-Olayeni, 2018; Momade *et al*, 2021; Okpo *et al*, 2023). In order to achieve reduction in costs, enhance efficiency, promote productivity and safety, and meet sustainability objectives, the construction industry is progressively incorporating new innovations into the design and construction process (Loosemore, 2014; Momade *et al,* 2022). Sepasgozar and Davis (2018) defined emerging construction technologies as new tools, machines, and innovations that can aid in achieving an objective, carrying out a specific task, or resolving a problem. The potential influence of technology on the construction sector is substantial, presenting construction businesses with an opportunity to streamline more traditional processes in order to achieve greater efficiency, reduce errors, and increase profits (Duncan *et al*., 2018). The use of global positioning systems (GPS), drones, virtual and augmented reality, block chain technology, digital twins, 3D printing, 3D laser scanners, 4D simulations and building information modelling (BIM) are a few examples of these emerging technologies. Technology can provide construction companies with tools for monitoring project completion time and digitizing paper forms. It can also provide a more efficient method of collecting field and site data (Tunji-Olayeni, 2018; Choi *et al*., 2023; Okpo *et al*, 2023).

The construction industry contributes significantly to economic growth globally (Osunsanmi *et al*, 2020). This has been further enhanced by the adoption of ET in the operation of the industry (Chen and Ying, 2022; Okpo *et al*, 2023; Choi *et al*, 2023). Among the advantages of these technologies are improved communication between team members and consultants, effective safety management, cost efficiency and integrated project delivery (Abioye *et al*., 2021; Babalola *et al*, 2022; Korke *et al*., 2023; Choi *et al*., 2023 and Karasu *et al*., 2023). Thus, ET offer platforms that are essential for guaranteeing communication in real-time within the project team in order to plan, cost, execute, supervise, and control the project from initiation to accomplishment (Momade *et al*, 2022).

Technology can aid in delivering pre-construction enhancements with significant bid team efficiency gains. In addition, the time spared by digital tools can be invested in relationship management and communication. Some empirical studies, for example, Zhao *et al*. (2022) have investigated issues related to the rate of adoption of ET in the construction industry of several nations. However, minute research has been carried out on the subject vis-à-vis the drivers of the adoption of ET in Nigeria. Liu and Zheng (2019) and Olanrewaju *et al* (2019) contended that the outcomes of related sectoral research cannot be generalized across countries or jurisdictions because of the complex impact of the unique regulatory, socio-cultural, economic, geo-political and industrial factors operating in the local construction business environment. A critical review of empirical studies carried out on the subject in Nigeria revealed that they focused more on the construction industry in Lagos except Okpo *et al* (2023) and none precisely investigated the drivers of the adoption of ET by indigenous construction and real estate development firms in the country. In the absence of such research and coupled with the fact that the construction industry is location-specific, contextual and geographical gaps exist on the principal factors that determine the adoption of ET by indigenous construction and real estate development firms in other parts of the country. This study is intended to fill this gap.

2. LITERATURE REVIEW

2.1 Adoption of ET in construction industry

The adoption of ET in the Nigerian construction industry is an ongoing process (Muhammad *et al*, 2014; Okpo *et al*, 2023). In order to fully utilize innovation, construction businesses in the country require the use of technology in every aspect of their operations. Wei and Lam (2014) investigated the barriers to innovation at the individual project level using a UK construction enterprise as the case study and found that the major barriers to innovation as perceived at the project level are client-industry relationship, procurement, organisational culture and organisation management with varying level of correlations amongst them. Likewise, Eze *et al.* (2019) argued that the hurdles to innovation at the macro level are the financial system and regulations, whilst the micro-level barriers to innovation include organisational culture together with its structure, team dynamics, human potentials, resources, and communication.

Digital technologies are now employed in the construction industry to design houses, prefabricated building components and the development of built environment assets that are physically, economically and environmentally sustainable. The emerging technologies utilised in the construction industry globally include artificial intelligence, drones for site surveys, photographs, inspections, and progress reports. Other forms of ET adopted by construction companies include machine learning, virtual reality, BIM, cloud-based solutions and blockchain technology. These are further discussed as follows:

2.1.1 Artificial Interlligence (AI)

AI is an aggregate term for describing when a machine mimics human cognitive functions like problem-solving and pattern recognition (Archdesk, 2023). It is simply the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings (Chen and Ying, 2022). The goal of AI is to make machines mimic cognitive functions of humans in order for them to conduct tasks that are normally performed by humans (Parveen, 2018). It enhances safety, cost-efficiency, effective management of construction waste and improved productivity in the construction industry among other merits (Abioye *et al*., 2021; Korke *et al*., 2023). AI is also able to analyse tasks and determine when crucial details are lacking. When new information is provided, AI can change the plan and ask questions. Thus, in the construction industry, AI can play a vital role in helping construction professionals to curtail accidents, sustain project efficiency and improve operational safety (Razi *et al*., 2023).

2.1.2 Machine Learning

Machine learning (ML) is a subfield of AI that uses statistics to enable computers to learn and make decisions without being explicitly programmed. It is a subset of AI that entails developing algorithms and models that can learn from data, rather than being overtly programmed (Xu *et al*., 2021). The basic steps of ML are collection of data, preparation of data, model specification, training, appraisal, hyper parameter timing and prediction.

2.1.3 Virtual Reality

Virtual reality immerses the user in a virtual world through the use of a headset with some type of screen showing a virtual environment (GCFGlobal, 2023). These headsets also use head tracking, which permits the user to look around the environment by physically moving his head. The display will follow any direction the user moves, giving him a 360-degree view of the virtual environment (Thabet *et al*, 2022; GCFGlobal, 2023). Equipment and safety management can be enhanced through virtual reality. Construction workers may practice potentially hazardous scenarios in a safe virtual environment by using virtual reality while working at a height, in a cramped area, or while there are loud blasts, for instance.

2.1.4 Building Information Modelling (BIM)

BIM has been viewed in different ways by different disciplines over the years (Karasu *et al*, 2023). The British Standards Institution (2019) as adopted by the Institution of Structural Engineers (2021) defines BIM as the use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions. Built assets in this context are buildings, bridges, roads, process plants, amongst others (IStructE, 2021). It is a process for merging information and technology to produce a digital image of a project. It blends data from several sources and changes correspondingly with the real project across its whole timeline, including design, construction and in-use operational information (Arayici *et al*, 2012; Bui *et al*., 2016; Kjartansdottir *et al*, 2017 and Zhang *et al*, 2020). Hence, BIM enables efficient flow of information required for integrated project delivery (Karasu *et al*., 2023) and also facilitates effective collaboration by the project team towards the success of the project (Arayici *et al*., 2012; Borrmann *et al*., 2018; Olanrewaju *et al*., 2020 and Babalola *et al*., 2022).

2.1.5 Cloud-Based Solutions

Cloud-based solution refers to applications, storage, on-demand services, computer networks or other resources that are accessed with an internet connection through another provider's shared cloud computing framework (Planergy, 2023). Construction teams may collaborate in a single shared workspace even when workers are not physically in the same place by means of portable devices and cloud services. A secure shared place for documents between the office and the field is provided by cloud solutions. Construction companies of all sizes may get the assistance needed to manage their projects digitally and without interruptions by using cloud services. With the help of these digital technologies, improved information management will be achieved in the industry.

2.1.6 Blockchain Technology

Blockchain is a distributed ledger technology that provides information to be recorded, maintained and shared by a community (Suman and Patel, 2021). It is an innovative, decentralized, and distributive "state-of-the-art" technology, which maintains confidentiality, integrity, and availability of all the transactions and data (Dutta *et al*, 2020). It is a digital ledger containing all transactions of a specific item recorded chronologically (Rijmenam and Ryan, 2019; Mintah *et al*, 2020). Blockchains assist a group of users to record dealings in a common ledger within

that community, such that under normal operation of the blockchain network no transaction can be altered once published (Yaga *et al*, 2018). There are diverse applications of blockchain technology (Konashevych, 2020; Garcia-Teruel, 2020) but in the construction industry, its usage is very indispensable in the areas of construction supply chain operations and contract administration.

2.1.7 Drone Technology

Drones are unmanned aerial vehicles that are furnished with sophisticated sensors, cameras, and GPS technology to obtain real-time data, create precise 3D models and conduct remote surveys (Mahajan, 2021; Choi *et al*., 2023). They are very useful at each phase of the construction process, from inspection and surveying of the construction site to the maintenance of the completed project or facility. The advantages of drones in the construction industry as highlighted by JOUAV (2023) include fast data collection, cost saving, increased safety, improved communication and real – time construction project data acquisition and processing, amongst several others.

2.2 Review of Empirical Studies

The adoption of new technologies in the construction industry has been the subject of academic inquiry in recent times. Usman and Said (2014) examined the vital factors that influence the use of technology by construction enterprises in Nigeria through a wide-ranging review of relevant literature. The study found that these factors are culture (national and organisational), policy (national and organisational) and cost (direct and indirect) and further developed a theoretical framework on how they interact to influence the decision of construction firms to adopt technology based on Roger's innovation diffusion theory. Although the theoretical framework developed by the study was not tested with empirical data, it provided insight on the basic drivers of technology adoption in the Nigerian construction industry. A similar study by Waziri *et al* (2017) found that Nigerian construction organisations are hesitant to implement new technologies because of hostile economic atmosphere. The study concluded that a proper alignment of technology, organisation and environmental variables are essential to the effective utilisation of technology by construction organisations in the country.

Eze *et al*. (2019) carried out a study to categorize the obstacles to Nigerian construction businesses' full adoption of process and product innovation as well as offering potential solutions to those obstacles. The study found that the factors limiting innovation in the construction industry in the country include inadequate funding, absence of management support and commitment, the disjointed nature of the construction industry, poor coordination and communication among project participants, inadequate competent and knowledgeable staff and clients who are unwilling to pay for inventive designs.

Olaniyan (2019) examined the barriers to technology adoption among construction project professionals in Nigeria and found that construction project managers in the country are not motivated to implement new technologies for enhancing the processes of decision making and the rate of project completion. This corroborates the findings of Waziri *et al* (2017) that construction organisations in the country are unenthusiastic to implement new technologies. The study attributes this scenario to certain factors such as government policy, cost of new technology, commitment to change, company culture, ethical culture, inadequate financial investments in technological innovations and lack of appropriate technology training, among others.

Khudzari *et al* (2021) assessed the factors affecting the adoption of emerging technologies in the Malaysian construction industry. The study identified nineteen components based on two categories: internal factors that project managers can control and external ones that cannot be controlled. The significant internal factors identified by the study are labour, cost, time, adaptability of technology, aim and functions of technology and technology's quality whilst third parties and leaders' opinion are the external factors.

Momade *et al* (2022) investigated the adoption of construction technologies (CT) in the construction industry in Vietnam. The goals of the study were to conduct a thorough analysis of the literature on CT adoption issues, look into particular CT adoption issues in Vietnam's construction industry, and suggest data-driven solutions for a higher rate of CT adoption. The study found that the biggest hindrances to CT adoption were the lack of knowledge about the impact on productivity, slow adoption of software in construction projects, ignorance of the significance and needs of the construction industry, insufficient funding during budget planning for technological advancements and execution, inadequate experts needed for technological change, and lack of necessary competencies in the sector.

Emerging technologies are subsets of digital technologies. In this regard, Okpo *et al* (2023) evaluated the influence of the adoption of digitalization (digital technology) on the delivery of construction projects in Nigeria using data obtained from cross sectional survey of medium and large-sized construction enterprises in the country and found that the adoption of digital technologies has moderate and substantial influence on the quality performance of construction projects in the locality. In the same way, Idowu *et al* (2023) assessed the barriers to digitalization in the Nigerian construction industry based on survey research design and identified them to include resistance to technology by stakeholders, high cost of digital technology and inadequate power supply.

3. METHODOLOGY

A combination of descriptive and exploratory research designs was used for the study. The rationale for the use of these research designs for the study emanates from the goal of the study which is to explore the adoption of emerging technologies by indigenous construction and real estate development companies in Abuja, Nigeria with a view to identifying the key driving factors. Likewise, the study's reliance on the survey research approach, coupled with the complexity of the research problem necessitated the use of these research designs. The population for the study comprises indigenous construction and real estate development (CRED) companies in the construction industry in Abuja registered with the Corporate Affairs Commission (CAC). The CAC is an agency of the federal government of Nigeria duly mandated by law to licence and regulate business organisations in the country. Their registration with the CAC indicates that they are legally licensed by the government to operate in the construction industry in Nigeria. Indigenous CRED companies are construction and real estate development companies wholly owned and operated by Nigerians without any form of foreign ownership and shareholding. Data were collected through structured questionnaire administered to thirty-eight indigenous CRED companies in the study area selected through purposive sampling technique. The questionnaire was designed in four parts. The first part elicited data on the institutional characteristics of indigenous CRED companies in the study area. The second part prompted information on ET used by indigenous CRED companies in the study area. The third part produced information on the effects of the use of ET on the performance of indigenous CRED companies in the study area while the last part produced information on the factors that influence the adoption of ET by indigenous CRED companies in the study area. The last part contained eleven opinion statements on the factors that influence the adoption of ET by indigenous CRED companies in the study area, based on 4 - point Likert scale (strongly agree = 4; strongly disagree = 1). These factors were extracted from the relevant literature of earlier empirical studies on the subject precisely Wei and Lam (2014), Usman and Said (2014), Waziri (2017), Eze *et al*. (2019), Olaniyan (2019), Khudzari *et al* (2021), Momade *et al* (2022) and Idowu *et al* (2023). The reliability of items in the instrument of data collection was done with the use of Cronbach's alpha reliability coefficient. The coefficient ranges between 0 and 1 (Cronbach, 1951 and Cronbach, 2004). The reliability test's result obtained for the study is presented in Table 1.

Table 1: Cronbach's Alpha of the Variables under study

Variables	Number of Items	Cronbach's Alpha
Rate of Usage of ET	7	0.822
Effects of ET Usage	9	0.935
Factors that Influence the adoption of ET	11	0.755

(Field Survey, 2023)

A reliability coefficient greater than 0.7 is considered reliable and hence acceptable (George and Mallery, 2003; Dangana and Udoekanem, 2024). The result in Table 1 suggests acceptable internal consistency of the items under study. Statistical techniques such as mean, standard deviation, relative importance index analysis (RII) and factor analysis (FA) were employed in data analysis for the study.

4. RESULTS AND DISCUSSION

4.1 Demographic characteristics of the respondents

Table 2 displays a brief description of the indigenous CRED companies selected for the study. From the Table, all the companies are registered with the Corporate Affairs Commission (CAC). 52.64% of the companies have been in construction business for more than 10 years, with a mean year of operation of 12 years. This suggests that the indigenous CRED companies are relatively experienced and are conversant with the trends in the construction industry in the study area. 57.89% of the construction companies are small-sized companies with an employee size of between

10 and 49 workers, while 42.11% are medium-sized companies with an employee size of between 50 and 250 workers with a mean number of employees of 53 workers. This implies that indigenous CRED companies in the study area have employed an average of 53 individuals. This denotes that the construction industry could be a major avenue for job creation if well leveraged by stakeholders involved in job creation for the unemployed youths in the country. Concerning the ownership structure of the companies, the result shows that 47.37% of the companies are companies limited by shares, 47.37% are private limited companies and 5.26% are companies limited by guarantee. Furthermore, 36.84% of the companies are involved in heavy engineering and construction, 26.32% are engaged in real estate development only, 15.79% provide architectural design services, 10.53% deliver construction management services and 10.53% are general building services contractors.

Table 2: Brief Description of the companies under study

	Frequency	**Percentage**	**Mean**
Registration with Corporate Affairs Commission (CAC)			
Yes	38	100	
No	0	0.00	
Years of Operation			**12**
0-5	6	15.79	
6-10	12	31.58	
11-15	10	26.32	
16-20	10	26.32	
Total Number of Employee			**53**
Small Size Companies (10-49)	22	57.89	
Medium Size Companies (50-250)	16	42.11	
Large Size Companies	0	0.00	
Ownership Structure of the Organization			
Company Limited by Guarantee	2	5.26	
Company Limited by Shares	18	47.37	
Private limited company	18	47.37	
Nature of Business (Major Activity Engaged in)			
Architectural design services	6	15.79	
Real estate development	10	26.32	
Heavy engineering/Construction	14	36.84	
Construction management services	4	10.53	
General building services	4	10.53	
Total	**38**	**100**	

(Field Survey, 2023)

4.2 Forms of ET used by indigenous construction and real estate development companies in the study area

The forms of ET used by indigenous CRED companies in Abuja are indicated in Figure 1. From the result, all the indigenous CRED companies in the study area use one form of ET or another. The result shows that drone technology is the most commonly used form of ET by the indigenous CRED companies in the study area with 26% of the total occurrence observed. This is followed by building information modelling (23%) and virtual reality (19%) respectively. Earlier studies by Mahajan (2021) and Choi *et al*. (2023) pointed out that drone technology offers many attractive advantages in the construction industry including better safety, cost savings, quicker data collection, and real-time project and material monitoring. These benefits may have attracted the companies to the use of drone technology in their operations in the study area. Other forms of ET used by the companies under study are artificial intelligence (11%), cloud-based solutions (10%), machine learning (8%) and blockchain technology (3%). Given a Cronbach alpha of 0.822, these responses are acceptable. This outcome suggests that CRED companies have embraced various forms of ET at varying levels in their operations in the study area and is consistent with the assertion of Olaniyan (2019) and Chen *et al* (2021) that in an attempt to address the challenges faced in the construction sector, digital technology is gradually being applied in the sector although at a slow pace.

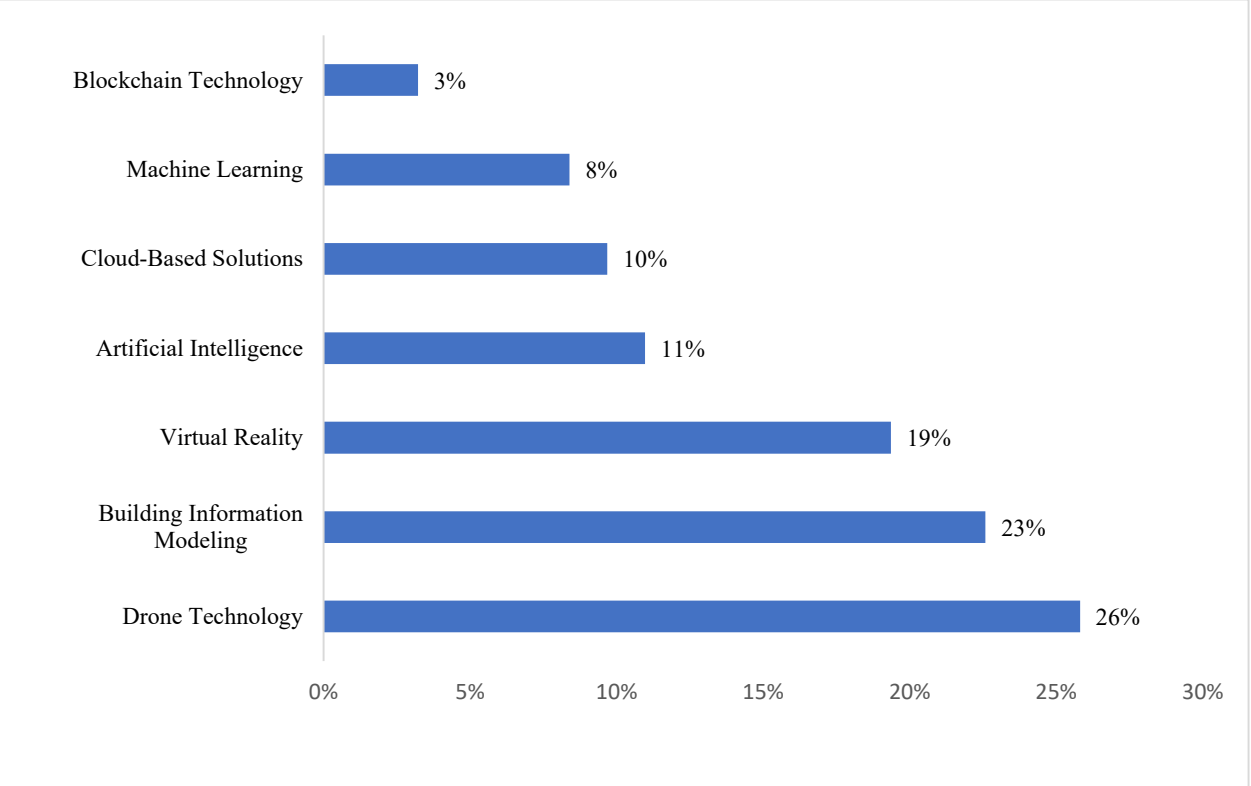

Figure 1: Forms of ET used by indigenous CRED companies in the study area (Field Survey, 2023).

4.3 Effects of the adoption of ET on the overall performance of indigenous construction and real estate development companies in the study area

Relative importance index analysis (RII) was employed to identify the important effects of the adoption of ET on the overall performance of indigenous CRED companies under study and the result is presented in Table 3. The most important effect of the adoption of ET on the overall performance of the companies under study is improved client satisfaction and is ranked first. This outcome agrees with those of Bozhuk *et al* (2019), Talebi and Khatibi (2023) who earlier posited that technology utilisation in companies has a positive impact on client satisfaction. When technology is utilised to boost the effectiveness of construction operations leading to the success of the project, the client is likely to be satisfied with such outcome. Ranked second are increased turnover, competitive edge and continuous capacity building whilst timely project delivery is ranked third. These key effects are intertwined. Appropriate application of technology in construction operations saves time, resulting in timely completion of the project (Chen *et al*, 2022). Similarly, timely project delivery enhances the turnover of the company as more construction projects are delivered promptly with the aid of technology. By so doing, the company achieves a competitive edge which requires continuous capacity building on emerging technological innovation to sustain. Based on a Cronbach alpha of 0.935, these responses are acceptable.

Table 3: Effects of the adoption of ET on the overall performance of indigenous construction and real estate development companies in the study area

	Mean	Standard Deviation	RII	Rank
Improved client satisfaction	3.474	0.762	0.869	1st
Increased turnover	3.316	0.809	0.829	2nd
Competitive edge	3.316	0.809	0.829	2nd
Continuous capacity building	3.316	0.574	0.829	2nd
Timely project delivery	3.263	0.724	0.816	3rd
Improved patronage	3.158	0.679	0.790	4th
Reduced personnel cost	3.158	0.823	0.790	4th
More expenditure on technological devices	3.053	0.695	0.763	5th
Loss of jobs by employees	3.053	0.613	0.763	5th

(Field Survey, 2023)

4.4 Factors that influence the adoption of ET by indigenous construction and real estate development companies in the study area

The factors investigated in this study were distilled from the literature of previous empirical studies on the issue specifically Wei and Lam (2014), Usman and Said (2014), Eze *et al*. (2019), Olaniyan (2019), Khudzari *et al* (2021), Momade *et al* (2022) and Idowu *et al* (2023). These comprise goal and technological viability of the project, government policy, availability of appropriate technology, size of the project's labour force, location, duration and cost of the project, adequacy of electric power supply, technical complexity of the project and client's influence. The descriptive statistics for these variables are presented in Table 4.

Table 4: Descriptive statistics of Factors that influence the adoption of ET by indigenous construction and real estate development companies in the study area

Variable	Mean	Standard Deviation
Goal of the project	2.789	1.018
Technological viability of the project	2.632	0.751
Government policy	2.526	1.059
Availability of appropriate technology	2.895	0.727
Size of the project's labour force	2.947	0.695
Location of the project	3.053	0.695
Duration of the project	3.211	0.622
Cost of the project	2.737	0.795
Adequacy of electric power supply	3.105	0.981
Technical complexity of the project	3.105	0.798
Client's influence	2.842	0.823

(Field Survey, 2023)

Factor analysis technique was utilised to identify the key factors from the variables in Table 4. The result of the test of sampling adequacy for the factor analysis is presented in Table 5.

Table 5: Result of KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.62
Bartlett's Test of Sphericity	Approx. Chi-Square	299.79
	Df	55
	Sig.	0.000

(Field Survey, 2023)

For satisfactory factor analysis to be carried out, the KMO should be close to 0.6. From Table 5, the KMO measure is 0.62, which exceeds 0.6 and is accepted. The Bartlett's test of sphericity is significant (0.000), which is less than 0.05. The first four components have eigenvalues greater than 1 based on the result in Table 6, and they account for about 79.56% of the total variance. This suggests that the first four common factors are crucial in influencing the adoption of ET by indigenous construction and real estate development companies in Abuja are in retained.

Table 6: Factors influencing the adoption of ET by indigenous construction and real estate development companies in the study area

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.560	32.362	32.362	3.560	32.362	32.362	2.452	22.289	22.289
2	2.140	19.456	51.818	2.140	19.456	51.818	2.341	21.283	43.572
3	1.780	16.179	67.997	1.780	16.179	67.997	2.049	18.630	62.203
4	1.271	11.559	79.556	1.271	11.559	79.556	1.909	17.353	79.556
5	0.799	7.264	86.820						
6	0.508	4.617	91.437						
7	0.383	3.481	94.918						
8	0.269	2.443	97.361						
9	0.187	1.698	99.059						
10	0.093	0.847	99.906						
11	0.010	0.094	100.000						

(Field Survey, 2023)

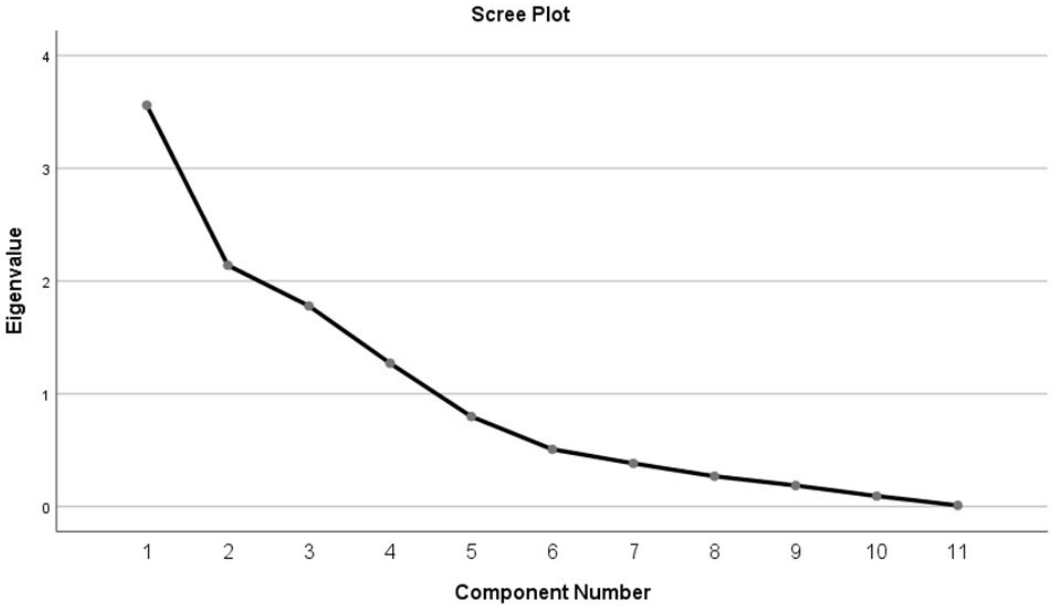

Figure 2: Scree plot of the factors that influence the adoption of ET by indigenous construction and real estate development companies in the study area

The scree plot of the factors that influence the adoption of ET by indigenous construction and real estate development companies in the study area is shown in Figure 2. The graph is valuable for ascertaining how many factors to retain. The point of notice is where the curve begins to flatten, which can be spotted between factors 4 and 5. Also, factor 5 onwards have eigenvalues less than 1, consequently only four factors have been retained.

Table 7: Rotated component matrix of the Factors influencing the adoption of ET by indigenous construction and real estate development companies in the study area

	Component			
	1	2	3	4
Location of the project	0.703			
Duration of the project	0.789			
Cost of the project				0.591
Technical complexity of the project				0.775
Size of the project's labour force		0.839		
Technological viability of the project				0.902
Government policy			0.921	
Goal of the project			0.916	
Client's influence		0.874		
Availability of appropriate technology		0.732		
Adequacy of electric power supply	0.782			

(Field Survey, 2023)

Table 7 shows the result of varimax rotation done on the data. Location of the project (0.703), duration of the project (0.789) and adequacy of electric power supply (0.782) have large positive loading on factor 1 and it can be labelled as locational factor. Incidentally, electric power supply in Nigeria is based on location. Certain locations in the country have greater power supply than others. Earlier study by Idowu *et al* (2023) identified inadequate power supply as a major impediment to the adoption of digital technologies in the Nigerian construction industry. Size of the project's labour force (0.839), client's influence (0.874) and availability of appropriate technology (0.732) have large positive loading on factor 2 and this factor can be labelled as labour factor. Government policy (0.921) and goal of the project (0.916) have large positive loading on factor 3 and this factor can be labelled as government policy. Technological viability of the project (0.902), technical complexity of the project (0.775) and cost of the project

(0.591) have large positive loading on factor 4 and this factor can be labelled as technical nature of the project. Together, all the four factors accounted for about 79.56% of the total variance. Two of these factors namely labour factor and government policy confirm those of Usman and Said (2014), Olaniyan (2019) and Khudzari *et al* (2021) whilst the other (technical nature of the project) is in tandem with that of Momade *et al* (2022). Thus, these factors should be considered in policy formulation and implementation by appropriate authorities to improve the use of emerging technologies in the construction industry in the city.

5. CONCLUSION

Drone technology is the most commonly used form of emerging technologies by indigenous construction and real estate development companies in Abuja with 26% of the total occurrence observed. Other forms of emerging technologies used by the companies under study are building information modelling (23%), virtual reality (19%), artificial intelligence (11%), cloud-based solutions (10%), machine learning (8%) and blockchain technology (3%) respectively. This finding suggests that indigenous construction and real estate development companies have adopted various forms of emerging technologies at varying levels in their operations in the city. It also affirms the assertion of Olaniyan (2019) and Chen *et al* (2021) that digital technology is gradually being applied in the construction sector although at a slow speed to address the challenges faced in the sector.

Also, location of the project, labour factor, government policy and technical nature of the project are the crucial factors that influence the adoption of emerging technologies by indigenous construction and real estate development companies in Abuja. Though these findings are specifically applicable to the Abuja construction industry, they may provide insight on the expected factors in the construction industry in other cities with size and other characteristics similar to the industry in Abuja. The study concludes that these factors are vital and should be considered in policy formulation by appropriate authorities to improve the adoption of emerging technologies in the construction industry in the city.

RECOMMENDATIONS

Based on the findings of this study, a robust regulatory framework should be developed by policy makers in the construction industry in Abuja. Such regulatory framework should clearly provide the technical and ethical standards required for the use of emerging technologies in the industry and the consequences for non-compliance especially regarding geographical coverage, data privacy and data security. Also, professional bodies in the real estate and construction industry in the city should organise regular workshops, seminars and technical training for indigenous industry practitioners on the use of emerging technologies and to keep them abreast of current developments regarding the adoption of new technologies in the industry.

6. REFERENCES

Abioye, S. O., Oyedele, L. O., Akanbi, L., Ajayi, A., Delgado, J. M. D., Bilal, M., Akinade, O.O. and Ahmed, A. (2021). Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. *Journal of Building Engineering*, 44, 103299

Arayici, Y., Egbu, C. and Coates, P. (2012). Building information modelling (BIM) implementation and remote construction projects: Issues, challenges and critiques. *Journal of Information Technology in Construction*, Vol.17, pp.75-92. http://www.itcon.org/2012/5

Archdesk (2023). Artificial intelligence in construction management. file:///C:/Users/USER/Downloads/Artificial%20Intelligence%20in%20Construction%20Management.html

Babalola, A., Musa, S., Akinlolu, M. T. and Haupt, T. C. (2023). A bibliometric review of advances in building information modelling (BIM) research. *Journal of Engineering, Design and Technology*, Vol. 21, No. 3, pp. 690-710, https://doi.org/10.1108/JEDT-01-2021-0013

Borrmann, A., K¨onig, M., Koch, C. and Beetz, J. (2018). Building Information Modeling – Why? What? How? In: Borrmann, A.; König, M.; Koch, C.; Beetz, J. (Eds): *Building Information Modeling - Technology Foundations and Industry Practice,* Springer, 2018, DOI: 10.1007/978-3-319-92862-3

Bozhuk, S., Maslova, T., Pletneva, N. and Evdokimov, K.V. (2019). Improvement of the consumers' satisfaction research technology in the digital environment. IOP Conference Series: *Materials Science and Engineering*. 6 (1), 2-5. 10.1088/1757-899X/666/1/012055.

Bui, N., Merschbrock, C. and Munkvold, B. (2016). A Review of Building Information Modelling for Construction in Developing Countries. Procedia Engineering. 164. 487- 494. 10.1016/j.proeng.2016.11.649.

Chen, X., Chang-Richards, A., Pelosi, A., Jia, Y., Shen, X., Siddiqui, M., & Yang, Nan. (2021). Implementation of technologies in the construction industry: a systematic review. *Engineering, Construction and Architectural Management*. Ahead-of-print. https://doi.org/10.1108/ECAM

Chen, H.-P. and Ying, K.-C (2022). Artificial intelligence in the construction industry: Main development trajectories and future outlook. *Applied Science*, 12, 5832. https://doi.org/10.3390/app12125832

Choi, H.-W.; Kim, H.-J.; Kim, S.-K. and Na, W.S. (2023).An overview of drone applications in the construction industry. *Drones*, 7, 515. https://doi.org/10.3390/drones7080515

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*. 16: 297-334

Cronbach, L. J. (2004). My current thoughts on coefficient alpha and successor procedures. *Educational and Psychological Measurement*. 64: 391

Duncan, A., Kingi, V. and Brunsdon, N. (2018). Adopting new ways in the building and construction industry: BRANZ study report SR406. Available at: https://d39d3mj7qio96p.cloudfront.net/media/documents/SR406_Adopting_new_ways.pdf

Dutta, P., Choi, T. M., Somani, S. and Butala, R. (2020). Blockchain technology in supply chain operations: Applications, challenges and research opportunities. *Transportation Research Part E*, 142, 102067.

Dangana, U.S. and Udoekanem, N.B. (2024), Valuation accuracy in the residential property markets in Minna and Abuja, Nigeria, *Property Management*, 42 (2), 166 - 191. https://doi.org/10.1108/PM-03-2023-0028

Eze, E. C., Sofolahan, O., Adegboyega, A. A. and Saidu, K. J. (2019). Factors limiting the full-scale adoption of process and product innovation in the Nigerian construction industry. *SEISENSE Journal of Management*, 2(3), 67-81. doi:10.33215/sjom.v2i3.145

Garcia-Teruel, R. M. (2020). Legal challenges and opportunities of blockchain technology in the real estate sector. *Journal of Property, Planning and Environmental Law*, Vol. 12 No. 2, pp. 129-145, https://doi.org/10.1108/JPPEL-07-2019-0039

GCFGlobal (2023). Understanding virtual reality and augmented reality. file:///C:/Users/USER/Downloads/VR%20%20The%20Now_%20Understanding%20Virtual%20Reality%20and%20Augmented%20Reality.html

George, D. and Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference. (4e)*. Boston: Allyn & Bacon.

Idowu, A. O., Aigbavboa, C. and Oke, A. E. (2023). *Barriers to digitalisation in the Nigerian construction industry*. Paper presented at the 40th International CIB W78 Conference, Heraklion, Crete, Greece, July 10-12.

IStructE (2021). *An introduction to building information modelling (BIM)*. London, The Institution of Structural Engineers.

JOUAV (2023). Drone in construction and infrastructure. file:///C:/Users/USER/Downloads/Drone%20in%20Construction_%20Benefits,%20Applications,%20and%20Use%20Cases%20-%20JOUAV.html

Karasu, T., Aaltonen, K. and Haapasalo, H. (2023). The interplay of IPD and BIM: a systematic literature review. *Construction Innovation*, Vol. 23, No. 3, pp. 640-664, https://doi.org/10.1108/CI-07-2021-0134

Khudzari. K., Rahman, R.A., & Ayer, S.K. (2021). Factors affecting the adoption of emerging technologies in the Malaysian construction industry. *IOP Conf. Ser.: Earth Environ. Sci*, 641, 1-10

Kjartansdóttir, I. B., Mordue, S., Nowak, P., Philp, D. and Snæbjörnsson, J. T. (2017). *Building information modelling (BIM)*. Iceland, Great Britain.

Konashevych, O. (2020). Constraints and benefits of the blockchain use for real estate and property rights. *Journal of Property, Planning and Environmental Law*, Vol. 12 No. 2, pp. 109-127, https://doi.org/10.1108/JPPEL-12-2019-0061

Korke, P., Gobinath, R., Shewale, M. and Khartode, B. (2023). Role of artificial intelligence in construction project management. *E3S Web of Conferences* 405, 04012, https://doi.org/10.1051/e3sconf /202340504012

Lew, Y., Toh, T., Lim, K., Yan, F. and Yow, L. (2019). A study on the constraints of implementing Information and Communication Technology (ICT) in Malaysian Construction Industry. IOP Conference Series: *Earth and Environmental Science*. 385. 012005. 10.1088/1755-1315/385/1/012005.

Loosemore, M. (2014). Improving construction productivity: a subcontractor's perspective, *Engineering, Construction and Architectural Management*, 21(3), 245-260.

Liu, G. and Zheng, J. (2019), Prediction model of compressive strength development in concrete containing four kinds of gelled materials with the artificial intelligence method, *Applied Sciences*, 9(6), 10-39.

Mahajan, A. (2021). Applications of drone technology in construction industry. *International Journal of Engineering and Advanced Technology*, 11. 224-239.

Mintah, K., Baako, K. T., Kavaarpuo, G. and Otchere, G. K. (2020). Skin lands in Ghana and application of blockchain technology for acquisition and title registration. *Journal of Property, Planning and Environmental Law*, Vol. 12, No. 2, pp. 147-169, https://doi.org/10.1108/JPPEL-12-2019-0062

Momade, M.H., Durdyev, S., Estrella, D. and Ismail, S. (2021), Systematic review of application of artificial intelligence tools in architectural, engineering and construction, *Frontiers in Engineering and Built Environment*, Vol. 1 No. 2, pp. 203-216. https://doi.org/10.1108/FEBE-07-2021-0036

Momade, M.H., Durdyev, S., Van Tam, N., Shahid, S., Mbachu, J. and Momade, Y. (2022), Factors influencing adoption of construction technologies in Vietnam's residential construction projects, *International Journal of Building Pathology and Adaptation*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJBPA-03-2022-0048

Moshood, T. D., Nawanir, G., Sorooshian, S., Mahmud, F. and Adeleke, A. Q. (2020). Barriers and benefits of ICT adoption in the Nigerian construction industry: A comprehensive literature review. *Applied System Innovation*, 3, 46; doi: 10.3390/asi3040046

Muhammad, A., Nor'Aini, Y. and Kamal, E. (2014). Empirical assessment of Nigerian construction industry consultancy services innovation practices. *International Journal of Managerial Studies and Research,* 2(9), 175-186.

Muhammad, N. Z., Zango, M. U., Suleiman, J. H., Egba, E. I., Auwal, A. A. and Usman, J. (2018). Implementation of information technology in Nigerian construction industry. *Advanced Science Letters,* 24(6), 3908-3913. doi: 10.1166/asl.2018.11509

Ogunlana, S. (2010). Sustaining the 20:20 vision through Construction: A Stakeholder Participatory Approach. Distinguished Guest Lecture Series. University of Lagos.

Okpo, H., Ikediashi, D. and Dania, A. (2023). Influence of digitalisation adoption level on construction project delivery in Nigeria. *Frontiers in Engineering and Built Environment*, Vol. 3 No. 4, pp. 221-232. https://doi.org/10.1108/FEBE-01-2023-0008

Olanrewaju, F., Chima Uzorh, A., and Nnanna, I. (2019), Lean six sigma methodology and its application in the manufacturing industry-a review, *American Journal of Mechanical and Industrial Engineering*, 4(3) 40-42

Olanrewaju, O. I., Chileshe, N., Babarinde, S. A. and Sandanayake, M. (2020). Investigating the barriers to building information modelling (BIM) implementation within the Nigerian construction industry. *Engineering, Construction and Architectural Management*, https://doi.org/10.1108/ECAM-01-2020-0042

Olaniyan, R. (2019). *Barriers to technology adoption among construction project managers in Nigeria*. A Doctoral thesis submitted to Walden University. Accessed at https://scholarworks.waldenu.edu/dissertations

Osunsanmi, T.O., Aigbavboa, C.O., Oke, E. A. and Liphadzi, M. (2020), Appraisal of stakeholders' willingness to adopt construction 4.0 technologies for construction projects, *Built Environment Project and Asset Management*, Vol. 10 No. 4, pp. 547-565. https://doi.org/10.1108/BEPAM-12-2018-0159

Parveen, R. (2018). Artificial intelligence in construction industry: Legal issues and regulatory challenges. *International Journal of Civil Engineering and Technology*, Vol. 9, No. 13, pp. 957-962. http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=13

Planergy (2023). What Is A Cloud Based Solution? Definition and Meaning. file:///C:/Users/USER/Downloads/What%20Is%20A%20Cloud%20Based%20Solution_%20Definition%20and%20Meaning%20_%20Planergy%20Software.html

Razi, P. Z., Sulaiman, S. K., Ali, M. I., Ramli, N. I., Saad, M. S. H., Jamaludin, O. and Doh, S. I. (2023). How artificial intelligence changed the construction industry in safety issues. IOP Conf. Series: *Earth and Environmental Science*, 1140, 012004, doi:10.1088/1755-1315/1140/1/012004

Rijmenam, V.M. and Ryan, P. (2019), *Blockchain: Transforming Your Business and Our World*, Routledge, New York, NY.

Rogers, E.M., (2003). *Diffusion of Innovations* (5th Edition). New York Press.

Sepasgozar, S.M.E. and Davis, S.R. (2018), Construction technology adoption cube: an investigation on process, factors, barriers, drivers and decision makers using NVivo and AHP analysis. *Buildings*, 8 (6), 2-5 Doi: 10.3390/buildings8060074

Suman, A. K. and Patel, M. (2021). An introduction to blockchain technology and its application in Libraries. *Library Philosophy and Practice (e-journal)*. 6630. https://digitalcommons.unl.edu/libphilprac/6630

Talebi, H. and Khatibi, B.A. (2023). The impact of information technology on service quality, satisfaction, and customer relationship management (Case Study: IT Organization Individuals). *Journal of Management Science and Engineering Research*, 6. 10.30564/jmser.v6i2.5823.

Thabet, W., Shiratuddin, M., and Bowman, D. (2022). Virtual Reality in Construction.

Tibaut, A., Rebolj, D., and Perc, M.N. (2016), Interoperability requirements for automated manufacturing systems in construction, *Journal of Intelligent Manufacturing*, 27(1), 251-262

Tunji-Olayeni, P., Mosaku, T., Oyeyipo, O. and Afolabi, A. (2018). Sustainability strategies in the construction industry: implications on Green Growth in Nigeria. IOP Conference Series: *Earth and Environmental Science*, 146, 012004. doi:10.1088/1755-1315/146/1/012004

Usman, N. and Said, I. (2014). Key factors that affect adoption of technology in the Nigerian construction firms: A theoretical framework. *International Journal of Accounting and Business Management*, 2(2), 1-10.

Waziri, A. Y., Mustapha, Y. and Idris, K. M. (2017). A theoretical model of factors influencing IT adoption in Nigerian construction organizations. *International Journal of Engineering and Technology*, 9(3), 1809–1815. doi:10.21817/ijet/2017/v9i3/170903547.

Wei, Y. and Lam, P. T. I. (2014). Innovation barriers at the project level: Study of a UK construction firm. *International Journal of Architecture, Engineering and Construction*, Vol 3, No 3, 182-194

Wingtra (2021). *Drones in construction and infrastructure: Why and how to use drones in construction and infrastructure*. https://wingtra.com/dronemapping-applications/drones-in-construction-andinfrastructure/. Accessed: 6/9/2023.

Xu, Y., Zhou, Y., Sekula, P. and Ding, L. (2021). Machine learning in construction: From shallow to deep learning. *Developments in the Built Environment*, Vol. 6, 100045.

Yaga, D., Mell, P., Roby, N. and Scarfone, K. (2018). *Blockchain Technology Overview*. https://doi.org/10.6028/NIST.IR.8202

Yahya, M., Hui, Y., Md. Yassin, A., Omar, R., and Kasim, N. (2019). The Challenges of the implementation of construction robotics technologies in the construction industry. MATEC Web of Conferences. 266. 05012. 10.1051/matecconf/201926605012.

Zhang, R., Tang, Y., Wang, L. and Wang, Z. (2020). Factors influencing BIM adoption for construction enterprises in China. *Advances in Civil Engineering*, Vol. 2020, Article ID 8848965, https://doi.org/10.1155/2020/8848965

Zhao, X., Webber, R., Kalutara, P., Browne, W. and Pienaar, J. (2022), Construction and demolition waste management in Australia: a mini-review, *Waste Management and Research*, 40(1), 34-46.