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ASSESSMENT OF LEVEL OF BLOCKCHAIN TECHNOLOGY IMPLEMENTATION IN THE NIGERIAN CONSTRUCTION INDUSTRY

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ABSTRACT

Purpose: The aim of this research is to assess the level of implementation of blockchain technology (BT) in projects in the Nigerian construction industry.

Design/methodology/approach: Survey design was adopted for the study. Data were obtained using 721 copies of structured questionnaire. The methods of data analysis were descriptive and inferential statistics.

Findings: The result revealed that the level of implementation of blockchain technology is low among construction firms in the Nigerian construction sector. There was a significant difference in the level of implementation of blockchain technology based on firms' size.

Research limitations/Implications: The study concluded that firm characteristics have significant impact on the level of implementation of blockchain technology.

Practical implications: The study recommends that construction firms should create awareness of BT among top management and other staff through seminars and workshops. Top management staff and other staff of the firms should be trained on BT so as to improve the level of implementation of BT in project delivery in the Nigerian construction industry. Government should pass into law, legislations that would encourage the implementation of construction ICT driven policy via an institutional framework in Nigeria.

Keywords: Blockchain technology, Implementation, Construction industry, Nigeria.

1. INTRODUCTION

The construction industry remains a high-risk and markup/profit industry (Jha and Devaya, 2008). The high rate of consumption of natural resources in the industry negatively impacts the environment (Sheng *et al.,* 2020). The industry contributes over 10% of national revenues and plays a significant role in the economic development of nations (Queiroz *et al.,* 2022); hence, the construction industry is desperately in need of adapting to innovation and creative techniques and concepts (Queiroz *et al.,* 2022). However, in recent times, technological trends and innovations have presented challenges to the industry due to decreased effectiveness, efficiency, and productivity (Raj and Jeyaraj, 2022).

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In some countries, the construction industry contributes 5-7% of the total gross domestic product and employs at least 7% of its workforce (Shojaei *et al.,* 2021) The construction industry (CI) has both economic and social dimensions, therefore, it is closely linked to the three main pillars of sustainability: society, economy, and environment (Bartocci *et al.,* 2017; Beatriz *et al.,* 2018). However, there are various challenges with creating sustainable building projects: managing a substantial amount of data, coordinating projects from several fields, namely: architecture, structural engineering, and mechanical engineering; and ensuring effective communication among various professionals (Gupta *et al.,* 2021; Yuan *et al.,* 2021).

Construction projects are confronted with other sorts of challenges such as mistakes, project delays, and accident at various levels (Fashina *et al.,* 2021). Another challenged identified is the lack of accountability in the construction sector (Boadu *et al.,* 2020). The effects of which has squeezed profits margins and have left projects suffer setback in turn delays and abandonment. Hence, organisation is determined to seek for ways to reduce cost and deflect blame from the resulting failures. Payment and project management issues have affected project delivery. Delayed payments and relating cash flow issues have been a headlong hindrance in the construction sector.

Abisuga *et al.,* (2014) opined that the Nigerian construction sector output in term of quality, time and cost has not been satisfactory. This has resulted in time and cost overrun factors which are directly and indirectly linked to construction delays. In addition, the challenge of diversion of funds paid to contractors for project execution has been common trend in the Nigerian construction sectors. These problems have persisted due to inability to embrace contemporary technologies (Tezez *et al.,* 2020). The issues ranging from little confidence and transparency among the important members in the construction process, weak systems of transaction recording and documentation, delayed project delivery, abandonment of projects, complex process structure and massive corruption (Umbenhauer and Younger 2018; Dwivedi and Carvalho 2022; El Baz *et al.,* 2022).

Distributed ledger technology (DLT) is the right strategy and innovation to overcome these challenges. However, there is also a need for caution, as some findings have identified some concerns about the potential negative effects of these technologies, such as the creation of e-waste and the unequal distribution of benefits (Bai *et al.,* 2020; Bildirici, 2023). Generally, it is necessary to consider both the opportunities and challenges of Industry 4.0 technologies for sustainability to confirm that they are implemented responsibly and equitably (El-Baz *et al.,* 2022; Yang *et al.,* 2023).

There have been general and persistent calls to embrace and implement contemporary technology in the construction sector so as to eliminate or reduce the aforementioned problems in developing economies in general, and Nigerian construction industry in particular. One of the contemporary technologies that will solve many problems in the Nigerian construction industry is blockchain technology. Therefore, this study assessed the level of implementation of blockchain technology in construction project delivery in the Nigerian construction industry. The study also tested the hypothesis which states that there is no significant difference in the level of implementation of Blockchain Technology among Construction Firms in the Nigerian construction Industry.

2. LITERATURE REVIEW

Blockchain technology is a novel technology with the potential to revolutionize construction methods and mitigate supply chain and contractual risks. According to Swan (2015), blockchain technology presents a new paradigm for discovering, valuing, and transferring all discrete units of anything, and potentially for coordinating all human activities on a much larger scale than has been possible before. Xu *et al.,* (2016) defined Blockchain as "an emerging technology that enables new forms of distributed software architectures, where components can find agreements on their shared states for decentralized and transactional data sharing across a large network of untrusted participants without relying on a central integration point that should be trusted by every component within the system". The blockchain uses smart contracts (chaincode) to ensure a correct execution of predefined business rules (Kostal *et al.,* 2019). Whereby work

progress is monitored and followed by the various agencies responsible. With this they can confirm the level of work attained and payments issued according to percentage of work executed. The disaggregated structure of the construction industry makes it suitable for the application of the BT and smart contracting (Shojaei, 2019), despite this loose structure being a disadvantage in the implementation of innovation and new technologies (Shojael, 2019). Likewise, the disjointed nature of the construction sector makes it suitable for using blockchain technology for smart contracting processes for ease of contractor's selection and monitoring during project execution. But by studying the construction environment to assess what fit its needs the BT would be a potential catalyst for projecting the industry to a greater height.

Blockchain technology which is a decentralised transaction and data management technology, has attracted growing attention from both academic and industrial sector (Akaba, 2020). Similarly, Blockchain deliberations are becoming prevalent and having a prospect for solving sustainable growth and productivity developments and is 'real game-changer for Construction' (Gueguen, 2018) however, it is vague within the industry concerning how to attain this. There has been trust issues faced by all stakeholders in a typical construction setting (Kim *et al,* 2020; Tezel *et al, 2*020).

3. METHODOLOGY

The aim of this research is to assess the level of implementation of blockchain technology in project in the Nigerian construction industry. Survey design was adopted for the study. Data were obtained using 721 copies of structured questionnaire. The methods of data analysis were simple percentage, mean score, and Kruskal-Wallis test. Using a 5-point scale, the decision rule in this study is that any elements of Blockchain technology with an overall mean score of 1.0-1.49, 1.5-2.49, 2.5-3.49, 3.5-4.49, and 4.5-5.0 is considered to have a very low level of implementation; low level of implementation, moderate level of implementation, high level of implementation; and very high level of implementation respectively (Ogenma 2018). Kruskal-Wallis test was used to test the hypothesis which states that there is no significant difference in the level of implementation of BT among construction firms in the Nigerian construction industry.

4. PRESENTATION AND DISCUSSION OF RESULTS

This section contains the results of the analysis of data collected for the study. It contains the descriptive results of the response rate of questionnaire distributed, and firm characteristics. This section also contains the result of evaluation of the levels of implementation of BT among construction firms in the Nigerian construction industry. and the result of the hypothesis which states that there is no significant difference in the Level of Implementation of Blockchain Technology among Construction Firms in the Nigerian Construction Industry.

4.1. Respondents' Characteristics

Table 1 shows the results of the analysis of respondents' characteristics. It shows that 64.1%, 66.1%, 72.2%, 58.7%, 64.7%, 57.0%, 71.4%, 52.1%, and 51.9% of the respondents were from the Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and Rivers region of Nigeria respectively. Table 1 also shows that the category of the respondents. These include the Public Authority/Client Private Client/ Developer, Architectural Consultancy, Quantity Surveying Consultancy, Project Management Consultancy, Civil/Structural Engineering Consultancy and Construction management. The results revealed that 1.1%, 14.1%, 26.2%, 8.6%, 11.9%, 31.2%, and 6.8% of the respondents were Public Authority/Client Private Client/ Developer, Architectural Consultancy, Quantity Surveying Consultancy, Project Management Consultancy, Civil/Structural Engineering Consultancy and Construction management respectively. Table 4.2 shows that 22.2%, 31.9%, and 45.9% were Executive/Director/Owner Department head/unit, head/senior management staff (policymakers) respectively. The level of educational qualification of the respondents was also examined. The result presented in table 1 also shows that 39.0% of the respondents have Doctorate Degree,

while 50.9% of the respondents have Masters' degree, also 8.3% hold Bachelor's degree, while 1.8% and have Higher Diploma degree and related qualification. This infers that the respondents that partook in this study are well educated and knowledgeable. Hence, data gotten from them are valid and dependable. Moreover, the overall years of experience of the respondents within the organisation was analysed, the result showed that 38.3%, 34.4%, 22.3%, and 5.0% of the respondents have years of experience with the organizations in the range of 1– 10years, 11– 20years, 21-30years, and 30years and above total correspondingly. Moreso, the results in Table 4.1 shows that 23.3%, 34.3%, 29.0%, and 13.5% of the respondents have 1– 10years, 11 – 20years, 21-30years, and 30years and above overall years of experience in the construction sector respectively. It infers that majority of the respondents considered in this study have worked more 20 years with their respective organizations and in the industry. Therefore, the information gotten from them are reliable. The level of professional qualification of the respondents was analysed, the results revealed that 14.7%, 10.7%, 10.1%, 17.6%, 4.3%, 42.6%, 77.3% of the respondents are Project Managers, Quantity Surveyor, Builder, Construction Manager, Procurement personnel/officer, and Engineering (Civil, Mechanical, Electrical) respectively. Also, the extent of professional development is seen in their level of registration in their various professions. The result reveals 48.7%, 3.1%, 11.7%, 18.3%,18.2%, and 0.1% of the respondent are COREN, CORBON, ARCON, NSE, NICE, QSRBN members respectively. This revealed a high level of professional commitment and development on the part of the respondents. Moreover, other respondents' grade of membership was revealed. The result showed that 56.2%, 33.6% and 10.3% are Corporate, Associate and Fellow cadre respectively of their professional bodies. This implies that the respondents are people who have worked and committed themselves in construction practice, hence their contributions and responses are reliable. Furthermore, to show that the respondents have always involved in continuous professional development (CPD), the result reveal that 460 persons have had a CPD within the past ten years, while 261 have not engaged in the CPD training with the past ten years. It is can be concluded that since the number that enrolled in the CPD training are greater than those that have not, the 460-persons response is reliable and insightful. Also, the perception about BT in the construction sector was analysed. The result showed that 15% rate Low in their perception, 69.5% rated medium and 15.5% rated high level of perception about BT in project construction. It then implies that 69.5% is a good percentage judging from the overall percentage of respondents who participated in the study. This shows the respondent in this study have an average knowledge of BT. Additionally, the nature of construction projects was analysed. The result reveals that 60.2% executed new construction projects, 30.1% refurbishment construction projects, and 9.7%, a demolition construction projects respectively. This reveals that a greater percentage of 60.2% is been attributed to new construction project. Also, the ranges of the construction projects were examined revealing that 27.3% Up to 6months, 46.6% between 7-12 months, 11.4% between 13-18 months, 7.4% between 19-24 months, and 7.4% over 24 months' respondent executed and handed over their projects. The results reveals that the duration of 7-12 months had a highest percentage of project duration., while 13-24 months had the lowest duration. This implies that the project with the low duration is most likely to be delivered on time, compared to those with high project duration. Moreover, Table 4.2 also shows the type of construction projects of the respondents. These consist of building work, Civil engineering work, and Specialized work (example Mechanical, electrical and plumbing). The results reveal that 22.9%, 64.9% and 12.2% of the construction projects were building work, Civil engineering work, and Specialized work (e.g. Mechanical, electrical and plumbing) respectively. Also, table 1 shows BT trainings for construction practitioners of the respondents. The results reveal that 60.2% of the respondents were trained, while and 39.8% of the respondents were not trained. Finally, table 4.2 shows the percentage of the respondents who are members of professional bodies. The results reveal 97.8% are registered members of one or more profession, while 2.2% are not members of any professional body.

Table 1: Respondents Characteristics

Respondents Characteristics	Frequency	Percentage
Location of organization		
Abia	75	64.1
Akwa Ibom	92	66.1
Bayelsa	70	72.2
Cross river	84	58.7
Delta	86	64.7
Edo	85	57.0
Imo	75	71.4
Ondo	74	52.1
River	80	51.9
Category of respondents		
Public Authority/Client	8	1.1%
Private Client/ Developer	102	14.1%
Architectural Consultancy	189	26.2%
Quantity Surveying Consultancy	62	8.6%
Project Management Consultancy	86	11.9%
Civil/Structural Engineering Consultancy	225	31.2%
Construction management	49	6.8%
Total	635	100.0
Level in organization		
Executive/Director/Owner	160	22.2%
Department head/unit head/senior management staff	230	31.9%
Team leader/middle management staff /senior staff	331	45.9%
Total	721	100.0
Educational qualification		
PHD	281	39.0%
MSC	367	50.9%
BSC	60	8.3%
HND	13	1.8%
OND	0	0.0%
Total	721	100.0
Overall years of experience with organization		
1 -10	276	38.3%
11-20	248	34.4%
21-30	161	22.3%
30 and above	36	5.0%
Total	635	100.0
Overall years of experience in the industry organization		
1 -10	168	23.3%
11-20	247	34.3%
21-30	209	29.0%
30 and above	97	13.5%
Total	721	100.0
Professional Qualification		
Project Manager	106	14.7%
Quantity Surveyor	77	10.7%
Builder	73	10.1%
Construction Manager	127	17.6%
Procurement personnel/officer	31	4.3%
Engineering (Civil, Mechanical, Electrical)	307	42.6%
Professional body		
COREN	351	48.7%
CORBON	22	3.1%

ARCON	84	11.7%
NSE	132	18.3%
NICE	131	18.2%
QSRBN	1	0.1%
Total	721	100.0
Grade of membership		
Corporate	405	56.2%
Associate	242	33.6%
Fellow	74	10.3%
Total	721	100
Level of Continuous professional development (CPD) training relating to BT in construction within the past ten years	YES	460
	NO	261
Total		721
Perception about BT in Construction Projects		
LOW	108	15.0%
MEDIUM	501	69.5%
HIGH	112	15.5%
Total	721	100
Common nature of the projects		
New construction	434	60.2%
Refurbishment	217	30.1%
Demolition	70	9.7%
Total	721	100
Range of duration of Construction Projects		
Up to 6 months	197	27.3%
7 – 12 months	336	46.6%
13 – 18 months	82	11.4%
19 – 24 months	53	7.4%
Over 24 months	53	7.4%
Total	721	100
Type of the Construction Projects		
Building work	165	22.9%
Civil engineering work	468	64.9%
Specialized work (e. g. mechanical, electrical & plumbing	88	12.2%
Total	721	100 %
BT Training as a Construction Practitioner		
YES	434	60.2%
NO	287	39.8%
Member of Professional Body		
Yes	705	97.8%
No	16	2.2%
Total	721	100 %

4.2. Level of Implementation of Blockchain Technology among Construction Firms in the Nigerian Construction Industry

The result in Table 2 reveals the level of implementation of blockchain technology among Construction firms in the Nigerian Construction Industry (NCI) practices among construction firms in Nigeria. In line with the decision rule in this study, which states that blockchain technology implementation among firm in NCI with an overall mean score (MS) of 1.0-1.49, 1.5-2.49, 2.5-3.49, 3.5-4.49, and 4.5-5.0 is considered to have a very low level of implementation (VLLI); low level of implementation (LLI), moderate level of adoption (MLI), high level of implementation (HLI); and very high level of implementation (VHLI) respectively.

The following blockchain technology recorded moderate level of implementation among small construction firms. These include Protection of intellectual property held in digital assets created to represent product sets (MS= 2.7333), Internet applications (MS= 2.6867), and Waste Management (MS= 2.5967). However, Payment Channels and Peer Banking Services which is one of the most intriguing ideas being developed in the blockchain industry(MS=2.4867), Smart Contract which is a computer program that break down work into smaller, measurable work packages and automate the fulfilment and payment process(MS=2.4633), Anti-counterfeit solutions that involves authenticity of products is verified by the blockchain network consisting of all market participants in electronic commerce (producers, merchants, marketplaces)(MS=2.4500), and Digital Asset Registries which is a distributed ledger technology that provides the ability to record and transmit digital goods over the internet while ensuring that those goods cannot be copied or duplicated(MS=2.4233) had low level of implementation among small construction firms in the study area. Furthermore, decentralized internet of things which reliably stores the communication of smart devices within the internet of things(MS=2.3733), Insurance (real estate, automobiles, asset management) might be registered using the blockchain technology which allows Insurers to check the transaction history (MS=2.3700), supply chain management and circular economy (MS=2.3367), integration of blockchain technology in building maintenance system which provides a reliable integrated system that can give the full history of the project and trace every detail of the building back to its origin (MS=2.3367), crypto currencies where Networks and mediums of exchange use cryptography to secure transactions(MS=2.3367), Securities issuance, trading, and settlement where Companies going public issue shares directly and without a bank syndicate (MS=2.3267), and Decentralized storage involves sharing documents without the need of a third party by using a peer-to-peer distributed cloud storage platform(MS=2.2800), Economic development and finance: Project finance alternative whereby projects of significant social or economic value could be 'crowd funded' with a distributed ledger and token used to reward them for their investment(MS=2.2467), Value added to the proof of ownership, provenance/traceability of goods and management of shipping documentation(MS=2.1200) had low level of implementation/adoption among small construction firms. Other blockchain principles/processes that recorded low level of implementation/adoption among small construction include Public Blockchain which allows access to anyone when proof of work (POW) is presented, thereby conferring membership on anyone who contributes to the community(MS=2.0600), Creation of a logistics network to improve the percentage of return trips after delivering products from manufacturing facilities(MS=2.0367), Private Blockchain or permissioned blockchain usually rolls back the decentration of blockchain and would confer authority over transactions and access on a single owner(MS=2.0267), application of Blockchain-based systems in sustainability management to solve the problems of Inaccurate records, data loss, and data unavailability (MS=1.9833), Removal of intermediaries from the manufacturer-to-customer value chain to support direct sales from manufacturing(MS=1.9600), and Improved collaboration in the real-time BIM environment(1.9500). The overall mean score (MS=2.2567) implied that there is low level of implementation/adoption of blockchain technology in construction project delivery among small construction firms in the study area.

The results in Table 4.9 showed that the following blockchain technology recorded moderate level of implementation among medium construction firms. These include Payment Channels and Peer Banking Services which is one of the most intriguing ideas being developed in the blockchain industry(MS=2.8407), Supply Chain Management and Circular Economy (MS= 2.8136), Internet applications: instead of governments and corporations, Domain Name Servers (DNS) are controlled by every user in a decentralized way (MS= 2.7966), Smart Contract which is a computer program consisting of if/then statements that break down work into smaller, measurable work packages and automate the fulfilment and payment process (MS= 2.7458), Waste Management (MS=2.6881), Protection of intellectual property held in digital assets created to represent product sets (MS=2.6678), Digital Asset Registries which involves distributed ledger technology provides the ability to record and transmit digital goods over the internet

while ensuring that those goods cannot be copied or duplicated (MS=2.6475), and Public Blockchain allows access to anyone when proof of work (POW) is presented, thereby conferring membership on anyone who contributes to the community(MS=2.6034). Other blockchain technology processes/principles that were moderately implemented by medium construction firms include Insurance (real estate, automobiles, asset management) might be registered using the blockchain technology which helps Insurers to check the transaction history (MS=2.5966), crypto currencies where Networks and mediums of exchange use cryptography to secure transactions (MS=2.5898), Leapfrog Technology which is one of the most impactful uses of blockchains, could be as a leapfrog technology for global financial inclusion (MS=2.5729), integration of blockchain technology in building maintenance system which provides a reliable integrated system that can give the full history of the project and trace every detail of the building back to its origin (MS=2.5424), decentralized internet of things which reliably stores the communication of smart devices within the internet of things(MS=2.5356), and economic development and finance: Project finance alternative whereby projects of significant social or economic value could be 'crowd funded' with a distributed ledger and token used to reward them for their investment(MS=2.5051). However, some of the blockchain technology principles/practices had low level of implementation among medium construction firms. They include Improved collaboration in the real-time BIM environment(MS=2.4780), decentralized storage which involves sharing documents without the need of a third party by using a peer-to-peer distributed cloud storage platform(MS=2.4678), anti-counterfeit solutions that involves authenticity of products verified by the blockchain network consisting of all market participants in electronic commerce (producers, merchants, marketplaces)(MS=2.4136), creation of a logistics network to improve the percentage of return trips after delivering products from manufacturing facilities(MS=2.3864) application of Blockchain-based systems in sustainability management to solve the problems of Inaccurate records, data loss, and data unavailability (MS=2.3831), Value added to the proof of ownership, provenance/traceability of goods and management of shipping documentation(MS=2.3695), hybrid or consortium blockchain is a combination of the functions across establishment and entities that work in partnership over the blockchain(MS=2.3288), decentralized proof of existence of documents: Storing and validating the signature and timestamp of a document using blockchain(MS=2.3153), private blockchain or permissioned blockchain has been executed which usually rolls back the decentration of blockchain and would confer authority over transactions and access on a single owner (MS=2.2542), Securities issuance, trading, and settlement where Companies going public issue shares directly and without a bank syndicate(MS=2.1932), improved financing and hire of Construction plant and equipment (MS=2.1966), and removal of intermediaries from the manufacturer-to-customer value chain to support direct sales from manufacturing(MS=2.0949). The overall mean score (MS=2.5011), indicated that there is moderate level of implementation/adoption of blockchain technology among medium construction firms operating in the study area.

The results in Table 2 showed that the following blockchain technology recorded moderate level of implementation among large construction firms operating in the study area. These include Protection of intellectual property held in digital assets created to represent product sets (MS=2.9048), Internet applications: Instead of governments and corporations, Domain Name Servers (DNS) are controlled by every user in a decentralized way (MS=2.8016), Supply Chain Management and Circular Economy (MS=2.8016), insurance of (real estate, automobiles, asset management) might be registered using the blockchain technology. Insurers can check the transaction history (MS=2.7857), Smart Contract which is a computer program consisting of if/then statements that break down work into smaller, measurable work packages and automate the fulfilment and payment process (MS= 2.7619), Payment Channels and Peer Banking Services is one of the most intriguing ideas being developed in the blockchain industry (MS=2.7222), Private Blockchain or permissioned blockchain which usually rolls back the decentration of blockchain and would confer authority over transactions and access on a single owner (MS= 2.6429), waste Management (MS=2.6349), Leapfrog Technology is one of the most impactful uses of blockchains as a leapfrog technology for global

financial inclusion (MS=.2.6190), Digital Asset Registries which involves distributed ledger technology provides the ability to record and transmit digital goods over the internet while ensuring that those goods cannot be copied or duplicated (MS=2.6111), anti-counterfeit solutions that involves authenticity of products verified by the blockchain network consisting of all market participants in electronic commerce (producers, merchants, marketplaces) (MS=2.6032), integration of blockchain technology in building maintenance system which provides a reliable integrated system that can give the full history of the project and trace every detail of the building back to its origin (MS=2.5873), creation of a logistics network to improve the percentage of return trips after delivering products from manufacturing facilities(MS=2.5556), Decentralized storage for Sharing documents without the need of a third party by using a peer-to-peer distributed cloud storage platform(MS=2.5556), economic development and finance: Project finance alternative whereby projects of significant social or economic value could be 'crowd funded' with a distributed ledger and token used to reward them for their investment (MS=2.5317), application of Blockchain-based systems in sustainability management to solve the problems of Inaccurate records, data loss, and data unavailability (MS=2.5159), crypto currencies where Networks and mediums of exchange use cryptography to secure transactions (MS=2.5159), and hybrid or consortium blockchain, a combination of the functions across establishment and entities that work in partnership over the blockchain(MS=2.5079). Moreso, some of the blockchain technology principles/processes that recorded low level of implementation/adoption among large construction firms include Securities issuance, trading, and settlement where Companies going public issue shares directly and without a bank syndicate (MS=2.4683), decentralized internet of things which reliably stores the communication of smart devices within the internet of things(MS=2.4603), Value added to the proof of ownership, provenance/traceability of goods and management of shipping documentation (MS=2.4206), Public Blockchain which allows access to anyone when proof of work (POW) is presented, thereby conferring membership on anyone who contributes to the community(MS=2.4127), removal of intermediaries from the manufacturer-to-customer value chain to support direct sales from manufacturing (MS=2.3889), Improved collaboration in the real-time BIM environment(MS=2.3810), Decentralized proof of existence of documents: Storing and validating the signature and timestamp of a document using blockchain(MS=2.1667), and improved financing and hire of Construction plant and equipment(MS=2.0079). The overall mean score (MS=2.5525) showed that there is moderate level of implementation/adoption of blockchain technology among large construction firms operating in the study area.

The combined mean score in table 2 implies that Protection of intellectual property held in digital assets created to represent product sets(MS=2.7686), Internet applications (MS= 2.7616), Smart Contract: a computer program consisting of if/then statements that break down work into smaller, measurable work packages and automate the fulfilment and payment process (MS= 2.6570), Supply Chain Management and Circular Economy (MS= 2.6506), Insurance (MS= 2.5841), and protection of intellectual property held in digital assets created to represent product sets recorded a moderate level of implementation of BT in the Nigerian construction industry (NCI). While, the combined mean score also reveals that Public Blockchain (MS= 2.3587), Private Blockchain(MS= 2.3079), Hybrid or Consortium Blockchain (MS= 2.2689), Crypto currencies (MS= 2.4808), Securities issuance, trading, and settlement (MS=2.3294), Decentralized proof of existence of documents (MS= 2.1462), Decentralized storage (MS=2.4345), Decentralized internet of things (MS=2.4564), Anti-counterfeit solutions (MS= 2.4889) recorded a low level of implementation among construction firms in the Nigerian construction industry. The overall mean score (MS=2.4367), indicated that there is low level of implementation/adoption of blockchain technology among the construction firms in the Nigerian construction sector.

Table 2: Level of BT Implementation in the Nigerian Construction Industry

Level of BT Implementation **Types of BT Applications**	**Small Firm** **Mean score**	**Medium Firm** **Mean score**	**Large Firm** **Mean score**	**Combined** **Mean score**	**Remark**
Public Blockchain it allows access to anyone when proof of work (POW) is presented, thereby conferring membership on anyone who contributes to the community	2.0600	2.6034	2.4127	2.3587	LLIMP
Private Blockchain or permissioned blockchain has been executed which usually rolls back the decentration of blockchain and would confer authority over transactions and access on a single owner.	2.0267	2.2542	2.6429	2.3079	LLIMP
Hybrid or Consortium Blockchain is a combination of the above two, which often functions across establishment and entities that work in partnership over the blockchain.	1.9700	2.3288	2.5079	2.2689	LLIMP
Crypto currencies: Networks and mediums of exchange using cryptography to secure transactions	2.3367	2.5898	2.5159	2.4808	LLIMP
Securities issuance, trading, and settlement: Companies going public issue shares directly and without a bank syndicate	2.3267	2.1932	2.4683	2.3294	LLIMP
Insurance: Properties (e.g., real estate, automobiles, asset management etc.) might be registered using the blockchain technology. Insurers can check the transaction history	2.3700	2.5966	2.7857	2.5841	MLIMP
Decentralized proof of existence of documents: Storing and validating the signature and timestamp of a document using blockchain	1.9567	2.3153	2.1667	2.1462	LLIMP
Decentralized storage: Sharing documents without the need of a third party by using a peer-to-peer distributed cloud storage platform.	2.2800	2.4678	2.5556	2.4345	LLIMP
Decentralized internet of things: The blockchain reliably stores the communication of smart devices within the internet of things	2.3733	2.5356	2.4603	2.4564	LLIMP
Anti-counterfeit solutions: Authenticity of products is verified by the blockchain network consisting of all market participants in electronic commerce (producers, merchants, marketplaces)	2.4500	2.4136	2.6032	2.4889	LLIMP
Internet applications: Instead of governments and corporations, Domain Name Servers (DNS) are controlled by every user in a decentralized way	2.6867	2.7966	2.8016	2.7616	MLIMP
Smart Contract: A smart contract can be described as a computer program consisting of if/then statements that break down work into smaller, measurable work packages and automate the fulfilment and payment process	2.4633	2.7458	2.7619	2.6570	MLIMP

Level of BT Implementation **Types of BT Applications**	**Small Firm** **Mean score**	**Medium Firm** **Mean score**	**Large Firm** **Mean score**	**Combined** **Mean score**	**Remark**
Supply Chain Management and Circular Economy: The decentralized and fragmented structure of the supply chain in the construction industry fits very well into the decentralized billing system of the blockchain. Blockchain can provide the necessary infrastructure.	2.3367	2.8136	2.8016	2.6506	MLIMP
Facility Management: Blockchain integration in building maintenance system would provide a reliable integrated system that can give the full history of the project and trace every detail of the building back to its origin.	2.3367	2.5424	2.5873	2.4888	LLIMP
Digital Asset Registries: This distributed ledger technology provides the ability to record and transmit digital goods over the internet while ensuring that those goods cannot be copied or duplicated	2.4233	2.6475	2.6111	2.5606	MLIMP
Leapfrog Technology: One of the most impactful uses of blockchains could be as a leapfrog technology for global financial inclusion. This type of FinTech solutions (i.e., financial technology: financial services delivered through technology) could have th	2.2700	2.5729	2.6190	2.4873	LLIMP
Payment Channels and Peer Banking Services: One of the most intriguing ideas being developed in the blockchain industry is effective payment channels.	2.4867	2.8407	2.7222	2.6832	MLIMP
Waste Management: Blockchain technology can be used for proper energy management in the built environment	2.5967	2.6881	2.6349	2.6399	MLIMP
Sustainability management: Inaccurate records, data loss, and data unavailability are among the top challenges in managing and tracking sustainability Blockchain-based systems can resolve these data-related issues. data-related problems on a significant l	1.9833	2.3831	2.5159	2.2941	LLIMP
Economic development and finance: Project finance alternative whereby projects of significant social or economic value could be 'crowd funded' with a distributed ledger and token used to reward them for their investment.	2.2467	2.5051	2.5317	2.4278	LLIMP
Supply chain & logistics					
Value added to the proof of ownership, provenance/traceability of goods and management of shipping documentation	2.1200	2.3695	2.4206	2.3034	LLIMP
Creation of a logistics network to improve the percentage of return trips after delivering products from manufacturing facilities	2.0367	2.3864	2.5556	2.3262	LLIMP
Removal of intermediaries from the manufacturer-to-customer value chain to support direct sales from manufacturing	1.9600	2.0949	2.3889	2.1479	LLIMP
Improved financing and hire of Construction plant and equipment	1.8933	2.1966	2.0079	2.0326	LLIMP

Level of BT Implementation **Types of BT Applications**	**Small Firm** **Mean score**	**Medium Firm** **Mean score**	**Large Firm** **Mean score**	**Combined** **Mean score**	**Remark**
Design					
Improved collaboration in the real-time BIM environment	1.9500	2.4780	2.3810	2.2697	LLIMP
Protection of intellectual property held in digital assets created to represent product sets	2.7333	2.6678	2.9048	2.7686	MLIMP
Average Mean Score	**2.2567**	**2.5011**	**2.5525**	**2.4367**	

4.3. Difference in the Level of Implementation of Blockchain Technology among Construction Firms in the Nigerian Construction Industry

Table 3 shows the result of Kruskal Wallis test that was conducted to test the second hypothesis which states that there is no significant difference in the level of implementation of Blockchain Technology among in Construction Firms in the Nigerian Construction Industry. The P-value of 0.001 is less than 0.05 significance level, hence the hypothesis was rejected. This indicates that there is a significant difference in the level of implementation of Blockchain Technology among in Construction Firms in the Nigerian Construction Industry.

Table 3: Kruskal Wallis Test for Comparing the Level of Implementation of BT among Construction Firms in the Nigerian Construction Industry

Level of Implementation of Construction Firms on Blockchain Technology in The Nigerian Construction Industry	Mean Rank	Decision @ 0.05 Sig. level.
Small Firm	23.38	
Medium Firm	44.62	
Large firm	50.50	
Chi- Square	20.603	
D.F	2	
P-Value	.001	Reject

4.4. Post Hoc Test on the Level of Implementation of Blockchain Technology among Construction Firms in the Nigerian Construction Industry

The result of post hoc test on level of implementation of blockchain technology among construction firms in the Nigerian construction industry is shown in Table 4 Because of the significant level in the level of implementation of blockchain technology among construction firms in the Nigerian construction industry, a post hoc test was conducted on the firm size using Bonferroni and Dunnest test (Bonferroni-Dunn test) to determine the source(s) of the difference. The result of Bonferroni's multiple comparisons and Dunnest test show that small construction firm is the source of the variation/ difference. This was validated by Dunnest test result which showed that the other firm size P-values greater than 0.05 significant level, except small firm which has the P-value (0.001) less than 0.05. This implies that the extent of implementation of blockchain technology among small construction firms is significantly different from medium and large construction in the Nigerian construction industry

Table 4: Post Hoc Test on the Level of Implementation of Blockchain Technology among Construction Firms in the Nigerian Construction Industry

	(I) Firm Size	(J) Firm Size	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval	
						Lower Bound	Upper Bound
Bonferroni	Small Firm	Medium firm	-.24438*	.05933	.000	-.3897	-.0991
		Large firm	-.29583*	.05933	.000	-.4411	-.1505
	Medium firm	Small Firm	.24438*	.05933	.000	.0991	.3897
		Large firm	-.05146	.05933	1.000	-.1967	.0938
	Large firm	Small Firm	.29583*	.05933	.000	.1505	.4411
		Medium firm	.05146	.05933	1.000	-.0938	.1967
Dunnett t (2-sided) [b]	Small firm	Large firm	-.29583*	.05933	.000	-.4296	-.1621
	Medium firm	Large firm	-.05146	.05933	.593	-.1852	.0823

* The mean difference is significant at the 0.05 level.

b. Dunnett t-tests treat one group as a control, and compare all other groups against it.

4.5. Discussion of Findings

The study showed that Protection of intellectual property held in digital assets created to represent product sets, Internet applications, smart contract: a computer program consisting of if/then statements that break down work into smaller, measurable work packages and automate the fulfilment and payment process, supply chain management and circular economy, insurance, and protection of intellectual property held in digital assets created to represent product sets recorded a moderate level of implementation of Blockchain technology in the Nigerian construction industry (NCI). While, the combined mean score revealed that Public Blockchain, Private Blockchain, Hybrid or Consortium Blockchain, Crypto currencies, Securities issuance, trading, and settlement, decentralized proof of existence of documents, decentralized storage, decentralized internet of things, and anti-counterfeit solutions recorded a low level of implementation among construction firms in the Nigerian construction industry. The overall mean score (MS=2.4367), indicated that there is low level of implementation/adoption of blockchain technology among the construction firms in the Nigerian construction sector. This low level of implementation/adoption of blockchain technology can be attributed to lack of knowledge, lack of education, absence of construction ICT driven policy via an institutional framework, reluctance to adopt, and lack of top management commitment. The result of hypothesis which states that there is no significant difference in the level of implementation of Blockchain Technology among Construction Firms in the Nigerian Construction Industry revealed that there is a significant difference in the level of implementation of blockchain technology among small, medium, and large construction firms, hence the hypothesis was rejected.

Because of the difference in the level of implementation among the construction firms, a posthoc test was carried out to know the source of difference/variation. The result of the posthoc test revealed that the extent of implementation of blockchain technology among small construction firms is significantly different from medium and large construction in the Nigerian construction industry. This could be attributed to the financial, and technical capacity of the small construction firms. This could also be due to the barriers that exist, namely lack of awareness, high cost of implementation, and resistance to change. This study is in consonance with Ebekozien *et al.*, (2021) who

posited that Blockchain Technology implementation is still in an early stage, particularly in developing nations like Nigeria. The result of this study is also in line with Abodei *et al.,* (2019), Ajao *et al.,* (2019), Jimoh *et al.,* (2019) and Akaba *et al.,* (2020) who acknowledged the low implementation of blockchain technology in the Nigerian.

5. CONCLUSION AND RECOMMENDATIONS

This study assessed the level of implementation of blockchain technology in construction project delivery in the Nigerian construction industry. The study also tested the hypothesis which states that there is no significant difference in the level of implementation of Blockchain Technology among Construction Firms in the Nigerian construction Industry. The result revealed that the level of implementation of blockchain technology is low among construction firms in the Nigerian construction sector. There is a significant difference in the level of implementation of blockchain technology based on firm size. The study concluded that firm characteristics have significant impact on the level of implementation of blockchain technology. The study recommends that construction firms should create awareness of BT among top management and other staff through seminars and workshops. Top management staff and other staff of the firms should be trained on BT so as to improve the level of implementation of BT in project delivery in the Nigerian construction industry. Government should pass into law, legislations that would encourage the implementation of construction ICT driven policy via an institutional framework in Nigeria.

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