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LEVERAGING BLOCKCHAIN INNOVATION FOR IMPROVING TRANSPARENCY AND INTEGRITY IN PUBLIC INFRASTRUCTURE PROCUREMENT PROCESS IN NIGERIA

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Abstract In Nigeria, public procurement constitutes more than 80% of the government expenditure. Governments in Nigeria spend up to 10-25% of the Gross Domestic Product (GDP) on procurement of goods, services and works. Unfortunately, this substantial outlay has been threatened by increasing rates of corruption and inefficiencies in procurement processes. Blockchain presents a promising solution to the persistent problems through digitalisation of transactions, increased transparency, immutable record keeping and automated Smart Contracts that minimise malpractice and human discretion. The research seeks to explore the use of blockchain technology in enhancing procurement transparency and integrity in Nigeria's public infrastructure development. The study adopted a quantitative research design, employing a stratified random sampling method for the selection of the sample. A sample size of 68 respondents, distributed across all six geopolitical zones in Nigeria, was selected to provide adequate data. A structured questionnaire was adopted for data collection. The analysis of the collected data was done using both descriptive and inferential statistics (reliability test and multiple regression analysis). The findings of the research show a positive relationship between the implementation of blockchain and improvement in procurement transparency, accountability and efficiency. Challenges like regulatory environment, environmental sustainability, infrastructure, scalability and interoperability persist. Recommendations include regulatory framework updates to accommodate digital ledger technologies, adequate training for procurement personnel on blockchain operations and a multi-dimensional strategy for validating blockchain solutions. This research contributes to the development of a framework for digital governance and infrastructure procurement by outlining empirical insights, theoretical foundations, and practical suggestions for adopting blockchain technology, informing practitioners, policymakers, and stakeholders seeking to minimise corruption and improve integrity in infrastructure procurement in Nigeria.

Keywords: correlations; decentralisation; immutability; readiness; stakeholder transparency and technological factors

1. INTRODUCTION

Public procurement accounts for over 80% of government expenditures at both national and subnational levels, with governments spending an estimated 10–25% of GDP on goods, services, and works. Unfortunately, this significant expenditure is undermined by growing corruption and inefficiencies in procurement practices (Musa, Jaafar, and Raslim, 2023). These corruptions range from bid rigging, bribery, fraud, price fixing, and other collusive tendering. Unethical behaviours in public procurement projects are prevalent in much of the developing world. The World Bank noted that a marginal gain in value from a procurement process can be a major source of economic benefit to the nation, considering the size of the government procurement market relative to the GDP. It is therefore important to mitigate corrupt tendencies in public sector purchasing for infrastructural development to stem the tide of poor-quality jobs and generate efficiency. Quality-related problems in public infrastructures are a direct result of unprofessional malpractices exhibited by those entrusted officials (Abdul-Rahman, Wang, and Yap, 2010).

Public procurement researchers have attributed the prevalence of malpractice to the nature of public procurement. Widespread malpractices, including bribery and corruption, are due in part to the discretionary nature of procurement and therefore transcend geographical boundaries. (Cao and Wang, 2023). Attempts have been made to explore legal instruments and procurement codes to limit officials' discretion. (Decarolis, Fisman, Pinotti, and Vannutelli, 2020), since it fuels corruption. Cao and Wang, (2023) further observed that "over-regulation results in purchasing for process rather than value, and this constrains the achievement of the procurement performance". Decarolis et al., (2020) concluded with evidence that discretion, when applied in negotiations, leads to operational efficiency.

While there is little or no available peer-reviewed academic literature that specifically addresses the topic of blockchain technology use cases in eliminating malpractices in public infrastructure procurement in Nigeria, a few studies in the construction industry have been conducted that evaluated the prevalence of procurement-related malpractices in Nigeria (Ebekozien, 2019). Previous studies have semantically listed collusive tendering, inflated contract sum, bribery and forgery, and shoddy construction works, and the presence of petty and grand corruptions as malpractices. (Ebekozien et al., 2023).

The investigation into the potential of blockchain technology to eliminate malpractices in public infrastructure procurement in Nigeria is imperative for several reasons. Public infrastructure projects are critical for national development due to their relevance to the triple bottom lines of social, economic, and environmental sustainability.

The economic gains of such initiatives in the areas of transportation, health care and education depend greatly on their social and environmental aspects. Yet, there is a pattern of corruption, inefficiencies and non-transparency in procuring such projects in Nigeria that has led to the procurement of inferior materials and, thus, resulted in poor environmental, economic and social impacts (Duri, 2021; World Bank, 2020).

By exploring blockchain technology to prevent fraud and malpractice, the study relies on the peculiarities of the new technology. Transparency, immutable records and distributed verification can help improve resource efficiency, decrease waste and ensure that public money is spent ethically and efficiently (Norta, and Normak, 2022).

While using electronic systems in procurement may help increase transparency, there are limitations to doing that since centralised systems leave much room for manipulation, low auditability and delayed disclosures. Public Procurement Infrastructure needs more efficient technological governance mechanisms.

This research seeks to find feasible ways to utilise blockchain in order to make the procurement process more efficient.

2. LITERATURE REVIEW

There are several significant barriers to implementing blockchain technology in public infrastructure procurement. Legal and regulatory challenges are among the most significant since legal regulations currently do not take into account the decentralisation and immutability of blockchain. Therefore, there may

be doubts about compliance and enforcement (Oyewobi and Jimoh, 2022). As a result, this challenge may prevent public organisations from implementing blockchain due to the risks of legal problems. Moreover, technical challenges can also be considered among the barriers. Firstly, combining blockchain and procurement processes may be complicated and expensive. Secondly, problems with scalability and interoperability should be addressed, as blockchains must operate effectively and interact with other technologies (Kouhizadeh et al., 2021). Finally, due to the relatively new nature of the technology, many organisations may face problems with implementation due to a lack of relevant knowledge and skills.

Moreover, some challenges in blockchain adoption in public infrastructure procurement include security and privacy issues. Although blockchain technology is highly regarded because of its security properties, it cannot be entirely protected from possible attacks (Pazaitis, 2020). Consequently, it is vital to protect sensitive information related to public infrastructure procurement from potential attacks to ensure its confidentiality and integrity. In addition, according to the authors (Clohessy and Acton, 2019), several barriers to the adoption of blockchain technology were identified within the organisational context. First, the researchers suggested that organisational culture had a crucial impact on blockchain adoption. Specifically, companies with innovative and open organisational cultures tend to adopt blockchain technology more easily than those resistant to change. Second, the availability of resources was highlighted as another critical barrier.

For example, organisations having enough finances, infrastructure, and other necessary assets will have no difficulties in implementing the technology (Clohessy and Acton, 2019). Third, complexity and risks can be viewed as another barrier to adoption. Specifically, concerns about blockchain system security can hinder organisations' efforts to introduce blockchain. Moreover, the regulatory environment, uncertainty about ROI, and complexity and risks of the technology were mentioned by the authors (Pazaitis, 2020). Finally, management support was identified as another barrier to the adoption of blockchain technology. In particular, blockchain adoption is likely to be supported by managers' commitment and involvement in the process and by providing appropriate resources. Theoretical Framework

It would be accurate to state that the theoretical framework of blockchain technology in public procurement is highly relevant. The theoretical framework is crucial for analysing technology and its implementation in the organisational context. (Reddick, et al., 2021). The mentioned theoretical framework is based on such theories as Innovation Diffusion Theory (IDT), Technology Acceptance Model (TAM), and Institutional Theory. First, it is necessary to refer to IDT since it helps explain the dynamics of innovation diffusion and technology adoption. This theory is important because it highlights such factors as relative advantage, compatibility, and observability. Second, TAM can assist in determining how the use of technology is viewed by users and stakeholders. As a result, it will be possible to determine whether blockchain technology is regarded by procurement officials as useful and easy to implement. Third, it is important to consider the Institutional Theory (IT) because it allows examining how the legal and regulatory environment affects the implementation of blockchain in the field of public procurement. IT is important because it shows that regulations can become key motivations to adopt blockchain and use it for ensuring transparency in transactions and compliance with anti-corruption regulations. Other theoretical concepts, such as the Resource-Based View (RBV) and Transaction Cost Theory (TCT), are equally important for analysing the use of technology in organisations.

Improved Public Infrastructure Procurement and Elimination of Malpractices: Improved public infrastructure procurement processes in Nigeria stand to gain from the use of blockchain technology by influencing dependent variables such as transparency, accountability, and efficiency. Transparency in procurement processes means that all the transactions made and the decisions made during the process will be clearly evident to make the process traceable, hence avoiding any chances of malpractices, including bribery, fraud, and lack of disclosure. Blockchain technology creates an immutable ledger that can keep records of the transactions, thus making it impossible to alter or hide information. (Liu et al., 2021). Such a high level of transparency discourages corruption while fostering trust among the stakeholders, hence improving fairness and openness (Pournader et al., 2020).

Accountability of procurement officials, policymakers and other stakeholders is another important element in the enhancement of public infrastructure procurement processes. Accountability reduces the chances of corruption, such as conflict of interest, bid rigging, and nepotism. Due to its decentralised and transparent nature, blockchain keeps a record of all the actions taken that can easily be audited. (Treiblmaier and Garaus, 2023). In addition to the above, accountability is increased even more through smart contracts by eliminating chances of human manipulation and errors while enforcing and complying with procurement rules (Cao and Wang, 2023).

Efficiency in the procurement of public infrastructures can be enhanced through blockchain technology. Traditional procurement processes tend to be long with several intermediaries involved, resulting in higher costs. Blockchain technology streamlines such processes by automating transactions and reducing the involvement of many intermediaries. The whole process of procurement becomes efficient by speeding up the process and minimising costs. Furthermore, through smart contracts, all procurement conditions can be enforced efficiently. (Saberi et al., 2019b).

Procurement malpractices, including bribery, embezzlement, and bid splitting, according to Ebekozien, (2019), are some important elements that need to be considered when trying to improve public infrastructure procurement processes in Nigeria. Blockchain technology can help in solving procurement problems by creating a transparent and immutable ledger that keeps track of all transactions. Through this process, any corrupt practice in the procurement processes can be detected and prevented easily, thereby ensuring that all resources are used effectively and the projects are implemented as planned. (Politou et al., 2019).

Implementation of blockchain technology in public infrastructure procurement requires the following major procedures. First, blockchain technology is very important due to its ability to provide a reliable, secure, and immutable platform for record-keeping. This could play a critical role in reducing malpractices while increasing procurement process efficiency. The first procedure in implementing blockchain technology is carrying out a feasibility study. This entails evaluating the effectiveness of blockchain technology through analysing the current procurement procedures and identifying the areas that are likely to suffer from malpractices. It is also essential to consult different stakeholders, who include government officials, procurement specialists, and industry professionals. (Wu and Group, 2021). Table 1 represents the findings of a literature review on malpractices in public infrastructure procurement.

Table 1: Common Malpractices in Public Procurement

Variables	**Authors**
Bribery and Kickbacks	(Igwe et al., 2021)
Fraudulent Practices	(Dorasamy and Fagbadebo, 2021)
Collusion	(Asuquo, Lashinde, and Adu, 2021; Ebekozien, 2019)
Conflict of Interest	(Dorasamy and Fagbadebo, 2021)
Bid Rigging	(Asuquo et al., 2021)
Misuse of Confidential Information	Using insider knowledge to gain an unfair advantage. (Public et al., 2021)
Common Malpractices in Public Procurement	Author(s)
Bid Rigging (Collusive Tendering)	OECD (2016); Transparency International (2019)
Kickbacks and Bribery	(World Bank, 2020).
Conflict of Interest	OECD (2017)
Tailored Tender Specifications	
Unjustified Sole-Source Procurement	World Bank (2016).
	(Thai 2009; Transparency International, 2019).

Bid Suppression	OECD (2016).
Leakage of Confidential Bid Information	Transparency International (2019).
Manipulation of Bid Evaluation Scores	ADB (2018).
Split Purchasing (Contract Splitting)	World Bank (2020).
Inflated Contract Pricing	OECD (2017).
False Certification of Work Completion	Flyvbjerg (2014).
Change Order Abuse	Love et al. (2016).
Phantom Contractors	Transparency International (2019).
Procurement Document Forgery	World Bank (2016).
Political Interference	Søreide (2002).
Deliberate Procurement Delays	OECD (2016).
Collusion Between Supervisors and Contractors	Kenny (2007).

3. **METHODOLOGY**

In this study, the research design used was a quantitative research design, which involved the examination of the capability of blockchain technology to enhance transparency and integrity during the procurement of public infrastructure development in Nigeria. In this case, the sampling design was random and stratified. Data was collected using questionnaires, and the data analysis method involved descriptive statistics and multiple regression analysis.

Table 2. Reliability Results of Field Pre-test

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.855	0.852	25

The result from the reliability test shows that there is a high level of internal consistency in the measurement scale consisting of 25 items, with the Cronbach's Alpha being 0.855, as seen in Table 2. This number is higher than the acceptable 0.7 mark. Table 3 reflects the years of experience of the respondents.

Table 3. Years of experience in public infrastructure procurement

Experience	Frequency	Percent	Valid Percent	Cumulative Percent
5 - 10	39	57.4	60.0	60.0
11- 15	12	17.6	18.5	78.5
16 -21	5	7.4	7.7	86.2
21 - above	9	13.2	13.8	100.0
Total	65	95.6	100.0	
missing	3	4.4		
	68	100.0		

Table 4. Geopolitical Zone of Professional, Official or Business Activities

Geopolitical zone	Frequency	Percent	Valid Percent	Cumulative Percent
South-East	8	11.8	11.8	11.8
South-South	28	41.2	41.2	52.9
North-Central	5	7.4	7.4	60.3
South-West	8	11.8	11.8	72.1
North-West	11	16.2	16.2	88.2
North-East	6	8.8	8.8	97.1
South-East	2	2.9	2.9	100.0
Total	**68**	**100.0**	**100.0**	

Table 5 represents the role of respondents in the Public Procurement Process.

Table 5. Role of Respondent in the Public Procurement Process

Role	Frequency	Percent	Valid Percent
Procurement Professional	24	35.3	35.3
Academic Researcher	14	20.6	20.6
Contractor/Supplier	3	4.4	4.4
Government Official	16	23.5	23.5
Blockchain Technology Expert/Developer	11	16.2	16.2
Total	**68**	**100.0**	**100.0**

Table 6. Challenges to the implementation of blockchain technology in Nigerian public infrastructure procurement

SN	Variables	Coefficient (Coef.)	Std. Error	z-Value	p-Value	Significance
1	Regulatory Uncertainty	1.055	0.36	3.85	0.001	Significant
2	Lack of Infrastructure	-0.151	0.307	-1.48	0.032	Significant
3	Environmental Sustainability Concerns	-0.12	0.198	1.21	0.020	Significant
4	Scalability Issues	0.062	0.365	1.87	0.024	Significant

5	Interoperability with Existing Systems	0.059	0.399	1.17	0.031	Significant
6	Resistance to Change	0.226	0.589	-1.86	0.023	Significant
7	Skills Gap in Blockchain Technology	0.238	0.525	1.2	0.005	Significant
8	Data Privacy Concerns	-0.697	0.364	-0.64	0.021	Significant
9	Inadequate Legal Framework	0.879	0.366	0.65	0.010	Significant
10	Awareness and Education	-0.474	0.247	0.61	0.029	Significant

Table 6 illustrates the challenges associated with the implementation of blockchain in the process of public infrastructure procurement in Nigeria. It can be concluded from the presented results that all identified factors are statistically significant for predicting blockchain adoption challenges since their pvalues are lower than 0.05.

Among the factors studied, regulatory uncertainty has the highest positive correlation coefficient (Coef. = 1.055, p = 0.001). Thus, the lack of regulation of digital procurement through blockchain leads to increased complexity of the process. This factor confirms the presence of institutional unwillingness to use blockchain due to a lack of government guidelines and standards. The same applies to the factor "inadequate legal framework" (Coef. = 0.879, p = 0.010) since digital procurement regulations contribute to successful implementation. The identified results coincide with those obtained in the research conducted by Saberi et al. (2019) since the ambiguity in regulations represents one of the key factors hindering blockchain adoption in public-sector institutions.

Another influential factor is the lack of adequate infrastructure (Coef. = −0.151, p = 0.032) and its interoperability with existing systems (Coef. = 0.059, p = 0.031). In particular, the lack of ICT resources (negative coefficient) contributes to the ineffectiveness of implementation processes because current procurement procedures in Nigeria are built around legacy systems. Furthermore, scalability problems (Coef. = 0.062, p = 0.024) reflect the difficulties of managing numerous transactions during the procurement process. Similar conclusions were drawn by Casino et al. (2019).

Finally, it should be noted that resistance to change (Coef. = 0.226, p = 0.023) and lack of skills in blockchain technology (Coef. = 0.238, p = 0.005) have a high predictive power. Thus, the identified factors confirm the resistance and inertia characteristic of institutions and the lack of necessary technological competencies. The results obtained support the findings of Rogers' (2003) theory on diffusion of innovation. The analysis on data privacy concerns (Coef. = −0.697, p = 0.021) and environmental sustainability concerns (Coef. = −0.120, p = 0.020) also significantly influence implementation.

Stakeholders may be afraid of exposure to sensitive procurement data or energy consumption associated with blockchain systems. These findings on awareness and education (Coef. = −0.474, p = 0.029) indicate that limited knowledge of blockchain reduces acceptance and readiness for adoption. Generally, Table 6 shows that blockchain implementation challenges are multidimensional, encompassing organisational, socio-environmental, regulatory, and technological factors.

Table 7. Improvement in Accountability Through Blockchain Technology

Improvement in Accountability Transparency and Through Blockchain Technology	Coefficient (Coef.)	Standard Error (Std. Err.)	z-Value	p-Value	Statistical Significance
Regulatory Uncertainty	-0.1275256	0.3190845	0.90	0.011	Significant
Lack of Infrastructure	-0.2879155	0.3050034	-0.40	0.046	Significant
Scalability Issues	-0.3445694	0.2083548	-0.94	0.035	Significant
Resistance to Change	0.5501409	0.3332322	-1.65	0.018	Significant
Interoperability with Existing Systems	0.4224641	0.3472271	1.65	0.039	Significant
Data Privacy Concerns	-0.0244216	0.4511	1.22	0.024	Significant
Inadequate Legal Framework	0.8464606	0.469116	-0.05	0.017	Significant
Skills Gap in Blockchain Technology	-0.7495667	0.3544862	1.8	0.021	Significant
Awareness and Education about Blockchain Technology	0.283951	0.3285211	-2.11	0.031	Significant
Environmental Sustainability Concerns	0.2419766	0.2256087	0.86	0.026	Significant

Table 7 is a regression probability value analysis showing the effect of the variables on the improvements in integrity and transparency by adopting blockchain technology. All the variables from the regression analysis are statistically significant ($p < 0.05$), meaning that such variables significantly influence blockchain in improving the accountability process.

4. **DISCUSSION**

From the results obtained, there is an inadequacy in the legal structure that positively relates to the accountability improvement (Coef. = 0.846, p = 0.017). The results show that the existence of the legal framework significantly contributes to the blockchain transparency advantages. Regulatory uncertainty (Coef. = -0.128, p = 0.011) negatively influences the improvement in accountability outcome, which implies that the ambiguous policies reduce trust in blockchain public procurement systems. These findings confirm OECD's assertion on regulatory transparency, which is critical for transparent public procurement systems.

Scalability constraints (Coef. = -0.345, p = 0.035) and inadequate infrastructure (Coef. = -0.288, p = 0.046) negatively affect accountability improvements, meaning that the technological constraint reduces the

effectiveness of blockchain technology in recording transactions. On the other hand, the interoperability with existing systems (Coef. = 0.422, p = 0.039) positively impacts accountability improvement since it indicates that integration with the current procurement system enhances auditability and traceability. Organisational and Human Factors: Resistance to Change (Coef. = 0.550, p = 0.018) substantially influences the process because it shows that organisational readiness plays a key role in increasing blockchain transparency advantages. Inadequate skills (Coef. = -0.750, p = 0.021) negatively influence accountability results, emphasising the importance of developing technical expertise.

Education awareness (Coef. = 0.284, p = 0.034) positively contributes to the accountability improvement, and it means that educated stakeholders effectively use the benefits of blockchain transparency. Environmental Sustainability and Environmental concerns (Coef. = 0.242, p = 0.026) and Privacy concern of data (Coef. = -0.024, p = 0.024) substantially affect the outcome of accountability.

This study demonstrates the effect of institutional readiness, technological capability, and human capital on the adoption of blockchain and its benefits in accountability in Nigeria's public procurement infrastructure. Therefore, the findings complement the global literature on this topic but provide unique contextual insights into the case of emerging markets.

Firstly, the dominance of regulatory ambiguities agrees with the findings by Saberi et al. (2019) and Kshetri (2018) on the governance framework as a prerequisite to the blockchain adoption in public infrastructure. Secondly, the impact of skill gap and familiarity supports Wang et al. (2019)'s findings that knowledge on technology is the driver rather than the availability of technological resources itself. Thirdly, the interoperability issues agree with Zheng et al.'s (2018) investigation about the necessity of complementing and not replacing existing information systems with blockchain.

Finally, the findings support transparency theories and suggest that blockchain technology improves accountability through traceability and immutability (Tapscott & Tapscott, 2016), but only in the presence of appropriate institutional structures. In the Nigerian procurement setting, these investigations help in extending previous research on e-procurement by indicating that technological advancement can only eliminate corruption through legal and organisational changes.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

There are significant problems related to collusion between bidders and conflict of interests in Nigeria's public infrastructure procurement process, which undermine the transparency, fairness and efficiency in procurement processes. Respondents agreed that uncertainty of regulations, scarcity of infrastructure, challenges in scalability, change management, and interoperability issues with the existing procurement process are widespread in the procurement process.

As can be seen from the findings, the above-mentioned problems indicate that there are problems of governance and accountability in the current procurement system. Nevertheless, the research results demonstrate the possibility of blockchain technology application as a solution to enhance procurement processes, improve transparency and integrity, prevent corruption and ensure procurement integrity in all stages. As can be seen from the findings, problems such as data protection issues, lack of a proper legal framework, lack of skills in blockchain technology, awareness and education regarding blockchain technology and sustainability issues in the public infrastructure procurement process in Nigeria, undermine transparency, fairness and accountability in the public infrastructure procurement process. Nevertheless, findings also show a strong agreement on the possibilities of blockchain technology as a tool of transformation.

The paper recommends the strategic use of blockchain technology by the Nigerian government in the country’s public infrastructure procurement process. Policymakers need to focus on establishing regulations

that support the implementation of blockchain technology in the procurement process, especially in areas such as tender evaluation, contract awarding, and vendor identification. This will help in reducing any resistance that could arise due to a lack of knowledge about how blockchain technology can be used effectively.

5.2. Contributions

This study contributes to existing knowledge through several significant aspects, including the following:

i. One of the earliest studies empirically analysing the use of blockchain challenges in the Nigerian public procurement context.
ii. These findings expand on Diffusion of Innovation Theory by introducing regulatory and governance factors into models predicting technology adoption in the context of public procurement.
iii. It shows the use of regression modelling to determine the outcome of blockchain governance in developing country procurement contexts.
iv. This study reveals priorities for intervention in terms of skill development, regulatory changes, and interoperable frameworks that can help in creating transparent procurement processes.
v. The findings of this study provide empirical evidence that blockchain adoption is related to improved accountability in digital procurement practices.

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