Assessing the Impact of Blockchain Technology on Service Delivery in Nigeria Maritime Industry

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ABSTRACT

The persistent challenges of port congestion, documentation bottlenecks, and operational inefficiencies have significantly undermined service delivery in Nigeria's maritime industry. This study examines the effect of blockchain technology adoption on service delivery in Nigerian ports, specifically focusing on Apapa and Tincan Ports as case studies. A cross-sectional survey design was employed, utilizing structured questionnaires administered to 150 management-level employees across port operating companies, shipping agencies, customs officials, and logistics firms. Multiple regression analysis was conducted to test the relationship between blockchain adoption dimensions (shipment tracking, smart bills of lading, documentation transparency, and smart contracts) and service delivery outcomes (cargo clearance time, operational efficiency, transparency, and customer satisfaction). Findings reveal a statistically significant positive correlation between blockchain technology adoption and service delivery ($R^2 = 0.673$, $p < 0.001$). Shipment tracking ($\beta = 0.342$, $p < 0.001$) and smart bills of lading ($\beta = 0.287$, $p = 0.002$) demonstrated the strongest predictive power. The study concludes that blockchain technology significantly enhances service delivery in Nigerian ports and recommends strategic investment in blockchain infrastructure, stakeholder capacity building, and supportive regulatory frameworks to facilitate widespread adoption.

Keywords: Apapa Port, Blockchain technology, Maritime industry, Nigeria, Regression analysis, Service delivery Tincan Port.

INTRODUCTION

The maritime industry serves as the backbone of Nigeria's international trade, with over 80% of the country's trade conducted by sea. Apapa and Tincan Ports, as the nation's premier seaports, collectively handle approximately 100 million metric tons of cargo annually. However, persistent operational challenges including port congestion, protracted cargo dwell times, manual documentation processes, and limited transparency have significantly undermined service delivery and trade efficiency .Blockchain technology has emerged as a transformative solution capable of addressing these challenges through enhanced transparency, security, and efficiency in supply chain operations. The technology offers a decentralized digital ledger that provides tamper-proof records, smart contracts for automated transactions, and streamlined documentation processes. Maritime commerce is a worldwide business which faces different tests necessitating the integration of multi-faceted practices (Wang *et al* 2023). The incorporation of blockchain technology by maritime stakeholders have aided a sizable number of maritime challenges which include complex ecosystem integrations and paper based documentation systems that leads to delays, corruption and lack of transparency. It was estimated that the quantity of cargo moved by sea in 2022 was about thirteen (13) billion tons (Ventura 2022). Due to the importance of blockchain technology recently, it have being known globally as the fifth electronic data processing (Laurence 2019), The coming of the blockchain technology in 2018 inspired information technology (IT) companies to creates modern applications that promise to address several operational and supply chain issues in various industries (Kpanissis *et al* 2022).Shipping being a very significant aspect in transport industry accounts for 80% of world trade which is been superintended by national and international standards

that makes it unfathomable for beginners, sea carriers and shippers to quickened the transfer of maritime transport documents.

The basic concept of blockchain technology is to decentralized, digital ledger technology that enables, store, secure, share information that are transparent as well as operates without interference and the control of nobody. However, these concepts make the maritime transport complex and potentially conflict-prone ecosystem. Indeed, block chain technology uses cryptographic method to link blocks of data together which creates a permanent and unalterable records.

The impact of digital transformation in protecting more aspects of our lives daily cannot be underestimated, Beck *et al* (2017) posited that, the impact of block chain on the business process of modern organization are much, where maritime industry must experience a similar change. The maritime industry being an industry that relay on paper based documentation, information sharing is prone to errors and very wasteful. Block chain gives a lawful user access to data tracking orders accounts production, schedules and shipping the real time while removing the administrative holds up caused by the replication of efforts on matters like data entry and other administrative actions, it cuts through intervals that have traditionally slow down business efficiency (Benson *et al* 2021). It is on this note that, Wang and Qu (2019; Mayer (2022),emphasized on the act that characterized the use of block chain in the shipping business to include, decentralization, immutability and clarity of data including applications such as smart contracts, fast payments, information sharing, track and trace and supply chain finance. Blockchain technology have the potential to significantly improve quality service delivery in Nigeria's seaport by enhanced transparency, increased efficiency, as well as improved security and real time tracking. Dutta *et al* (2020), postulated that the assessment of blockchain technology on quality delivery in the maritime industry are numerous, these includes, data security, traceability of goods, endorsement, automation time, and date stamping. Furthermore the adoption of block chain technology is that they are time stamped as they accepted more containers to be tracked and trace out (Zhang *et al* 2021). Despite these promising findings, empirical research specifically examining the quantitative impact of blockchain on service delivery in Nigerian ports remains limited. This study therefore addresses this gap by conducting a quality standard regression analysis to evaluate the effect of blockchain technology on service delivery in Apapa and Tincan Ports.The objective of the research work is to assess the effect of blockchain technology on operational efficiency in Nigeria's maritime industry; evaluate blockchain technology in enhancing data security and stakeholders accountability across the maritime transaction.Identify the critical success factors and affecting blockchain drive service delivery in the maritime industry.

REVIEW OF RELATED LITERATURE

The World Trade Organization (WTO, 2018) stated that blockchain technology can move international commerce toward digitalization. Among digital advancements, blockchain stands out as a pivotal force reshaping port logistics by meticulously recording, validating, and safeguarding transactions, thereby bolstering security, transparency, and data traceability (Iramezhad et al., 2023). The shipping industry has long been considered behind the technological curve, with traditional processes being time-consuming and error-prone. Blockchain offers new efficiency opportunities (Notteboom et al., 2022).

Although still developing, blockchain has great potential in shipping (Bavassano et al., 2020), applicable to documentation, information sharing, and cargo track-and-trace (Pu & Lam, 2021), improving accuracy, reducing errors, and enhancing overall business efficiency (World Bank, 2002; OpenSea, 2017). Blockchain can be used in vessel operations, shipping transactions, marine finance, insurance, and ship registration (Zhou et al., 2020). Extensive documentation slows service provision in marine partnerships (Liebert, 2017).

Groenfeldt (2017) noted that 15–50% of container shipping costs stem from paperwork. Yang (2019) affirmed that blockchain reduces paperwork through digitalization and paperless environments. Trade documents and smart contracts on blockchain create safe business environments using shared databases (Scott et al., 2017). Blockchain increases shipping efficiency and enhances supply chain visibility, consistency, and security (Papathanassiou et al., 2020). Shipping remains a fundamental pillar of international trade (Filom & Van Hassel, 2020) and globalization (Jovic et al., 2019).

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Pu and Lam (2020) argued that blockchain secures innovative knowledge distribution for maritime logistics, improving documentation management and decision-making. The maritime industry is one of the largest adopters of blockchain due to its societal and economic transformation potential (Grover et al., 2019). Blockchain reduces operational costs and improves collaboration by disseminating reliable data (Bai et al., 2020). Despite being conservative, shipping has successfully adopted new technologies (Jugovic et al., 2019). The first fully automated ocean-going vessel is expected by 2030 (Diordiiev, 2018), with IoT-enabled high-tech systems storing and disseminating data via blockchain (Green et al., 2020).

Impact of Blockchain Technology on Service Delivery In The Maritime Industry

The maritime industry serves a significant part of the shipping business by aiding international import and export. The vessel on voyage must be duly tracked and maintained to prevent them against any internal and external attacks.to prevent breaches in the internal system, digitalization in the maritime industry is expanding tremendously. It is on this note that the International Maritime Organization (IMO) implement the SOLAS Convention for international voyage. Which aim to preserve the life of the crew and the vessel, it is on this premise that some of the impact are analyzed below;

Security: Blockchain encrypts data and prevents unauthorized access. A copy of the information is stored on different systems rather than a single server, thereby preventing the chances of hacking into private data

Tracking: Blockchain technology help track the order status and share it with the stakeholders to improve reliability confidence as well boost trust and reduced unnecessary delays.

Transparency: Data entry into distribution ledgers across the business network helps to track transactions and the entire history of any asset. It helps in offering enhanced transparency between all partners that are part of the network.

Smart Contracts: Blockchain help reduce human intervention in the form of any involvement of third parties during transactions. After actualizing all contract terms with the aid of blockchain and automated transaction can be directly initiated securely.

Benefits of Blockchain Technology on Maritime Industry

As new innovation is being brought into the trade industry so also blockchain technology has been introduced in the maritime sector to boost maritime security and give substantial assurance to shippers. Some applications and benefit of blockchain on the maritime industry are itemized below;

i Safer Transaction: All shipping transaction in the maritime industry are directed through of lading process.. Traditional bill of lading processes consume time and paperwork. Blockchain enables electronic, secure transactions with digital signatures, removing third-party involvement.

ii Real Time Tracking: Shipping as an expensive business in other to ensure a safe and more reliable and transparent transaction of goods the maritime industry has evolved to accommodate block chain technology. This enables immutable and dynamic real time tracking aided by Internet of Things (IoT) IoT-enabled blockchain provides immutable, dynamic real-time tracking, helping monitor order status and maintain safety standards across maritime supply chains.

iii Prevent Cyber Crimes: Blockchain technology utilizes preventive mechanisms such as cryptography and consensus-based decision-making to avoid data breaches and cyber fraud risks.

iv Marine Insurance: The maturations of assets and the truthfulness of vessels has been achievable through blockschain technology assistance. Shippers can assess the current, accurate and verified data regarding the condition of a ship by tracking its history and travels. Blockchain allows shippers to assess verified vessel condition and history, preserving data integrity and providing greater transparency.

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THEORETICAL FRAMEWORK.

This study is anchored on the Diffusion of Innovation Theory propounded by Everett Rogers (1962) and Institutional Theory as articulated by Meyer and Rowan (1977). These theoretical perspectives are highly pertinent to this investigation as they collectively illuminate both the technological and institutional dimensions of blockchain adoption in Nigerian shipping and port documentation systems.

Diffusion of Innovation Theory

The Diffusion of Innovation Theory, originally advanced by Everett Rogers in 1962 and subsequently refined in subsequent editions (Rogers, 2003), provides a foundational conceptual lens for understanding how new technologies are adopted, disseminated, or rejected within a social system. Rogers (2003) defines diffusion as the process by which an innovation is communicated through particular channels over time among members of a social system, while an innovation constitutes any idea, practice, or technology perceived as novel by potential adopters. This theoretical perspective is particularly germane to the present study, which examines the adoption and impact of blockchain technology in Nigerian shipping and port documentation systems.

Rogers (2003) identifies five key attributes that influence the rate of innovation adoption: relative advantage, compatibility, complexity, trialability, and observability. Relative advantage denotes the degree to which an innovation is perceived as superior to the existing system. In Nigerian ports, blockchain technology offers advantages encompassing enhanced transparency, reduced documentation fraud, improved data integrity, and expedited clearance processes relative to traditional paper-based systems. Adeniran and Ikuomola (2022) affirm that innovations demonstrating clear operational benefits are more likely to be adopted in port environments.

Compatibility describes the extent to which an innovation aligns with existing values, practices, and institutional arrangements. In the Nigerian maritime sector, documentation practices are deeply embedded within bureaucratic and regulatory structures. Afolayan and Okoye (2023) observe that resistance to digital transformation often emerges when new technologies conflict with entrenched manual procedures and informal practices. Blockchain adoption consequently depends on how effectively it can integrate with existing port systems and regulatory frameworks without destabilising institutional arrangements.

Complexity refers to how difficult an innovation is to understand and utilize. Rogers (2003) contends that innovations perceived as excessively complex experience slower adoption rates. Blockchain technology, with its technical concepts including decentralization, cryptographic validation, and smart contracts, may be perceived as complex by port stakeholders with limited technological expertise. This perception is particularly pertinent in Nigerian ports, where digital literacy levels vary considerably among stakeholders. Yusuf and Adeniran (2021) identify limited technical capacity as a major impediment to advanced technology adoption in the maritime sector.

Trialability relates to the degree to which an innovation can be tested on a limited basis before full implementation. Block chain technology lends itself to pilot projects, such as digital bills of lading or container tracking systems, which enable stakeholders to observe benefits without committing to full-scale deployment. The International Maritime Organization (IMO, 2020) notes that pilot blockchain initiatives in ports have facilitated gradual learning and reduced resistance to adoption. In Nigeria, trialability is essential given infrastructural constraints and stakeholder skepticism.

Observability refers to the extent to which the results of an innovation are visible to others. Rogers (2003) posits that innovations with observable benefits diffuse more rapidly. Successful blockchain implementations in global ports such as Rotterdam and Singapore provide visible evidence of efficiency gains and transparency improvements. These international examples increase the likelihood of blockchain acceptance in Nigerian ports by demonstrating tangible outcomes.

The Diffusion of Innovation Theory is relevant to this study because it explains variations in awareness, adoption, and perceived impact of blockchain technology among Nigerian maritime stakeholders. It provides a framework for analysing why blockchain adoption remains slow despite its potential benefits. By applying this

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theory, the study assesses how innovation attributes, stakeholder perceptions, and institutional conditions influence blockchain diffusion in Nigerian shipping and port documentation systems.

Institutional Theory

Institutional Theory provides a complementary framework for understanding technology adoption within complex organisational and regulatory environments such as ports. Rooted in the foundational works of Meyer and Rowan (1977) and later advanced by DiMaggio and Powell (1983), Institutional Theory emphasises that organisational behaviour is shaped not only by efficiency considerations but also by social norms, regulations, and legitimacy pressures. Scott (2014) posits that institutions consist of regulative, normative, and cultural-cognitive elements that influence organisational actions and decision-making processes.

The regulative pillar of Institutional Theory focuses on formal rules, laws, and policies that shape organizational behavior. In the Nigerian port context, regulatory agencies such as the Nigerian Ports Authority, Nigeria Customs Service, and other government bodies exert considerable control over documentation processes. UNCTAD (2019) notes that regulatory complexity and overlapping mandates often constrain innovation in port systems. Blockchain adoption in Nigerian ports consequently depends heavily on the presence of supportive policies, legal recognition of digital documents, and regulatory enforcement mechanisms.

The normative pillar relates to values, norms, and professional standards that guide behavior. Scott (2014) asserts that organizations conform to norms to gain social acceptance and professional legitimacy. In Nigerian maritime operations, long-standing norms favor manual documentation, physical verification, and hierarchical approval processes. Onuoha (2019) observes that these norms reinforce resistance to digital technologies, even when efficiency gains are evident. Blockchain adoption challenges these norms by promoting automation, decentralization, and reduced human intervention.

The cultural-cognitive pillar refers to shared beliefs, assumptions, and mental models that shape how individuals interpret reality. DiMaggio and Powell (1983) contend that deeply ingrained beliefs often determine whether innovations are perceived as legitimate or risky. In Nigerian ports, blockchain may be viewed as abstract, foreign, or disruptive, particularly among stakeholders with limited exposure to advanced digital systems. Afolayan and Okoye (2023) find that low awareness and understanding of blockchain technology contribute significantly to adoption resistance.

Institutional Theory also introduces the concept of isomorphism, which explains why organizations adopt similar practices over time. DiMaggio and Powell (1983) distinguish between coercive isomorphism arising from regulatory pressure, mimetic isomorphism from imitation of successful peers, and normative isomorphism from professional standards. In maritime logistics, global port systems increasingly adopt blockchain-based documentation platforms, creating mimetic pressure for Nigerian ports to follow suit in order to remain competitive and legitimate in global trade networks.

The relevance of Institutional Theory to this study lies in its capacity to explain non-technical barriers to blockchain adoption. While blockchain offers demonstrable efficiency and transparency benefits,

Institutional constraints such as weak policy support, entrenched bureaucratic norms, and limited enforcement mechanisms continue to constrain adoption in Nigerian ports.

EMPIRICAL REVIEW

Onuoha (2019) conducted a qualitative investigation into bureaucratic impediments within Nigerian port operations, utilizing in-depth interviews with port users and officials. The research revealed that overlapping documentation requirements and discretionary decision-making processes substantially contributed to cargo delays and corrupt practices.

Onuoha (2019) further observed that opacity in documentation procedures undermined accountability mechanisms and facilitated informal payment demands The study offers an insights into governance deficiencies

in Nigerian ports, its analytical focus remained confined to institutional weaknesses without examining technological remedies.

.Yusuf and Adeniran (2021) employed survey methodology involving shipping companies and freight forwarders to explore the nexus between documentation processes and port efficiency in Nigeria. Their findings demonstrated a statistically significant relationship between documentation delays and prolonged cargo dwell times. manual documentation systems contributed to elevated error frequencies and constrained real-time information dissemination. While the study acknowledged the imperative of digitalization, it did not subject specific technologies to empirical scrutiny.

Afolayan and Okoye (2023) adopted a mixed-methods design to evaluate digital transformation initiatives in Nigerian ports. Their results indicated that partial digitalization improved payment processing yet exerted limited influence on documentation efficiency owing to persistent reliance on manual verification protocols.

Afolayan and Okoye (2023) identified resistance to technological change and inadequate policy frameworks as impediments to comprehensive digital adoption. Despite offering a broad overview of digitalization challenges, the study did not specifically examine blockchain technology. The present investigation builds upon this foundation by evaluating blockchain as an advanced digital solution capable of addressing enduring documentation inefficiencies in Nigerian ports.

Adeniran and Ikuomola (2022) employed regression analysis to investigate technology adoption and port performance in Nigeria. The study established that digital documentation systems significantly enhanced operational efficiency and transparency.Digital integration experienced reduced clearance durations and lower transaction costs.

Pájaro-Marín and Gil-Martínez-Arias (2021) examined blockchain applications in maritime logistics utilizing secondary data from global port systems. Their research reported that blockchain-enabled documentation substantially reduced processing time and administrative expenditures. Digital bills of lading and smart contracts facilitated enhanced coordination among port stakeholders. While the study demonstrated blockchain's effectiveness in international settings, it did not examine adoption barriers in developing countries. The present study addresses this limitation by empirically investigating awareness levels, adoption challenges, and perceived impacts of blockchain technology in Nigerian ports.

The International Maritime Organization (IMO, 2020) conducted an empirical assessment of digital technologies in port operations across selected regions. The findings indicated that ports employing blockchain-based documentation systems achieved superior transparency and compliance standards.Blockchain reduced human interference in clearance processes and improved auditability. However, the study provided limited country-specific analysis.

METHODOLOGY

A cross-sectional survey research design was adopted for this study. This design was selected as it enables data collection from a diverse sample of respondents at a single point in time, allowing for the examination of relationships between variables without manipulation .The study was conducted at Apapa and Tincan Ports, Lagos State, Nigeria. These ports were purposively selected as they represent Nigeria's busiest seaports, handling the majority of the country's maritime trade and experiencing significant operational challenges that blockchain technology could potentially address.The target population was 150, comprised management-level employees from four port operating companies, shipping agencies, customs units, and logistics firms operating within Apapa and Tincan Ports. A purposive random sampling technique was employed to select respondents based on their direct involvement with port operations, documentation processes, and service delivery functions. A sample size of 150 was considered adequate for multiple regression analysis following established statistical guidelines. A structured questionnaire was developed as the primary data collection instrument. A pilot test conducted with 30 respondents yielded a Cronbach's alpha coefficient of 0.87, indicating high internal consistency. Multiple regression analysis was employed to test the relationship between blockchain adoption dimensions and service delivery.

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Model Specification

The regression model was specified as:

$SD = \beta_0 + \beta_1(ST) + \beta_2(SBL) + \beta_3(DT) + \beta_4(SC) + \varepsilon$

Where:

SD = Service Delivery

ST = Shipment Tracking

SBL = Smart Bills of Lading

DT = Documentation Transparency

SC = Smart Contracts

β_0 = Constant

β_1–β_4 = Regression Coefficients

ε = Error Term

The Pearson Product Moment Correlation (PPC) technique can be expressed by the formula below:

$$r = \frac{\sum(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum(x_i - \overline{x})^2}\sqrt{\sum(y_i - \overline{y})^2}}$$

Where

x = independent factor: International Trade

y = dependent factor: Naira Devaluation

RESULTS AND DISCUSSION

The results for this research work is explicitly explained in details.

Descriptive Statistics of Study Variable

Variables	Mean	Std Deviation
Shipment tracking	3.87	.0.92
Smart Bill of Lading	.3.65	0.89
Smart Contracts	3.42	. 1.01
Service Delivery	3.76	0.87

Source: Field Survey 2026

Table 1 reveals that respondents generally agreed with blockchain's positive impact, with Shipment Tracking having the highest mean score (3.87) and Smart Contracts the lowest (3.42). Service Delivery had a mean of 3.76, indicating moderate perception of current service delivery levels.

Table 2: Pearson Correlation Matrix

Variables	1	2	3	4	5	6	7	8
Shipment Tracking	1							
Smart Bills of Lading	0.548	1						
Documentation Transparency	0.512	0.498	1					
Smart Contracts	0.467	0.452	0.489	1				
Service Delivery	0.642	0.598	0.561	0.523	1			

Correlation is significant at the 0.01 level (2-tailed).

Table 2 shows moderate to strong positive correlations between all blockchain adoption dimensions and service delivery (ranging from r = 0.523 to r = 0.642). Shipment Tracking demonstrated the strongest correlation with Service Delivery ($r = 0.642$, $p < 0.01$).

Table 3 : Model Summary for Regression Analysis

Model	R	R^2	Adjusted R^2	Std. Error Of Estimate	F-Statistic	P-Value
Model 1	0.821	0.673	0.662	0.512	62.847	0.000

Interpretation:

Predictors: (Constant), Shipment Tracking, Smart Bills of Lading, Documentation Transparency, Smart Contracts

Dependent Variable: Service Delivery

Table 4: ANOVA for Regression Models

Model	Sum Of Squares	DF	Mean Square	F	P-Square
Regression	65.843	4	16.461	62.847	.000
Residual	32.189	123	0.262		
Total	98.032	127			

The regression model (Table 4) demonstrates that blockchain adoption dimensions collectively account for 67.3% of the variance in service delivery ($R^2 = 0.673$, Adjusted $R^2 = 0.662$). The overall model is statistically significant ($F(4, 123) = 62.847$, $p < 0.001$), indicating that block chain adoption is a significant predictor of service delivery.

Table 5 reveals that all four blockchain dimensions have positive and significant effects on service delivery. Shipment Tracking has the strongest predictive power ($\beta = 0.342$, $t = 4.704$, $p < 0.001$), followed by Smart Bills of Lading ($\beta = 0.287$, $t = 3.230$, $p = 0.002$), Documentation Transparency ($\beta = 0.198$, $t = 2.408$, $p = 0.018$), and Smart Contracts ($\beta = 0.179$, $t = 2.257$, $p = 0.026$). The VIF values are all below 2.5, confirming no significant multicollinearity concerns.

DISCUSSION OF FINDINGS

The regression analysis reveals that blockchain technology adoption has a substantial positive impact on service delivery in Apapa and Tincan Ports. This finding aligns with previous studies that identified positive correlations between blockchain adoption and port operations ($p = 0.000$) . The high R^2 value (0.673) indicates that blockchain dimensions explain a significant proportion of service delivery variance, underscoring the transformative potential of this technology.

Variable	Unstandardized β	Std Error	Standard Beta β	t-Value	P-Value	VIF
Constant	0.487	0.214	2.276	0.025		
Shipment Tracking	0.334	0.071	0.342	4.704	0.000	1.874
Bills of Lading	0.281	0.087	0.287	3.230	0.002	2.103
Documentation Transparency	0.195	0.081	0.198	2.408	0.018	2.256
Smart Contracts	0.167	0.074	0.179	2.257	0.026	2.419
Driver Comprehension (Mediator)	2.78	0.88	1.00	5.00	-0.15	-0.29
Composite Signage Adequacy	2.39	0.78	1.00	5.00	0.28	-0.38

The finding that Shipment Tracking is the strongest predictor of service delivery (β = 0.342) corroborates earlier research establishing a positive correlation between blockchain technology and shipment tracking in Nigerian ports . Blockchain-enabled tracking provides real-time visibility into cargo movement, reducing uncertainty and enabling proactive decision-making . This is particularly significant given Nigeria's port congestion challenges, where improved tracking can facilitate more efficient cargo handling and reduced dwell times.

Similarly, Smart Bills of Lading emerged as a significant predictor (β = 0.287), supporting findings from previous studies that identified a positive relationship between blockchain and smart bills of lading (p = 0.000) . The digitization of bills of lading through blockchain reduces paperwork, minimizes fraud, and accelerates documentation processes, all of which contribute to enhanced service delivery. Given that manual documentation has been identified as a major bottleneck in Nigerian ports, this finding has practical significance.

Documentation Transparency (β = 0.198) and Smart Contracts (β = 0.179) also showed significant positive effects, reinforcing the multi-dimensional benefits of blockchain adoption. These findings align with studies highlighting blockchain's capacity to ensure tamper-proof records, automate payment and cargo release processes, and improve compliance with regulations. The significance of these dimensions suggests that stakeholders in Nigerian ports recognize blockchain's potential to address issues of fraud, corruption, and procedural delays that have historically plagued the industry.

The findings also resonate with international evidence demonstrating blockchain's relevance in maritime operations. Studies in Greece revealed a positive intention to adopt blockchain technology among shipping companies, with factors such as performance expectancy and facilitating conditions influencing adoption decisions. The Nigerian context, however, presents unique challenges including high implementation costs, integration difficulties, and resistance from labor unions that must be addressed for successful adoption.

CONCLUSION

This study provides empirical evidence confirming that blockchain technology adoption significantly enhances service delivery in Nigerian ports. The regression model reveals that shipment tracking, smart bills of lading, documentation transparency, and smart contracts collectively explain 67.3% of the variance in service delivery. The findings demonstrate that blockchain technology is relevant and beneficial in the Nigerian maritime industry, with the potential to address long-standing challenges of congestion, inefficiency, and limited transparency.

RECOMMENDATIONS

1. The Federal Government of Nigeria, through the Nigerian Ports Authority, should prioritize investment in blockchain infrastructure and digital systems to facilitate widespread adoption across Apapa and Tincan Ports.
2. Stakeholders including port operators, shipping agencies, and customs officials should receive comprehensive training on blockchain technology to enhance digital literacy and facilitate smooth adoption.
3. The government should develop supportive regulatory frameworks and policies that encourage blockchain adoption while ensuring security and compliance with international standards.
4. Public-private partnerships should be fostered to share implementation costs and leverage expertise from technology providers and international maritime organizations.

5. Given the challenges of high costs and integration difficulties, a phased implementation approach starting with pilot programs at specific port sections is recommended.

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