The Effect of Blockchain Technology on the Business Performance of Selected Manufacturing Firms in Delta State, Nigeria

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ABSTRACT

This study critically examined the effect of blockchain technology on the business performance of selected manufacturing firms in Delta State, Nigeria. The research focused on four core dimensions of blockchain adoption Blockchain Transparency (BTC), Blockchain Traceability (BTB), Blockchain Security (BS), and Blockchain Data Integrity (BDI) to determine their collective and individual influence on organizational outcomes. Employing a survey research design, data were collected from a population of 150 respondents, with 109 as sampled size were valid questionnaires retrieved, representing a robust 96.7% response rate. Analytical techniques including descriptive statistics, correlation, and regression analyses were applied to evaluate the relationships between blockchain dimensions and business performance. The findings revealed that all four dimensions significantly enhanced business performance. Blockchain Transparency fostered improved decision-making and strengthened stakeholder trust, while Blockchain Traceability facilitated effective supply chain monitoring and operational efficiency. Blockchain Security emerged as the most critical determinant, safeguarding sensitive data and transactional processes, whereas Blockchain Data Integrity ensured the reliability and consistency of information for strategic planning. Mean adoption scores across dimensions ranged between 4.05 and 4.20, with correlation coefficients ($r = 0.613–0.688$, $p < 0.01$) confirming strong positive associations. Regression analysis further demonstrated that blockchain collectively explained 57.4% of the variance in performance ($R^2 = 0.574$), with security ($\beta = 0.301$) exerting the strongest predictive influence. The study concludes that blockchain technology is not merely a technological innovation but a strategic enabler of competitiveness, efficiency, and stakeholder confidence in manufacturing firms. It contributes to scholarship by offering empirical evidence from a developing economy, underscoring blockchain's transformative potential in the Nigerian manufacturing sector. Practical recommendations include holistic adoption of blockchain, prioritization of security measures, integration into supply chain management, employee training, and establishment of governance frameworks. These insights highlight transparency, traceability, security, and data integrity as pivotal drivers of organizational success.

Keywords: *Business performance, Blockchain Transparency (BTC), Blockchain Traceability (BTB), Blockchain Security (BS), Blockchain Data Integrity (BDI)*

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INTRODUCTION

Blockchain technology has emerged as a transformative force across various industries, offering solutions that enhance transparency, traceability, security, and data integrity. In the manufacturing sector, these attributes are pivotal in optimizing operations and improving business performance. This study delves into the impact of blockchain technology, focusing on its facets of transparency, traceability, security, and data integrity, on the business performance of selected manufacturing firms in Delta State, Nigeria.The manufacturing industry is a cornerstone of economic development, contributing significantly to employment and GDP. However, it faces challenges such as supply chain inefficiencies, counterfeit products, and data breaches, which can impede performance **(**Azzi, et al 2019**).** Blockchain technology, with its decentralized and immutable ledger system, offers potential solutions to these issues. By recording transactions across a distributed network, blockchain ensures that data is transparent, traceable, and secure, thereby enhancing operational efficiency and trust among stakeholders (Casino et al., 2019**).**

Transparency in manufacturing processes is crucial for building trust with consumers and partners. Blockchain's decentralized ledger records all transactions in a manner that is accessible and verifiable by all authorized participants **(**Dai & Vasarhelyi, 2017**).** This level of openness can reduce information asymmetry and foster trust among supply chain partners. For instance, a study highlighted that by using a distributed ledger system, all transactions are recorded and can be accessed by anyone on the network, helping to reduce corruption, fraud, and other illegal activities **(**Dobrovnik, et al, 2018).

Traceability is another critical aspect where blockchain can make a significant impact. In complex supply chains, tracking the origin and movement of products can be challenging, leading to issues like counterfeiting and quality control problems **(**Francisco & Swanson, 2018**).** Blockchain provides a tamper-proof record of a product's journey from its origin to the consumer, thereby enhancing traceability. This capability is particularly beneficial in industries where product authenticity and quality are paramount. For example, blockchain allows for real-time tracking of goods, ensuring transparency and accountability at each stage of the supply chain **(**Hackius & Petersen, 2017**).**

Security in data management is a pressing concern for manufacturing firms, especially with the increasing digitization of operations. Blockchain's immutable ledger ensures that once data is recorded, it cannot be altered or deleted without consensus from the network, thereby safeguarding data integrity **(**Kshetri, 2018**).** This feature protects sensitive information from unauthorized access and tampering, which is crucial for maintaining the confidentiality and integrity of manufacturing processes. Integrating AI and blockchain into quality management systems transforms how organizations ensure data integrity and automate processes **(**Kouhizadeh, et al, 2021).

Data integrity is fundamental to decision-making and operational efficiency in manufacturing. Blockchain ensures that data remains accurate, consistent, and reliable throughout its lifecycle. This reliability enables firms to make informed decisions, optimize processes, and maintain compliance with industry standards. A study emphasized that blockchain technology has the potential to improve the efficiency of numerous areas of the financial industry, which can be extrapolated to manufacturing sectors where data integrity is critical **(**Li, et al, 2021**).** The adoption of blockchain technology in manufacturing is not without challenges. Issues such as the need for substantial investment in infrastructure, the requirement for technical expertise, and concerns about data privacy and regulatory compliance can hinder implementation. However, the potential benefits, including enhanced transparency, improved traceability, strengthened security, and assured data integrity, make a compelling case for its integration into manufacturing processes.

In the context of Delta State, Nigeria, manufacturing firms operate in a dynamic environment with unique challenges. The integration of blockchain technology could address specific issues such as supply chain inefficiencies, product counterfeiting, and data management challenges. By enhancing transparency and traceability, firms can build trust with consumers and partners, leading to improved market competitiveness. Strengthened security and data integrity can protect against data breaches and ensure compliance with industry regulations, thereby enhancing overall business performance. Empirical studies have begun to explore the impact of blockchain technology on manufacturing firms in Nigeria. For instance, a study of Chukwu, et al. (2024), investigated materials management and the adoption of blockchain technology on supply chain efficiency in Nigerian Breweries Plc Ama, Enugu. The findings suggest that the application of blockchain technology improves supply chain efficiency, which can be a driver of profitability in manufacturing firms.

Furthermore, blockchain's role in enhancing supply chain transparency and traceability has been recognized as a key factor in reducing administrative costs and improving operational efficiency. By providing a verifiable record of a product's origin, blockchain helps prevent the circulation of counterfeit goods and ensures that all participants in the supply chain have access to the same information, thereby reducing discrepancies and disputes **(**Manupati, et al, 2022**).** The potential of blockchain technology to revolutionize manufacturing processes extends beyond supply chain management. It can also play a significant role in areas such as quality control, contract management, and data sharing **(**Mao, et al, 2018**).** For example, in quality control, blockchain can establish

tamper-proof records, boosting consumer confidence in the products. In contract management, smart contracts can automate execution, enhancing efficiency and reducing the need for intermediaries. Blockchain also fosters secure collaboration in manufacturing, which is crucial for system stability and safety **(**Nandi & Dey, 2021**).** Despite the promising benefits, the adoption of blockchain technology in manufacturing firms in Delta State, Nigeria, remains in its nascent stages. Factors such as limited awareness, lack of technical expertise, and infrastructural challenges impede widespread implementation. However, as global trends move towards increased digitization and the demand for transparency and accountability in business operations grows, the impetus for adopting blockchain technology becomes stronger. Thus, blockchain technology holds significant potential to enhance the business performance of manufacturing firms by improving transparency, traceability, security, and data integrity. While challenges to adoption exist, the benefits offer a compelling case for integration into manufacturing processes. As firms in Delta State, Nigeria, navigate the complexities of the modern manufacturing landscape, embracing blockchain technology could serve as a catalyst for improved operational efficiency and competitiveness.

The manufacturing sector in Nigeria is pivotal to the nation's economic development but faces significant challenges, including supply chain inefficiencies, counterfeit products, and data breaches, which hinder operational performance and profitability (Queiroz & Wamba, 2020). Blockchain technology, with its decentralized and immutable ledger system, offers potential solutions by enhancing transparency, traceability, security, and data integrity (Tönnissen & Teuteberg, 2020). However, despite its transformative potential, blockchain adoption in Nigeria's manufacturing industry is still in its early stages, and empirical studies examining its impact remain limited (Hastig & Sodhi, 2020). While blockchain's potential benefits are widely discussed, there is a scarcity of empirical studies focusing on its application within Nigeria's manufacturing sector. Existing research primarily addresses theoretical aspects, leaving a gap in practical, data-driven insights (Durach et al., 2020). Nigeria presents unique challenges such as infrastructure deficits, regulatory hurdles, and market dynamics that may affect blockchain implementation differently compared to other regions. Current literature does not adequately address these context-specific factors (Queiroz & Wamba, 2020). Although blockchain is touted to improve supply chain efficiency, there is limited evidence demonstrating how it influences key performance indicators within Nigerian manufacturing firms. Understanding this impact is crucial for informed decision-making (Tönnissen & Teuteberg, 2020). Factors hindering the adoption of blockchain technology in Nigeria's manufacturing sector, such as high implementation costs, lack of technical expertise, and resistance to change, are not thoroughly explored in recent studies (Hastig & Sodhi, 2020).

Addressing these gaps will provide valuable insights into the practical implications of blockchain technology in enhancing the performance and competitiveness of manufacturing firms in Nigeria. This study aims to fill this gap by investigating the effects of blockchain technology proxied with Blockchain Transparency (BTC), Blockchain Traceability (BTB), Blockchain Security (BS) and Blockchain Data Integrity (BDI) on business performance (BP) of selected manufacturing firms in Delta State, Nigeria. The main objective of this study is to examine the effect of blockchain technology on the business performance of selected manufacturing firms in Delta State, Nigeria.

Literature Review

Blockchain Technology

Blockchain technology is a decentralized and distributed ledger system that allows secure and transparent recording of transactions across multiple nodes in a network. Introduced in 2008 as the foundation of Bitcoin (Nakamoto, 2008), it has evolved to become a tool with transformative potential in various sectors, including finance, healthcare, logistics, and manufacturing. The primary characteristic of blockchain is its ability to ensure data immutability, which means once data is recorded, it cannot be altered without consensus from the network (Zohar et al., 2021). This feature is particularly advantageous in sectors where transparency and security are paramount. Recent studies have underscored blockchain's capacity to streamline processes and reduce operational costs. For example, according to a report by Tapscott and Tapscott (2020), blockchain's decentralized nature enhances trust between parties, making it a powerful tool in industries that involve complex supply chains and numerous stakeholders. Additionally, blockchain's integration with technologies like the Internet of Things (IoT) and Artificial Intelligence (AI) has further amplified its potential in optimizing manufacturing and logistics operations (Garg & Yadav, 2021).

Blockchain Transparency (BTC)

Blockchain transparency refers to the openness and accessibility of data stored within the blockchain system. It allows all authorized users to view and verify transaction records, promoting accountability and reducing opportunities for fraud. In the context of manufacturing, transparency is essential for enhancing operational visibility and fostering trust between business partners (Seitz et al., 2021). A study by Chen et al. (2021) demonstrated that blockchain transparency significantly reduced inefficiencies in the supply chain by enabling real-time monitoring of product movement and transaction status. Transparency through blockchain ensures that all parties involved in the manufacturing process from

suppliers to consumers have access to the same verifiable data, minimizing the potential for conflicts or discrepancies. The application of blockchain transparency in manufacturing can lead to better decision-making, as stakeholders can make informed choices based on the immutable and transparent nature of the data.

Blockchain Traceability (BTB)

Traceability refers to the ability to track the history and movement of a product throughout its entire lifecycle, from raw material sourcing to final consumption. In manufacturing, traceability is critical for maintaining quality control, preventing counterfeit goods, and ensuring compliance with regulatory standards (Li et al., 2021). Blockchain enhances traceability by creating a tamper-proof record of every transaction or change in the supply chain, ensuring that product origins and movements are well-documented. According to Wang et al. (2022), the traceability feature of blockchain technology provides manufacturers with a clear and auditable history of a product's journey, significantly reducing the occurrence of counterfeit goods and enhancing the credibility of products. This feature also allows for quick identification and resolution of quality issues, making it easier to recall defective products, if necessary. In Nigeria, where issues like counterfeit products in manufacturing are rampant, blockchain traceability presents an effective solution for ensuring product authenticity and safety (Adeyemo et al., 2021).

Blockchain Security (BS)

Security is one of the fundamental attributes of blockchain technology. Blockchain uses advanced cryptographic techniques to ensure the integrity and confidentiality of data. Unlike traditional databases, where data can be altered or deleted by authorized parties, blockchain's immutability feature prevents unauthorized changes once data is recorded, making it highly secure (Crosby et al., 2020). In the manufacturing sector, security concerns related to data breaches, cyberattacks, and unauthorized access to sensitive information are prevalent (Shetty & Singh, 2021). Blockchain's security features are vital in mitigating these risks by ensuring that data is securely stored and accessible only by authorized users. This aspect of blockchain can also protect intellectual property, trade secrets, and sensitive customer information, which are valuable assets in manufacturing firms (Chang et al., 2021). A study by Alzahrani et al. (2020) revealed that the implementation of blockchain in supply chain management enhanced the security of transactions, particularly in industries dealing with sensitive or high-value products, such as pharmaceuticals and electronics. In Nigeria, where cybercrime poses a significant challenge to businesses, the adoption of blockchain security can bolster trust and protect critical business assets.

Blockchain Data Integrity (BDI)

Data integrity is the assurance that data remains accurate, consistent, and trustworthy over its lifecycle. Blockchain ensures data integrity through its immutable ledger, where once data is recorded, it cannot be tampered with without altering every subsequent block, which would require the consensus of the network (Böhme et al., 2020). This capability is particularly valuable in manufacturing, where accurate data is essential for maintaining quality, ensuring compliance, and making informed decisions. Research by Park and Kim (2021) highlighted that blockchain enhances data integrity by eliminating errors associated with manual data entry and mitigating risks related to data manipulation. In manufacturing environments, where data is constantly generated across various stages of production, blockchain technology ensures that information related to inventory, production schedules, and supply chain status remains reliable. This also aids in maintaining compliance with industry regulations, such as product safety standards.

Business Performance (BP)

Business performance in the manufacturing sector is a measure of a firm's operational efficiency, profitability, and ability to meet market demands. Blockchain technology can significantly impact business performance by optimizing processes, enhancing transparency, and improving supply chain management. According to a study by Sharma et al. (2021), the adoption of blockchain led to reduced operational costs, improved product quality, and greater customer satisfaction. In the context of Nigeria's manufacturing sector, where inefficiencies and fraud often hinder business performance, blockchain presents a solution to optimize operations. Adeyemo et al. (2021) noted that blockchain integration improved decision-making by providing reliable and real-time data, which is crucial for manufacturing firms operating in dynamic and competitive markets. Furthermore, the increased transparency and traceability enabled by blockchain enhance relationships with suppliers and customers, improving trust and market competitiveness.

Blockchain Technology on Business Performance in Manufacturing in Nigeria

In Nigeria, the manufacturing industry faces numerous challenges; including supply chain inefficiencies, counterfeit goods, and security risks. The adoption of blockchain technology has the potential to address these issues and enhance business performance in the sector. A study by Okoli and Nwachukwu (2021) suggested that blockchain technology could enhance supply chain

transparency, reduce operational costs, and improve product quality in Nigerian manufacturing firms. Blockchain's ability to provide real-time, verifiable data on product movements and transaction histories can foster trust among stakeholders and lead to more efficient operations (Afolabi & Nwachukwu, 2021). In addition, blockchain's ability to prevent fraud and ensure data integrity is particularly important in Nigeria, where counterfeiting and data breaches are major concerns (Alabi et al., 2021). As such, blockchain adoption can help Nigerian manufacturers improve operational efficiency, enhance product quality, and strengthen relationships with customers and suppliers, ultimately improving their business performance.

Theoretical Review

Distributed Ledger Theory (DLT)

The study was anchored on Distributed Ledger Theory (DLT) is a foundational concept that describes a decentralized database that is maintained and shared across multiple nodes within a network. The origin of DLT can be traced back to the early developments of cryptographic systems, particularly the introduction of blockchain in the context of Bitcoin by Satoshi Nakamoto in 2008. Nakamoto's work demonstrated that a decentralized ledger could be used to ensure secure transactions without the need for intermediaries like banks (Nakamoto, 2008). This theory has evolved from a pure cryptocurrency application into a broader technology used in various industries to ensure data integrity, transparency, and security. DLT supports blockchain transparency (BTC) by enabling an immutable record of transactions that are visible and accessible to all participants in the network. Through this feature, blockchain ensures that manufacturing firms' operations are more transparent, providing real-time information to all stakeholders. For instance, in Delta State, Nigeria, the use of blockchain-based DLT can ensure that every transaction, such as raw material procurement or product distribution, is recorded in an open ledger. This reduces the opportunity for fraudulent activities and enhances trust among manufacturers, suppliers, and customers (Seitz et al., 2021). Furthermore, DLT supports traceability (BTB) by providing an auditable trail of all product transactions, allowing firms to track the origin of raw materials, product movement, and quality at every stage. This visibility contributes to greater operational efficiency and better business performance (Wang et al., 2022). In relation to business performance (BP), DLT's ability to create a secure, transparent, and immutable ledger allows manufacturing firms in Delta State to improve operational processes, reduce supply chain inefficiencies, and increase stakeholder confidence. By enhancing transparency and traceability, DLT facilitates smoother transactions and decision-making, which ultimately drives better business outcomes.

Empirical Review

Wang, Zhao, and Jiang (2022) explored the potential of blockchain to improve transparency and traceability in supply chains, focusing on the manufacturing sector. The study employed a survey methodology, collecting data from 150 firms in China. The data were analyzed using structural equation modeling (SEM) to assess the effect of blockchain's transparency and traceability on supply chain performance. Findings revealed that blockchain's transparency significantly improved supply chain visibility, while traceability reduced the occurrence of counterfeit products. The study concluded that blockchain enhances business performance by increasing operational transparency and reducing risks associated with counterfeit goods. The authors recommended that firms integrate blockchain to optimize supply chain operations and improve performance.

Chang, Liu, and Yang (2021) examined the role of blockchain technology in enhancing operational performance, focusing on transparency, traceability, and data integrity in the manufacturing sector. The study adopted a mixed-methods approach, combining qualitative interviews with industry experts and quantitative surveys from 150 manufacturing firms in China. Data analysis was conducted using multiple regression to assess the relationship between blockchain technology and business performance. The results revealed that blockchain's security and data integrity features significantly improved manufacturing performance by reducing fraud and ensuring accurate and reliable data. The study concluded that blockchain adoption can enhance the overall operational efficiency of firms, and recommended that manufacturers consider integrating blockchain into their business processes to improve security and traceability.

Li, Guo, and Liu (2021) focused on the impact of blockchain on supply chain efficiency and performance, specifically examining blockchain's transparency (BTC), traceability (BTB), and data integrity (BDI) in the automotive industry. The researchers used a quantitative survey methodology, collecting data from 120 firms in Europe. Structural equation modeling (SEM) was used to analyze the data. The study found that blockchain's transparency and traceability significantly enhanced supply chain performance by providing real-time access to product information and ensuring the authenticity of products. Data integrity also played a crucial role in improving operational efficiency and reducing costs. The authors concluded that blockchain is a powerful tool for improving business performance in the automotive sector and recommended its adoption across manufacturing supply chains.

Shetty and Singh (2021) examined the role of blockchain technology in enhancing the security and data integrity of

manufacturing firms. The study employed a survey methodology, collecting data from 100 manufacturing firms in India. Regression analysis was used to analyze the relationship between blockchain features, such as security (BS) and data integrity (BDI), and business performance (BP). The results indicated that blockchain's security features significantly enhanced data protection, reducing the risks of data breaches and improving the trustworthiness of operations. The study concluded that blockchain technology improves business performance by strengthening data security and integrity. The authors recommended that manufacturing firms adopt blockchain to safeguard sensitive data and enhance operational efficiency.

Literature gap

The application of blockchain technology in manufacturing has received growing scholarly attention, particularly for its potential to enhance transparency, traceability, security, and data integrity. While prior studies have demonstrated blockchain's positive impact on supply chain efficiency and organizational outcomes, several gaps remain. First, findings often lack consensus on the specific mechanisms through which blockchain attributes influence broader business performance.

For example, transparency and traceability are linked to efficiency, but their effects on profitability, customer satisfaction, and market share remain underexplored in Nigeria. Similarly, the role of data integrity in strengthening decision-making has not been systematically examined in this context. Second, existing studies tend to focus on individual blockchain variables without integrating their combined effects.

The interplay between transparency, traceability, security, and data integrity is rarely analyzed, leaving a gap in understanding how these attributes collectively drive organizational success. Third, methodological limitations are evident, as most research relies on quantitative, cross-sectional designs that provide statistical associations but overlook qualitative insights into implementation challenges or long-term impacts. Mixed-methods and longitudinal approaches are needed to capture both outcomes and processes of blockchain adoption.

Finally, there is a clear geographical gap. Much of the literature originates from Asia and the Middle East, with limited attention to sub-Saharan Africa. In Nigeria, where blockchain adoption is still emerging, contextual challenges such as infrastructure deficits, regulatory frameworks, and market conditions remain underexplored. Addressing these gaps is essential to provide context-specific evidence on how blockchain can enhance business performance in Nigerian manufacturing firms.

METHODOLOGY

This study adopted a descriptive survey research design. The population of this study consisted of employees from five selected manufacturing firms in Delta State, Nigeria, who were involved in operations that could be impacted by blockchain technology. These employees included supply chain managers, IT personnel, and senior executives within Nigerian Breweries Plc, West African Plastics Ltd, Delta Steel Company Ltd, Dufil Prima Foods Plc, and Excel Paints Manufacturing Ltd. These individuals were considered ideal as they were in positions to provide insights on how blockchain attributes such as transparency, traceability, security, and data integrity influenced business performance within their respective firms. The total population was estimated to be approximately 150 employees across the five firms, based on internal records. The sample size for this study was determined using the Taro Yamane formula, commonly used for determining sample sizes in social science research when the population is finite. The formula is given as:

$n= N /1+N(e)^2$
Where:
n = sample size
N = population size
e = margin of error (0.05, used for a 95% confidence level)

The total population (N) was 150 employees, and the margin of error (e) was set at 0.05. Using the formula, the sample size was calculated as:
$n=150/1+150(0.05)^2=150/1+150(0.0025)$
$=150/1.375\approx109$.

Thus, the sample size for the study stood at 109 respondents. This study employed a stratified random sampling technique. The stratification was based on job roles within the selected manufacturing firms, including supply chain managers, IT personnel, and senior executives. This approach ensured that each group was adequately represented in the sample. Respondents within each stratum were selected randomly, ensuring that the sample was representative of the population. This technique was deemed appropriate as it allowed for capturing various perspectives from different roles within the firms, providing a more comprehensive view of how blockchain technology impacted business performance. Primary data were collected using a structured questionnaire. The questionnaire was distributed to respondents in the selected manufacturing firms. It was designed with a Likert-scale format, with respondents asked to rate their agreement with statements related to blockchain transparency, traceability, security, data integrity, and business performance. The Likert scale ranged from "Strongly Disagree" (1) to "Strongly Agree"

(5). This method enabled the systematic collection of data that was easy to analyze quantitatively. The research instrument for this study was a structured questionnaire, which was divided into sections. The first section collected demographic information about the respondents, such as their job role and years of experience. The second section focused on the independent variables (blockchain transparency, traceability, security, and data integrity), while the third section addressed business performance, the dependent variable. Each section contained questions designed to capture respondents' perceptions and experiences with blockchain technology in their respective firms. To ensure the validity of the research instrument, content validity was assessed. The content validity was evaluated by experts in blockchain technology, business performance, and supply chain management, who reviewed the instrument to ensure the questions accurately measured the constructs of blockchain transparency, traceability, security, data integrity, and business performance. Feedback from the experts led to revisions and refinements to improve the instrument's validity.

Reliability of Research Instruments:

The reliability of the research instrument was tested using Cronbach's alpha coefficient. A pilot study was conducted with a small group of respondents from similar manufacturing firms not included in the main study. The Cronbach's alpha values for each of the variables were calculated as follows:

Blockchain Transparency (BTC): α=0.82
Blockchain Traceability (BTB): α=0.79
Blockchain Security (BS): α=0.85
Blockchain Data Integrity (BDI**):** α=0.88
Business Performance (BP): α=0.81

These values indicated that the instrument had acceptable internal consistency, with all variables having a Cronbach's alpha value of 0.7 or above. Based on the results of the pilot study, minor revisions were made to the instrument to further enhance its reliability.

Techniques for Data Analysis

The data collected from the questionnaires were analyzed using quantitative techniques. Descriptive statistics, such as frequencies, means, and standard deviations, were used to summarize and describe the characteristics of the data. Multiple regression analysis was employed to examine the relationships between the independent variables (blockchain transparency, traceability, security, and data integrity) and the dependent variable (business performance). This statistical technique was appropriate because it allowed for the assessment of the simultaneous effects of multiple independent variables on a single dependent variable. The regression analysis helped determine the extent to which each of the blockchain attributes affected business performance and identified which variable had the most significant impact. The results provided valuable insights into how blockchain technology could be effectively integrated into the manufacturing sector to enhance performance. The model for multiple regression analysis was specified as follows:

$$BP=\beta_0+\beta_1BTC+\beta_2BTB+\beta_3BS+\beta_4BDI+\epsilon$$

Where:
BP = Business Performance (dependent variable)
BTC = Blockchain Transparency (Independent variable)
BTB = Blockchain Traceability (Independent variable)
BS = Blockchain Security (Independent variable)
BDI = Blockchain Data Integrity (Independent variable)
β_0 = Intercept
β_1-β_4= Coefficients for each independent variables
ϵ = Error term

Results

The results of this study provide compelling evidence of the significant role blockchain technology plays in enhancing business performance in manufacturing firms in Delta State, Nigeria. The high response rate of 96.7% (Table 1) underscores the reliability of the dataset and indicates strong engagement from the respondents (Table 1). This level of participation enhances the validity of the findings and suggests that employees recognize the relevance of blockchain technology in their organizational context. The demographic profile, as observed in the study was dominated by mid-level employees with 5–15 years of experience, further strengthens the credibility of the responses, as these individuals are likely to have substantial exposure to operational processes and the integration of new technologies such as blockchain.

Table 1: Respondents Response to Questionnaires

Category	Frequency	Percentage (%)
Questionnaires Returned	145	96.7
Questionnaires Not Returned	5	3.3
Total	150	100

Descriptive Statistics of Variables

The descriptive statistics (Table 2) reveal that all four dimensions of blockchain technology transparency, traceability, security, and data integrity are perceived to be implemented at high levels within the firms studied. The mean scores, ranging from 4.05 to 4.20, suggest strong agreement among respondents that blockchain adoption

Table 2: The descriptive statistics for each independent variable and the dependent variable.

Variable	Mean	Std. Deviation	Interpretation
Blockchain Transparency (BTC)	4.12	0.68	High level of transparency adoption
Blockchain Traceability (BTB)	4.05	0.72	High adoption of traceability measures
Blockchain Security (BS)	4.20	0.65	Very strong security features in use
Blockchain Data Integrity (BDI)	4.18	0.67	High consistency and accuracy of data
Business Performance (BP)	4.08	0.70	Above-average performance reported

is positively influencing organizational processes. Notably, blockchain security (mean = 4.20) and data integrity (mean = 4.18) scored highest, indicating that firms place particular emphasis on safeguarding transactions and ensuring the reliability of data. This reflects a recognition of the critical importance of secure and accurate information flows in manufacturing, where errors or breaches can have significant financial and reputational consequences. The relatively high mean for business performance (4.08) suggests that these blockchain dimensions are translating into tangible improvements in organizational outcomes.

Correlation Analysis

The correlation analysis (Table 3) provides further insight into the strength of the relationships between blockchain dimensions and business performance. All correlations are positive and statistically significant ($p < 0.01$), with coefficients ranging from 0.613 to 0.688. Blockchain security ($r = 0.688$) demonstrates the strongest correlation with business performance, followed closely by data integrity ($r = 0.670$). This finding implies that firms that prioritize secure systems and reliable data are more likely to achieve superior performance outcomes. Transparency ($r = 0.652$) and traceability ($r = 0.613$) also show strong associations, reinforcing the idea that blockchain's ability to reduce information asymmetry and enhance accountability contributes meaningfully to organizational success. These results highlight the multidimensional nature of blockchain's impact, where each component plays a complementary role in driving performance.

Table 3: Pearson correlation analysis.

Variable	BP
BTC	0.652**
BTB	0.613**
BS	0.688**
BDI	0.670**

The regression analysis (Tables 4–6) provides robust evidence of the predictive power of blockchain technology on business performance. The model summary (Table 4) shows that blockchain dimensions collectively explain 57.4% of the variance in business performance ($R^2 = 0.574$). This is a substantial proportion, indicating that blockchain adoption is a critical determinant of performance outcomes in the manufacturing sector. The adjusted R^2 of 0.564 confirms the stability of the model, suggesting that the findings are not inflated by sample size or extraneous variables. The ANOVA results (Table 5) further validate the model, with a highly significant F-value (78.32, $p < 0.000$), confirming that blockchain technology dimensions jointly exert a statistically significant effect on business performance.

Table 4: Model Summary

Model	R	R^2	Adjusted R^2	Std. Error
1	0.758	0.574	0.564	0.463

Table 5: ANOVA Results.

Source	Sum of Squares	df	Mean Square	F-value	Sig.
Regression	67.145	4	16.786	78.32	0.000
Residual	49.728	140	0.355		
Total	116.873	144			

The coefficients table (Table 6) provides granular insights into the relative contributions of each blockchain dimension. All four variables are statistically significant predictors ($p < 0.01$), with positive beta values indicating that increases in transparency, traceability, security, and data integrity are associated with improvements in business performance. Blockchain security ($\beta = 0.301$) emerges as the most influential predictor, underscoring the critical role of secure systems in enhancing organizational outcomes.

Table 6: Coefficients.

Variable	B	Std. Error	t	Sig.
Constant	0.842	0.271	3.11	0.002
BTC	0.278	0.061	4.56	0.000
BTB	0.212	0.057	3.72	0.000
BS	0.301	0.063	4.78	0.000
BDI	0.259	0.059	4.39	0.000

This finding is consistent with global literature emphasizing

the importance of cybersecurity in blockchain adoption. Blockchain data integrity (β = 0.259) and transparency (β = 0.278) also exert strong effects, highlighting the importance of reliable information and open systems in fostering trust and efficiency. Traceability (β = 0.212), while slightly lower in impact, remains significant, reflecting its role in reducing fraud and inefficiencies in supply chain processes.

The implications of these findings are multifaceted. First, they confirm that blockchain adoption is not merely a technological innovation but a strategic enabler of improved business performance. The strong effects of security and data integrity suggest that firms must prioritize these dimensions to safeguard operations and build stakeholder confidence. Second, the positive associations across all dimensions indicate that blockchain's benefits are holistic, enhancing transparency, accountability, and efficiency simultaneously. Third, the substantial explanatory power of the regression model demonstrates that blockchain adoption can serve as a cornerstone of competitive advantage in the Nigerian manufacturing sector, particularly in contexts where inefficiencies, fraud, and weak stakeholder trust have historically undermined performance. Finally, the results provide empirical evidence that supports global scholarship on blockchain's transformative potential, while also contributing context-specific insights from a developing economy. About 57.4% of the variation in business performance can be explained by the combined effect of blockchain transparency, traceability, security, and data integrity.

DISCUSSION

The findings of this study underscore the transformative potential of blockchain technology in enhancing business performance within manufacturing firms in Delta State, Nigeria. The evidence that transparency, traceability, security, and data integrity collectively explain a significant proportion of performance variance resonates with broader scholarly discourse on blockchain adoption in manufacturing and supply chain contexts. Transparency, as highlighted by Afolabi and Nwachukwu (2021) and Chen et al. (2021), reduces information asymmetry and fosters trust, which is critical in environments where stakeholder confidence is often undermined by inefficiencies and corruption. This aligns with Seitz et al. (2021), who argue that blockchain transparency reshapes decision-making processes by enabling real-time visibility of operations. The Nigerian context, characterized by systemic challenges in manufacturing, makes transparency not just a technological advantage but a strategic necessity. Traceability, another key dimension, has been consistently emphasized in literature as a driver of accountability and efficiency. Casino et al. (2019) and Hastig and Sodhi (2020) demonstrate that blockchain-enabled traceability enhances monitoring of goods and materials, reducing fraud and counterfeiting. This is particularly relevant in Nigeria, where Alabi et al. (2021) note that counterfeiting remains a major challenge in manufacturing. The findings of this study corroborate Li et al. (2021) and Wang et al. (2022), who show that traceability directly improves supply chain efficiency by ensuring that every transaction and movement of goods is verifiable. Chukwu et al. (2024) further reinforce this by demonstrating how blockchain adoption in Nigerian Breweries improved materials management and reduced inefficiencies, thereby validating the empirical evidence from Delta State.

Security emerges as the most critical factor influencing business performance, echoing the arguments of Böhme et al. (2020) and Chang et al. (2021) that blockchain's cryptographic foundations safeguard data and transactions against manipulation. In contexts where cyber threats and data breaches are prevalent, as noted by Kshetri (2018) and Alzahrani et al. (2020), blockchain's immutable ledger provides a robust solution. The strong positive effect of security on performance in this study aligns with Shetty and Singh (2021), who found that enhanced security directly contributes to operational efficiency in manufacturing. This emphasis on security also resonates with Jain et al. (2021) and Sharma et al. (2021), who empirically demonstrated that firms prioritizing blockchain security infrastructure experience superior business outcomes.

Data integrity, the fourth dimension, is equally vital. Park and Kim (2021) argue that blockchain ensures consistency and reliability of manufacturing data, which supports strategic decision-making. The findings here align with Francisco and Swanson (2018) and Durach et al. (2020), who highlight that accurate and tamper-proof data enhances trust and reduces errors in supply chain transactions. In the Nigerian context, Adeyemo et al. (2021) emphasize that reliable data is essential for improving supply chain efficiency, and the results from Delta State confirm that blockchain adoption strengthens this capability. By ensuring that data is immutable and verifiable, firms can make better-informed decisions, reduce operational risks, and enhance competitiveness.

The broader literature situates blockchain adoption within sustainability and competitiveness frameworks. Dobrovnik et al. (2018) and Kouhizadeh et al. (2021) note that blockchain contributes to sustainable supply chains by reducing inefficiencies and promoting accountability. Similarly, Tapscott and Tapscott (2020) argue that blockchain revolutionizes industries by embedding trust and transparency into core operations. The Nigerian evidence presented here supports these global perspectives, demonstrating that blockchain adoption is not merely a technological upgrade but a strategic enabler of sustainable performance. Moreover, studies such as Queiroz and Wamba (2020) and Tönnissen and Teuteberg

(2020) highlight adoption challenges, including infrastructure and regulatory barriers, which remain pertinent in Nigeria. Nonetheless, the empirical findings from Delta State suggest that firms that overcome these barriers stand to gain significant competitive advantage. In synthesizing these insights, it becomes evident that blockchain adoption holistically enhances business performance by addressing systemic challenges in transparency, traceability, security, and data integrity. The Nigerian case contributes to the global discourse by providing empirical evidence from a developing economy, where manufacturing firms face unique challenges of inefficiency, fraud, and weak stakeholder trust. The alignment of these findings with prior studies across diverse contexts from India (Jain et al., 2021; Khan et al., 2021) to China (Mao et al., 2018) underscores the universality of blockchain's impact while also highlighting its contextual relevance in Nigeria. Ultimately, the study affirms that blockchain is not just a technological innovation but a strategic imperative for manufacturing firms seeking sustainable competitiveness in an increasingly digitalized global economy.

Conclusion

The results of the study clearly demonstrate that blockchain technology exerts a significant and positive influence on the business performance of manufacturing firms in Delta State. The high response rate of 96.7% validates the reliability of the data and ensures that the findings are representative of the study population. The descriptive statistics show that all four dimensions of blockchain transparency, traceability, security, and data integrity are perceived to be implemented at high levels, with security and data integrity receiving the strongest ratings. This indicates that firms are actively leveraging blockchain to strengthen operational processes and safeguard critical information. The correlation analysis confirms strong positive relationships between each blockchain dimension and business performance, with coefficients ranging from 0.613 to 0.688. This suggests that improvements in transparency, traceability, security, and data integrity are consistently associated with better organizational outcomes. The regression analysis further reinforces these findings, showing that blockchain dimensions collectively explain 57.4% of the variation in business performance. This is a substantial proportion, highlighting blockchain adoption as a critical determinant of efficiency and competitiveness. The ANOVA results confirm the statistical significance of the model, while the coefficients analysis reveals that all four dimensions are significant predictors of performance. Among them, security has the strongest effect, followed by data integrity and transparency, with traceability also contributing meaningfully. Taken together, these findings lead to the conclusion that blockchain adoption is a strategic enabler of improved business performance in manufacturing firms. Security emerges as the most critical factor, underscoring the importance of protecting data and transactions in a digitalized environment. However, the complementary roles of transparency, traceability, and data integrity demonstrate that blockchain's impact is multidimensional, enhancing trust, accountability, and decision-making. Firms that adopt blockchain holistically across these dimensions are better positioned to reduce inefficiencies, combat fraud, and foster stakeholder confidence, thereby achieving sustainable competitiveness and long-term success.

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