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Adoption of blockchain technology and agricultural supply chain efficiency: Insights from Wa East District, Ghana

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Abstract

This study examines the effect of blockchain technology adoption on supply chain management in the agricultural sector of Ghana's Wa East District, with particular attention to transaction costs, supply chain transparency, and regulatory compliance. A quantitative research design was employed, using regression analysis to test the relationship between blockchain adoption and supply chain performance. The findings reveal a statistically significant relationship between blockchain adoption and transaction cost, a significant relationship between blockchain adoption and transparency, and a significant relationship between blockchain adoption and regulatory framework compliance. Specifically, blockchain adoption was found to reduce transaction costs through automation and disintermediation, enhance transparency through secure and tamper proof traceability mechanisms, and strengthen regulatory compliance by enabling real time auditing and immutable record keeping. The findings suggest that blockchain adoption offers a strategic pathway for addressing longstanding inefficiencies in agricultural supply chains, particularly in rural and fragmented systems, by improving efficiency, accountability, and governance. For policymakers and practitioners, the study recommends targeted investment in digital infrastructure, regulatory frameworks, farmer education, and collaborative partnerships to support sustainable blockchain adoption. The originality of this study lies in its empirical evidence from a rural Ghanaian context, contributing to the limited body of knowledge on blockchain adoption in developing country agricultural supply chains and highlighting its transformative potential for reshaping agricultural value chains in resource constrained settings.

Keywords: Blockchain Adoption, Supply Chain Management, Agriculture, Transaction Costs, Transparency, Regulatory Compliance, Ghana

JEL Classification: O33, Q13, L14, D23, O55

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1. Introduction

Globally, supply chain management in the agricultural sector faces several challenges, including issues of traceability, transparency, inefficiency, and fraud (Duan et al., 2020). Traditional agricultural supply chains often involve multiple intermediaries, resulting in information silos and delayed communication between stakeholders, from farmers to consumers. These challenges can lead to significant losses in quality and quantity of produce, affecting both economic returns for farmers and food security for consumers (Rejeb et al., 2021). In recent years, blockchain technology has emerged as a transformative solution capable of addressing these inefficiencies and enhancing the integrity of agricultural supply chains (Yaga et al., 2018). Blockchain technology, which offers a decentralized and immutable digital ledger, enables stakeholders in a supply chain to trace product origins and track transactions with a high level of accuracy and security (Yaga et al., 2018). This technology has gained attention for its potential to improve transparency and accountability, reduce fraudulent activities, and promote sustainable agricultural practices worldwide. The adoption of blockchain within agricultural supply chains has demonstrated promising results in countries such as China, the United States, and parts of Europe, where it has been applied to monitor crop origins, ensure compliance with quality standards, and facilitate real-time access to data across the supply chain (Ling & Wahab, 2020). In developing countries, particularly in Africa, the agricultural sector remains a major economic driver and source of employment (Dutta et al., 2020). However, the sector also faces challenges with poor infrastructure, fragmented markets, and limited access to financing, making blockchain technology especially relevant in improving efficiencies and fostering trust within supply chains (Kamble et al., 2024; Mao et al., 2024; Tan et al., 2025). Current reforms and sustainable development goals in agriculture emphasize the need for innovative techniques that promote transparency and accountability within the sector (Tripoli & Schmidhuber, 2018). Blockchain technology has emerged as a promising tool capable of transforming agricultural practices. Unlike traditional, centralized, and monopolistic agricultural management systems (Lin & Liao, 2017), blockchain introduces a decentralized data structure that enables secure data storage and sharing among multiple, potentially untrusted parties (Casino et al., 2024).

According to Crosby et al. (2016), the Blockchain technology is a set of blocks that records data in a hash function using a time stamp and a linkage to the previous block. Blockchain technology is a digital, decentralized, and distributed ledger that stores data in an irreversible and immutable form, which allows transaction flows without needing a third party (Stranieri et al., 2021). This completely removes the major vulnerabilities that cyber fraudsters can take advantage of. By allowing immutable and decentralized transactions, Blockchain technology is applied in various sectors, both financial and non-financial more specifically (Tapscott & Tapscotts, 2016), the agriculture sector is constantly facing numerous challenges, including the steady growth of the population, climate change, the increasing number of catastrophes, the loss of biodiversity and the spread of parasites. Therefore, innovation in agricultural processes is necessary to overcome these

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challenges and make agriculture a profitable activity for small- and large-scale farmers. For regions like Ghana, where agriculture is central to economic activity, the early stages of blockchain adoption in supply chains present promising potential. Studies have highlighted the relevance of blockchain for addressing specific supply chain issues within Ghana's agricultural sectors, particularly in regions like the Wa East District, which relies heavily on agriculture (Dzanku et al., 2020; Nyantakyi-Frimpong & Bezner-Kerr, 2015).

Blockchain can help mitigate common issues related to inefficiency, transparency, and traceability within agricultural supply chains. By enabling secure data sharing and enhancing product traceability, blockchain could improve trust among stakeholders, foster stronger market linkages, and boost income opportunities for local farmers (Ankrah & Manu, 2020). Research also suggests that enhancing market linkages through blockchain technology could facilitate better price discovery and reduce transaction costs in agriculture, benefiting regions like the Wa East District, where access to markets remains a challenge (Osei-Asare et al., 2015). The primary components of blockchain technology include distributed computation, decentralized consensus mechanisms, and cryptographic tools like public key infrastructure and hashing (Salviotti et al., 2018). Blockchain establishes a paradigm of trust built on a consensus framework, enabling secure transactions and linking data into a chained format (Trautman, 2016). Wang and Kogan (2018) propose a blockchain-based enterprise transaction processing system that could greatly enhance the efficiency and accuracy of accounting and auditing functions.

This research aims to expand understanding of blockchain network technology and its applications in the Ghanaian agricultural sector, as well as explore the substantial benefits this technology might bring, particularly in simplifying processes for both producers and consumers. In this regard, the researchers conducted an extensive review of academic papers sourced from the Web of Science database. The review targeted studies focusing on blockchain's current role in agriculture, related challenges, contributions of this technology, geographical distribution of relevant research, and its future potential in agriculture, which are all discussed in this study. The main question of this research is: To what extent does the adoption of blockchain technology influence transaction cost, transparency and regulatory framework in the agricultural supply chains.

Thus, there are three specific objectives:

1- To examine to what extent the adoption of blockchain technology influences transaction cost in the agricultural supply chains;

2- To determine to what extent the adoption of blockchain technology influences transparency in the agricultural supply chains;

3- To examine to what extent the adoption of blockchain technology influences regulatory framework in the agricultural supply chains.

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2. Literature Review

2.1 Adoption of Blockchain Technology

Adoption of blockchain technology refers to a distributed ledger system that allows for secure, transparent, and tamper-proof recording of transactions. In agriculture, its adoption enables the digitization of records across the supply chain, improving traceability and reducing the risk of fraud and inefficiencies (Saberi et al., 2019; Kamilaris et al., 2019). Blockchain adoption in the agricultural sector is more than a technological innovation; it is a catalyst for inclusive development. It can empower smallholder farmers, reduce dependency on middlemen, and build trust among actors. However, implementation challenges such as infrastructural deficits and digital illiteracy must be addressed to foster widespread use. Blockchain technology is a decentralized and distributed digital ledger system that enables secure, transparent, and tamper-proof recording of transactions across a network of computers. Unlike traditional centralized systems, blockchain operates on peer-to-peer networks, making it more resistant to fraud, data manipulation, and single points of failure. Originally developed to support cryptocurrencies like Bitcoin, blockchain has evolved and found applications across multiple sectors such as finance, agriculture, healthcare, supply chain, governance, and education (Yli-Huumo et al., 2016; Casino et al., 2019). The fundamental features of blockchain, immutability, decentralization, transparency, and consensus mechanisms, have made it an attractive technology for organizations seeking secure and efficient systems. The adoption of blockchain technology is influenced by several critical factors. One of the most significant drivers is the perceived benefits it offers. Blockchain enhances operational transparency, reduces transaction costs, ensures real-time traceability of goods and services, and minimizes fraud and corruption. These attributes make it especially appealing in industries where trust and accountability are essential (Wamba et al., 2020). In supply chain management, for instance, blockchain helps monitor the movement of goods from production to delivery, ensuring authenticity and reducing counterfeiting (Saberi et al., 2019). Another factor that encourages the adoption of blockchain technology is technological readiness. Organizations that already have a robust IT infrastructure and a culture that embraces innovation are more likely to adopt blockchain successfully (Paliwal et al., 2020). These entities typically have the resources and technical expertise required to integrate blockchain into their existing operations. Institutional pressures, including regulations, industry standards, and competitive dynamics, also play a role in driving adoption. Governments and regulatory bodies are increasingly recognizing the potential of blockchain and introducing policies that support its integration into public and private sector operations (Raimo et al., 2022). Trust and security are other key enablers of blockchain adoption. The cryptographic and decentralized nature of blockchain fosters trust among users and stakeholders. Transactions recorded on a blockchain cannot be altered without consensus from the network, thereby reducing the risks of data manipulation and unauthorized access (Casino et al., 2019). In sectors like finance and healthcare, where data security is paramount, blockchain offers a reliable solution for protecting sensitive information. Moreover, top management support is

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crucial. When senior executives understand the strategic benefits of blockchain and commit to its implementation, adoption is more likely to succeed (Saberi et al., 2019).

2.2 Transaction Cost

Transaction cost refers to the costs associated with market exchanges, including costs of searching for information, negotiating contracts, and enforcing agreements (Williamson, 1981). In agricultural markets, these costs can be high due to information asymmetries and a lack of formal institutions (North, 1990). Blockchain has the potential to lower transaction costs significantly by automating contract enforcement, ensuring real-time verification, and reducing reliance on intermediaries. This shift can make markets more accessible, especially for marginalized producers in remote areas. Transaction costs are generally categorized into three main types: search and information costs, bargaining and decision costs, and monitoring and enforcement costs (North, 1990). Search and information costs involve finding the right products, services, or partners. Bargaining and decision costs arise during negotiations to reach mutual agreements. Monitoring and enforcement costs are incurred to ensure that all parties fulfill their obligations as per the agreed terms. These costs are especially prominent in complex or uncertain transactions where trust and enforceability are in question. In today's global and digital economy, the reduction of transaction costs has become a major advantage offered by digital platforms and technologies. For instance, blockchain technology is often lauded for its potential to lower transaction costs by removing intermediaries, reducing fraud, and enhancing transparency (Tapscott & Tapscott, 2018). Smart contracts, enabled by blockchain, can automatically execute agreements based on pre-set conditions, thus reducing negotiation and enforcement costs. Similarly, e-commerce platforms significantly reduce search and information costs for consumers by offering a wide range of products and services in one place, often accompanied by reviews, comparisons, and real-time pricing (UNCTAD, 2021). In finance, digital payment systems and fintech solutions reduce both time and cost associated with traditional banking procedures, making transactions more efficient, especially in developing economies (World Bank, 2022). However, transaction costs can also increase under certain conditions, such as regulatory complexity, lack of institutional trust, or information asymmetry. In environments with weak legal systems or high corruption, the cost of enforcing contracts may outweigh the benefits of engaging in trade or investment. In such cases, high transaction costs discourage entrepreneurship, limit market access, and slow economic development (North, 1990; Acemoglu & Robinson, 2012).

In the context of public administration and development projects, transaction costs are associated with stakeholder coordination, procurement, regulatory compliance, and implementation monitoring. For example, overly bureaucratic procedures in public procurement can inflate transaction costs, reduce efficiency, and provide opportunities for rent-seeking behavior (OECD, 2020). Streamlining procedures and enhancing transparency can help minimize these inefficiencies and improve service delivery. Reducing transaction costs is also a key goal of institutional reform

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and governance improvements in both the public and private sectors. Investments in digital infrastructure, legal reforms to strengthen contract enforcement, and policies that promote market competition are critical strategies. In international trade, harmonizing standards and simplifying customs procedures under frameworks such as the WTO's trade facilitation agreement also help reduce transaction costs across borders (World Trade Organisation, 2022).

The literature review allows us to stipulate the first hypothesis:

Hypothesis 1: The adoption of blockchain technology influences transaction cost in the agricultural supply chains.

2.3 Transparency

Supply chain transparency involves the disclosure and visibility of product flows, processes, and origin throughout the supply chain (Behnke & Janssen, 2020). In the agricultural context, transparency ensures food safety, ethical sourcing, and sustainability, which blockchain facilitates through immutable records. Today's consumers demand visibility into where and how their food is produced. Blockchain technology can meet this demand by offering real-time data on the journey of food products. This improves trust, supports certification claims (e.g., organic or fair trade), and helps detect problems like contamination faster. Supply chain transparency refers to the degree to which information about supply chain actors, processes, and sourcing practices is openly shared with stakeholders, and it has become a critical factor in promoting ethical conduct, accountability, and sustainability. Transparent supply chains help build consumer trust, improve brand reputation, ensure regulatory compliance, and enhance operational efficiency by enabling better visibility and coordination across the supply network (Christopher, 2016). Driven by consumer demand, regulatory requirements, and technological advancements such as blockchain and IoT, companies are increasingly investing in tools and practices to improve traceability and disclosure (Saberi et al., 2019; Kouhizadeh et al., 2021). However, achieving full transparency is often hindered by the complexity of global supply chains, a lack of standardized reporting metrics, and concerns over competitive confidentiality (Hartmann & Moeller, 2014). Despite these challenges, strategies such as supplier mapping, third-party audits, stakeholder collaboration, and the use of digital technologies can significantly enhance transparency and help firms meet environmental, social, and governance (ESG) expectations (Mol, 2015; Egels-Zandén et al., 2015).

The review of the literature allows us to stipulate the second hypothesis:

Hypothesis 2: The adoption of blockchain technology influences transparency in the agricultural supply chains.

2.4 Regulatory Framework

Regulatory framework refers to the legal and policy environment that governs the deployment and use of technologies like blockchain. Effective regulation ensures data security, standardization,

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and legal recognition of smart contracts and digital records (Casino et al., 2019). In agriculture, a supportive regulatory framework can encourage innovation and trust in blockchain systems. Without clear policies, uncertainties around data privacy, jurisdiction, and liability could slow adoption. Government collaboration with industry and researchers is necessary to establish balanced regulations. An effective regulatory framework ensures transparency, accountability, and predictability in both the public and private sectors. It defines the rights and responsibilities of stakeholders, sets operational standards, and outlines sanctions for non-compliance. In the digital economy, for example, frameworks regulate data protection, digital transactions, cybersecurity, intellectual property rights, and competition. These regulations provide certainty for investors and protect consumers from exploitation and abuse (UNCTAD, 2021). The relevance of a strong regulatory framework has become increasingly evident in the wake of technological advancements and globalization. As economies evolve, especially with the rise of digital platforms and cross-border trade, regulatory systems must adapt to address emerging risks while fostering innovation. In many developing countries, however, regulatory institutions remain weak or outdated, often lacking the capacity to implement and enforce new regulations effectively (World Bank, 2022). This regulatory lag can hinder progress, discourage investment, and contribute to corruption or regulatory capture. In sectors such as finance and banking, regulatory frameworks are essential to maintain stability and protect depositors. Financial regulations typically cover areas like capital adequacy, anti-money laundering (AML), consumer protection, and financial reporting. Institutions such as central banks and financial supervisory authorities enforce these regulations to ensure that banks operate safely and transparently (BIS, 2022). Similarly, in the environmental sector, regulations ensure that natural resources are used sustainably, environmental degradation is minimized, and climate targets are met. The development and implementation of regulatory frameworks involve multiple stakeholders, including governments, industry players, civil society, and international organizations. The consultative and participatory approach to regulation-making improves legitimacy and compliance. Additionally, harmonization of regulations across countries, especially in regional blocs like the European Union (EU) or the Economic Community of West African States (ECOWAS), facilitates trade and cooperation by reducing regulatory fragmentation (UNECA, 2021).

Nevertheless, the effectiveness of regulatory frameworks often depends on institutional capacity, political will, and public trust. Weak enforcement mechanisms, lack of human and technical resources, and bureaucratic inefficiencies can undermine the integrity of regulatory systems. In some cases, over-regulation can stifle innovation, increase the cost of doing business, and create opportunities for rent-seeking behavior. Therefore, regulatory frameworks should strike a balance between oversight and flexibility, ensuring that rules protect societal interests without becoming unnecessarily burdensome (OECD, 2020). One of the current areas receiving global attention is the regulation of emerging technologies, such as artificial intelligence (AI), blockchain, and biotechnology. These fields pose complex challenges for regulators due to their rapid pace of

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development and potential ethical, privacy, and security implications. For instance, regulating blockchain requires addressing issues like digital identity verification, legal recognition of smart contracts, and prevention of financial crimes in decentralized systems (WEF, 2023). In such cases, regulatory sandboxes and adaptive governance models are being employed to allow innovation while monitoring risk.

The review of the literature allows us to stipulate the third hypothesis:

Hypothesis 3: The adoption of blockchain technology influences regulatory framework in the agricultural supply chains.

2.5 Theoretical Review

The theoretical framework for this study on the adoption of blockchain technology in Ghana's agricultural supply chains is grounded in three foundational theories: Diffusion of Innovations Theory, Institutional Theory, and the Technology-Organization-Environment (TOE) Framework. Together, these theories provide a structured approach to understanding the drivers, barriers, and contextual factors influencing blockchain adoption among agribusinesses in Ghana. Diffusion of Innovations Theory, proposed by Rogers (2010), explains how new technologies are communicated and adopted within a social system. This theory is crucial for identifying the attributes that make blockchain appealing to agricultural businesses, such as its potential to enhance transparency and traceability in supply chains. The theory also highlights the role of social influences and external pressures in accelerating adoption, which can be vital for understanding how blockchain technology may gain traction in Ghana's agricultural sector. Institutional Theory (Scott, 2014) emphasizes how organizational decisions are shaped by formal and informal rules, norms, and pressures from the environment. For blockchain adoption in Ghana, institutional factors like regulatory frameworks, market demands for transparency, and pressure from international stakeholders play a significant role. By analyzing these institutional influences, the study can shed light on the regulatory and economic conditions that either support or hinder blockchain adoption. Lastly, the Technology-Organization-Environment (TOE) Framework provides a multi-dimensional view, considering how technological readiness, organizational capacity, and environmental pressures collectively impact adoption. This framework enables a nuanced understanding of the internal and external factors influencing blockchain implementation, such as technological infrastructure, organizational resources, and competitive pressures. By integrating these theories, the study creates a comprehensive framework that captures the complexity of blockchain adoption in Ghana's agribusiness landscape, laying a robust foundation for exploring both enablers and constraints in the adoption process.

2.6 Diffusion of Innovation Theory

Diffusion of Innovation (DOI) Theory, proposed by Rogers (1961), is a foundational framework that explains how new ideas and technologies spread through social systems. This theory is

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relevant for understanding the adoption of blockchain in Ghana's agricultural sector, as it provides insights into how innovations move through populations and organizations. DOI categorizes adopters into groups such as innovators, early adopters, early majority, late majority, and laggards, each with unique characteristics affecting their adoption rate. For blockchain in agriculture, understanding these categories can help identify which stakeholders are likely to embrace the technology first and which may need more support or incentives to adopt it. In the context of Ghana's agricultural supply chains, DOI Theory suggests that early adopters of blockchain, such as larger agribusinesses or export-focused farms, may set the trend for smaller and more localized entities. These early adopters can demonstrate blockchain's potential benefits, such as improved traceability and enhanced market access, encouraging others in the sector to follow suit (Lee & Xia, 2020). Research shows that early adopters often influence their peers, and in the agricultural sector, this could mean that successful implementations of blockchain could drive wider adoption, especially among smallholders who initially perceive blockchain as complex or costly. Additionally, DOI Theory emphasizes the role of social networks in influencing adoption decisions. For Ghana's agriculture, farmer cooperatives, trade associations, and community-based organizations can act as conduits for information about blockchain technology, helping spread awareness and understanding. These networks could encourage laggards and late adopters by reducing perceived risks and demonstrating tangible benefits. Thus, DOI Theory highlights how the social structure within Ghana's agricultural community can play a significant role in the diffusion of blockchain technology.

2.7 Transaction Cost Theory

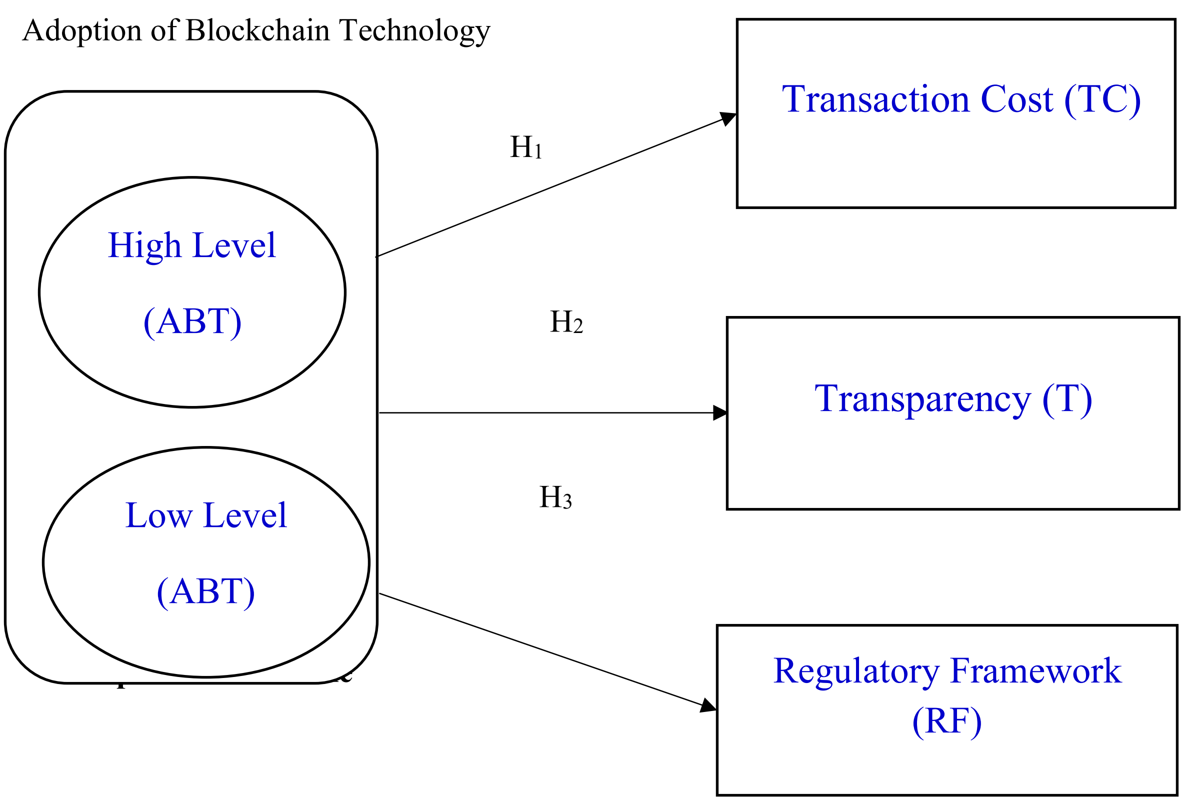
Transaction Cost Theory (TCT), introduced by Coase and later developed by Williamson, provides a lens for analyzing the economic impact of adopting new technology by focusing on transaction costs associated with exchanges (Williamson, 2010). In the context of blockchain in agriculture, TCT suggests that blockchain could reduce transaction costs by enhancing transparency and minimizing the need for intermediaries, which is particularly relevant for Ghana's agricultural sector. By improving the efficiency of transactions, blockchain has the potential to create more streamlined and cost-effective supply chains. For Ghana's agriculture, TCT implies that blockchain can reduce costs associated with information asymmetry and trust issues. Currently, smallholder farmers in Ghana often face high transaction costs due to inefficiencies in verifying product authenticity, coordinating with suppliers, and meeting buyer requirements (Rejeb et al., 2021). Blockchain's decentralized nature can facilitate trust among parties, thus reducing the need for intermediaries and lowering the costs involved in managing complex transactions (Saberi et al., 2019). This efficiency aligns with TCT's premise that organizations seek to minimize transaction costs to maximize profitability.

DOI: https://doi.org/10.56879/ijbm.v5i2.80

2.8 Resource-Based View Theory

The Resource-Based View (RBV) Theory, developed by Barney (1991), posits that organizations gain a competitive advantage by leveraging unique resources and capabilities. Blockchain technology, as a digital asset, can be seen as a valuable, rare, and hard-to-imitate resource, which aligns with the RBV framework (Barney, 2014). This theory is relevant for understanding how blockchain can serve as a strategic tool for agribusinesses in Ghana, enabling them to differentiate themselves by improving supply chain transparency, reducing fraud, and enhancing trust with international buyers. According to RBV, resources must be valuable, rare, inimitable, and non-substitutable (VRIN) to provide a sustainable competitive advantage. Blockchain meets these criteria in several ways: it adds value by enhancing transparency and trust, is relatively rare in Ghana's agricultural sector, and is difficult to replicate due to its technological complexity (Wamba et al., 2020). For Ghanaian agribusinesses, adopting blockchain can create a competitive edge, especially when targeting export markets where product traceability and ethical sourcing are valued (Zhou et al., 2022).

Figure 1. Conceptual Model



Source: Adapted from Nacoulma, Akouwerabou and Nassè (2020)

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3. Materials and Methods

3.1 Research Design/Procedure

The study adopts a quantitative orientation, grounded in the positivist paradigm, which emphasizes objective measurement and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data. This approach is appropriate given the nature of the research problem and strategy, which require empirical testing of hypotheses and examination of relationships between measurable variables (Creswell, 2014). Quantitative research is characterized by its reliance on structured tools and standardized data collection instruments to ensure replicability and consistency (Babbie, 2013). As noted by Creswell (2014), this approach enables researchers to quantify behaviors, attitudes, opinions, and other defined variables—and to generalize results from a larger sample population. The methodological focus is on obtaining data that can be subjected to statistical analysis to validate or refute theoretical propositions. A variety of quantitative research designs exist, including descriptive studies, correlational studies, experimental and quasi-experimental studies, and causal-comparative studies. These designs often make use of tools such as structured questionnaires, closed-ended surveys, standardized tests, and existing databases. Data analysis techniques typically involve descriptive statistics, inferential statistics, regression models, and hypothesis testing procedures. In this study, data is gathered through structured instruments and analyzed using statistical software to determine patterns, relationships, and significance levels. The aim is to ensure objectivity and reliability while minimizing researcher bias. According to Bryman (2016), the strength of the quantitative approach lies in its ability to produce findings that are both replicable and generalizable to larger populations.

3.2 Research Instrument

To effectively examine the effects of blockchain technology on agricultural supply chains in the Wa East District, this study employs structured quantitative data collection instruments**.** These tools are designed to yield measurable data that can be statistically analyzed to determine patterns, relationships, and potential causal links. The instruments include structured questionnaires**,** survey checklists**,** secondary data records**,** and observation schedules**,** each tailored to ensure objectivity, reliability, and validity in line with the study's quantitative orientation.

3.3 Research Setting

This study adopts a positivist research orientation to examine the effects of blockchain technology on agricultural supply chains in the Wa East District. The primary aim is to identify and measure the impact of blockchain adoption on key supply chain outcomes such as efficiency, transparency, trust, traceability, and value creation. A positivist approach is suitable for this inquiry, as it allows the research to objectively assess the relationships between blockchain technology and supply

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chain performance using measurable indicators and structured data collection tools (Creswell, 2014).

3.4 Research Participants

The target population for this study comprises key stakeholders involved in the agricultural supply chain in the Wa East District. These include farmers, both smallholder and commercial, who are engaged in the production of agricultural goods. It also includes agricultural input suppliers who provide essential resources such as seeds, fertilizers, and other inputs. Middlemen and traders, who play a role in facilitating the distribution of agricultural products, as well as processors who add value to these products, are also part of the target population. Furthermore, the study involves retailers and wholesalers who sell agricultural products to end consumers. Agricultural cooperatives and associations, which often serve as collective platforms for farmers, are also be considered.

3.5 Sample Technique and Sampling Size

In the context of this study, sampling is necessary due to the impracticality of engaging the entire population within the Wa East District. Additionally, sampling facilitates the researcher's ability to account for variations in characteristics, opinions, and experiences within the target population, especially those involve in agricultural supply chains and the adoption of blockchain technology. The sampling approach is significant in ensuring that the findings are representative and reflective of the district's broader engagement with blockchain technology. The sample technique that is used to select the respondends is the simple random sampling. This randomization ensured equal chances of selection, minimizing bias and promoting representativeness. The sampling size for the study was obtained by taking total number of households and stakeholders in the four selected communities (Bulenga, Bunaa, Goripie, Yaala) which is 2,460. The sample size determination formula by Yamane (1967) was used to calculate the sample size.

$n = N/ [1+Ne^2]$

Where n = Sample size, N = Sampled frame = 2,460 and e = Sample error/Significant level = 5% = 0.05

Thus, n = 2,460/ (1+2,460 x 0.052) = 344.0 = rounded to the nearest 10, results in 344. Hence, a sample size of 344 is enough for this study.

3.6 Data Analysis

Following data collection, the initial step involves preparing and cleaning the dataset to ensure accuracy and reliability. Structured questionnaire responses are entered into statistical software such as SPSS, STATA, or R. Data is screened for completeness, consistency, and accuracy by identifying and treating missing values, detecting and managing outliers, and verifying proper

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coding of all variables. This ensures the data set is suitable for rigorous analysis. Next, the responses are numerically coded to allow for quantitative analysis. For instance, Likert-scale items are coded (e.g., 1 = Strongly Disagree to 5 = Strongly Agree), and categorical responses are converted into numerical labels. Where appropriate, composite indices are developed to measure constructs such as blockchain benefits or supply chain efficiency. Internal consistency of these indices are assessed using Cronbach's alpha to ensure reliability. Descriptive statistical analysis are then be conducted to summarize the basic features of the dataset. Frequencies and percentages are used to describe categorical variables such as gender and stakeholder group, while measures such as means, standard deviations, and ranges describe continuous variables like years of farming experience or blockchain use. These descriptive statistics provide a general overview of the data and highlight key trends and distributions. Inferential statistical techniques are applied to test hypotheses and examine relationships between variables. Depending on the nature of the data, Pearson correlation are used for relationships between continuous variables, chi-square tests for associations between categorical variables, and t-tests or ANOVA for comparing group means (e.g., blockchain adopters vs. non-adopters). All analyses are conducted at a 5% significance level ($p < 0.05$).

3.7 Ethical Consideration

As with any research endeavor, ethical concerns hold great significance and necessitate the researcher's diligent attention to ensure that the resulting work adheres to the requisite ethical standards, particularly the APA Ethics Code of 2002. Consequently, the study in question meticulously incorporated a multitude of ethical considerations in its procedural undertakings. In the course of the study, the researchers rigorously adhered to the anonymity of the respondents and the confidentiality of the information provided. The study provided a guarantee to the respondents regarding the concealment of their identities and the protection of information disclosed, such that no individual or reader of the report could discern their identities or attributions (Nassè et al., 2026).

4. Results

4.1 Demographic Characteristics of Respondents

With a focus on the demographic characteristics of respondents, the study examined key attributes that may influence the adoption and effectiveness of blockchain technology in agricultural supply chain management. These characteristics included the age, sex, educational level, number of years engaged in farming or agribusiness, years of experience within the agricultural supply chain, and the income levels of the respondents (see Table 1). Understanding these features provides deeper insights into the profile of participants and helps contextualize their responses regarding blockchain adoption in the Wa East District.

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Table 1. Demographic Characteristics of Respondents (N = 344)

Variable	Category	Count	%	Std. Dev
Sex	Male	251	73%	
	Female	93	27%	**0.4471**
	Total	**344**	100%	
Age	20–29	14	4%	
	30–39	189	55%	
	40–49	83	24%	
	50+	58	17%	**0.5901**
	Total	**344**	100%	
Highest Educational Level	SHS	52	15%	
	Diploma	83	24%	
	Bachelor's Degree	196	57%	
	Master's Degree	13	4%	**0.5789**
	Total	**344**	100%	
Years of Experience in Agriculture	1–5	162	47%	
	6–10	117	34%	
	11–15	31	9%	
	15–20	17	5%	
	21+	17	5%	**0.6975**
	Total	**344**	100%	

Source; Field Survey, 2025

Out of the 344 respondents, 73% were male (251), while 27% were female (93). This indicates a significant gender imbalance, suggesting male dominance in agricultural supply chain activities in the Wa East District. This finding is consistent with observations by Doss et al. (2018), who argue that men often have greater access to agricultural resources, digital tools, and decision-making roles in rural Ghana. The limited participation of women may reflect structural barriers such as limited land ownership, low digital literacy, and restricted access to capital. The majority of respondents (55%) fell within the 30–39 age bracket, followed by 24% between 40–49 years, 17% above 50 years, and only 4% aged 20–29. This age distribution suggests that the agricultural supply chain in the area is largely driven by adults in their productive and economically active years. It is noted that youth participation in agriculture remains low due to perceptions of agriculture as labor-intensive and low-yielding. However, the dominance of middle-aged individuals presents a unique opportunity for blockchain adoption, as this group is more likely to appreciate innovations that increase efficiency and reduce transaction risks.

A substantial proportion of respondents had attained at least a Bachelor's degree (57%), followed by Diploma holders (24%), SHS graduates (15%), and Master's degree holders (4%). This high

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educational level among participants is encouraging for the adoption of blockchain technology, as education correlates positively with the willingness to adopt and utilize digital innovations. According to Rogers' Diffusion of Innovations Theory (2003), individuals with higher education are more likely to adopt new technologies because they better understand the relative advantages and complexity of innovations like blockchain. Approximately 47% of respondents had 1–5 years of experience in the agricultural sector, followed by 34% with 6–10 years, 9% with 11–15 years, and 5% each with 15–20 years and over 21 years of experience. This indicates that nearly half of the participants are relatively new to the sector, which may imply openness to innovation. It is observed that individuals newer to a sector are often more adaptive to technological change due to fewer entrenched practices and openness to efficiency-enhancing tools. Moreover, those with moderate experience may have already observed inefficiencies in traditional supply chains and may welcome blockchain solutions for traceability, transparency, and trust-building.

4.2 Reliability Analysis

The concept of reliability in testing refers to the consistency and stability of a measurement instrument in capturing the latent construct it is intended to assess. In other words, a reliable test ensures that the items within a scale consistently reflect the underlying concept being measured. This is typically evaluated by examining the item-total statistics, which involve assessing the correlation of each individual item with the total score of the scale. Items with high loadings on the item-total correlation indicate that they contribute meaningfully to the overall construct and, therefore, enhance the internal consistency of the scale. To determine the reliability of each latent construct in this study, a reliability analysis was conducted using Cronbach's alpha coefficient, a widely accepted measure of internal consistency. Cronbach's alpha values range from 0 to 1, with higher values (generally ≥0.70) indicating greater reliability. In this context, the reliability analysis provides insight into how well the selected items for each construct collectively measure the intended underlying factor. Henceforth, the reliability analysis results for each of the identified latent constructs are presented below, highlighting the Cronbach's alpha values, item-total correlations, and the impact of item deletion, if any, on the overall reliability of the scale. Henceforth, the reliability analysis for each of the latent constructs is indicated on Table 2.

Table 2. Summary of Reliability

Variable	Number of items	Alpha Cronbach value
Adoption of Blockchain Technology	5	0.93
Regulatory framework	5	0.93
Transaction cost	7	0.94
Transparency	5	0.85

Source: Field Survey, 2025

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Given this results on Table 2, it was determined that all items are essential and contribute meaningfully to the measurement of the different constructs. These findings confirm the appropriateness and reliability of the items used to capture the constructs.

4.3 Testing of Hypotheses

Following the ability to determine the reliability of the test items, a regression test was used to test the hypotheses that were raised. Cognizant of the results of the normality test, the ordinary square model and the multiple regression analysis were used to test the hypothesis as shown in Table 3.

Table 3. Correlation Analysis Results

Hypothesis	Variables	Coef.	Stand. Err	t-value	p-value	Significance
H_1	Adoption of blockchain technology and transaction cost	4.24	0.47	3.40	0.002	Significant
H_2	Adoption of blockchain technology and transparency	4.20	0.46	96.65	0.002	Significant
H_3	Adoption of blockchain technology and regulatory framework	3.55	0.3	87.23	0.003	Significant

Source: Field survey, 2025

There is a need to test these hypotheses.

H_1: The adoption of blockchain technology influences transaction cost in the agricultural supply chains.

H_0: The adoption of blockchain technology does not influence transaction cost in the agricultural supply chains.

H_2: The adoption of blockchain technology influences transparency in the agricultural supply chains.

H_0: The adoption of blockchain technology does not influence transparency in the agricultural supply chains.

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H_3: The adoption of blockchain technology influences regulatory framework in the agricultural supply chains.

H_0: The adoption of blockchain technology does not influence regulatory framework in the agricultural supply chains.

4.3.1 Adoption of Blockchain Technology and Transaction Cost in the Agricultural Supply Chains

The findings reveal that there is a significant link between adoption of blockchain technology and transaction cost with a t-value of 3.40, and a p-value of 0.002 (see Table 3). Thus, the null hypothesis (H_0) is rejected and the alternative hypothesis is accepted. Hypothesis one (H_1) is confirmed.

H_1: The adoption of blockchain technology influences transaction cost in the agricultural supply chains.

4.3.2 Adoption of Blockchain Technology and Transparency in the Agricultural Supply Chains

The findings reveal that there is a significant link between the adoption of blockchain technology and transparency with a t-value of 96.65, and a p-value of 0.002 (see Table 3). Thus, the null hypothesis (H_0) is rejected and the alternative hypothesis is accepted. Hypothesis two (H_2) is confirmed.

H_2: The adoption of blockchain technology influences transparency in the agricultural supply chains.

4.3.3 Adoption of Blockchain Technology Influences Regulatory Framework in the Agricultural Supply Chains

The findings reveal that there is a significant link between the adoption of blockchain technology and regulatory framework with a t-value of 87.23, and a p-value of 0.003 (see Table 3). Thus, the null hypothesis (H_0) is rejected and the alternative hypothesis is accepted. Hypothesis three (H_3) is confirmed.

H_3: The adoption of blockchain technology influences regulatory framework in the agricultural supply chains.

4.4 Additional Findings

Table 4. Regression Analysis

Variable	**Coef.**	**Stand. Err**	**T**	**P>t**	**[95% Conf. Interval**	
					Lower	Upper
Constant	1.42	0.52	2.72	0.007	0.40	2.44

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Transaction Cost	0.63	0.19	3.32	0.002	0.26	1.00
Transparency	0.58	0.17	3.41	0.001	0.24	0.92
Regulatory Framework	0.47	0.15	3.13	0.003	0.18	0.76
Chi-square	16.31					
Df	3					
F=0.00						
R^2=0.93						

Model Statistics	Value
Observations (N)	210
F-statistic	34.62
Prob > F	0.000
R^2	0.68
Adjusted R^2	0.66

Key: TC = Transaction Cost, T = Transparency, and RF = Regulatory Framework

Source: Field survey, 2025

The regression analysis was conducted to examine the factors influencing blockchain technology adoption in agricultural supply chains. In this model, Adoption of Blockchain Technology (ABT) is the independent variable, while Transparency (T)**,** Transaction Cost (TC**)**, and Regulatory Framework (RF) are the dependent variables. On Table 4, the results of the regression analysis indicate that the adoption of blockchain technology has a positive and statistically significant link with transaction cost with $\beta = 0.63$, and $p = 0.002$. The positive coefficient indicates the adoption of blockchain technology reduces operational and transaction cost in the agricultural supply chains. This suggests that blockchain systems help to minimize intermediary cost, verification cost, and to streamline payment and contract processes in the agricultural value chain. Therefore, this supports the hypothesis that blockchain technology adoption influences transaction cost in the agricultural supply chains. Again, on Table 4, the results of the regression analysis indicate that the adoption of blockchain technology has a positive and statistically significant link with transparency with $\beta = 0.58$, and a $p = 0.001$. This implies that the adoption of blockchain technology improves the transparency within the agricultural supply chains. The finding suggests that when stakeholders in the agricultural sector perceive blockchain as a tool that enhances traceability, accountability, and visibility of transactions, they are more inclined to adopt it. This

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supports the hypothesis that blockchain technology adoption influences transparency in the agricultural supply chains. Similarly, on Table 4, the results of the regression analysis indicate that the adoption of blockchain technology has a positive and statistically significant link with regulatory framework with $\beta = 0.47$, and $p = 0.003$. This result indicates that the adoption of blockchain technology plays an important role in promoting supportive policies, and regulatory clarity in agricultural supply chains. Blockchain-based systems help governments and regulatory bodies to provide clear guidelines, supportive legislation, and institutional support to stakeholders with confidence. Thus, this supports the hypothesis that the adoption of blockchain technology influences regulatory framework in the agricultural supply chains.

Overall, the model demonstrates a strong explanatory power, with an R^2 value of 0.68**,** indicating that approximately 68% of the variation in blockchain technology adoption is explained by supply chain transparency, lower transaction costs, and regulatory framework. The F-statistic (34.62) with a probability value of 0.000 further confirms that the regression model is statistically significant and that the independent variables jointly influence blockchain technology adoption in the agricultural sector. These findings highlight the importance of the adoption of blockchain technology to reduce transaction cost, to improve transparency, and to establish supportive regulatory environments in agricultural supply chains.

4.5 Discussion

4.5.1 Adoption of Blockchain Technology and Transaction Cost in the Agricultural Supply Chains

The findings of some researchers such as Kamble et al. (2020) and Saberi et al. (2019) show that blockchain improves efficiency and reduces operational redundancies in agri-supply chains. The present findings rather reveal that the adoption of blockchain technology influences transaction cost in the agricultural supply chains within an emerging economy context.

4.5.2 Adoption of Blockchain Technology and Transparency in the Agricultural Supply Chains

Aro et al. (2024) have shown that the adoption of blockchain technology has an effect on corporate governance and transparency. Additionally, some researchers such as Francisco and Swanson (2018) demonstrate that blockchain technology fosters data integrity and transparency across decentralized networks. In the same line, the current findings show that the adoption of blockchain technology influences transparency in the agricultural supply chains.

4.5.3 Adoption of Blockchain Technology and Regulatory Framework in the Agricultural Supply Chains

Sheel and Nath (2019) have shown that the adoption of blockchain technology has a significant effect on supply chain agility, adaptability, agility, and alignment, and this can improve performance. Additionally, Nassè et al. (2026) demonstrate that digital technology adoption enhances traditional procurement systems by improving the service delivery in rural healthcare

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environments. However, the current findings show that the adoption of blockchain technology influences regulatory framework in the agricultural supply chains in the context of Wa, Ghana.

5. Conclusion and Recommendations

The findings clearly demonstrate that blockchain technology adoption significantly enhances agricultural supply chain performance in the Wa East District by improving efficiency and reducing transaction costs. The strong positive relationship between blockchain adoption and supply chain outcomes indicates that digital innovation is a key driver of modernization in rural agricultural systems. Specifically, blockchain reduces operational bottlenecks such as fraud, delays, and excessive intermediary involvement by enabling transparent, secure, and automated transactions. Moreover, the significant role of blockchain in lowering transaction costs highlights its potential to make agricultural trade more accessible and profitable, especially for smallholder farmers and aggregators. The cost savings realized through automation and decentralized verification can be redirected toward value addition, improving productivity, and increasing market competitiveness. The integration of blockchain into agricultural supply chains presents a viable strategy for improving transparency, reducing inefficiencies, and fostering trust among value chain actors. For this potential to be fully realized, stakeholders must invest in digital infrastructure, capacity building, and regulatory support to facilitate broad-based adoption and sustainable impact. The findings from the regression analysis provide strong evidence that blockchain technology adoption significantly improves supply chain management in the agricultural sector of Wa East District. The positive and statistically significant relationship between blockchain adoption and supply chain performance confirms that blockchain is a transformative tool capable of enhancing the efficiency, reliability, and integrity of agricultural supply chains. A major pathway through which blockchain achieves this impact is supply chain transparency. By enabling real-time, secure, and tamper-proof data sharing, blockchain fosters trust, traceability, and accountability among supply chain actors. This not only improves operational efficiency but also reduces information asymmetry, disputes, and transaction delays, factors that often undermine productivity in traditional agricultural systems. Blockchain adoption, particularly through its ability to improve transparency**,** serves as a critical enabler for building more resilient, inclusive, and efficient agricultural value chains. Promoting its use, therefore, holds great potential for advancing agricultural transformation and rural development in Wa East District and other similar rural economies. The study demonstrates that blockchain technology adoption has a strong and statistically significant positive effect on agricultural supply chain management in Wa East District. This confirms the transformative power of blockchain in enhancing transaction integrity, transparency, and operational efficiency. Blockchain facilitates secure, decentralized data sharing that builds trust and accountability among value chain actors, leading to improved coordination and performance across the supply chain. Moreover, the study highlights that the regulatory framework serves as a vital enabler in maximizing the impact of blockchain technology. A well-structured and supportive regulatory environment not only promotes adoption but also

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ensures that blockchain operates within safe, secure, and legally sound boundaries. It provides the necessary guidelines for data protection, identity verification, and transaction legitimacy, which are critical for user confidence and system reliability. The synergistic relationship between blockchain adoption and an effective regulatory framework is essential for unlocking the full potential of digital transformation in agriculture. This underscores the need for policymakers, industry stakeholders, and development partners to prioritize both technological innovation and regulatory readiness. Together, these efforts can build a more resilient, transparent, and efficient agricultural value chain that supports rural development and economic growth.

5.1 Recommendations

Based on the findings of the study, the researchers recommend that stakeholders such as farmers, aggregators, processors, and input dealers should be sensitized and trained on the benefits and use of blockchain systems. Public-private partnerships and development agencies can support the rollout of pilot projects and digital literacy campaigns to encourage adoption, especially among smallholder farmers. The government, through relevant regulatory bodies, should develop and enforce clear legal and policy guidelines to govern blockchain usage in agriculture. This includes standards for data protection, transaction verification, and digital identity management, which foster trust and legal assurance among users. To support blockchain implementation, there must be reliable internet access and digital platforms across rural areas. Investments should be made in rural ICT infrastructure, including network coverage and digital tools (such as mobile devices and apps), to bridge the digital divide and enable seamless blockchain integration.

5.2 Limitations and Future Research

This research is a quantitative one. Thus, it is good to carry out a qualitative research to get the perceptions of the respondents on the topic. Future research could also explore the long-term socioeconomic impacts of blockchain adoption on smallholder farmers' income, market access, and financial inclusion in rural agricultural communities. This would provide deeper insights into how blockchain technology contributes not only to supply chain efficiency but also to broader rural development and poverty reduction goals.

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