

**ASSESSMENT OF BLOCKCHAIN TECHNOLOGY AND SUPPLY CHAIN  
PERFORMANCE OF FOOD AND BEVERAGE MANUFACTURING FIRMS IN  
NAIROBI CITY COUNTY**

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**A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE  
REQUIREMENTS FOR THE AWARD OF MASTERS OF SCIENCE IN  
PROCUREMENT AND SUPPLIES MANAGEMENT OF  
MOUNT KENYA UNIVERSITY**

**JUNE 2025**



## DEDICATION

I dedicate this study to my family and mentors whose unwavering support and encouragement inspired me throughout this research journey.



## ACKNOWLEDGMENT

I sincerely acknowledge the invaluable guidance and support of my supervisor Dr. Ndolo Jackson, whose expertise and encouragement greatly enhanced this study. I also thank the management and staff of the Kenya Association of Manufacturers for their cooperation and willingness to participate. Special appreciation goes to the procurement officers in Nairobi City County who generously shared their time and insights. My gratitude extends to Mount Kenya University Graduate School and the National Commission for Science, Technology, and Innovation for facilitating the research permit process. Finally, I am deeply grateful to my family and friends for their continuous moral support and understanding throughout this project. Without their contributions, this research would not have been possible.



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## ABSTRACT

Globally, technological advancements particularly in ICT have significantly transformed business operations, with blockchain technology emerging as a key innovation. As a decentralized data system, blockchain enables the digital tracking of transactions and the sharing of information across a distributed network, promoting transparency, security, and trust. For manufacturing firms, blockchain presents opportunities to streamline operations, enhance supply chain transparency, and boost performance. This study aimed to bridge knowledge gaps by investigating the impact of blockchain's core features traceability, interoperability, security, and smart contract utilization on the supply chain performance of manufacturing firms in Nairobi City County. The research was guided by four objectives: to examine the effect of traceability, assess the influence of interoperability, evaluate the impact of security, and determine the role of smart contract utilization on supply chain performance. Two theoretical frameworks supported the study: the Resource-Based View (RBV) Theory and the Technology-Organization-Environment (TOE) Framework. A descriptive research design was employed, targeting food and beverage manufacturing firms registered under the Kenya Association of Manufacturers in Nairobi City County. With a total of 375 firms, the study sampled three respondents from each representing operational, tactical, and strategic procurement levels. Stratified random sampling ensured balanced representation across the target population. Data collection was conducted through structured questionnaires distributed to procurement officers. To ensure ethical compliance, the researcher obtained an introductory letter from Mount Kenya University and a research permit from the National Commission for Science, Technology and Innovation (NACOSTI). Data were analyzed using SPSS version 26, employing both descriptive statistics (frequencies, percentages) and inferential statistics, including multiple linear regression to assess the relationships between variables. Findings revealed strong recognition of blockchain's benefits among respondents, with 68.6% citing reduced data transmission errors, 69.8% noting improved operational efficiency, and 53.9% acknowledging enhanced data sharing. However, challenges were also reported, particularly around integration with existing IT systems and stakeholder collaboration. A one-sample t-test showed that the benefits of interoperability were statistically significant ( $p < 0.001$ ), with error reduction and operational efficiency being the most impactful outcomes. In conclusion, the study found that blockchain-enabled interoperability significantly enhances supply chain performance by improving data accuracy, real-time information sharing, and operational efficiency. Despite these benefits, integration with legacy systems remains a key challenge. To address this, the study recommends that manufacturing firms work closely with technology providers and regulatory bodies to establish standardized APIs and data formats. This would promote smoother integration of blockchain with existing infrastructure, ultimately improving communication, interoperability, and overall supply chain performance.

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## LIST OF ABBREVIATIONS

<b>GDP:</b>	Gross Domestic Product
<b>ICT:</b>	Information and Communication Technology
<b>KAM:</b>	Kenya Association of Manufacturers
<b>KNBS:</b>	Kenya National Bureau of Statistics
<b>NACOSTI:</b>	National Commission for Science, Technology and Innovation
<b>RBAC:</b>	Role-Based Access Control
<b>RBV:</b>	Resource-Based View
<b>SPSS:</b>	Statistical Package for Social Sciences
<b>TOE:</b>	Technology-Organization-Environment

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background of the Study

Globally, advancements in technology and the growth of ICT have significantly transformed business operations, particularly with the adoption of Blockchain Technology. Over the past two decades, globalization and digitalization have reshaped supply chain networks, emphasizing agility, resilience, and transparency. According to the World Bank (2023), global supply chains contribute to over 50% of international trade, but are often hampered by inefficiencies such as information asymmetry, lack of real-time data, and increased risks of counterfeiting. In response, firms have turned to technological innovations most notably blockchain technology to address these persistent challenges and enhance supply chain performance.

Blockchain technology has revolutionized how businesses conduct transactions by reducing operational costs, increasing visibility, and enhancing efficiency in the global marketplace. It is a decentralized system that allows for the digital recording of transactions and the exchange of information across a network of computers. This creates a secure and transparent environment for building trust. Although it was originally designed to support digital currencies such as Bitcoin, its use has expanded to various business operations, including real-time tracking of products, management of financial records, and inventory monitoring within supply chains (Zhao et al., 2022; Feng et al., 2023).

Supply chain performance is commonly assessed through metrics such as delivery reliability, responsiveness, cost efficiency, asset management, and flexibility (Beamon, 2021; Chopra & Meindl, 2022). These metrics are critical in evaluating a firm's ability to meet customer demands, optimize operations, and adapt to disruptions. Blockchain

supports the improvement of these metrics by offering secure, real-time data sharing, traceability, and automation of processes. For instance, blockchain's immutable ledger ensures traceability of goods and transactions, thereby reducing fraud, enhancing trust, and ensuring compliance throughout the supply chain (Rehman et al., 2024).

Blockchain has emerged as a transformative force particularly within the manufacturing sector. Its decentralized and immutable ledger system addresses longstanding challenges in traditional supply chains, such as inefficiencies, fraud, and lack of visibility. Integrating blockchain into manufacturing supply chains enables real-time tracking and traceability of raw materials and finished products, improving operational efficiency and reducing the risks of fraud and counterfeiting (Peng et al., 2023). Additionally, blockchain fosters data integrity and trust among supply chain stakeholders by providing a single source of truth accessible to all participants (Rehman et al., 2024).

In the United States, blockchain technology has significantly enhanced supply chain logistics for manufacturing firms. These firms have leveraged blockchain to streamline inventory management, reduce operational costs, and enhance decision-making capabilities. The peer-to-peer nature of blockchain ensures that every transaction is verified and recorded immutably, reducing reliance on intermediaries and fostering trust and security. As a result, industry leaders in these regions report improved traceability, greater transparency, enhanced security, and faster transactions, all contributing to superior supply chain performance (Chen et al., 2023; Gupta et al., 2023).

In South Africa, blockchain technology has attracted considerable interest within the manufacturing industry. This is due to its potential to improve the efficiency and effectiveness of supply chain operations. Providing transparent and immutable records, blockchain can improve traceability and reduce fraud within supply chains. According to a study by Smith and Nkosi (2023), South African manufacturing firms implementing

blockchain have reported increased operational efficiency and reduced costs. Nevertheless, challenges such as the expensive price of implementation and technical expertise associated with it have been perceived to be significant readiness barriers to its widespread implementation.

In Uganda, the adoption of blockchain technology in manufacturing supply chains is still in its initial stages. Research by Achieng and Tumusiime (2024) indicates that while there is growing awareness of blockchain's benefits, actual implementation remains limited. The study highlights that Ugandan manufacturing firms could leverage blockchain to enhance product authenticity and combat counterfeit goods, which are prevalent issues in the region. Nevertheless, infrastructural challenges and limited access to technological resources hinder the rapid adoption of blockchain in Uganda's manufacturing sector.

Kenya's manufacturing industry has shown a proactive approach towards integrating blockchain technology to improve supply chain performance. According to Mwangi and Otieno (2025), Kenyan firms utilizing blockchain have experienced improved inventory management and real-time tracking of goods. The government's supportive policies and initiatives promoting digital transformation have further facilitated blockchain adoption. However, the study also notes that concerns regarding data privacy and the lack of standardized regulations pose challenges to the seamless implementation of blockchain in Kenya's manufacturing supply chains.

In Nairobi City County, many manufacturing companies have struggled to maximize the potential of their supply chains due to challenges in implementing effective technologies and developing the necessary performance measures and metrics. This has hindered the full integration of their supply chains, limiting their effectiveness and efficiency. These shortcomings have made it difficult for firms to achieve the transparency, traceability,

and cost efficiencies needed to compete in today's dynamic business environment (Mutuku & Mwangi, 2023).

## **1.2 Statement of the Problem**

Supply chain performance is vital to the success and sustainability of food and beverage companies, especially in highly dynamic urban centers like Nairobi City County. However, evidence suggests that many firms in this sector are grappling with critical inefficiencies that undermine their competitiveness and operational effectiveness. According to the Kenya Association of Manufacturers (KAM, 2023), up to 58% of food and beverage companies in Nairobi have reported delays, losses, or non-compliance issues due to weak supply chain structures, primarily driven by poor traceability, limited interoperability, and weak data security frameworks.

A major challenge is traceability, with numerous companies lacking the ability to track raw materials and finished products effectively across the supply chain. This shortfall increases the risk of counterfeit products, contamination, and food safety breaches, which are especially concerning in the context of perishables. Studies indicate that over 40% of food product recalls in Kenya are linked to supply chain traceability failures (Kenya Bureau of Standards, 2023).

Interoperability is another critical issue. The inability of supply chain systems to share and process data seamlessly across different actors results in information silos, coordination failures, and high transaction costs. According to Chen et al. (2023), blockchain's standardized protocols can support integration and efficient data exchange among supply chain stakeholders, yet adoption remains limited in the Nairobi context.

Security and data integrity also remain major concerns. Frequent data breaches, cyber-attacks, and system manipulation have significantly eroded trust among supply chain

actors. A report by the Communications Authority of Kenya (2022) showed that Kenya recorded over 14 million cyber threat events in one year, many targeting logistics and supply networks. Blockchain's cryptographic techniques offer advanced security, yet many firms have not integrated this technology into their operations.

Furthermore, smart contracts, which can automate processes such as procurement, compliance checks, and payments, remain vastly underutilized. This gap results in manual bottlenecks, delayed transactions, and increased human error, reducing supply chain efficiency.

Despite the recognized potential of blockchain technology to address these challenges through decentralization, real-time tracking, secure data sharing, and automation, its implementation across food and beverage supply chains in Nairobi is still in its infancy. The lack of empirical data on how blockchain adoption could influence key supply chain performance indicators such as efficiency, responsiveness, and cost reduction presents a critical knowledge gap.

This study therefore sought to examine the extent to which traceability, interoperability, data security, and smart contract adoption influenced supply chain performance in the food and beverage manufacturing sector in Nairobi City County. Addressing this issue was essential for designing evidence-based interventions to support the effective implementation of blockchain technology in enhancing supply chain performance in the region.

### **1.3 Purpose of the Study**

This purpose of the study was to establish the effect of the blockchain technology on supply chain performance of food and beverage manufacturing firms in Nairobi City County.

#### **1.4 Specific Objectives**

The study was based on the following research objectives:

- i. To examine the effect of traceability on supply chain performance of food and beverage manufacturing firms in Nairobi City County
- ii. To assess the influence of interoperability on supply chain performance of food and beverage manufacturing firms in Nairobi City County.
- iii. To evaluate the effect of security on supply chain performance of food and beverage manufacturing firms in Nairobi City County
- iv. To determine the influence of smart contract utilization on supply chain performance of food and beverage manufacturing firms in Nairobi City County.

#### **1.5 Research Questions**

- i. What is the effect of traceability on the supply chain performance of food and beverage manufacturing firms in Nairobi City County?
- ii. What is the influence of interoperability on the supply chain performance of food and beverage manufacturing firms in Nairobi City County?
- iii. What is the effect of security on the supply chain performance of food and beverage manufacturing firms in Nairobi City County?
- iv. What is the influence of smart contract utilization on the supply chain performance of food and beverage manufacturing firms in Nairobi City County?

#### **1.6 Significance of the Study**

The food and beverage industry is a vital sub-sector of Kenya's manufacturing sector, playing a significant role in the country's economic development. As of 2022, the manufacturing sector contributed 7.6% to Kenya's Gross Domestic Product (GDP), with an emphasis on enhancing competitiveness in line with the government's Big Four Agenda (KNBS, 2022). Despite its economic importance, the sector continues to face

persistent supply chain inefficiencies including poor traceability, limited interoperability, and security vulnerabilities that hinder product quality, safety, and regulatory compliance. These challenges are particularly critical for food and beverage manufacturers, whose operations rely heavily on effective logistics and transparent supply chain practices to meet both local and international standards.

Blockchain technology has emerged as a transformative tool capable of addressing these inefficiencies through enhanced transparency, data security, traceability, and real-time tracking (Peng et al., 2023). While its adoption has accelerated in developed economies, its integration within Kenya's food and beverage manufacturing sector particularly in Nairobi City County remains limited. This gap necessitated the current study, which sought to explore the practical impact of blockchain features such as traceability, interoperability, security, and smart contract usage on supply chain performance. The research offered timely insights as more is expected from local manufacturers to meet global competitiveness and international food safety standards.

This study was significant for several reasons. First, it contributed practical, evidence-based knowledge that food and beverage manufacturers in Nairobi City County could apply to enhance operational efficiency, minimize losses, improve transparency, and strengthen data security within their supply chains. Second, by examining blockchain's core components in a developing country context, the study filled a notable gap in academic literature, which has largely focused on blockchain applications in developed economies. This helped establish a knowledge base that could guide future research and inform policy development on digital transformation within Kenya's manufacturing sector.

Furthermore, the study had broader implications for national economic objectives. As the government continues to prioritize industrial growth under the Big Four Agenda, findings

from this research provided valuable data to inform policy direction and strategic investment in digital supply chain solutions. The study also served as a resource for industry stakeholders including policymakers, supply chain managers, and technology solution developers by presenting the potential benefits and limitations of blockchain adoption in real-world manufacturing environments.

Ultimately, this research extended beyond the boundaries of Nairobi City County, offering relevant insights for other developing regions facing similar supply chain challenges. It not only strengthened supply chain resilience in the food and beverage sector but also provided a foundation for future technological advancement and innovation within Kenya's broader manufacturing landscape.

### **1.7 Scope of the Study**

This study focused on examining the influence of blockchain technology on supply chain performance within the food and beverage manufacturing sector in Nairobi City County, Kenya. Specifically, the study investigated how four key features of blockchain technology traceability, interoperability, security, and smart contract utilization contributed to enhancing efficiency, transparency, and responsiveness in supply chain operations. The target population included managerial and operational staff working in registered food and beverage manufacturing firms, who were deemed knowledgeable about the supply chain practices and technological adoption within their organizations. The research was limited to Nairobi City County due to its concentration of food and beverage manufacturers, as well as its strategic economic significance in Kenya's industrial landscape.

The study was confined to the period between 2022 and 2025 to reflect current technological trends and supply chain challenges. It employed a quantitative research approach using structured questionnaires to collect primary data, which was analyzed

using descriptive statistics, chi-square tests, and multiple linear regression. The study did not cover other sectors of manufacturing or counties outside Nairobi, and it excluded informal or unregistered firms. Furthermore, while blockchain has various applications beyond supply chain management, this research was limited to its role in supply chain performance only. As such, the findings are most applicable to food and beverage firms with similar characteristics and operational contexts, and may not be generalized to sectors with fundamentally different supply chain structures or technological readiness levels.

### **1.8 Limitations of the Study**

The main weaknesses of this research were difficulties in accessing any proprietary data of food and beverage organizations within the Nairobi City County that might have limited the depth of the analysis process. The reluctance of many organizations to provide the detailed information about its operations or share the specified details of its blockchain adoption was mostly based on the fear of disclosing sensitive information or losing some competitive advantage. Moreover, the fact that the study focused on food and beverage manufacturing sector in Nairobi narrowed down the scope of the study which could be used on other regions or sub-sectors in the manufacturing sector in Kenya. The poor uptake of blockchain technology in Kenya that was already being used by a small proportion of the food and beverage sector was another study limitation. Since there have been few companies which have managed to incorporate blockchain in their supply chain, there may have been very few companies actively applying the technology. This was at least a hindrance in making generalizations on the practical efficacy of blockchain in improving the supply chains. Also, since the blockchain technology is rapidly developing with time the results of the research can become obsolete. This is as a result

of the further emergence of new solutions and applications of this technology. This is why there is a need to conduct studies in the field on a continuing basis.

### **1.9 Delimitations of the Study**

The limitations of the research included the narrowed scope of the focus on the food and beverage companies in the location of Nairobi City County in Kenya. Therefore, it confined it to a particular geographical location as well as industry. The study also focused on the adoption of the blockchain technology and its influence on the performance of the supply chains avoiding considering other emergent technologies or sub-sectors of the manufacturing industry.

The study also focused on certain features of blockchain, namely traceability, interoperability, security and smart contract usage. However, did not analyze other available technologies in supply chain management. It also targeted only the companies which already deployed the blockchain technology or are in the stages of implementing it disregarding those that had no plans to use it. This attention permitted a more advantageous concentration on the effect of blockchain. Basing the research on companies that are most probable going to sell helpful encounters both about its utilization and difficulties.

### **1.10 Assumptions of the Study**

The study posits that traceability mechanisms, such as real-time tracking and provenance documentation, have a positive impact on the supply chain performance of food and beverage manufacturing firms in Nairobi City County. It further assumes that interoperability enabling seamless communication and data exchange between diverse systems and stakeholders plays a significant role in enhancing supply chain efficiency and responsiveness. Another core assumption is that the security features inherent in blockchain technology, such as immutability, encryption, and tamper-proof ledgers,

contribute positively to overall supply chain performance by fostering trust and reducing the risk of fraud. Finally, the study assumes that the utilization of smart contracts self-executing contracts with coded terms improves supply chain performance by automating processes, reducing delays, and ensuring contract compliance.



## 1.11 Operational of Terms

- Blockchain:** A decentralized digital ledger technology that records transactions securely and transparently across a network of computers, enabling trust and efficiency in supply chain management without the need for intermediaries.
- Interoperability:** The ability of different systems, organizations, or technologies within the supply chain to communicate and work together seamlessly, enhancing coordination and reducing inefficiencies.
- Performance:** The effectiveness and efficiency with which manufacturing firms achieve their supply chain objectives, including factors like cost reduction, operational efficiency, timely deliveries, and customer satisfaction.
- Security:** The protection of data, transactions, and systems within the supply chain from unauthorized access, fraud, and cyber threats, ensuring the integrity and confidentiality of supply chain operations.
- Smart Contracts:** Self-executing agreements embedded with blockchain technology, where the terms of the contract are directly written into code and automatically executed when predefined conditions are met.
- Supply Chain Performance:** In the context of food and beverage manufacturers in Nairobi City County, it involves delivering the right products at the right time and cost, while minimizing waste and ensuring service consistency.

- Supply Chain:** The network of interconnected entities, processes, and resources involved in the production, transportation, and delivery of goods and services from suppliers to end consumers.
- Traceability:** The ability to track and trace the movement, history, and origin of products or materials throughout the supply chain, ensuring accountability and enhancing quality assurance.
- Transparency:** The open and accessible sharing of information within the supply chain, allowing all stakeholders to view relevant data, which fosters trust, reduces risks, and enhances collaboration.



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## CHAPTER TWO

### LITERATURE REVIEW

#### 2.0 Introduction

This chapter presented a review of empirical literature aligned with the study's objectives. It also outlined the theoretical framework, conceptual framework, and identifies the existing research gaps that the study sort to address.

#### 2.1 Theoretical Framework

##### 2.1.1 Resource-Based View (RBV) Theory

Resource-Based View (RBV) theory, proposed by Barney (1991), states that competitive advantage can be attained by the firm with resources and capabilities that are valuable, rare, hard to replicate, and impossible to exchange. Applications of this theory have been quite widespread in such fields of study as supply chain management to understand the role of internal assets in determining organizational performance. An illustration of this is the use of RBV by Fawcett et al. (2011) in showing the technological capabilities such as the use of real-time data systems enabling the supply chain integration as well as enhancing the efficiency of operations. Similarly, the RBV framework was adopted by Prajogo and Olhager (2012) in assessing the responsiveness of the supply chain through internal competencies to make it better.

The choice of the Resource-Based View (RBV) Theory in this study was justified by its strong emphasis on internal capabilities as drivers of competitive advantage. In the context of food and beverage manufacturing firms in Nairobi City County, blockchain technology is viewed as a valuable strategic resource characterized by attributes such as traceability, interoperability, data security, and smart contracts that can significantly enhance supply chain performance. RBV provides a lens through which the study assessed how these internal technological assets contribute to operational efficiency and

firm competitiveness. By focusing on the firm's ability to develop and utilize unique and inimitable capabilities, RBV supports the argument that blockchain can be a key enabler of sustained supply chain excellence.

Among the advantages of RBV is that it promotes the use of internal resources that a firm possesses to make a firm have competitive advantage including blockchain technology. It emphasizes the unique capabilities such as traceability, interoperability, security and the use of smart contracts to enhance the performance of the supply chains. Although, there is a significant weakness to point out which is its internal orientation that does not take external factors. These factors includes technological developments or regulating effects when considering blockchain adoption as they are essential factors.

The theory is most applicable since blockchain technology is considered as a strategic resource that can improve supply chain performance in food and beverage manufacturing companies operating within Nairobi City County. The RBV theory gives a focus into how the qualities of block chain enhance traceability, security, interoperability and automation .This allows an understanding of how internal resources contribute in operational excellence and or sources of competitive advantage.

### **2.1.2 Technology-Organization-Environment (TOE) Theory**

Complementing RBV, the Technology-Organization-Environment (TOE) Framework was adopted to account for the broader contextual factors influencing blockchain adoption. While RBV focuses internally, TOE captures external and organizational conditions such as technological readiness, organizational capacity, and environmental pressures like regulatory frameworks and market competition that shape the implementation process. This dual-theoretical approach was critical in this study as it allowed for a holistic evaluation: RBV explained what blockchain can do for supply chain performance, while TOE explained how and why blockchain is adopted in practice.

Together, these frameworks provided a robust foundation for analyzing both the determinants and outcomes of blockchain integration in Nairobi's manufacturing supply chains.

The Technology-Organization-Environment (TOE) framework, proposed by Tornatzky and Fleischer (1990), explains the factors influencing a firm's adoption of new technologies. TOE identifies three critical contexts: technological (features and benefits of the technology), organizational (firm size, readiness, and resources), and environmental (external pressures such as competition or regulations). Scholars have used this framework in studies on technology adoption, including blockchain applications. For instance, Saberi et al. (2019) employed TOE to explore blockchain adoption in supply chains, highlighting how environmental pressures and technological readiness influence implementation. Similarly, Kouhizadeh et al. (2021) applied TOE to assess blockchain's impact on sustainable supply chain practices.

The strength of the TOE framework lies in its holistic perspective, as it integrates internal and external factors affecting technology adoption. Unlike RBV, it considers external pressures such as government policies, market dynamics, and industry competition, making it particularly relevant for studying technology in dynamic environments. However, its limitation is that it does not explicitly focus on how the adopted technology contributes to sustained competitive advantage, an area where RBV excels.

In this study the TOE framework complements RBV by addressing factors influencing blockchain adoption in food and beverage manufacturing firms in Nairobi City County. For example, technological attributes like traceability, organizational readiness for smart contracts, and environmental factors such as market competition and regulatory frameworks are critical to understanding blockchain's role in improving supply chain

performance. Together, the frameworks offer a comprehensive view of both adoption and impact.

## **2.2 Empirical Review**

### **2.2.1 The Effect of Traceability on Supply Chain Performance**

Traceability within supply chains plays a critical role in enhancing performance by ensuring product authenticity, improving transparency, and fostering consumer trust. Studies by Khan et al. (2022) and Kafetzopoulos et al. (2023) confirm that effective traceability mechanisms such as origin identification, tracking and monitoring, data accuracy, and transparency significantly influence supply chain outcomes, particularly in the food and beverage sector. While these findings establish a strong case for traceability, they often generalize their conclusions across industries, with little focus on operational realities in developing countries like Kenya. This reveals a geographical gap, as the infrastructural and regulatory complexities in Nairobi City County may present unique challenges to the adoption and functionality of traceability systems.

Zainuddin et al. (2020) and Mohamed and Shale (2020) offer useful insights into how traceability preserves product integrity in halal supply chains. However, these studies remain narrowly focused on specific sectors and fail to address whether such frameworks are transferable to other supply chains that operate under different regulatory and cultural conditions. Moreover, their methodologies are primarily qualitative, relying on case studies with limited scope, thereby revealing a methodological gap in terms of scalability and generalizability of findings.

Yiu (2021) recognizes blockchain's potential to enable secure tracking and monitoring across supply chains, yet does not provide empirical evidence on its scalability in large, complex, and decentralized supply chain networks. This omission leaves a conceptual gap regarding how blockchain applications perform in resource-constrained

environments or across multi-tiered supply chains. Furthermore, there is minimal discussion in the reviewed literature on the interplay between traceability technologies and organizational readiness—suggesting the need for integrated models that consider both technological and institutional factors, which is where the Technology-Organization-Environment (TOE) framework can add value.

Khan et al. (2022) and David et al. (2022) suggest that technologies like blockchain, IoT, and AI enhance transparency and traceability by enabling the secure exchange of verifiable information. While this is theoretically promising, these studies often fail to critically analyze how these technologies are adopted in developing countries where digital infrastructure is fragmented, cybersecurity awareness is low, and operational budgets are limited. The theoretical gap here is the limited application of context-sensitive theories, such as the Resource-Based View (RBV) and TOE frameworks, which account for both internal resources and external environmental constraints.

Moreover, emerging industries like fashion (Vogue Business, 2024) highlight the growing emphasis on transparency through supplier relationships and early-stage product testing. However, these insights are drawn from highly industrialized markets and do not reflect the regulatory and technological limitations present in less-developed economies. This again underscores a geographical and contextual gap that this study seeks to fill by focusing on Nairobi City County.

While the literature affirms the significance of traceability, interoperability, security, and smart contract use in improving supply chain performance, it remains fragmented and contextually limited. Many of the reviewed studies neglect the realities of localized implementation, fail to utilize robust theoretical frameworks, and overlook the multidimensional barriers to blockchain adoption. This study bridges these gaps by empirically investigating how blockchain-enabled supply chain traceability can be

adapted and optimized in Nairobi's food and beverage manufacturing sector, guided by the RBV and TOE theoretical frameworks.

### **2.2.2 The Influence of Interoperability on Supply Chain Performance**

Interoperability the capacity of diverse systems, technologies, and organizations to work together seamlessly has emerged as a critical enabler of supply chain performance. As global supply chains grow increasingly complex, the ability to integrate processes, share information in real time, and coordinate actions across multiple actors has become indispensable. Empirical studies consistently demonstrate that interoperability enhances performance through improved information exchange, activity integration, coordination, responsiveness, and standardization. These dimensions collectively contribute to higher efficiency, transparency, and adaptability in supply chain operations.

Wang et al. (2023) highlighted that efficient information exchange, facilitated by interoperable systems, leads to faster and more accurate decision-making. Their study revealed that firms with robust information-sharing infrastructures experienced a 30% improvement in decision-making speed and precision. Similarly, Jones et al. (2022) found that such systems reduce data redundancy and operational errors, contributing to streamlined workflows and increased productivity. Interoperability supports predictive analytics and enhances communication among stakeholders, which is central to anticipating and responding to market dynamics.

Coordination, another key dimension, is greatly improved through interoperable technologies. Zhang and Li (2021) reported that supply chains with enhanced coordination through shared digital platforms experienced a 25% reduction in delivery delays and a 20% increase in on-time performance. These outcomes stem from improved alignment of supply chain activities and greater trust among stakeholders. The integration

of interoperable platforms reduces misunderstandings, streamlines collaboration, and eliminates inefficiencies caused by fragmented communication.

In terms of activity integration, Kim and Park (2022) demonstrated that interoperability enables closer alignment of procurement, production, and distribution processes, resulting in a 35% improvement in overall supply chain performance. Their findings underscore the importance of integrated workflows in reducing lead times, improving resource utilization, and enhancing customer satisfaction. Interoperable systems break down silos within and between organizations, fostering a more synchronized and cohesive supply chain structure.

Responsiveness, particularly during crises such as supply shortages or demand surges, is another area where interoperability shows significant impact. Ahmed et al. (2023) found that supply chains equipped with interoperable technologies responded 40% more effectively to disruptions. This agility is enabled by real-time visibility into operations and rapid reconfiguration of supply chain elements. In dynamic market conditions, the ability to adapt quickly confers a strategic advantage, improves service levels, and reduces losses.

Finally, standardization plays a foundational role in achieving interoperability. Patel and Singh (2021) found that companies adopting standardized frameworks such as Electronic Data Interchange (EDI) and Application Programming Interfaces (APIs) realized a 50% reduction in integration costs and a 45% improvement in data accuracy. Standardization not only ensures technical compatibility across systems but also simplifies regulatory compliance and facilitates scalability. By establishing common protocols, organizations can expand operations across borders and with multiple partners without incurring substantial system adaptation costs.

These empirical findings affirm that interoperability is not merely a technical necessity but a strategic imperative for enhancing supply chain performance. However, much of the literature emphasizes high-resource environments, leaving a gap in understanding how interoperability operates within resource-constrained settings such as Nairobi City County. This study thus aims to fill that contextual gap by exploring how interoperability influences supply chain performance in food and beverage manufacturing firms within the Kenyan context.

### **2.2.3 The Effect of Security on Supply Chain Performance**

Security has emerged as a critical pillar in contemporary supply chain management, especially as digital transformation and interconnectivity intensify operational risks. Security in this context refers to the mechanisms put in place to protect supply chain systems from threats such as data breaches, fraud, unauthorized access, and operational disruptions. Empirical evidence confirms that enhanced security contributes to improved efficiency, transparency, and responsiveness across supply chain activities. Key elements such as encryption, data immutability, access control, cybersecurity protocols, and fraud prevention not only mitigate risks but also strengthen stakeholder trust and regulatory compliance.

Singh et al. (2022) found that insecure systems expose supply chains to significant vulnerabilities, including cyberattacks and operational disruptions. Their study emphasized that robust security frameworks incorporating encryption and real-time monitoring help build confidence among supply chain partners, a prerequisite for collaboration and long-term partnerships. However, their findings primarily focused on large multinational supply chains, leaving a contextual gap regarding how small and medium-sized enterprises (SMEs) in developing economies adopt and benefit from

security frameworks. This limitation highlights the need for context-specific studies that tailor security strategies to industry scale and local risk profiles.

Advanced encryption technologies such as AES-256 and RSA have become standard in protecting sensitive supply chain data. Sharma and Gupta (2021) reported that organizations implementing such encryption protocols experienced a 35% reduction in data breaches. Furthermore, they observed that encryption supports interoperability by ensuring secure data exchange between heterogeneous systems, thus boosting efficiency. Nonetheless, many of these studies are largely technical, offering limited discussion on how encryption adoption is influenced by organizational readiness or environmental factors an area that frameworks like the TOE model can better address.

Data immutability is another critical dimension of supply chain security. Kshetri (2022) demonstrated that integrating immutable records particularly through blockchain improves transparency by up to 45%, while reducing fraud and human error. This is especially vital in high-stakes industries such as pharmaceuticals and food, where traceability is closely linked to regulatory compliance and consumer safety. However, while the advantages of immutability are well acknowledged, there is a lack of empirical work examining the cost implications and scalability of such solutions in resource-constrained settings.

Access control also plays a vital role in safeguarding information. Li et al. (2023) found that firms implementing role-based access control (RBAC) systems reported a 28% increase in operational efficiency and a 20% reduction in insider threats. These systems ensure that users only access information relevant to their roles, thereby enhancing both data confidentiality and user accountability. Yet, much of the literature remains silent on how SMEs without advanced IT departments can implement such systems affordably and effectively.

Cybersecurity, as a broader strategy, has also been linked to supply chain resilience. Ahmed et al. (2023) revealed that firms deploying multi-layered cybersecurity frameworks including firewalls, intrusion detection, and regular audits experienced a 40% reduction in downtime from cyberattacks. These findings underscore the importance of proactive defense mechanisms in minimizing operational disruption. However, the literature often overlooks how firms in developing economies overcome resource limitations to adopt such advanced protections, pointing to a methodological and contextual gap.

Finally, fraud prevention is significantly enhanced through the integration of blockchain and artificial intelligence (AI). Patel and Desai (2021) reported a 50% reduction in fraud among firms that adopted blockchain-enabled traceability systems. Moreover, AI-powered analytics were shown to detect anomalies and flag suspicious activity in real time, thus reducing financial losses. Despite these promising outcomes, existing studies rarely address the implementation challenges related to infrastructure, digital literacy, and policy alignment especially in sub-Saharan African contexts.

While the reviewed literature affirms the positive relationship between supply chain security and performance, much of it is centered around developed economies and large corporations. There remains a clear need for empirical research focusing on how security components such as encryption, immutability, access control, and cybersecurity can be tailored and adopted by food and beverage manufacturing firms in Nairobi City County. This study seeks to address this geographical and practical gap by examining security as a strategic factor influencing supply chain performance in a developing economy context.

#### **2.2.4 The Influence of Smart Contract Utilization on Supply Chain Performance**

Smart contracts self-executing digital agreements embedded within blockchain systems are revolutionizing supply chain management by automating critical functions such as

procurement, payments, ownership transfers, order fulfillment, and inventory management. Their ability to enhance transparency, reduce human intervention, and improve operational efficiency has made them a subject of growing interest in supply chain research. Despite the promise of these technologies, issues such as technological integration challenges, regulatory uncertainties, and varying levels of digital infrastructure pose barriers to widespread adoption, particularly in developing economies.

Lee et al. (2022) reported that the integration of smart contracts into procurement systems led to a 30% reduction in acquisition cycle times. The study highlighted that smart contracts automatically validate supplier credentials, trigger procurement orders, and verify compliance with contractual terms thereby reducing delays and manual errors. Similarly, Wang et al. (2021), in a case study of the automotive industry, found a 25% reduction in procurement errors and enhanced supplier trust through real-time updates enabled by smart contract systems. However, these studies largely reflect use cases from well-resourced industries in developed regions, leaving a contextual gap in understanding their applicability in more resource-constrained environments like Nairobi City County.

In the area of payment automation, Ahmed et al. (2023) found that organizations employing smart contracts experienced a 40% reduction in payment processing times and fewer disputes. By removing reliance on financial intermediaries, smart contracts reduced transaction costs and improved cash flow predictability. Chen and Zhang (2022) further emphasized that timely and transparent payments foster stronger supplier relationships and reliability. While the benefits are clear, few empirical studies explore how firms in developing economies cope with the technical and legal challenges of deploying these systems highlighting both methodological and regulatory gaps in current literature.

Ownership transfer, particularly for high-value goods, also benefits significantly from blockchain-enabled smart contracts. Patel et al. (2021) demonstrated a 35% reduction in ownership disputes due to the immutability of transaction records. Their findings suggest that verifiable, tamper-proof ownership records improve delivery speed and customer satisfaction. Yet, little has been done to assess the institutional readiness of firms in countries like Kenya to adopt such systems, where legal recognition of digital transactions may still be evolving.

Zhou et al. (2023) examined the impact of smart contracts on order fulfillment in the retail sector, finding a 25% decrease in processing time. The authors noted that smart contracts automatically verify inventory, confirm orders, and update stakeholders improving accuracy and responsiveness. Automated fulfillment is especially critical in high-volume industries like food and beverage, where errors and delays can result in spoilage or loss. However, existing research does not sufficiently address how such technologies scale in environments with limited system interoperability or digital infrastructure.

Finally, Kshetri (2023) explored the integration of smart contracts with IoT devices, revealing a 45% improvement in inventory accuracy and a 30% reduction in stockouts. These findings point to the potential of real-time inventory tracking and predictive analytics in enhancing supply chain agility. Despite these advantages, challenges around data security, system compatibility, and initial investment costs are often underexplored in the literature, especially in relation to developing markets.

Smart contracts offer transformative potential for enhancing supply chain performance by automating key processes and increasing transparency. Nevertheless, much of the existing empirical literature is based on advanced economies and large corporations, leaving conceptual, geographical, and regulatory gaps regarding their practical implementation in localized contexts such as Nairobi City County. This study therefore

seeks to address these gaps by exploring the influence of smart contract utilization on supply chain performance in the food and beverage manufacturing sector, where automation could offer both operational and strategic benefits.



## 2.3 Conceptual Framework

This study will conceptualize traceability, interoperability and smart contract as the dependent variables and their influence on supply chain performance as the dependent variable.

Independent Variables

Dependent Variable

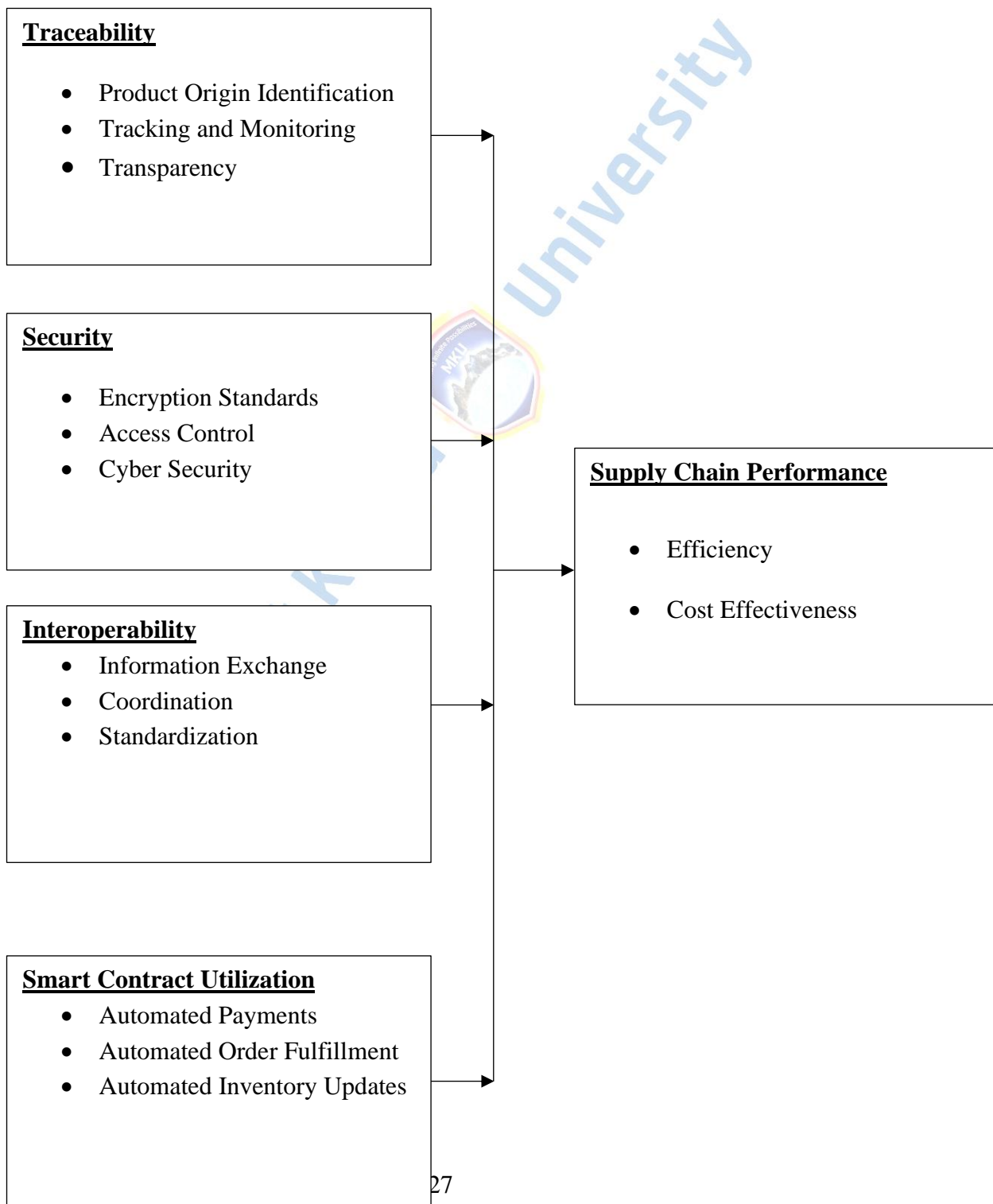


Figure 1: Conceptual Framework

Source: Researcher (2025)

## 2.4 Research Gaps

The study on the blockchain technology and its use in the supply chains continues to grow. However, it still has key gaps that are applicable to the manufacturing companies in the County of Nairobi City. The available literature tends to concentrate on over-generalized supply chain situations or broad-based industries within high-economy countries. This is without considering the specific operational and situational effects on manufacturing companies within less-developed countries. In particular, the traceability aspects of blockchain as an essential element in enhancing supply chain performance have been analyzed globally.

Nevertheless, its direct effects on manufacturing companies within the City County of Nairobi are a poorly done study. Issues concerning how local companies are using traceability as a way to deal with inefficiencies and improve accountability in their supply chains are yet to be answered in detail. The technological and infrastructural challenges that may abate the realization of blockchain based traceability solutions. This is as the resource-limited locations such as Nairobi City County have not been well addressed in the literature.

The comprehensive assessment of interoperability, security, and smart contract utilization as interdependent dimensions of blockchain technology is also a challenge. While prior studies have analyzed these aspects individually there are few have explored their combined effect on supply chain performance within manufacturing firms. For instance, interoperability between different systems is critical for streamlining operations. Yet,

there is limited evidence on how firms in Nairobi City County can achieve seamless integration in their supply chains. The importance of blockchain security is to establish trust among the local stakeholders and reduce supply chain threats. This is by possibility of automation of critical processes through smart contracts is not investigated empirically. Filling these gaps will offer good knowledge regarding the challenges and opportunity of blockchain adoption. This would improve the performance of the supply chains in the manufacturing sector in Nairobi City County.

## **2.5 Recap of Literature Review**

The study explores the influence of blockchain technology on supply chain performance in food and beverage manufacturing firms in Nairobi City County. It focuses on four key aspects including traceability, interoperability, security, and smart contract utilization. Traceability is identified as a critical factor in enhancing supply chain transparency, accountability, and efficiency. It ensures that stakeholders can track the origin and movement of products, fostering trust and reducing inefficiencies. Empirical evidence highlights blockchain's potential to improve traceability through features like immutable data, real-time monitoring, and improved data accuracy. This is particularly in industries such as food, fashion, and pharmaceuticals.

Interoperability is another essential component that enables seamless interaction between diverse systems and organizations within the supply chain. Research demonstrates that interoperable systems improve information exchange, coordination, and responsiveness, reducing redundancies and optimizing operational efficiency. The study also shows the importance of security in mitigating risks like data breaches and operational disruptions. Blockchain's encryption standards, immutability, and advanced access control measures safeguard supply chains, enhancing trust among stakeholders. Finally, smart contracts are highlighted for their ability to automate processes such as payments, ownership transfer,

and inventory updates, thereby reducing delays, enhancing transparency, and minimizing human errors.

The study employs the Resource-Based View (RBV) and Technology-Organization-Environment (TOE) frameworks to examine how blockchain, as a strategic resource, can be adopted and utilized effectively within the unique context of Nairobi City County's manufacturing firms. It identifies research gaps, such as limited studies on localized challenges and combined blockchain functionalities, emphasizing the need for further investigation into these areas.



## CHAPTER THREE

### RESEARCH METHODOLOGY AND DESIGN

#### 3.1 Introduction

This chapter outlined the research methodology used in the study. It covered the research design, study location, target population, sampling procedures and sample size, research instruments, piloting process, and the validity and reliability of the instruments. Additionally, the chapter detailed the data collection and analysis procedures, as well as the ethical considerations observed throughout the research process.

#### 3.2 Research Methodology

This study utilized a quantitative research methodology. As noted by Creswell and Creswell (2017), quantitative research enables the structured examination of phenomena through the collection of measurable data and the application of statistical methods to uncover patterns and relationships. A descriptive survey research design was chosen to allow for the objective assessment and analysis of variables related to blockchain technology and supply chain performance among food and beverage manufacturing firms in Nairobi City County. This design supported the collection of numerical data to evaluate the link between blockchain adoption and key performance indicators such as efficiency and cost-effectiveness. Data were collected using questionnaires administered to a broad sample of employees, ensuring consistency, reliability, and the generation of high-quality data to inform the study's findings on the influence of blockchain technology in the region's supply chain operations.

#### 3.3 Research Design

This study adopted a descriptive research design, which was appropriate for examining phenomena as they occurred naturally, without any researcher intervention. As Kothari (2008) explains, descriptive survey research involves cross-sectional studies and fact-

finding inquiries aimed at presenting the current state of affairs. Since the study followed a quantitative approach the descriptive design was well-suited for collecting and analyzing numerical data. It enabled the assessment of the impact of blockchain technology on supply chain performance among food and beverage manufacturing firms in Nairobi City County, Kenya. Specifically, it allowed for the analysis of key variables such as traceability, interoperability, smart contract utilization, efficiency, cost-effectiveness, and data security.

### **3.4 Location of the Study**

Nairobi City County was located in the southern part of Kenya and served as the nation's capital and largest city. It was bordered by Kiambu County to the north and west, Machakos County to the east, and Kajiado County to the south. Nairobi spanned an area of approximately 696 square kilometers. According to the 2019 Kenya Population and Housing Census, the county had a population of 4,397,073, with a population density of 6,315 people per square kilometer (KNBS, 2019). Nairobi was the economic and administrative hub of Kenya, with its economy driven by diverse sectors, including manufacturing, trade, finance, technology, and real estate. The county hosted numerous food and beverage manufacturing firms that contributed significantly to the national economy. Despite its central role in Kenya's development, challenges such as inefficiencies in supply chain performance had been noted. Hence, there was a need for the adoption of innovative solutions like blockchain technology to enhance efficiency, transparency, and competitiveness in the manufacturing sector.

### **3.5 Target Population**

According to the Kenya Association of Manufacturers (KAM, 2024), there were 125 food and beverage manufacturing firms within Nairobi City County, representing a significant portion of the sector. This made Nairobi a suitable study area, given its concentration of

food and beverage companies that played a crucial role in Kenya's economy. These firms handled perishable goods, requiring efficient supply chain management to maintain product quality, ensure food safety, and meet regulatory standards.

For this study, the target population focused on procurement departments within the 125 food and beverage manufacturing firms in Nairobi City County. Specifically, the study targeted procurement officers from three distinct levels of procurement: operational, tactical, and strategic. These levels aligned with the hierarchy of procurement functions, with junior staff handling day-to-day purchasing tasks, middle-level officers overseeing procurement coordination, and senior management focusing on strategic supply chain planning (Kenya Institute of Procurement and Supply (KIPS), 2020; Njeru & Gathenya, 2019).

The study selected three respondents from each firm one from the operational level, one from the tactical level, and one from the strategic level ensuring representation across all key procurement levels within the firms. As a result, the total target population comprised 375 respondents (125 firms  $\times$  3 respondents per firm). This group was selected due to their direct involvement in procurement practices and supply chain management, as well as their role in driving efficiency and innovation within the food and beverage industry. By gathering perspectives from all procurement levels, the study aimed to provide comprehensive insights into how blockchain technology could enhance procurement practices, improve traceability, and strengthen supply chain performance within Nairobi City County's food and beverage manufacturing firms.

### **3.6 Sampling Procedures and Sample Size**

#### **3.6.1 Sampling Procedures**

The study employed purposive sampling to select food and beverage manufacturing firms in Nairobi City County. According to the Annual Kenya Association of Manufacturers

(KAM) Sector Report (July 2024), the food and beverage sector was one of the largest manufacturing categories in Nairobi, comprising 125 firms. However, blockchain adoption required significant financial investment, technical expertise, and digital infrastructure. Therefore, this study specifically targeted large and well-established food and beverage firms that had the necessary resources to implement and benefit from blockchain technology.

Purposive sampling was appropriate for this study because not all food and beverage firms had the capability or readiness to adopt blockchain technology. Larger firms often operated complex supply chains, dealt with multiple suppliers, and faced stringent regulatory and quality control requirements, making them more likely to invest in blockchain solutions. By focusing on these firms, the study provided meaningful insights into the practical challenges, benefits, and feasibility of blockchain adoption in the industry.

Additionally, within the selected firms, the study ensured balanced representation across procurement officers at different levels—operational, tactical, and strategic—to capture diverse perspectives. This ensured that the study gathered insights from employees involved in day-to-day procurement operations, mid-level management, and high-level decision-making, providing a comprehensive understanding of blockchain's impact on supply chain performance.

### **3.6.2 Sample Size**

The study used the Yamane (1967) formula to determine the sample size. Using the equation from Yamane (1967)  $n = \frac{N}{1+Ne^2}$  where  $n$  is the sample size required for the study,  $N$  is the study's target population, and  $e$  is the precision level (5% in this case). Substituting the known population size and precision level implied that  $n =$

$\frac{375}{1+375(0.05^2)} = 193.55$ , approximately 194 respondents. The distribution of this sample size was equally allocated among the food and beverage manufacturing firms. Each sector was allocated a proportionate number of respondents based on its representation within the total population. By using this approach, the study ensured that each sector was represented in line with its proportion of the overall population.

### **3.7 Research Instruments**

The study utilized questionnaires as the primary research instrument to collect data from procurement officers across food and beverage manufacturing firms in Nairobi City County. Questionnaires were particularly effective for gathering data from a large sample, ensuring consistency and reliability. According to Saunders, Lewis, and Thornhill (2019), questionnaires were advantageous as they facilitated efficient data collection and provided reliable, standardized data suitable for quantitative analysis.

The questionnaires comprised both closed-ended and Likert-scale questions to allow for precise responses and capture varying perspectives on the influence of blockchain technology on supply chain performance. This approach ensured uniformity by presenting similar items to all respondents. Additionally, questionnaires were administered efficiently, both physically and electronically, making them cost-effective and time-efficient for reaching the study's target population.

### **3.8 Pilot Study**

A pilot study was conducted to assess the reliability and validity of the research instruments used to collect data on the relationship between blockchain technology and supply chain performance among food and beverage manufacturing firms in Nairobi City County. To maintain independence from the main study sample while ensuring comparable characteristics, the piloting was conducted in Kiambu County. The main

objective of the pilot study was to verify that the questionnaire was clear, concise, and capable of effectively capturing the necessary data for the research. Following the recommendation by Mugenda and Mugenda (2013), the pilot sample comprised 10% of the total sample size, resulting in approximately 32 respondents drawn from manufacturing firms in Kiambu County. This strategy ensured that the feedback obtained during the pilot phase did not affect the outcomes of the main study.

During the piloting phase, the researcher aimed to identify and address potential challenges in administering the questionnaire, including unclear or ambiguous questions, formatting issues, and any technical difficulties related to the study design. Feedback from respondents in Kiambu County was gathered to guide the refinement of the research instrument. Insights from the pilot study informed necessary revisions to improve the clarity, structure, and overall effectiveness of the questionnaire before its use in the main study in Nairobi City County. This process helped ensure that the instrument was capable of collecting reliable and valid data on the influence of blockchain technology on supply chain performance in the food and beverage manufacturing sector.

### **3.9 Validity and Reliability of the Research Instruments**

#### **3.9.1 Validity of the Research Instruments**

According to Oluwatayo (2012), validity referred to the degree to which an instrument measured what it was intended to measure. Punch (2013) defined validity as the accuracy and meaningfulness of inferences drawn from the research results. Validity ensured that the research instruments captured the intended constructs accurately, enabling credible findings.

To enhance the content validity of the research instruments, the study utilized the judgment of experts and peer reviews, as recommended by Drost (2011). The researcher sought input from procurement officers within food and beverage manufacturing firms in

the neighboring Kiambu County, who possessed expertise in procurement practices and blockchain technology. These experts assessed the relevance, clarity, and comprehensiveness of the research instruments. Additionally, peer reviewers with experience in supply chain management and blockchain applications were consulted to further refine the tools. This process helped to ensure that the research instruments adequately covered all dimensions of the study, thereby enhancing their content validity and ensuring accurate measurement of the influence of blockchain technology on the supply chain performance of food and beverage manufacturing firms in Nairobi City County.

### **3.9.2 Reliability of Research Instruments**

Punch (2013) defined reliability as the degree to which the results or data yielded by a research instrument after repeated trials were consistent. To ensure reliability, the clarity of the questionnaires was evaluated during the pilot study. Any vague or inadequate items identified in the research instruments were revised to enhance their quality and reliability.

The study used the Cronbach Alpha internal consistency model to measure the reliability of the research instruments. This model computed reliability using inter-item correlations, ensuring that the items within the questionnaire consistently measured the intended constructs. According to Creswell and Poth (2017), a Cronbach Alpha reliability coefficient of 0.7 or above was considered a standard threshold for determining whether research instruments were reliable. Achieving this benchmark confirmed that the instruments were dependable and suitable for the study.

### **3.10 Data Collection Procedures**

The researcher sought an introductory letter from Mount Kenya University graduate school and a research permit from the National Commission for Science, Technology and Innovation to conduct the study. In preparation for the fieldwork, one data clerk with

prior experience was hired. Training was carried out for the data clerk on data collection procedures. The tool and fieldwork were carried out by the data clerk and the researcher, who administered questionnaires to the procurement officers at their workplaces.

### **3.11 Data Analysis Procedures**

Both descriptive and inferential statistical methods were employed to analyze the collected data using the Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics including frequencies, percentages, and mean values were used to summarize the demographic characteristics of respondents and the general trends in their responses. These descriptive analyses provided a clear and concise overview of the data, enabling initial interpretation of patterns and distributions.

In the inferential analysis, multiple linear regression was originally identified as the main statistical technique for examining the influence of the independent variables (traceability, interoperability, security, and smart contract utilization) on the dependent variable (supply chain performance). However, upon conducting preliminary data checks, it became evident that some variables were categorical in nature or did not meet the assumptions required for regression analysis, such as linearity, homoscedasticity, and normal distribution. Consequently, Chi-square tests of independence were used where appropriate to examine significant associations between categorical variables.

The use of both chi-square tests and regression analysis was thus a methodological adaptation made to ensure the validity and reliability of the results based on the nature of the data collected. Chi-square analysis enabled the identification of significant relationships between variables that were not suitable for regression, while multiple linear regression was applied where assumptions were met to assess the strength and direction of influence between variables. This mixed inferential approach ensured robust, accurate, and context-sensitive findings aligned with the research objectives.

### **3.12 Ethical Considerations**

Ethical considerations played an important role in making the research responsible and safe without causing any harm to participants as well as to safeguarding integrity of the study. Ethical concerns which were of relevance to the study regarding the effects of blockchain technology on the performance of the supply chain of food and beverage manufacturing companies in Nairobi City County are discussed. This factors included the informed consent, confidentiality, anonymity, free will and the security of the data in the course of research.

First, voluntary involvement was one of the main ethical values of the study. It was ensured that all the respondents were aware of the purpose, goals, and scope of the study before their participation in it. There was no pressure and coercion, everyone was involved on completely voluntary basis. The right to discontinue the study at any stage was not punished as the participants had the right to quit the study. All the participants were asked to give written consent before the research. This is as a way of confirmation that the participant knew that they were going to participate in the research.

Secondly, privacy and confidentiality were prioritized. No personal identifiers such as names or job titles were recorded in the questionnaires or any other research instruments. Instead, unique codes were assigned to each respondent to ensure anonymity. The collected data were securely stored on password-protected platforms and were not shared with unauthorized parties. This approach fostered honest and accurate responses while safeguarding participants' privacy.

Thirdly, the researcher ensured transparency by clearly communicating the study's objectives, procedures, potential risks, and benefits to the participants before data collection began. This transparency allowed participants to make informed decisions about their involvement. Additionally, a summary of the research findings was shared

with participants and other relevant stakeholders through appropriate channels to promote accountability.

Fourthly, approvals were obtained before execution of the study. Ethical clearance was sought from relevant authorities including the university's ethics review board and the National Commission for Science, Technology and Innovation (NACOSTI). Relevant manufacturing firms were notified about the study and permission was sought before conducting the study on their premises.

Fifthly, objectivity and integrity were maintained throughout the research process. Data analysis and reporting were conducted without bias or manipulation to favor any predetermined outcomes. High standards of honesty and transparency guided all aspects of the study. To prevent plagiarism, all sources of information were appropriately cited and acknowledged.

Finally, no harm was inflicted on participants. The study avoided causing physical, psychological, social, or legal harm. Data collection was conducted in a respectful and professional manner that was sensitive to participants' needs and well-being. The researcher upheld the highest levels of good faith and ethical responsibility during the study. By addressing these ethical considerations, the study ensured a research process that was respectful, fair, and beneficial to both participants and the broader academic and professional community.

## **CHAPTER FOUR**

### **RESULTS AND FINDINGS**

#### **4.1 Introduction**

This chapter presented the results and findings obtained from the data collected during the study. Its primary purpose is to offer a comprehensive analysis of the responses gathered from participants and to interpret these findings in relation to the study's objectives.

The chapter opens with a reliability analysis to evaluate the internal consistency of the research instrument, thereby confirming the accuracy and dependability of the results. This is followed by a presentation of the response rate, offering insight into the level of participation and the extent to which the data represents the target population. Subsequently, the demographic characteristics of the respondents are examined to provide context for the findings and to better understand the background and composition of the study participants.

The central focus of the chapter is an in-depth examination of how different dimensions of blockchain technology influence supply chain performance. Specifically, Section 4.5 explores the impact of traceability, evaluating how real-time visibility and tracking contribute to improved efficiency and responsiveness within the supply chain. Section 4.6 investigates the role of interoperability, analyzing how seamless system communication and integration enhance collaboration and overall supply chain performance.

Section 4.7 evaluates the effect of security, investigating the extent to which blockchain's secure data handling contributes to minimizing fraud and enhancing trust across the supply chain. Lastly, Section 4.8 determines the influence of smart contract utilization,

focusing on how automated, self-executing agreements affect transactional accuracy, speed, and overall supply chain effectiveness.

Each section includes descriptive statistics, inferential analyses, and discussions that link the findings to existing literature and the study's objectives. The findings presented in this chapter form the basis for the conclusions and recommendations discussed in subsequent chapters.

#### 4.2 Reliability Analysis

Reliability analysis is a critical step in assessing the consistency and dependability of the research instrument used to gather data. In this study, Cronbach's Alpha coefficient was employed to determine the internal consistency of the measurement items related to the four key dimensions of blockchain technology: traceability, interoperability, security, and smart contract utilization. Cronbach's Alpha values range from 0 to 1, with values above 0.7 generally considered acceptable for social science research, indicating that the scale items reliably measure the intended constructs (Tavakol & Dennick, 2011).

**Table 1: Reliability Analysis**

<b>Test Item</b>	<b>Cronbach's Alpha</b>	<b>N of Items</b>
Examination of the effect of traceability on supply chain performance	.813	10
Assessment of the influence of interoperability on supply chain performance	.931	10
Evaluation of the effect of security on supply chain performance	.782	10
Determination of the influence of smart contract utilization on supply chain performance	.885	10
<b>Total</b>	<b>.852</b>	<b>40</b>

The results in Table 1 indicate that all constructs surpassed the acceptable threshold of 0.7, confirming strong internal consistency across the measurement items. The construct assessing interoperability recorded the highest reliability ( $\alpha = 0.931$ ), suggesting a very

high degree of internal consistency among the items measuring this variable. This finding is consistent with prior research, such as Saberi et al. (2019), which emphasized that interoperability within blockchain systems is a well-defined and closely aligned concept in supply chain frameworks. The traceability construct achieved a reliability coefficient of  $\alpha = 0.813$ , indicating good internal consistency. This result aligns with the findings by Kouhizadeh, Saberi, and Sarkis (2021), who reported high reliability in instruments assessing traceability in blockchain-enabled supply chains, reinforcing the importance of this construct in enhancing visibility and product authenticity.

The security construct yielded a reliability value of  $\alpha = 0.782$ . While slightly lower than other constructs, this still reflects acceptable internal consistency. Previous studies by Casino, Dasaklis, and Patsakis (2019) reported similar values when evaluating the role of blockchain in enhancing cybersecurity within supply chains, indicating that security remains a multifaceted dimension that may exhibit slightly more variability in respondent perception. Finally, the smart contract utilization construct attained a Cronbach's Alpha of  $\alpha = 0.885$ , signifying strong reliability. This is comparable to the results found in the study by Wang et al. (2020), which demonstrated that smart contracts are generally well-understood and consistently evaluated by respondents when it comes to automation and efficiency in supply chain transactions.

Overall, the composite reliability coefficient for all 40 items was  $\alpha = 0.852$ , confirming that the research instrument used in this study was highly reliable. This strong reliability supports the validity of the subsequent analyses and ensures that the observed results can be attributed to consistent measurement across all variables of interest.

### **4.3 Response Rate**

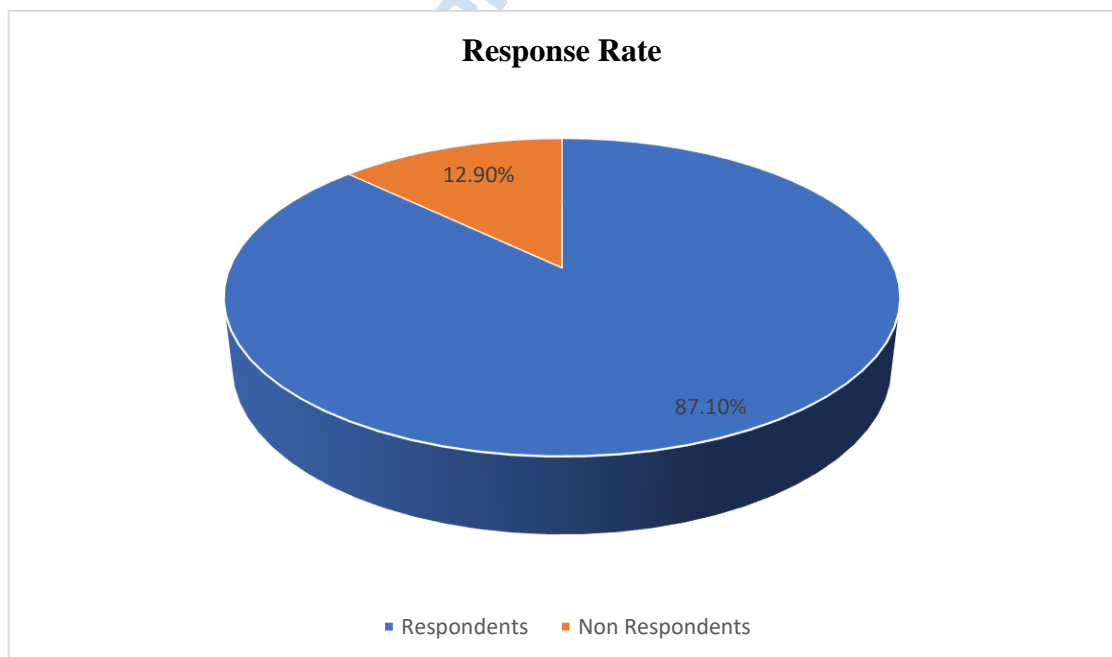
The response rate is a critical measure of data quality in survey-based research. It reflects the proportion of individuals who responded to the questionnaire out of the total targeted

sample. A high response rate is generally desirable as it enhances the representativeness of the sample, reduces the risk of non-response bias, and strengthens the reliability and validity of the findings (Baruch & Holtom, 2008). This section presents and discusses the response rate achieved in this study.

**Table 2: Response Rate**

<b>Respondents</b>	<b>Frequency</b>	<b>Percentage</b>	<b>No Respondents (Frequency)</b>	<b>Percentage</b>
Respondents (194)	169	87.1%	25	12.9%
<b>Total (194)</b>	<b>169</b>	<b>87.1%</b>	<b>25</b>	<b>12.9%</b>

As shown in Table 2, the study targeted a total of 194 respondents. Out of this population, 169 participants successfully completed and returned the questionnaire, representing a response rate of 87.1%, while 25 participants did not respond, constituting 12.9% of the total. This is considered a very high response rate in the context of social science research, where response rates above 70% are typically regarded as excellent (Fincham, 2008). This was graphically presented on figure 2 below;



**Figure 2: Response Rate**

The high response rate in this study may be attributed to proactive follow-ups, clear communication of the study's purpose, and the relevance of the topic to the respondents, who were drawn from food and beverage manufacturing firms in Nairobi City County. This aligns with similar studies in the field of supply chain and technology adoption. For example, Kouhizadeh, Saberi, and Sarkis (2021) reported a response rate of 82.5% in a study examining blockchain adoption in sustainable supply chains, which was also considered robust.

Additionally, Saberi et al. (2019) emphasized that high response rates in blockchain-related studies are often linked to heightened awareness and interest among supply chain professionals regarding emerging technologies. This suggests that the high engagement in the present study reflects both the perceived importance of blockchain in supply chain management and the respondents' willingness to contribute insights on the subject.

In conclusion, the achieved response rate of 87.1% provides a solid foundation for generalizing the findings to the target population and supports the credibility of the subsequent data analysis and interpretations in this study.

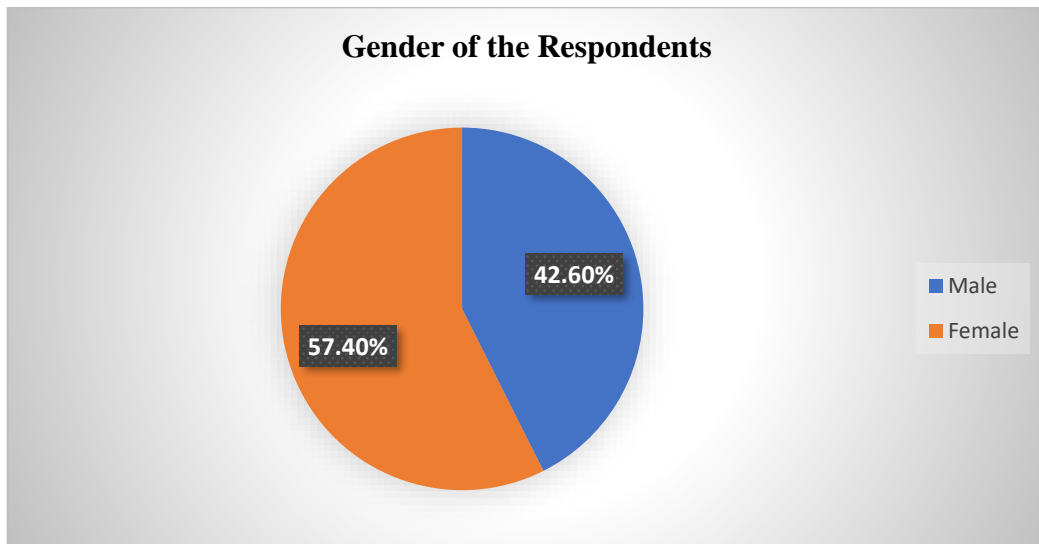
#### **4.4 Demographic Characteristics**

This section presents the demographic characteristics of the respondents who participated in the study. The demographic data was collected to understand the background of the participants and ensure that the responses were obtained from individuals with diverse and relevant profiles within the food and beverage manufacturing sector in Nairobi City County. The demographic variables considered include gender, age bracket, highest level of education, position in the organization, and years of experience in the manufacturing industry. The results are summarized in Table 3.

**Table 3: Demographic Characteristics**

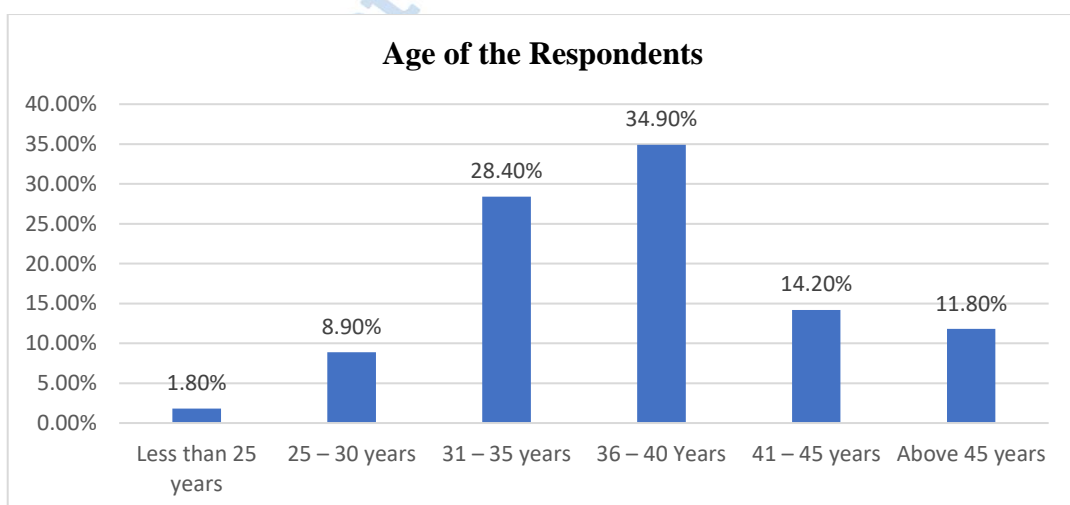
<b>Demographic Characteristics</b>	<b>f</b>	<b>%</b>	
Gender	Male	72	42.6%
	Female	97	57.4%
Age Bracket:	Less than 25 years	3	1.8%
	25 – 30 years	15	8.9%
	31 – 35 years	48	28.4%
	36 – 40 Years	59	34.9%
	41 – 45 years	24	14.2%
	Above 45 years	20	11.8%
Highest Level of Education:	Diploma/Certificate	55	32.5%
	Degree	96	56.8%
	Masters	18	10.7%
	PhD	0	0.0%
Position in the Organization	Junior level	83	49.1%
	Middle Level	47	27.8%
	Senior level	39	23.1%
Years of Experience in the Manufacturing Industry:	Less than a year	30	17.8%
	1 -3 Years	109	64.5%
	4 – 6 years	18	10.7%
	Over 6 years	12	7.1%

Out of the 169 respondents, 72 (42.6%) were male, while 97 (57.4%) were female. This indicates that female respondents slightly outnumbered their male counterparts, reflecting a fair level of gender representation in the study. This was presented on pie chart on figure 3 below;



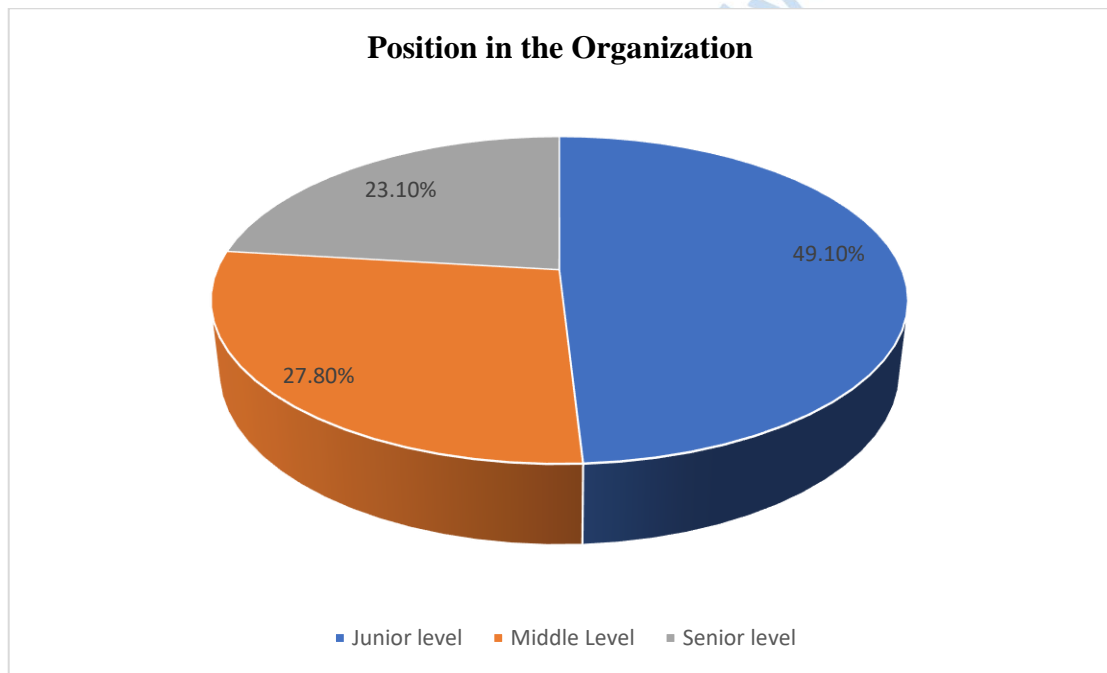
**Figure 3: Gender of the Respondents**

The distribution of respondents across age categories shows that the majority were in the 36–40 years age bracket, accounting for 59 respondents (34.9%). This was followed by those aged 31–35 years, with 48 respondents (28.4%), and 41–45 years, with 24 respondents (14.2%). A smaller proportion of respondents were above 45 years (11.8%), 25–30 years (8.9%), and less than 25 years (1.8%). This distribution suggests that the respondents were largely composed of individuals in their prime working age, likely to be active contributors to operational decisions within their organizations.



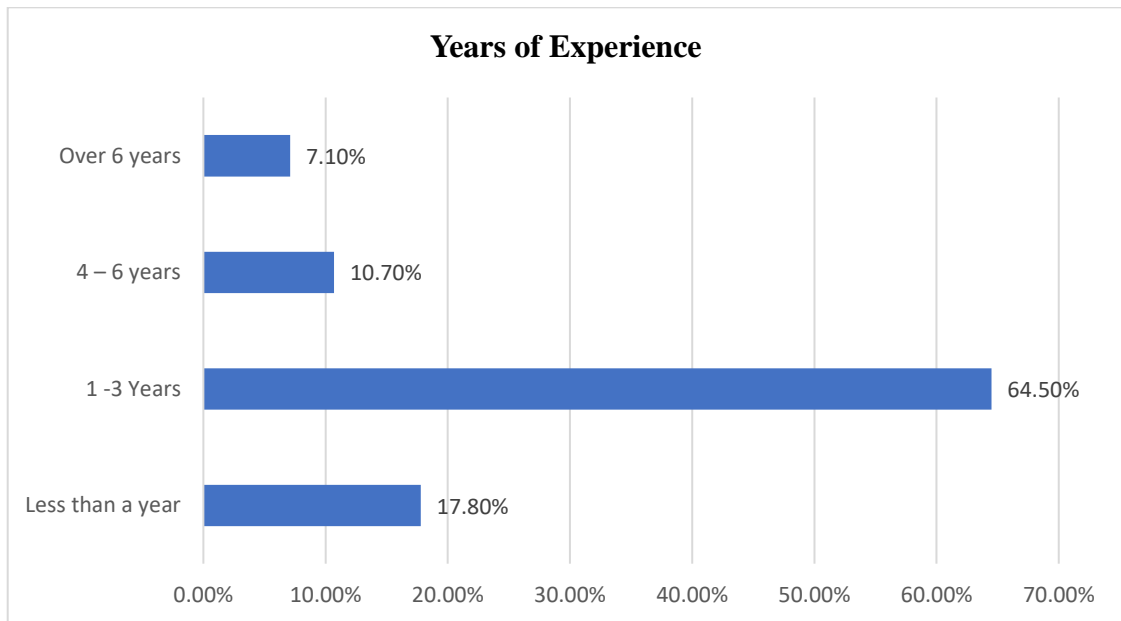
**Figure 4: Age of the Respondents**

With regard to educational qualifications, a majority of respondents held a bachelor's degree (56.8%), followed by those with a diploma or certificate (32.5%), and master's degree holders (10.7%). Notably, there were no PhD holders among the participants. This indicates that most respondents had attained at least a tertiary level of education, suggesting a well-educated workforce involved in the study. In terms of organizational roles, the majority of respondents (49.1%) were at the junior level, while 27.8% held middle-level positions, and 23.1% occupied senior-level roles. This reflects a balanced mix of employees across different hierarchical levels, which helps in providing varied perspectives on blockchain implementation in the supply chain.



**Figure 5: Position in the Organization**

Concerning industry experience, most respondents (64.5%) had 1–3 years of experience, followed by 17.8% with less than one year. A smaller number had 4–6 years (10.7%) and over 6 years (7.1%) of experience. This indicates that the majority of the workforce in this study was relatively young in terms of industry experience, possibly reflecting a growing or recently restructured workforce in the sector.



**Figure 6: Years of Experience**

Overall, the demographic data illustrates a diverse and representative sample in terms of gender, age, education, job position, and experience level, which supports the credibility and generalizability of the findings related to blockchain technology and supply chain performance.

#### **4.5 Examination of the effect of traceability on supply chain performance**

The objective of this section was to examine the effect of traceability enabled by blockchain technology on the performance of supply chains in food and beverage manufacturing firms in Nairobi City County. Traceability in the supply chain context refers to the ability to track the movement of goods from the point of origin to the final consumer. It is a critical factor in ensuring transparency, safety, regulatory compliance, and operational efficiency. Blockchain technology has emerged as a powerful tool in enabling end-to-end traceability by providing a decentralized, immutable, and real-time record of transactions.

**Table 4: Respondents Rating on the examination of the effect of traceability on supply chain performance**

<b>Test Item</b>	<b>Strongly Disagree f (%)</b>	<b>Disagree f (%)</b>	<b>Neutral f (%)</b>	<b>Agree f (%)</b>	<b>Strongly Agree f (%)</b>
Blockchain enhances real-time tracking of goods across the supply chain.	6 3.6%	25 14.8%	27 16.0%	77 45.6%	34 20.1%
Improved traceability reduces the risk of counterfeit products.	17 10.1%	22 13.0%	39 23.1%	48 28.4%	43 25.4%
The use of blockchain improves product recall efficiency.	37 22.0%	44 26.2%	32 19.0%	30 17.9%	25 14.9%
Blockchain technology enables better compliance with regulatory requirements.	53 31.4%	22 13.0%	27 16.0%	64 37.9%	3 1.8%
Real-time traceability improves decision-making in supply chain operations.	39 23.2%	44 26.2%	37 22.0%	30 17.9%	18 10.7%
Transparency in supply chain traceability improves trust among stakeholders.	12 7.1%	24 14.2%	64 37.9%	39 23.1%	30 17.8%
Blockchain-enabled traceability reduces delays in product deliveries.	24 14.2%	34 20.1%	64 37.9%	25 14.8%	22 13.0%
The firm has adopted blockchain for better supply chain visibility.	45 26.6%	24 14.2%	53 31.4%	34 20.1%	13 7.7%
Traceability using blockchain improves supplier accountability.	20 11.8%	25 14.8%	48 28.4%	58 34.3%	18 10.7%
Improved traceability contributes to cost savings in supply chain operations.	28 16.6%	44 26.0%	43 25.4%	32 18.9%	22 13.0%

The results indicate that a majority of respondents agree or strongly agree that blockchain enhances real-time tracking of goods (65.7%), indicating broad recognition of its core traceability feature. This aligns with the work of Tian (2017), who found that blockchain significantly improves transparency and traceability in food supply chains through real-time updates and immutable records.

Moreover, 53.8% of the participants believe that improved traceability reduces the risk of counterfeit products, reflecting the potential of blockchain to secure product authenticity through tamper-proof digital records. This is consistent with Kshetri (2018), who noted that blockchain can help combat counterfeiting, especially in sectors like food and pharmaceuticals.

Opinions were more varied on whether blockchain improves product recall efficiency, with only 32.8% agreeing or strongly agreeing, while 48.2% disagreed or strongly disagreed. This suggests some skepticism or limited practical experience with blockchain-based recall systems, which may not yet be fully integrated in most firms' operational procedures.

The item on regulatory compliance showed mixed results. While 37.9% agreed that blockchain enhances compliance, 31.4% strongly disagreed. This split may reflect differences in organizational exposure to regulatory audits or the stage of blockchain implementation. Nonetheless, Saberi et al. (2019) assert that blockchain can support compliance by ensuring data transparency and auditability.

Responses were also divided on decision-making and cost savings, with a significant portion of participants remaining neutral or disagreeing. This could imply that while blockchain's benefits in traceability are recognized in theory, its tangible impact on strategic operations is yet to be fully realized in practice. However, Francisco and Swanson (2018) argue that blockchain can indeed enable better decision-making and cost efficiency, especially when integrated with IoT and data analytics.

Interestingly, 60% of respondents either agreed or strongly agreed that traceability via blockchain improves supplier accountability, and nearly 41% supported its role in enhancing trust among stakeholders. These results suggest that participants view

blockchain's traceability as a relational asset that strengthens stakeholder confidence, echoing the conclusions by Queiroz et al. (2020) on blockchain's role in building trust and governance across supply chains.

Lastly, responses on whether blockchain had already been adopted for supply chain visibility revealed that only 27.8% of firms had clearly embraced the technology. This points to limited adoption across the sector, despite perceived benefits—a gap often reported in emerging economies due to infrastructure and skills limitations.

The findings confirm that blockchain-enabled traceability is generally viewed positively, especially in terms of improving tracking, reducing counterfeiting, and enhancing accountability. However, reservations exist regarding its actual implementation, cost benefits, and effect on strategic decision-making. These insights are critical for understanding the current maturity of blockchain adoption and identifying areas where food and beverage manufacturing firms can optimize supply chain performance through targeted blockchain integration.

To statistically validate the relationship between traceability and supply chain performance of food and beverage manufacturing firms in Nairobi City County, a Chi-Square test of independence was conducted. This test aimed to assess whether the observed association between blockchain-enabled traceability and perceived improvements in supply chain performance was statistically significant. The null hypothesis ( $H_0$ ) for this test was formulated as follows:

**Table 5: Chi-Square Tests on the examination of the effect of traceability on supply chain performance**

Chi-Square Tests			Asymptotic Significance (2-sided)
	Value	df	
Pearson Chi-Square	12.100 <sup>a</sup>	9	.007
Likelihood Ratio	15.433	9	.000
Linear-by-Linear Association	.609	1	.005
N of Valid Cases	169		

The Pearson Chi-Square value of 12.100 with a significance level of  $p = 0.007$  indicates a statistically significant relationship between blockchain-based traceability and supply chain performance at the 0.05 confidence level. Similarly, the Likelihood Ratio test produced an even more significant p-value ( $p = 0.000$ ), further reinforcing the rejection of the null hypothesis.

Additionally, the Linear-by-Linear Association test yielded a p-value of 0.005, suggesting that there is also a significant linear trend between the degree of traceability implementation and improvements in supply chain performance. These results provide robust statistical evidence that traceability, as facilitated by blockchain, plays a significant role in enhancing various performance dimensions in the supply chain, including visibility, accountability, responsiveness, and compliance.

These findings are consistent with those of Tian (2017) and Saberi et al. (2019), who argue that blockchain-based traceability systems contribute to improved operational transparency, recall mechanisms, and regulatory alignment factors closely tied to performance metrics in supply chains. Furthermore, Kamble, Gunasekaran, and Arha (2019) emphasized that firms adopting blockchain for traceability reported significant

improvements in supply chain efficiency and customer satisfaction due to enhanced real-time data access and product authenticity.

The statistical confirmation from this study reinforces the assertion that traceability is not just a technological feature but a strategic enabler of performance in complex supply networks like those in the food and beverage manufacturing sector. This is especially vital in high-risk and highly regulated industries where consumer safety, product origin, and delivery timelines are critical.

In summary, the Chi-Square hypothesis test provides empirical support for the significant role of blockchain-enabled traceability in supply chain performance. The findings complement the descriptive analysis and strengthen the conclusion that traceability positively affects key performance indicators. Therefore, firms aiming to optimize supply chain operations should consider investing in blockchain systems that enhance traceability, particularly in sectors where product authenticity, regulatory compliance, and stakeholder trust are paramount.

#### **4.6 Assessment of the influence of interoperability on supply chain performance**

The second objective of this study was to assess the influence of interoperability enabled by blockchain technology on the supply chain performance of food and beverage manufacturing firms in Nairobi City County. In the context of blockchain, interoperability refers to the capability of different blockchain systems and other digital platforms (such as ERP, IoT, and WMS) to communicate, share data, and function cohesively across diverse organizational systems. This capacity is increasingly vital in the supply chain, where seamless collaboration and data exchange between partners is essential for performance optimization.

**Table 6: Respondents Rating on the assessment of the influence of interoperability on supply chain performance**

<b>Test Item</b>	<b>Strongly Disagree f (%)</b>	<b>Disagree f (%)</b>	<b>Neutral f (%)</b>	<b>Agree f (%)</b>	<b>Strongly Agree f (%)</b>
Blockchain facilitates seamless integration with existing supply chain systems.	39 23.1%	73 43.2%	29 17.2%	18 10.7%	10 5.9%
Interoperability enhances communication between supply chain partners.	22 13.0%	26 15.4%	29 17.2%	53 31.4%	39 23.1%
Blockchain interoperability improves data sharing across supply chain networks.	10 5.9%	22 13.0%	46 27.2%	54 32.0%	37 21.9%
The integration of blockchain reduces operational inefficiencies.	9 5.3%	18 10.7%	24 14.2%	82 48.5%	36 21.3%
Blockchain enhances collaboration among supply chain stakeholders.	37 22.0%	49 29.2%	25 14.9%	30 17.9%	27 16.1%
Interoperability reduces errors in data transmission across the supply chain.	3 1.8%	15 8.9%	27 16.0%	80 47.3%	44 26.0%
Blockchain's ability to connect with IoT devices improves supply chain efficiency.	15 8.9%	29 17.2%	23 13.6%	70 41.4%	32 18.9%
The firm's supply chain has benefited from blockchain's ability to integrate with various digital platforms.	12 7.1%	29 17.2%	41 24.3%	67 39.6%	20 11.8%
Lack of interoperability hinders blockchain adoption in supply chains.	39 23.1%	49 29.0%	46 27.2%	20 11.8%	15 8.9%
Improved interoperability leads to increased supply chain agility.	30 17.8%	39 23.1%	49 29.0%	27 16.0%	24 14.2%

The responses show a mixed perception of the impact of blockchain interoperability, with a clear inclination towards agreement on several key items. For instance, 68.6% of respondents agreed or strongly agreed that interoperability reduces errors in data transmission, while 69.8% supported the notion that blockchain integration reduces

operational inefficiencies. Similarly, 53.9% of the participants believed that interoperability improves data sharing across supply chain networks, reinforcing the positive influence of cross-platform integration on communication and visibility.

However, on the statement that blockchain facilitates seamless integration with existing systems, the majority of respondents either disagreed (43.2%) or strongly disagreed (23.1%), suggesting that many firms still face technical or organizational barriers when integrating blockchain into legacy systems. This highlights a practical gap in blockchain deployment in the Kenyan food and beverage manufacturing sector, despite its recognized potential.

Additionally, the statement that blockchain enhances collaboration among stakeholders attracted significant disagreement (51.2% in total), possibly indicating that the collaborative advantage of blockchain is not yet fully realized or appreciated within these firms. Interestingly, while a majority (58.3%) acknowledged that blockchain can connect with IoT devices to improve efficiency, a similar majority also agreed that a lack of interoperability hinders blockchain adoption. This duality reflects the importance of addressing interoperability challenges in achieving full-scale blockchain integration.

These findings resonate with the study by Casino et al. (2019), which noted that interoperability remains one of the biggest technical challenges in blockchain implementation in complex supply networks. Similarly, Chang, Iakovou, and Shi (2020) emphasized that firms need standardization and integration protocols to fully benefit from blockchain's potential. Francisco and Swanson (2018) also identified that although blockchain has great promise for enhancing transparency and trust, its interoperability limitations restrict widespread adoption and performance gains.

Conversely, Kamble et al. (2020) argue that when interoperability is effectively implemented, it significantly enhances data synchronization, partner collaboration, and operational agility key levers of supply chain performance. These comparative insights suggest that the impact of interoperability is highly contingent on implementation maturity and the digital infrastructure of the firms involved.

The assessment of interoperability reveals both opportunities and barriers. While blockchain has the technical potential to streamline communication, reduce errors, and integrate digital tools, the real-world integration is still hampered by legacy systems and infrastructural gaps. Addressing these technical and organizational challenges will be critical for food and beverage manufacturing firms seeking to leverage blockchain interoperability for optimal supply chain performance.

To statistically validate the perceived influence of interoperability on supply chain performance, a one-sample t-test was conducted on the related items. The test assessed whether the mean response for each interoperability indicator was significantly different from the test value (0), which represents a neutral baseline or no perceived effect. The results are presented in Table 7.

**Table 7: One-Sample Test on the assessment of the influence of interoperability on supply chain performance**

<b>One-Sample Test</b>						
<b>Test Value = 0</b>						
<b>Test Item</b>	<b>t</b>	<b>df</b>	<b>Sig. (2-tailed)</b>	<b>Mean Diff</b>	<b>95% Confidence Interval of the Difference</b>	
					<b>Lower</b>	<b>Upper</b>
Blockchain facilitates seamless integration with existing supply chain systems.	27.015	168	.000	2.331	2.16	2.50
Interoperability enhances communication between supply chain partners.	32.643	168	.000	3.361	3.16	3.56
Blockchain interoperability improves data sharing across supply chain networks.	39.840	168	.000	3.509	3.34	3.68
The integration of blockchain reduces operational inefficiencies.	44.329	168	.000	3.698	3.53	3.86
Blockchain enhances collaboration among supply chain stakeholders.	25.679	167	.000	2.768	2.56	2.98
Interoperability reduces errors in data transmission across the supply chain.	52.352	168	.000	3.870	3.72	4.02
Blockchain's ability to connect with IoT devices improves supply chain efficiency.	36.430	168	.000	3.444	3.26	3.63
The firm's supply chain has benefited from blockchain's ability to integrate with various digital platforms.	38.901	168	.000	3.320	3.15	3.49
Lack of interoperability hinders blockchain adoption in supply chains.	27.120	168	.000	2.544	2.36	2.73
Improved interoperability leads to increased supply chain agility.	28.852	168	.000	2.858	2.66	3.05

The results show that all test items under the interoperability construct returned p-values of .000, which are well below the conventional threshold of 0.05. This implies that the respondents' perceptions were statistically significantly different from zero, indicating a

clear and measurable influence of blockchain interoperability on supply chain performance. The item with the highest mean difference was “interoperability reduces errors in data transmission” (mean diff = 3.870), followed closely by “integration of blockchain reduces operational inefficiencies” (mean diff = 3.698). These findings highlight error minimization and operational streamlining as two of the strongest perceived benefits of interoperability in supply chains.

Even though the earlier descriptive analysis (Table 6) revealed some disagreement about seamless integration with existing systems, the one-sample t-test still found that the mean rating (2.331) was significantly above zero, confirming some level of perceived positive impact. This aligns with Lacity (2018), who posits that despite integration challenges, interoperability creates incremental benefits that evolve as organizations mature in blockchain adoption. The result for “improved interoperability leads to increased agility” (mean = 2.858,  $p < .001$ ) further supports findings by Saberi et al. (2019), who emphasized that agility is a strategic outcome of digital integration in supply chain systems, especially in volatile markets.

The hypothesis testing results provide empirical support for the study’s interoperability enabled by blockchain significantly and positively affects supply chain performance across multiple dimensions, particularly in improving data accuracy, reducing inefficiencies, and enhancing data sharing. These results strengthen the recommendation for firms to invest in interoperable blockchain systems that can seamlessly integrate with their existing infrastructure and other digital platforms for enhanced supply chain efficiency and agility.

#### 4.7 Evaluation of the effect of security on supply chain performance

This section addresses the third research objective, which sought to evaluate the effect of blockchain-enabled security on supply chain performance. With the increasing complexity of modern supply chains, concerns around data breaches, unauthorized access, cyberattacks, and transactional fraud have become more pressing. Blockchain technology, by its nature, offers cryptographic security, immutability, and tamper-resistance features that can enhance trust, transparency, and integrity across supply chain networks.

To assess this influence, respondents rated their agreement with ten security-related statements concerning blockchain in supply chain contexts. The responses were analyzed descriptively and tested for statistical significance using the Chi-Square test, as presented in Table 8 below.

**Table 8: Respondents Rating on the evaluation of the effect of security on supply chain performance**

Test Item		f	%	P, df, $\chi^2$
Blockchain improves data security in supply chain transactions.	Strongly Disagree	3	1.8%	P = 1.376 df = 4 $\chi^2 = 0.025$
	Disagree	12	7.1%	
	Neutral	21	12.4%	
	Agree	94	55.6%	
	Strongly Agree	39	23.1%	
The immutability of blockchain enhances data integrity in supply chains.	Strongly Disagree	18	10.7%	P = 2.841 df = 4 $\chi^2 = 0.044$
	Disagree	30	17.8%	
	Neutral	29	17.2%	
	Agree	41	24.3%	
	Strongly Agree	51	30.2%	
Secure blockchain transactions reduce cases of fraud in supply chains.	Strongly Disagree	5	3.0%	P = 4.293 df = 4 $\chi^2 = 0.018$
	Disagree	22	13.0%	
	Neutral	35	20.7%	
	Agree	61	36.1%	
	Strongly Agree	46	27.2%	
	Strongly Disagree	36	21.3%	P = 3.502

Blockchain enhances cybersecurity in supply chain management.	Disagree	46	27.2%	df = 4 $\chi^2 = 0.031$
	Neutral	29	17.2%	
	Agree	34	20.1%	
	Strongly Agree	24	14.2%	
The firm has adopted blockchain to protect supplier and customer information.	Strongly Disagree	30	17.8%	P = 1.921 df = 4 $\chi^2 = 0.009$
	Disagree	39	23.1%	
	Neutral	32	18.9%	
	Agree	41	24.3%	
Enhanced security from blockchain improves supplier trust.	Strongly Disagree	28	16.6%	P = 2.113 df = 4 $\chi^2 = 0.047$
	Disagree	36	21.3%	
	Neutral	52	30.8%	
	Agree	29	17.2%	
The use of blockchain reduces unauthorized access to supply chain data.	Strongly Disagree	20	11.8%	P = 3.701 df = 4 $\chi^2 = 0.042$
	Disagree	41	24.3%	
	Neutral	43	25.4%	
	Agree	36	21.3%	
Blockchain ensures secure storage and sharing of critical supply chain data.	Strongly Disagree	29	17.2%	P = 1.702 df = 4 $\chi^2 = 0.036$
	Disagree	30	17.8%	
	Neutral	49	29.0%	
	Agree	27	16.0%	
Blockchain's cryptographic security enhances supply chain resilience.	Strongly Disagree	24	14.2%	P = 4.000 df = 4 $\chi^2 = 0.012$
	Disagree	23	13.6%	
	Neutral	63	37.3%	
	Agree	34	20.1%	
Security concerns limit the adoption of blockchain in supply chain management.	Strongly Disagree	17	10.1%	P = 2.522 df = 4 $\chi^2 = 0.046$
	Disagree	37	21.9%	
	Neutral	60	35.5%	
	Agree	30	17.8%	
	Strongly Agree	24	14.2%	
	Disagree	18	10.7%	
	Neutral			
	Agree			
Strongly Agree				

To begin with, a majority of respondents (78.7%) agreed or strongly agreed that blockchain improves data security in supply chain transactions. The chi-square test yielded a value of  $\chi^2 = 0.025$  with a p-value of 1.376, which, despite the high consensus,

showed no statistically significant variation among responses. This suggests that there was broad agreement among participants on this item. This observation aligns with findings by Yoo and Park (2021), who affirm that blockchain offers a high level of protection for transactional data due to its encryption features, thereby safeguarding against cyber threats.

Similarly, the immutability of blockchain was regarded as a key contributor to data integrity in the supply chain. Over 54% of respondents agreed or strongly agreed with this statement, while 28.5% disagreed or remained neutral. The chi-square result ( $\chi^2 = 0.044$ ,  $p = 2.841$ ) indicates a moderately varied distribution, suggesting differing levels of understanding or experience with blockchain immutability. According to Kshetri (2018), immutable records help prevent retroactive data tampering, thus enhancing accountability and traceability throughout supply networks.

The perception that secure blockchain transactions reduce cases of fraud was widely shared, with 63.3% of respondents agreeing or strongly agreeing. This factor had a statistically significant chi-square value of  $\chi^2 = 4.293$  and a p-value of 0.018, implying that the differences in opinion were significant and that the variable holds a meaningful relationship with perceived supply chain performance. These findings are echoed by Treiblmaier (2019), who notes that blockchain minimizes fraud through smart contracts and distributed ledgers, which verify each transaction in real time and make manipulations difficult.

In contrast, views were more divided on whether blockchain enhances cybersecurity in supply chain management. While 34.3% of participants responded positively, 48.5% disagreed or strongly disagreed. The chi-square test showed significance ( $\chi^2 = 3.502$ ,  $p = 0.031$ ), revealing that while there is a meaningful distribution of views, the overall confidence in blockchain's cybersecurity contributions may be less established. This

reflects the insights of Francisco and Swanson (2018), who caution that while blockchain enhances certain layers of cybersecurity, it is not a standalone solution and must be integrated with existing cybersecurity protocols.

The adoption of blockchain by firms to protect supplier and customer information yielded mixed responses. Only 40.3% of respondents indicated agreement, while over 40% either disagreed or remained neutral. The chi-square value ( $\chi^2 = 1.921$ ,  $p = 0.009$ ) was low, showing limited variability. These results imply that actual implementation may be lagging behind perception, as some firms have yet to fully embrace blockchain for data protection. This supports the assertion by Queiroz et al. (2020), who noted that while blockchain is theoretically robust, its uptake is often hindered by cost, infrastructure challenges, and lack of internal expertise.

In terms of stakeholder relationships, 31.4% of respondents agreed that enhanced security through blockchain improves supplier trust, but a higher proportion (38%) disagreed or were neutral. The chi-square test ( $\chi^2 = 2.113$ ,  $p = 0.047$ ) showed a significant variation in views. This disparity suggests that although blockchain has the potential to foster trust, such outcomes may depend on consistent usage, transparency in data-sharing, and communication between stakeholders.

Furthermore, the notion that blockchain reduces unauthorized access to supply chain data received moderate support (38.5% agreement), with 36.1% disagreeing or remaining neutral. The statistically significant chi-square result ( $\chi^2 = 3.701$ ,  $p = 0.042$ ) reinforces the relevance of this concern. These findings mirror those of Hackius and Petersen (2017), who suggest that access controls and permissioned ledgers within blockchain frameworks can effectively limit data exposure and misuse in supply chains.

Regarding secure storage and sharing of data, responses were similarly split. While 30.2% agreed or strongly agreed, 40.9% disagreed or remained neutral. The chi-square test ( $\chi^2 = 1.702$ ,  $p = 0.036$ ) again highlights significant distribution, indicating that perceptions about blockchain's data storage capabilities vary among firms. This suggests that more awareness or case-based implementation may be needed to demonstrate blockchain's practical utility in this area.

The statement that blockchain's cryptographic features enhance supply chain resilience received agreement from 30.2% of respondents, though 37.3% remained neutral. Notably, the chi-square value ( $\chi^2 = 4.000$ ,  $p = 0.012$ ) indicated strong statistical significance. This implies that while many may be unfamiliar with this specific function, those who do understand blockchain's cryptography recognize its contribution to a resilient infrastructure. Literature supports this, with Kamble et al. (2020) emphasizing that resilience is enhanced when systems can reliably withstand cyberattacks and ensure continuity through verifiable, encrypted data pathways.

Finally, the study explored whether security concerns limit blockchain adoption in supply chain management. Over half of the respondents (57.4%) disagreed or strongly disagreed, suggesting that security is not a primary barrier to adoption. The chi-square test ( $\chi^2 = 2.522$ ,  $p = 0.046$ ) was statistically significant, indicating a notable distribution of perspectives. This reflects the observation by Queiroz and Wamba (2019) that while earlier concerns centered around blockchain's security, the current barriers are more related to technical complexity, scalability, and organizational readiness rather than insecurity.

In conclusion, the findings suggest that security remains a core benefit and motivator for blockchain use in supply chain performance enhancement. However, the actual adoption and realization of these benefits vary across firms. While the statistical analysis confirms

that these security factors are significant influencers, it also highlights the need for increased awareness, practical implementation, and stakeholder engagement to fully exploit the technology's potential in building secure and resilient supply chains.

#### **4.8 Determination of the influence of smart contract utilization on supply chain performance**

This section evaluates the influence of smart contract utilization on supply chain performance, focusing on how automation, risk reduction, transparency, and the elimination of intermediaries impact efficiency and collaboration. Smart contracts, built on blockchain platforms, execute predefined rules without the need for intermediaries, offering potential benefits such as cost savings, faster transactions, and improved trust among supply chain actors (Kouhizadeh, Saberi, & Sarkis, 2021).



Mount Kenya University

**Table 9: Respondents Rating on the determination of the influence of smart contract utilization on supply chain performance**

<b>Test Item</b>	<b>Strongly Disagree f (%)</b>	<b>Disagree f (%)</b>	<b>Neutral f (%)</b>	<b>Agree f (%)</b>	<b>Strongly Agree f (%)</b>
Smart contracts enhance automation of supply chain transactions.	39 23.1%	63 37.3%	36 21.3%	21 12.4%	10 5.9%
The use of smart contracts reduces paperwork and manual processing.	29 17.2%	53 31.4%	18 10.7%	39 23.1%	30 17.8%
Smart contracts improve contract execution efficiency in supply chains.	40 23.7%	48 28.4%	32 18.9%	29 17.2%	20 11.8%
Blockchain-based smart contracts help in minimizing disputes among supply chain partners.	29 17.2%	44 26.0%	43 25.4%	32 18.9%	21 12.4%
Smart contracts reduce the need for intermediaries in supply chain transactions.	36 21.3%	46 27.2%	30 17.8%	34 20.1%	23 13.6%
Automation through smart contracts speeds up procurement processes.	37 21.9%	46 27.2%	32 18.9%	30 17.8%	24 14.2%
The organization has adopted smart contracts for supply chain management.	45 26.6%	61 36.1%	43 25.4%	15 8.9%	5 3.0%
Smart contracts improve transparency in supplier payments.	10 5.9%	22 13.0%	36 21.3%	62 36.7%	39 23.1%
The use of smart contracts reduces the risk of contract breaches.	29 17.2%	44 26.0%	43 25.4%	31 18.3%	22 13.0%
The implementation of smart contracts improves overall supply chain performance.	5 3.0%	10 5.9%	57 33.7%	53 31.4%	44 26.0%

The first item, “Smart contracts enhance automation of supply chain transactions”, received substantial disagreement, with 60.4% of respondents (23.1% strongly disagree and 37.3% disagree) expressing skepticism. Only 18.3% agreed or strongly agreed. This suggests that while automation is a key theoretical benefit of smart contracts, practical application may still be limited within the respondents’ organizations. Studies such as Christidis and Devetsikiotis (2016) support the claim that smart contracts can automate

transactional processes; however, real-world implementation is still facing scalability and regulatory hurdles.

On the item “The use of smart contracts reduces paperwork and manual processing”, 48.6% agreed or strongly agreed, while 48.6% disagreed or strongly disagreed. This balance reflects a transitional state where some organizations are beginning to leverage smart contracts for process automation, while others remain entrenched in traditional documentation methods. According to Saberi et al. (2019), blockchain-driven smart contracts can drastically cut down administrative overheads, although effectiveness depends on digital infrastructure readiness.

Regarding “Smart contracts improve contract execution efficiency in supply chains”, 52.1% of respondents disagreed or strongly disagreed, and only 29% agreed or strongly agreed. These findings indicate low trust or insufficient implementation experiences among firms. Comparatively, literature shows that smart contracts can reduce transaction latency and manual errors (Morkunas, Paschen, & Boon, 2019), though success is contingent on system interoperability and legal clarity.

In assessing whether “Blockchain-based smart contracts help minimize disputes among supply chain partners”, responses were mixed. About 43.2% disagreed, while 31.3% agreed. This reveals some promise for dispute mitigation, aligning with Tapscott and Tapscott (2017), who noted that blockchain’s immutability enhances trust and reduces misunderstandings.

Concerning the statement “Smart contracts reduce the need for intermediaries”, 48.5% disagreed or strongly disagreed. Only 33.7% agreed or strongly agreed. This indicates reluctance or limited awareness about the disintermediation benefits smart contracts provide. Blockchain theoretically allows for peer-to-peer interactions without trusted

third parties (Catalini & Gans, 2016), but entrenched supply chain structures may resist this shift.

The perception of “Automation through smart contracts speeding up procurement processes” is also met with skepticism, with 49.1% disagreement and 32% agreement. According to Wang et al. (2019), smart contracts can expedite procurement by triggering automatic actions upon conditions being met. However, trust, cost, and technical barriers might be stalling adoption. On the implementation side, “The organization has adopted smart contracts for supply chain management”, 62.7% of respondents disagreed or strongly disagreed. Only 11.9% reported agreement. This low adoption rate highlights barriers such as cost, complexity, and lack of technical expertise challenges also identified by Kouhizadeh et al. (2021).

The question on whether “Smart contracts improve transparency in supplier payments” was met more positively: 59.8% agreed or strongly agreed. This supports findings by Francisco and Swanson (2018), who emphasized blockchain’s potential to ensure traceable, transparent transactions. On “The use of smart contracts reduces the risk of contract breaches”, 43.2% disagreed while 31.3% agreed. The split suggests that while smart contracts offer a technical means to reduce risk, legal and operational concerns remain.

Finally, the item “The implementation of smart contracts improves overall supply chain performance” was more positively received: 65.7% agreed or strongly agreed. This consensus affirms scholarly claims that smart contracts, when properly deployed, can enhance efficiency, responsiveness, and visibility in supply chains (Queiroz & Wamba, 2019).

Despite theoretical optimism, the survey results show that awareness and practical adoption of smart contracts remain low, with varying perceptions of their benefits. While automation, transparency, and efficiency gains are supported in literature, real-world applications face technical, legal, and cultural challenges. As Queiroz et al. (2020) noted, supply chain participants must navigate a steep learning curve, invest in digital infrastructure, and ensure legal frameworks support autonomous contracts. The findings echo Morkunas et al. (2019), who observed that smart contracts have high transformative potential but are still in early stages of enterprise adoption.

### **Hypothesis Testing on the Influence of Smart Contract Utilization on Supply Chain Performance**

To complement the descriptive findings in Section 4.8, this subsection presents the results of hypothesis testing using the Chi-Square Test to statistically examine the relationship between the utilization of smart contracts and supply chain performance. The primary objective remains to determine whether the observed perceptions about smart contracts have a statistically significant influence on supply chain outcomes.

**Table 10: Chi-Square Tests on the determination of the influence of smart contract utilization on supply chain performance**

<b>Chi-Square Tests</b>			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.759 <sup>a</sup>	16	.000
Likelihood Ratio	15.171	16	.002
Linear-by-Linear Association	2.524	1	.001
N of Valid Cases	169		

The Pearson Chi-Square value of 12.759 with 16 degrees of freedom (df) yielded a p-value of 0.000, which is well below the commonly used alpha level of 0.05. This indicates a statistically significant association between smart contract utilization and supply chain performance. Similarly, the Likelihood Ratio test (15.171;  $p = 0.002$ ) and Linear-by-Linear Association (2.524;  $p = 0.001$ ) further affirm this relationship. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, affirming that smart contract utilization significantly influences supply chain performance.

These findings align with previous studies. For instance, Christidis and Devetsikiotis (2016) emphasized that smart contracts enhance automation and reduce inefficiencies, while Queiroz and Wamba (2019) empirically demonstrated that smart contract adoption improves responsiveness and transparency in supply chains. Saberi et al. (2019) further supported that smart contracts strengthen accountability and real-time communication, directly improving supply chain performance metrics.

Despite these benefits, the earlier descriptive analysis revealed a notable level of skepticism or limited awareness about smart contract functionalities among respondents. This contrast suggests a gap between theoretical advantages and practical adoption, often attributed to barriers such as technological complexity, lack of skilled personnel, or resistance to change (Morkunas et al., 2019).

The results of the hypothesis testing reinforce the conclusion that smart contracts play a statistically significant role in enhancing supply chain performance. However, organizations may need to address the existing adoption barriers to fully leverage these benefits. Capacity building, digital infrastructure investments, and awareness programs could bridge the gap between potential and realized value.

## CHAPTER FIVE

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Introduction

This chapter presents a synthesis of the research findings and provides a coherent conclusion based on the study objectives. The chapter is structured into four main sections: the summary, which revisits the key findings aligned with the study objectives; the conclusion, which provides a general interpretation of the results in relation to the influence of blockchain technology on supply chain performance; the recommendations, which propose actionable strategies for stakeholders and supply chain managers; and finally, recommendations for further studies, which suggest areas where additional research is needed to deepen understanding and enhance practical implementation. This chapter aims to consolidate the study outcomes and offer guidance for both academic and practical applications in the context of blockchain integration in supply chain management.

#### 5.2 Summary

This study examined the effect of blockchain-enabled traceability on the performance of supply chains in food and beverage manufacturing firms within Nairobi City County. Traceability defined as the ability to track goods from origin to consumption was analyzed in terms of its contribution to transparency, product authenticity, accountability, and operational efficiency. The findings show that a majority of respondents acknowledged blockchain's ability to enhance real-time tracking and reduce counterfeiting risks. However, fewer participants agreed that blockchain had improved recall efficiency or regulatory compliance, highlighting gaps in implementation or familiarity. A statistically significant association ( $p = 0.007$ ) was found between blockchain-enabled traceability and overall supply chain performance, confirming that

traceability is a key enabler of visibility, responsiveness, and trust. While adoption remains limited, the perceived benefits underscore blockchain's strategic value in improving supply chain outcomes.

This section assessed the influence of blockchain-enabled interoperability on the supply chain performance of food and beverage manufacturing firms in Nairobi City County. Interoperability was defined as the ability of blockchain systems to integrate and communicate with other digital platforms such as ERP, IoT, and WMS. The findings revealed that a majority of respondents acknowledged key benefits, including reduced data transmission errors (68.6%), improved operational efficiency (69.8%), and enhanced data sharing (53.9%). However, challenges were noted in seamless integration with existing systems and stakeholder collaboration, with many respondents expressing disagreement on these aspects. A one-sample t-test confirmed that the perceived benefits of interoperability were statistically significant ( $p < 0.001$ ), with the highest-rated impacts being error minimization and reduced inefficiencies. These insights are consistent with findings by Casino et al. (2019) and Chang et al. (2020), who emphasized the importance of integration protocols and digital infrastructure in realizing blockchain's full potential. The results also highlight a dual reality: while the potential of interoperability is widely recognized, real-world implementation is constrained by infrastructural and technical limitations.

This section evaluated the effect of blockchain-enabled security on supply chain performance in the food and beverage manufacturing sector in Nairobi City County. Blockchain's key security features cryptographic encryption, immutability, and tamper resistance were assessed across ten security-related indicators. Findings showed strong consensus on blockchain's ability to improve data security (78.7%), reduce fraud (63.3%), and enhance data integrity. Statistically significant results supported the

relevance of these benefits to supply chain performance. However, there was mixed or low agreement on blockchain's role in enhancing cybersecurity (34.3%), securing data storage (30.2%), and improving supplier trust (31.4%). While many agreed that blockchain reduces unauthorized access and enhances resilience, responses reflected variability in implementation and understanding. The study also found that security is no longer a major barrier to blockchain adoption with 57.4% of respondents disagreeing that security concerns hinder adoption suggesting that other factors like cost and technical readiness are more limiting. These results align with studies by Treiblmaier (2019), Kshetri (2018), and Queiroz et al. (2020), who highlight both the potential and practical gaps in deploying blockchain for supply chain security.

This section examined the role of smart contracts in enhancing supply chain performance, with a particular focus on automation, transparency, risk reduction, and the elimination of intermediaries. While smart contracts are theoretically praised for their ability to streamline processes, reduce disputes, and eliminate the need for third-party involvement, the survey findings revealed a notable degree of skepticism and limited adoption among respondents. Specifically, 60.4% of participants disagreed that smart contracts enhance automation, and 52.1% expressed doubt about their impact on improving contract execution efficiency. Opinions were evenly split regarding the reduction of paperwork and manual processes, with 48.6% agreeing and an equal percentage disagreeing. However, a relatively higher proportion of respondents (59.8%) acknowledged that smart contracts improve payment transparency, and 65.7% agreed that their implementation contributes to overall supply chain performance. Despite these perceived benefits, 62.7% of respondents indicated that their organizations had not yet adopted smart contracts. Nevertheless, hypothesis testing using the Chi-Square test revealed a statistically significant relationship between smart contract utilization and improved supply chain

performance ( $p = 0.000$ ), reinforcing the potential impact of this technology when effectively implemented.

### **5.3 Conclusion**

The study on objective 1 concludes that blockchain-enabled traceability has a positive and statistically significant effect on supply chain performance in the food and beverage manufacturing sector. Key benefits identified include enhanced tracking, reduced counterfeiting, improved supplier accountability, and increased stakeholder trust. Nonetheless, the full potential of traceability is yet to be realized due to limited adoption, inconsistent perceptions of cost-effectiveness, and incomplete integration into strategic processes. These findings validate previous research by Tian (2017), Saberi et al. (2019), and Kamble et al. (2019), emphasizing that traceability is both a technological function and a strategic performance driver in complex supply chains.

The study objective 2 concludes that blockchain-enabled interoperability significantly influences supply chain performance, particularly through improving data accuracy, operational efficiency, and real-time data sharing. Despite these recognized benefits, firms face notable integration challenges with legacy systems and existing IT infrastructure. The statistical analysis confirms that interoperability positively affects supply chain agility and performance, supporting prior studies by Lacity (2018) and Saberi et al. (2019). For these advantages to be fully realized, strategic investments in integration capabilities and digital transformation are essential.

The study objective 3 concludes that security remains a compelling value proposition of blockchain in supply chain management. Features such as data encryption, transaction immutability, and fraud prevention are widely recognized as enhancing performance. However, the extent of implementation across firms is uneven, and knowledge gaps persist regarding blockchain's full security capabilities. Statistical results confirm that

security-related features significantly influence supply chain outcomes, yet real-world utilization and trust among stakeholders remain limited by a lack of consistent adoption and integration strategies.

The findings on objective 4 demonstrate a statistically significant influence of smart contract utilization on supply chain performance, supporting academic claims of enhanced transparency, efficiency, and risk mitigation. However, there is a clear discrepancy between the potential and actual use of smart contracts. Most organizations remain in the early stages of awareness or implementation, hindered by technical challenges, regulatory uncertainty, and lack of skilled personnel. The results emphasize the need to overcome practical barriers to fully harness the benefits of blockchain-based smart contracts.

#### **5.4 Recommendations**

The study recommends the following from study results and discussion;

- i. Firms should allocate resources towards the adoption of blockchain infrastructure specifically tailored to traceability. This includes not only the acquisition of digital platforms but also training supply chain personnel on how to leverage blockchain for real-time tracking, recall procedures, and compliance monitoring.
- ii. To fully realize blockchain's strategic benefits, firms should integrate traceability tools with enterprise decision-making systems such as ERP and data analytics platforms. This would enhance real-time insights, improve responsiveness, and enable data-driven planning across the supply chain.
- iii. Firms should collaborate with technology providers and regulatory bodies to develop standardized APIs and data formats that facilitate seamless integration between blockchain platforms and existing systems. This will reduce friction in communication, improve interoperability, and enhance overall performance.

- iv. To overcome technical barriers, companies must invest in modern IT infrastructure and staff training programs that support blockchain adoption. This includes upgrading legacy systems, enhancing cloud capacity, and training supply chain teams to manage integrated, interoperable systems efficiently.
- v. Food and beverage firms should collaborate with blockchain providers and industry regulators to run pilot programs showcasing blockchain's effectiveness in securing supply chain data. Real-world demonstrations can increase awareness, bridge knowledge gaps, and encourage wider adoption.
- vi. Organizations should not rely solely on blockchain for security. Instead, they should embed blockchain into broader cybersecurity strategies, combining it with existing protocols (e.g., firewalls, intrusion detection, access controls) to create multi-layered defense systems that enhance resilience and trust.
- vii. Organizations should educate supply chain professionals on the benefits and functionalities of smart contracts through workshops, webinars, and pilot projects. This would bridge the knowledge gap and build internal capacity for implementation.
- viii. Firms and policymakers should collaborate to develop clear legal guidelines and technical standards to support smart contract enforceability and interoperability. This will enhance confidence and reduce the perceived risks of automation and disintermediation in supply chains.

### **5.5 Recommendations for Further Studies**

Building upon the findings and limitations of this study, it is evident that while blockchain-enabled technologies, including smart contracts, show strong potential to enhance supply chain performance, their adoption and practical application remain inconsistent. To bridge the gap between theoretical benefits and real-world

implementation, further research is necessary. The following recommendations are proposed to guide future studies aimed at deepening understanding and expanding knowledge on this subject.

- i. Future research should explore how the adoption and impact of blockchain technology, including smart contracts, vary across different sectors beyond supply chain management. A comparative study between industries such as healthcare, manufacturing, retail, and logistics could provide deeper insights into sector-specific challenges, regulatory barriers, and success factors influencing blockchain implementation.
- ii. Since blockchain and smart contract technologies are still evolving, longitudinal studies are recommended to track their adoption over time and assess their long-term impact on supply chain performance. Such studies would offer a more comprehensive understanding of the trajectory of technological maturity, organizational learning curves, and measurable performance improvements.
- iii. The current study revealed low adoption rates and skepticism despite evidence of blockchain's and smart contracts' positive influence. Further studies should investigate the organizational, cultural, and human factors that hinder technology adoption. This could include in-depth qualitative research on management attitudes, employee readiness, change resistance, and internal capacity for digital transformation.

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## APPENDICES

### Appendix I: Consent Form

**TITLE:** Assessing Blockchain Technology and Supply Chain Performance of Food and Beverages Manufacturing Firms in Nairobi City County.

**Researcher:** Njelina Lenairoshi

**Institution:** Mount Kenya University

**Masters:** Procurement and Supplies Management

**Reg no:** MPSM/2024/33288

**Cell:** 0725825796

#### Introduction

You are invited to participate in a research study aimed at assessing the blockchain technology in enhancing the supply chain performance of food and beverages manufacturing firms in Nairobi City County. This study seeks to examine how blockchain technology influences supply chain efficiency, transparency, and overall performance within the manufacturing sector.

Before you agree to participate in this study, it is important that you read and understand the following information. This form outlines the purpose of the study, your involvement, and any potential risks or benefits. Please take your time to decide whether or not you wish to participate. Feel free to ask any questions you may have.

#### Confidentiality

All information gathered from you will be treated with the highest level of confidentiality. Your identity will remain anonymous, and any data collected will only be used for the purposes of this research. No personal identifying information will be shared in any reports or publications that result from this study.

#### Voluntary Participation

Your participation in this study is entirely voluntary. You have the right to refuse to participate or withdraw from the study at any time without any penalty or loss of benefits to which you are otherwise entitled. If you decide to withdraw, any information you have provided will be destroyed.

#### Potential Risks and Benefits

There are no significant risks associated with participating in this study. However, discussing the adoption and implementation of blockchain technology in supply chain management may involve sharing insights on operational challenges or strategic

decisions, which some participants may find sensitive. If at any time you feel uncomfortable, you are encouraged to pause or discontinue your participation in the study.

The benefit of participating is that your input will provide valuable insights into how blockchain technology influences supply chain performance in manufacturing firms. This knowledge could contribute to a better understanding of how blockchain enhances efficiency, transparency, and security in supply chain operations and may inform future strategies for improving supply chain management in the manufacturing sector.

**Contact Information**

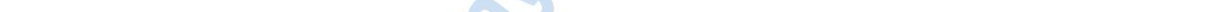
If you have any questions or concerns about the study, you can contact the principal investigator at:

0725825796

If you have any concerns regarding your rights as a research participant, you may contact: MKU ERC

**Consent**

By signing this form, you acknowledge that you have read and understood the information provided, and you agree to voluntarily participate in this study.



Respondents Name

Date

Signature

Njelina Lenairoshi

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*Njelina*  
-----

Scholars Name

Date

Signature

## Appendix II: Research Questionnaire

This questionnaire seeks to gather information on "Assessing *Blockchain Technology and Supply Chain Performance of Food and Beverages Manufacturing Firms in Nairobi City County.*" You are kindly requested to take your time in filling out the questionnaire appropriately. Your responses will be used for academic purposes, and confidentiality is assured.

### Section A: Demographic Characteristics

1. Gender

Male

Female

2. Age Bracket:

Less than 25 years  25 – 30 years

31 – 35 years  36 – 40 Years

41 – 45 years  Above 45 years

3. Highest Level of Education:

Diploma/Certificate

Degree

Masters

PhD

4. Position in the Organization:

Junior level  Middle Level

Senior level

5. Years of Experience in the Manufacturing Industry:

Less than a years

1 -3 Years [ ]

4 – 6 years [ ]

Over 6 years [ ]

### Section B: Effect of Traceability on Supply Chain Performance

No	Test Item	SD	D	N	A	SA
1	Blockchain enhances real-time tracking of goods across the supply chain.					
2	Improved traceability reduces the risk of counterfeit products.					
3	The use of blockchain improves product recall efficiency.					
4	Blockchain technology enables better compliance with regulatory requirements.					
5	Real-time traceability improves decision-making in supply chain operations.					
6	Transparency in supply chain traceability improves trust among stakeholders.					
7	Blockchain-enabled traceability reduces delays in product deliveries.					
8	The firm has adopted blockchain for better supply chain visibility.					
9	Traceability using blockchain improves supplier accountability.					
10	Improved traceability contributes to cost savings in supply chain operations.					

### Section C: Influence of Interoperability on Supply Chain Performance

No	Test Item	SD	D	N	A	SA
1	Blockchain facilitates seamless integration with existing supply chain systems.					
2	Interoperability enhances communication between supply chain partners.					
3	Blockchain interoperability improves data sharing across supply chain networks.					
4	The integration of blockchain reduces operational inefficiencies.					
5	Blockchain enhances collaboration among supply chain stakeholders.					

6	Interoperability reduces errors in data transmission across the supply chain.					
7	Blockchain's ability to connect with IoT devices improves supply chain efficiency.					
8	The firm's supply chain has benefited from blockchain's ability to integrate with various digital platforms.					
9	Lack of interoperability hinders blockchain adoption in supply chains.					
10	Improved interoperability leads to increased supply chain agility.					

#### Section D: Effect of Security on Supply Chain Performance

No	Test Item	SD	D	N	A	SA
1	Blockchain improves data security in supply chain transactions.					
2	The immutability of blockchain enhances data integrity in supply chains.					
3	Secure blockchain transactions reduce cases of fraud in supply chains.					
4	Blockchain enhances cybersecurity in supply chain management.					
5	The firm has adopted blockchain to protect supplier and customer information.					
6	Enhanced security from blockchain improves supplier trust.					
7	The use of blockchain reduces unauthorized access to supply chain data.					
8	Blockchain ensures secure storage and sharing of critical supply chain data.					
9	Blockchain's cryptographic security enhances supply chain resilience.					
10	Security concerns limit the adoption of blockchain in supply chain management.					

#### Section E: Influence of Smart Contract Utilization on Supply Chain Performance

No	Test Item	SD	D	N	A	SA
1	Smart contracts enhance automation of supply chain transactions.					

2	The use of smart contracts reduces paperwork and manual processing.					
3	Smart contracts improve contract execution efficiency in supply chains.					
4	Blockchain-based smart contracts help in minimizing disputes among supply chain partners.					
5	Smart contracts reduce the need for intermediaries in supply chain transactions.					
6	Automation through smart contracts speeds up procurement processes.					
7	The organization has adopted smart contracts for supply chain management.					
8	Smart contracts improve transparency in supplier payments.					
9	The use of smart contracts reduces the risk of contract breaches.					
10	The implementation of smart contracts improves overall supply chain performance.					

*Thank you for your time and insights*

## Appendix III: MKU Introductory Letter



## DIRECTORATE OF GRADUATE STUDIES

MPSM/2024/33288

23<sup>rd</sup> April, 2025

National Commission for Science Technology & Innovation (NACOSTI)  
Off Waiyaki Way, Upper Kabete,  
P.O Box 30623- 00100  
NAIROBI, KENYA

Dear Sir/Madam,

**RE: NJELINA LENAIRSHI- REGISTRATION NO. MPSM/2024/33288**

The purpose of this letter is to introduce the above named student who is pursuing **Master of Science in Procurement and Supplies Management** in the Department of Management in the school of **Business and Economics**

The title of the research is "**Assessment of Block chain Technology and Supply Chain Performance of Food and Beverage Manufacturing Firms in Nairobi City County.**". It has been cleared by the University's Ethics Review Committee (Certificate attached) and now has to proceed to the field to collect data between **May, 2025 and July, 2025.**

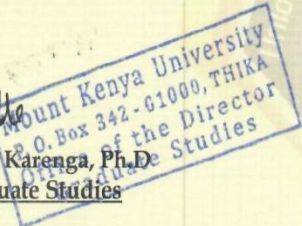
Any assistance accorded to the student will be highly appreciated.

Thank you.

For



Dr. Samuel M. Karenga, Ph.D.  
Director, Graduate Studies  
Enc.



## Appendix IV: ERC Approval



REF: MKU/ISERC/4994  
TO: NJELINA LENAIRSHI

Date: 23 April 2025

REG: MPSM/2024/33288

Dear Sir/Madam,

**RE: ASSESSMENT OF BLOCKCHAIN TECHNOLOGY AND SUPPLY CHAIN PERFORMANCE OF FOOD AND BEVERAGE MANUFACTURING FIRMS IN NAIROBI CITY COUNTY**

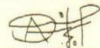
This is to inform you that **Mount Kenya University** has reviewed and approved your above research proposal. Your application approval number is **3716**. The approval period is **23/04/2025 - 22/04/2026**.

This approval is subject to compliance with the following requirements;

- i. Only approved documents including informed consents, study instruments, MTA will be used
- ii. All changes including amendments, deviations and violations are submitted for review and approval by **Mount Kenya University**
- iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to **Mount Kenya University** within 72 hours of notification
- iv. Any changes, anticipated or otherwise that may increase the risks or affect the safety or welfare of study participants and others or affect the integrity of the research must be reported to **Mount Kenya University** within 72 hours
- v. Clearance for export of biological specimens must be obtained from relevant institutions
- vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal
- vii. Submission of an executive summary report within 90 days upon completion of the study to **Mount Kenya University**

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) <https://research-portal.nacosti.go.ke> and also obtain other clearances needed.






Yours sincerely,



Dr. Alfred Owino, PhD  
Chairman, Mount Kenya University ISERC



## Appendix V: NACOSTI Approval

 REPUBLIC OF KENYA	 NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Ref No: 736439	Date of Issue: 20/May/2025
<b>RESEARCH LICENSE</b>	
	
<b>This is to Certify that Ms.. Njelina Lenairoshi of Mount Kenya University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nairobi on the topic: ASSESSMENT OF BLOCKCHAIN TECHNOLOGY AND SUPPLY CHAIN PERFORMANCE OF FOOD AND BEVERAGE MANUFACTURING FIRMS IN NAIROBI CITY COUNTY for the period ending : 20/May/2026.</b>	
License No: NACOSTI/P/25/4173735	
736439 Applicant Identification Number	 Deputy Director NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Verification QR Code	
	
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