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SUPPLY CHAIN VISIBILITY AND PERFORMANCE OF MANUFACTURING FIRMS IN NAIROBI CITY COUNTY, KENYA

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ABSTRACT

Supply chain visibility plays a critical role in enhancing the efficiency and performance of manufacturing firms by enabling real-time tracking, seamless ICT integration. However, despite its importance, many manufacturing firms in Nairobi City County, Kenya, continue to face challenges in achieving full supply chain visibility, leading to inefficiencies, delays, and increased operational costs. This study sought to examine the influence of real-time tracking, ICT integration, on the performance of manufacturing firms in Nairobi City County, Kenya. The study was guided by Systems Theory and Technology Acceptance Model (TAM). The study employed a descriptive research design and targets 119 manufacturing firms with a total population of 714 managerial employees. Using Yamane's (1967) formula, a sample size of 256 respondents was selected through simple random sampling. Primary data was collected through structured questionnaires containing closed-ended questions measured on a 5-point Likert scale. A pilot study was conducted with 14 respondents (10% of the sample size) to test the reliability of the questionnaire using Cronbach's Alpha coefficient. Data analysis was conducted using descriptive statistics (frequency distributions, mean, standard deviation) and inferential statistics, including Pearson correlation and multiple regression analysis, to determine the relationships between variables. The study investigated the influence of supply chain visibility—operationalized through real-time tracking, ICT integration—on the performance of manufacturing firms in Nairobi City County, Kenya. Using a structured questionnaire and quantitative analysis of responses from 234 managers across various manufacturing sectors, the study found that all four visibility dimensions had a statistically significant and positive impact on firm performance. ICT integration and real-time tracking emerged as the most influential factors, enhancing operational efficiency, coordination, and decision-making. It recommends that firms invest in scalable real-time tracking technologies, adopt integrated ICT platforms through AI and real-time analytics to fully realize the benefits of visibility-driven performance.

Key Words: Supply chain visibility, Performance, Real-Time Tracking, ICT Integration, Manufacturing Firms

Background of the Study

The manufacturing sector is a critical pillar of economic development in many countries, providing a substantial source of employment, export revenue, and technological innovation (Sirirat, Martine, & Wout, 2024). It supports various industries and is often at the heart of industrialization efforts in developing nations. Manufacturing has a powerful multiplier effect, meaning its growth stimulates other sectors, such as logistics, retail, and services, by creating demand for materials, distribution, and other resources (Charles, Acquah, & Ofori, 2020). Furthermore, manufacturing enhances productivity by driving the use of advanced technologies, automation, and efficient processes. Through export-oriented manufacturing, a country can achieve a favorable balance of trade and increase foreign exchange earnings. The manufacturing sector also plays a vital role in addressing social issues by providing jobs, reducing poverty, and fostering economic inclusion. In developed economies, the sector is a hub for research and innovation, attracting skilled labor and contributing to the development of cutting-edge products and processes (Adegoke, & Mark, 2020).

A well-functioning manufacturing sector holds immense potential for a country's economic resilience and global competitiveness. When manufacturing firms operate efficiently, they help stabilize the national economy by reducing dependency on imports and enhancing local production capacity (Hsiao-Lan, & Wang, 2020). A thriving manufacturing sector promotes self-sufficiency, which is particularly valuable in times of global economic disruptions, such as those seen during supply chain crises or international trade conflicts (Wambua, & Noor, 2024). Additionally, as manufacturing firms invest in advanced technologies and digitalization, they contribute to the digital transformation of the economy, setting the stage for a knowledge-based economy. These investments not only improve production efficiencies but also spur innovation, resulting in products that can compete on the international stage. This, in turn, positions the country as a significant player in the global market, enhancing its trade relationships and economic influence (Ogwang, Wachiuri, & Nyaberi, 2024).

Supply Chain Visibility is the ability of a company to monitor and understand every step in the supply chain, from raw materials through production and final delivery to the customer (Kimwaki, 2023). This visibility ensures a more resilient, efficient, and responsive supply chain, enhancing operational performance and customer satisfaction (Mose, Osoro, & Nyang'au, 2024). Key aspects like real-time tracking, ICT integration, contribute significantly to improving supply chain visibility. Real-Time Tracking is essential for pinpointing the exact location of goods as they move through the supply chain (Munanira & Mulyungi, 2020). By using GPS and IoT-enabled sensors, companies can track shipments, monitor transit conditions, and respond proactively to delays or disruptions. Real-time tracking enables businesses to provide accurate information to both managers and customers, allowing them to make immediate adjustments to schedules, routes, and inventory management (Mose, Osoro, & Nyang'au, 2024). This constant, live stream of data supports not only smoother logistical operations but also helps avoid costly delays that can affect both the business and the customer experience (Kimwaki, 2023). ICT Integration serves as the backbone of supply chain visibility, linking various components of the supply chain with technology to streamline processes, improve data accessibility, and automate decision-making. Information and Communication Technology (ICT) tools enable data collection, storage, and analysis, allowing different departments and partners to share real-time data effectively (Munanira & Mulyungi, 2020). For instance, Enterprise Resource Planning (ERP) systems and Supply Chain Management (SCM) platforms provide comprehensive insights into inventory, procurement, and distribution processes. When integrated, ICT systems can facilitate seamless communication, leading to greater agility and responsiveness throughout the supply chain (Bichanga, & Mwangi, 2020). This study therefore sought to establish the influence of supply chain visibility on performance of manufacturing firms in Nairobi City County, Kenya.

Statement of the Problem

The manufacturing sector is a cornerstone of economic development, contributing significantly to Kenya's GDP, job creation, and export revenue. As a driver of industrialization, the manufacturing industry supports the growth of other sectors, such as logistics, retail, and services, creating a multiplier effect that strengthens the overall economy (Wambua & Noor, 2024). Manufacturing also plays a pivotal role in technological advancement and infrastructure development, which are critical for sustained economic growth (Ogwang, Wachiuri & Nyaberi, 2024). In Nairobi City County, a hub for industrial activity, manufacturing is particularly vital. It provides numerous employment opportunities, drives urbanization, and supports various industries that rely on locally manufactured goods. Thus, the performance of manufacturing firms directly impacts not only the city's economy but also the national economy by fostering self-sufficiency, reducing reliance on imports, and contributing to foreign exchange earnings (Bichanga & Mwangi, 2020).

Despite its importance, the performance of Kenya's manufacturing sector has been declining in recent years. The decline in Kenya's manufacturing sector is a pressing issue, with key statistics illustrating its challenges and the need for targeted solutions. In recent years, manufacturing's share of Kenya's GDP has remained stagnant at around 7.5% in 2022, far below the 15% target set by the Kenya Vision 2030 initiative (Kimwaki, 2023). This stagnation reflects ongoing struggles within the sector, such as high production costs, inefficient supply chains, and limited access to raw materials. Furthermore, Kenya's industrial growth rate dropped to just 2.5% in 2021, down from 4.3% in 2019, highlighting a reduction in manufacturing productivity and output. Nairobi City County, being a central manufacturing hub, contributes nearly half of Kenya's industrial output (Mose, Osoro & Nyang'au, 2024). However, the city's manufacturing firms have been significantly affected by issues like rising utility costs, which have increased by approximately 15% annually, and frequent power outages, which disrupt production and inflate operational costs (Kimwaki, 2023).

Additionally, Nairobi's manufacturing sector faces logistical inefficiencies that impact performance. The average time to import goods through Kenya's ports, for instance, is around 11 days, while exporting takes approximately 10 days, both well above the 6-day average for competitive economies in the region (Bichanga & Mwangi, 2020). These delays are compounded by congestion and poor road infrastructure, particularly in Nairobi's industrial zones, where traffic bottlenecks cause delivery delays and increased transportation costs (Kimwaki, 2023). A 2022 report from the Kenya Association of Manufacturers (KAM) also noted that nearly 40% of manufacturing firms in Nairobi reported operational delays due to supply chain disruptions, resulting in average losses of 10-15% in annual revenue (Kimwaki, 2023). The COVID-19 pandemic further amplified these challenges, with over 60% of firms reporting disruptions to supply chains, inventory management, and demand forecasting, leading to a slowdown in productivity and market responsiveness (Mose, Osoro & Nyang'au, 2024).

Research has shown that supply chain visibility influences firm performance. Various studies have been conducted on supply chain visibility and firm performance. For instance; Wambua and Noor (2024) researched on supply chain visibility and performance of distribution firms in Nairobi city county, Kenya. Ogwang, Wachiuri and Nyaberi (2024) conducted research on supply chain visibility and performance of commercial state corporations in Kenya. Bichanga and Mwangi (2020) conducted a case study on evaluating the effectiveness of supply chain visibility in the retail supply chain: a case study of Uchumi super markets limited-Kenya. Kimwaki (2023) Role of supply chain visibility on performance of manufacturing sector in Sub-Saharan Africa: A Study in Kenya. However, none of these studies focused on performance of manufacturing firms in Nairobi City County, Kenya. To fill the highlighted gaps, the current study sought to establish the influence of supply chain visibility on performance of manufacturing firms in Nairobi City County, Kenya

Objectives of the Study

The general objective of the study was to establish the influence of supply chain visibility on performance of manufacturing firms in Nairobi City County, Kenya

The study was guided by the following specific objectives;

i. To determine the effect of real time tracking on performance of manufacturing firms in Nairobi City County, Kenya
ii. To establish the effect of ICT integration on performance of manufacturing firms in Nairobi City County, Kenya

LITERATURE REVIEW

Theoretical Review

Systems Theory

Systems Theory, introduced by Ludwig von Bertalanffy in the 1940s, provides a holistic framework for analyzing how interconnected components within a system interact to maintain efficiency and stability (Bertalanffy, 1968). Initially developed in biological sciences, the theory has since been widely applied in management, engineering, and supply chain studies due to its emphasis on interdependence and information flow (Skyttner, 2005). The fundamental premise of the theory is that organizations function as complex adaptive systems, where coordination, feedback loops, and real-time information exchange are crucial for maintaining operational efficiency and resilience (Kast & Rosenzweig, 1972). The theory underscores the importance of continuous adaptation, making it highly relevant to modern supply chain visibility practices (Forrester, 1961).

Supply chain visibility, particularly through real-time tracking technologies such as GPS, RFID, and IoT sensors, aligns with Systems Theory by enabling continuous data exchange and immediate responsiveness to disruptions (Sterman, 2000). Real-time tracking allows supply chain managers to monitor the movement of goods, anticipate potential bottlenecks, and optimize decision-making in manufacturing operations (Akkermans, Bogerd, & Vos, 2020). By integrating real-time tracking systems, firms can achieve synchronized operations, reducing delays and ensuring efficient resource allocation (Ivanov, Dolgui, & Sokolov, 2021). Research indicates that organizations with high supply chain visibility experience improved efficiency, enhanced supplier collaboration, and better inventory management, as all components of the system function cohesively (Wieland & Durach, 2021).

Despite its widespread application, Systems Theory has been criticized for assuming that all system components operate in harmony and adapt effectively to external changes (Skyttner, 2005). Modern supply chains are highly dynamic and influenced by factors such as geopolitical risks, economic fluctuations, and technological disruptions that may not always align with a systems-based equilibrium approach (Kast & Rosenzweig, 1972). Additionally, the theory does not account for organizational barriers such as resistance to technology adoption, cost constraints, and cybersecurity threats, which can hinder the effectiveness of real-time tracking solutions (Ivanov et al., 2021). Some scholars argue that Systems Theory lacks specificity in addressing micro-level decision-making, as it assumes a closed-loop system where data flows seamlessly, whereas in reality, supply chains often operate in fragmented networks with incomplete information sharing (Akkermans et al., 2020).

Despite these critiques, Systems Theory remains a valuable framework for understanding real-time tracking in supply chains, particularly in analyzing how interconnected processes influence overall performance (Forrester, 1961). Its emphasis on interdependence and adaptability is relevant for manufacturing firms seeking to enhance efficiency through digital supply chain solutions (Sterman, 2000). When complemented with modern technological advancements such as artificial intelligence and cloud computing, Systems Theory provides a strong foundation for evaluating the impact of real-time visibility on supply chain performance

(Ivanov et al., 2021). This study utilized Systems Theory to assess how real-time tracking improves coordination, minimizes inefficiencies, and enhances manufacturing performance in Nairobi City County, Kenya.

Technology Acceptance Model

The Technology Acceptance Model (TAM), developed by Fred Davis (1989), is a widely recognized framework for explaining how users come to adopt and utilize technology. The model posits that two primary factors influence technology adoption: perceived usefulness—the extent to which a person believes that using a technology enhance their performance, and perceived ease of use—the degree to which an individual believes that adopting the technology require minimal effort (Davis, 1989). These two factors shape users' attitudes toward technology, which subsequently influence their intention to use and ultimately determine the actual adoption and continued utilization of the technology (Venkatesh & Davis, 2000). As an extension of the Theory of Reasoned Action (TRA), TAM highlights that a user's perception of technology directly affects their willingness to engage with and integrate it into their operations (Fishbein & Ajzen, 1975).

In the context of ICT integration in supply chain management, TAM provides valuable insights into how manufacturing firms adopt and implement digital tools such as cloud computing, ERP systems, and IoT-based supply chain platforms (Venkatesh & Bala, 2008). When ICT solutions are perceived as user-friendly and beneficial in improving efficiency, firms are more likely to integrate them into their supply chain processes (Chau & Hu, 2002). However, barriers such as technological complexity, lack of training, and resistance to change can negatively influence adoption rates (Holden & Karsh, 2010). Organizations that proactively address these concerns by enhancing perceived ease of use—through intuitive system design and adequate user support—and demonstrating perceived usefulness—by showcasing tangible improvements in performance—can significantly enhance technology adoption within their operations (Gefen & Straub, 2000).

Despite its broad applicability, TAM has been critiqued for its oversimplification of the technology adoption process, as it assumes that user perceptions alone determine adoption, neglecting external factors such as organizational culture, regulatory influences, and economic constraints (Bagozzi, 2007). Additionally, TAM primarily focuses on individual user adoption, making it less effective in explaining large-scale technological transitions within enterprises that require collective decision-making and structural changes (Venkatesh et al., 2003). Recent adaptations, such as the Unified Theory of Acceptance and Use of Technology (UTAUT), have attempted to address these gaps by incorporating additional factors such as social influence and facilitating conditions (Venkatesh, Thong, & Xu, 2012).

This study applied TAM to assess the influence of ICT integration on the performance of manufacturing firms in Nairobi City County, Kenya, particularly focusing on how perceived usefulness and perceived ease of use affect the adoption of digital supply chain solutions. Given the increasing reliance on real-time data analytics, automated inventory systems, and AI-driven decision-making tools, understanding the drivers and barriers of ICT adoption is critical for optimizing supply chain performance and overall manufacturing efficiency.

Conceptual Framework

A conceptual framework is an assumed model that aids in the identification of study concepts as well as their interactions with one another (Mugenda & Mugenda, 2019). In this study the independent variables are real time tracking, ICT integration while the dependent variable is performance of manufacturing firms in Nairobi City County, Kenya.

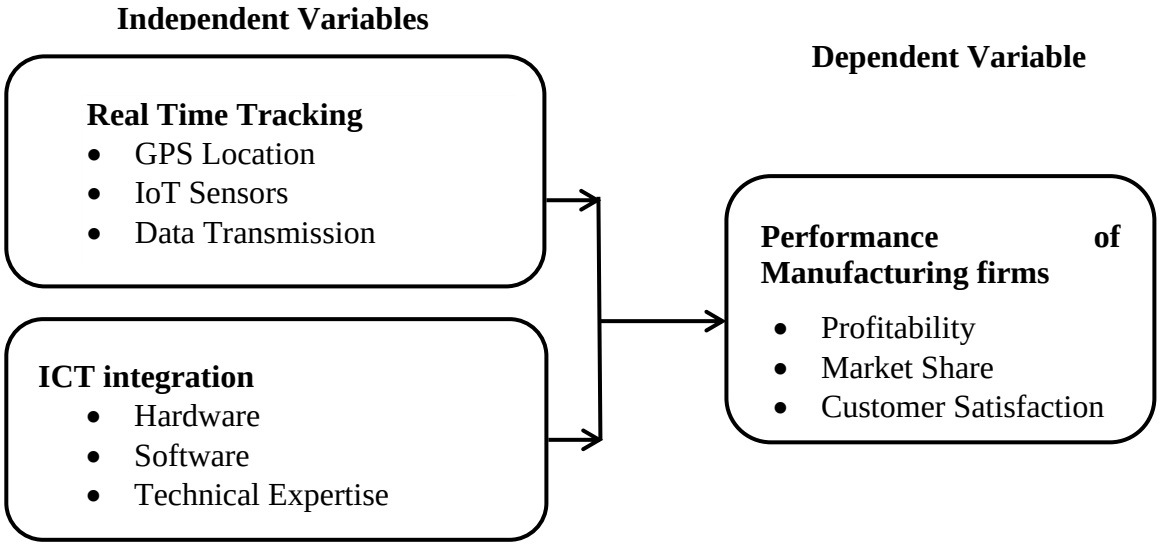

Figure 2. 1: Conceptual Framework

Real-Time Tracking

Real-time tracking is a fundamental component of modern supply chain management, enabling organizations to monitor and optimize their logistical processes with high accuracy. The introduction of IoT-based tracking devices, GPS navigation, RFID sensors, and cloud-based monitoring platforms has transformed traditional logistics into highly responsive, data-driven networks (Holloway, 2024). By leveraging these technologies, firms can track shipments, predict delays, and reduce risks associated with inventory mismanagement and transportation inefficiencies (Pethe, Sahu, & Kodarlikar, 2024). This level of visibility is particularly critical in industries such as e-commerce, healthcare, and food supply chains, where product freshness, security, and timely delivery are paramount (Olufemi-Phillips et al., 2024).

In addition to basic tracking capabilities, AI-driven analytics and blockchain integration have further strengthened the reliability and efficiency of real-time monitoring systems (Mia & Noman, 2024). AI-powered predictive modeling enables proactive decision-making by identifying potential disruptions before they escalate, allowing companies to re-route shipments or adjust inventory allocations in response to changing conditions (Toromade et al., 2024). Blockchain, on the other hand, enhances data transparency and security, providing a tamper-proof ledger of all tracking records across multiple supply chain stakeholders (Sawicka, 2024). These advancements mitigate fraud, improve supplier accountability, and foster trust between businesses and consumers (Richard & Akram, 2024).

Despite these advancements, the implementation of real-time tracking faces several challenges, including high infrastructure costs, cybersecurity vulnerabilities, and resistance to digital transformation among traditional supply chain operators (Zahir, 2024). Many SMEs and companies in developing regions struggle with the cost burden of installing sophisticated tracking systems, limiting their ability to compete with larger, tech-enabled enterprises (Majumdar, 2024). Additionally, cybersecurity concerns remain a significant hurdle, as hacking risks and data breaches could expose sensitive shipment details and disrupt global supply chains (Fernando, 2024).

To address these challenges, firms should adopt scalable, cost-effective tracking solutions tailored to their specific operational needs (Siddiqi, Rasel, & Ahmed, 2025). Governments and industry regulators must also invest in digital infrastructure and cybersecurity frameworks to support wider adoption of real-time tracking technologies (Yogi, Gowda, & HanumanthaRao, 2024). Moving forward, 5G technology and edge computing are expected to enhance real-time tracking precision, further improving supply chain visibility and agility (Ramasamy & Natarajan, 2024).

ICT Integration

ICT integration has redefined supply chain operations by facilitating seamless data exchange, automation, and advanced analytics (Richard & Akram, 2024). The adoption of Enterprise Resource Planning (ERP) systems, cloud computing, and blockchain technology has enabled organizations to streamline logistics, procurement, and order fulfillment processes, resulting in cost savings and improved efficiency (Majumdar, 2024). ICT solutions provide a centralized digital infrastructure that eliminates manual errors, enhances decision-making speed, and ensures real-time information sharing between supply chain partners (Holloway, 2024).

A significant development in ICT integration is the increasing use of artificial intelligence (AI) and big data analytics to enhance supply chain forecasting and risk management (Pethe et al., 2024). AI-powered demand prediction models help organizations anticipate fluctuations in consumer demand, adjust inventory levels accordingly, and optimize production schedules (Siddiqi et al., 2025). Machine learning algorithms further analyze past purchasing patterns, logistics delays, and supplier performance metrics to suggest optimal supply chain strategies (Toromade et al., 2024). Moreover, cloud-based supply chain solutions allow businesses to access critical data remotely, fostering greater collaboration between suppliers, manufacturers, and distributors (Mia & Noman, 2024).

Despite its transformational impact, ICT integration presents several challenges, particularly in developing economies where limited digital infrastructure, high implementation costs, and cybersecurity threats hinder adoption (Zahir, 2024). Many businesses continue to struggle with legacy systems that lack interoperability with modern ICT platforms, delaying digital transformation (Yogi et al., 2024). Additionally, data security risks and regulatory compliance—such as adherence to General Data Protection Regulation (GDPR) policies—pose further complications for organizations attempting to scale ICT-driven supply chain models (Ramasamy & Natarajan, 2024).

To ensure smoother ICT adoption, organizations must invest in workforce digital training, enhance cybersecurity protocols, and leverage modular ICT solutions that allow gradual transition from traditional to digital supply chains (Majumdar, 2024). Governments should support businesses through tax incentives and subsidies for ICT investments, ensuring that companies of all sizes can benefit from digital supply chain innovations (Fernando, 2024).

Performance of Manufacturing Firms in Nairobi City County, Kenya

The performance of manufacturing firms is a critical measure of their efficiency, profitability, competitiveness, and overall operational effectiveness. It encompasses various dimensions, including production efficiency, financial stability, customer satisfaction, product quality, and market share (Olufemi-Phillips et al., 2024). Manufacturing performance is often assessed using key performance indicators (KPIs) such as inventory turnover, production lead time, order fulfillment rate, capacity utilization, and defect rate (Majumdar, 2024). These indicators help firms evaluate their operational efficiency, identify bottlenecks, and optimize their supply chain processes to improve overall productivity and profitability (Richard & Akram, 2024).

Technological advancements, particularly in Industry 4.0 and digital transformation, have significantly improved the performance of manufacturing firms by enhancing automation, data analytics, and process optimization (Siddiqi, Rasel, & Ahmed, 2025). The integration of smart manufacturing systems, IoT-based production tracking, AI-driven predictive maintenance, and real-time quality control systems has allowed firms to minimize operational waste, reduce production costs, and enhance product quality (Pethe, Sahu, & Kodarlikar, 2024). By leveraging digital tools, manufacturers can also enhance their agility, enabling them to respond swiftly to changing market demands and external disruptions such as supply chain shocks or economic downturns (Holloway, 2024).

However, the performance of manufacturing firms is influenced by various external and internal factors, including global supply chain dynamics, regulatory policies, workforce

productivity, and competitive pressures (Zahir, 2024). Disruptions caused by geopolitical conflicts, pandemics, and raw material shortages have highlighted the vulnerability of manufacturing operations to external shocks, emphasizing the importance of resilience and risk management strategies (Toromade et al., 2024). Additionally, internal challenges such as limited ICT adoption, outdated production techniques, and insufficient investment in research and development (R&D) can hinder the performance and long-term sustainability of manufacturing firms (Ramasamy & Natarajan, 2024).

To enhance performance, manufacturing firms must adopt lean manufacturing principles, invest in digital technologies, and strengthen supplier relationships to streamline their operations and minimize inefficiencies (Sawicka, 2024). Moreover, focusing on sustainable manufacturing practices, workforce upskilling, and continuous innovation enable firms to improve their competitiveness and achieve long-term growth (Fernando, 2024). By aligning their operational goals with broader industry trends and market demands, manufacturing firms can enhance their performance, reduce operational risks, and create value for all stakeholders (Yogi, Gowda, & HanumanthaRao, 2024).

Empirical Review

Real-Time Tracking

Pethe, Sahu, and Kodarlikar (2024) conducted a quantitative study analyzing the impact of IoT-based real-time tracking on manufacturing firms' logistics efficiency. Their research focused on large-scale manufacturing firms in India, where the integration of RFID, GPS, and IoT sensors played a critical role in improving supply chain visibility. The study revealed that firms implementing real-time tracking systems experienced a 30% reduction in shipment delays and a 25% improvement in overall supply chain coordination. The researchers attributed these improvements to the ability of real-time tracking to provide accurate and timely data on product location, transit conditions, and estimated delivery times. Additionally, the study highlighted that real-time tracking enabled proactive problem resolution, as logistics managers could identify disruptions in the supply chain and reroute shipments or adjust schedules in real time. The study concluded that firms integrating real-time tracking experienced greater operational efficiency, cost reductions, and increased customer satisfaction due to improved order fulfillment accuracy.

Agyeman, Boateng, and Oppong (2023) conducted an empirical study in Ghana on the adoption of real-time tracking solutions in the manufacturing sector. The study surveyed 120 manufacturing firms, focusing on the effectiveness of IoT and AI-powered logistics monitoring systems. The results showed that firms using real-time tracking reduced inventory discrepancies by 40%, improved supply chain coordination by 35%, and experienced a 20% decline in logistics-related losses. The study also emphasized that while real-time tracking has transformed supply chain visibility, some firms struggle with high technology adoption costs and cybersecurity vulnerabilities. Additionally, the lack of skilled personnel to manage real-time tracking systems was identified as a significant barrier to adoption in some firms. The researchers recommended that government and industry stakeholders provide training and subsidies to encourage greater adoption of tracking technologies in Ghana's manufacturing industry.

In Kenya, Mwangi and Mutua (2022) examined the impact of real-time tracking on supply chain efficiency in Nairobi-based manufacturing firms. The study surveyed 90 firms across various industries, including food processing, pharmaceuticals, and textiles. Findings revealed that companies that adopted GPS and RFID tracking technologies reduced product loss during transit by 28% and improved last-mile delivery efficiency by 32%. Additionally, the study found that firms using AI-based tracking systems enhanced their ability to predict and mitigate supply chain disruptions, leading to a 20% increase in customer satisfaction ratings. However, data privacy concerns and weak enforcement of supply chain regulations in Kenya were cited

as obstacles to full adoption. The study concluded that government incentives and stronger regulatory frameworks could enhance the adoption and effectiveness of real-time tracking solutions in Kenya's manufacturing sector.

ICT Integration

Siddiqi, Rasel, and Ahmed (2025) investigated the impact of ICT integration on supply chain efficiency in the manufacturing sector. Their study was conducted on 150 medium-to-large manufacturing firms across Europe, focusing on the implementation of cloud-based ERP systems, AI-driven automation, and blockchain technology. Their findings showed that firms that fully integrated ICT into their supply chain operations experienced a 25% increase in production efficiency, a 20% reduction in inventory holding costs, and a 30% improvement in demand forecasting accuracy. The study emphasized that cloud-based ERP systems played a pivotal role in automating procurement processes, minimizing manual errors, and facilitating seamless data exchange between different departments. Moreover, the adoption of AI-driven predictive maintenance reduced unplanned machine downtime by 15%, leading to increased production output and reduced operational losses.

Tshuma and Dube (2023) conducted a study on ICT integration in manufacturing firms in South Africa, focusing on the role of AI-driven supply chain automation and blockchain for transparency. Their study surveyed 200 firms, finding that companies implementing blockchain-enhanced ICT systems improved supplier accountability by 45% and reduced procurement fraud cases by 30%. Additionally, the study found that firms that fully digitized their operations reduced administrative costs by 22% and experienced a 35% improvement in inventory management. However, the research highlighted challenges, including poor ICT infrastructure in some industrial areas and the reluctance of older firms to transition to digital supply chain management systems. The study concluded that South African manufacturers must prioritize ICT investment to remain competitive in the global market.

In Kenya, Omondi and Wambua (2022) examined the role of ICT integration in the performance of medium-sized manufacturing firms. Their study focused on cloud computing, ERP systems, and AI-powered automation in the textile and food processing industries. Findings revealed that firms integrating ICT into their supply chains experienced a 30% increase in order processing efficiency, a 25% reduction in production downtime, and a 20% improvement in supplier collaboration. Additionally, firms leveraging AI-powered analytics for inventory management reduced stockouts by 18%. However, the study also found that small manufacturers faced challenges such as high implementation costs and skills shortages in ICT system management. The researchers recommended government-backed ICT training programs and financial incentives for manufacturing firms to accelerate ICT adoption in Kenya's industrial sector.

RESEARCH METHODOLOGY

This study adopted a descriptive research design, which, according to Mugenda and Mugenda (2019), is used to describe characteristics, behaviors, or phenomena without manipulating variables. Descriptive research is commonly applied in observational studies, where data is collected systematically and analyzed to establish patterns and relationships (Kumar, 2020). This study focused on manufacturing firms in Nairobi City County. According to KAM (2023) report, there are 119 manufacturing firms in Nairobi City County

This study therefore targeted 714 management employees working in the 119 manufacturing firms in Nairobi City County. According to Mugenda and Mugenda (2018), a sample is a smaller group of individuals selected from the population. The Yamane formula was adopted to calculate the study sample size. Therefore, the study sample size was 256 respondents. The study used simple random sampling in selecting the sample from study population. The advantage of random sampling is that it ensures that the sampling error is minimal which increases precision of techniques of estimation in use (Cooper & Schindler, 2019).

Table 1: Sample Size

Category	Target Population	Sample Size
Top Managers	119	43
Middle Managers	238	85
Lower-Level Managers	357	128
Total	**714**	**256**

This study utilized a questionnaire as the primary data collection instrument. According to Creswell and Creswell (2020), pilot testing helps refine questions, identify ambiguities, and improve instrument reliability before full-scale data collection. The pilot test involved 26 respondents (10% of the sample size), following recommendations by Mugenda and Mugenda (2018) that pilot tests should cover 5-10% of the total sample. SPSS version 28 was used to analyze the data that was collected from the field. In order to allow data to be entered into the software, the questionnaires were referenced, and the data coded. Quantitative data collected was analyzed using descriptive statistics techniques. Descriptive statistics such as frequency distribution, mean (measure of dispersion), standard deviation, and percentages was used. Inferential data analysis was conducted by use of Pearson correlation coefficient, and multiple regression analysis.

RESEARCH FINDINGS AND DISCUSSIONS

The study targeted a sample size of 256 respondents drawn from various management levels across manufacturing firms in Nairobi City County. Out of the 256 questionnaires distributed, 234 were correctly filled and returned, yielding a response rate of 91.4%. This high response rate is considered adequate for data analysis and generalization of the findings, as it surpasses the minimum recommended threshold of 70% for survey-based research (Mugenda & Mugenda, 2018).

Descriptive Analysis

This section presents the descriptive analysis of the study variables, offering insights into how respondents perceive the implementation and effects of supply chain visibility components within their firms. The variables under investigation include real-time tracking, ICT integration along with their overall influence on firm performance. Data were collected using a structured questionnaire where participants responded to a series of statements using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). To interpret the findings meaningfully, mean scores were computed for each item and categorized as follows: scores between 1.00 and 1.80 indicate strong disagreement; 1.81 to 2.60 suggest disagreement; 2.61 to 3.40 reflect neutrality; 3.41 to 4.20 indicate agreement; and 4.21 to 5.00 represent strong agreement. These mean scores provide a basis for understanding how widely adopted and effective each visibility factor is perceived to be in enhancing supply chain operations and overall firm performance. The analysis begins with an examination of responses related to real-time tracking.

Real-Time Tracking

This section sought to assess the extent to which real-time tracking technologies are used in the supply chain and their perceived impact on the performance of manufacturing firms in Nairobi City County. Real-time tracking, enabled through technologies such as GPS, RFID, and IoT sensors, plays a critical role in supply chain visibility by providing timely and accurate information about goods in transit. Respondents evaluated eight statements on a five-point Likert scale, where 1 = Strongly Disagree and 5 = Strongly Agree. The descriptive statistics (mean and standard deviation) are presented in Table 2.

Table 2: Descriptive Statistics for Real-Time Tracking

Statement	Mean	Std. Dev.
Our firm has adopted real-time tracking technologies in supply chain operations.	3.912	0.640
Real-time tracking improves supply chain efficiency and transparency.	4.546	0.683
GPS, RFID, and IoT help monitor goods in transit in real-time.	4.305	0.408
The use of real-time tracking has minimized supply chain disruptions.	4.159	0.788
Real-time tracking improves delivery accuracy and customer satisfaction.	3.672	0.733
Our firm actively utilizes tracking data for decision-making.	4.096	0.553
The cost of implementing real-time tracking is a challenge for our firm.	3.757	0.712
Limited technological infrastructure affects our ability to fully utilize real-time tracking.	3.828	0.695
Aggregate Score	**4.035**	**0.652**

The analysis reveals that respondents strongly believe real-time tracking contributes significantly to enhancing supply chain efficiency and transparency, with a mean score of 4.546 (0.683). This high level of agreement reflects widespread recognition that digital tracking technologies streamline operations, reduce ambiguity in supply chain processes, and support timely communication across departments and stakeholders. Closely following was the recognition of the effectiveness of GPS, RFID, and IoT technologies in monitoring goods in transit, which recorded a mean of 4.305 (0.408). The low standard deviation indicates a high level of consensus, suggesting that these tools are not only widely adopted but also consistently valued for providing live updates on shipment status, location, and condition. This consistent tracking capability enhances supply chain visibility and responsiveness.

Respondents also agreed that the application of real-time tracking has helped minimize supply chain disruptions, as evidenced by a mean score of 4.159 (0.788). This finding points to the role of visibility technologies in enabling firms to anticipate and address interruptions proactively, thus reducing delays and operational bottlenecks. Though agreement levels varied slightly, the overall trend suggests that tracking systems are seen as enablers of supply chain resilience. The utilization of tracking data in managerial and operational decision-making also received favorable responses, with a mean of 4.096 (0.553). This indicates that many firms are not merely collecting data through tracking systems, but are actively integrating this information into their planning and execution frameworks. Such data-driven decision-making practices are instrumental in optimizing resource allocation, scheduling, and customer service.

A general agreement was also observed on the adoption of real-time tracking technologies within firms, reflected in a mean score of 3.912 (0.640). This suggests that while many firms have implemented these systems, there may still be inconsistencies in the level or scope of adoption. Some organizations may be in the early stages of adoption or using partial solutions. Respondents acknowledged that limited technological infrastructure affects their ability to fully exploit real-time tracking capabilities, with a mean score of 3.828 (0.695). This suggests that challenges such as poor internet connectivity, outdated hardware, or lack of system integration limit the effectiveness of tracking tools, particularly in less digitized operational environments.

Cost emerged as another barrier to adoption, with a mean of 3.757 (0.712). Respondents moderately agreed that implementing and maintaining real-time tracking technologies can be financially demanding, especially for small and medium-sized enterprises. The cost factor may influence the depth and pace of adoption across firms. The lowest mean score among the eight items was recorded for the impact of tracking on delivery accuracy and customer satisfaction, which stood at 3.672 (0.733). While this score still reflects agreement, it may indicate that the

benefits of tracking on customer-facing outcomes are not as consistently realized or that firms are still working to align internal efficiencies with external service delivery standards.

The aggregate mean score of 4.035 (SD= 0.652) places the respondents' perception within the "Agree" range, indicating that real-time tracking is generally recognized as a beneficial tool in supply chain management across manufacturing firms in Nairobi. These results are consistent with the findings of Pethe, Sahu, and Kodarlikar (2024), who reported that the implementation of IoT-based tracking technologies in Indian manufacturing firms led to a 30% reduction in shipment delays and enhanced supply chain coordination. Similarly, this study's high rating for efficiency and disruption mitigation mirrors the outcomes of Mwangi and Mutua (2022), who found that Nairobi-based firms utilizing GPS and RFID experienced a 28% reduction in product loss and a 32% improvement in last-mile delivery. These parallels suggest that despite regional and technological differences, real-time tracking yields measurable operational benefits across diverse contexts. However, the moderate agreement on infrastructure and cost challenges also resonates with Agyeman, Boateng, and Oppong (2023), who highlighted that while real-time tracking boosts supply chain visibility in Ghana, its adoption is hampered by high technology costs and cybersecurity concerns. The implication for Kenyan firms is clear: while adoption is growing, addressing financial and infrastructural barriers is crucial for maximizing the full potential of tracking systems.

ICT Integration

This section evaluates the extent to which ICT integration enhances supply chain management within manufacturing firms. Information and Communication Technologies (ICT) such as cloud computing, enterprise resource planning (ERP) systems, and digital platforms play an essential role in streamlining operations, enhancing collaboration, and increasing supply chain transparency. Respondents assessed eight statements concerning ICT integration using a five-point Likert scale, where 1 = Strongly Disagree and 5 = Strongly Agree. The results, based on descriptive statistics, are summarized in Table 2.

Table 3: Descriptive Statistics for ICT Integration

Statement	Mean	Std. Dev.
Our supply chain operations are increasingly reliant on digital platforms.	4.173	0.637
Cloud computing has enhanced supply chain efficiency.	4.077	0.714
ERP systems improve procurement and inventory management.	3.975	0.480
Cybersecurity concerns hinder full adoption of ICT in supply chain operations.	3.903	0.468
Our firm has integrated ICT systems in supply chain management.	3.835	0.582
ICT solutions enhance supplier collaboration and data-sharing.	3.821	0.643
ICT adoption has reduced paperwork and increased operational efficiency.	3.820	0.606
Lack of digital skills among employees limits ICT adoption in our firm.	3.653	0.419
Aggregate Score	**3.907**	**0.569**

The highest-rated statement was that supply chain operations are increasingly reliant on digital platforms, with a mean score of 4.173 (0.637). This indicates strong agreement that firms are embracing digitalization in their supply chain processes, particularly in areas like data sharing, tracking, and inventory systems. This widespread reliance on digital platforms underscores the shift toward technologically enabled supply chains. Following closely, the statement that cloud computing has enhanced supply chain efficiency recorded a mean of 4.077 (0.714). This shows that firms view cloud-based systems as essential tools for streamlining operations, facilitating real-time access to data, and improving overall responsiveness.

The role of ERP systems in improving procurement and inventory management was also rated highly, with a mean of 3.975 (0.480). This suggests that ERP systems are effectively used to optimize key supply chain functions by reducing manual work, increasing integration, and improving real-time data availability. Respondents also acknowledged cybersecurity as a notable concern in ICT adoption, with a mean score of 3.903 (0.468). This suggests that even as firms integrate more digital tools, they remain cautious about vulnerabilities and risks associated with data breaches, system attacks, and loss of sensitive information. The integration of ICT systems into supply chain management was supported with a mean score of 3.835 (0.582), indicating that most firms have taken meaningful steps in digitizing supply chain functions, even though full integration may still be in progress.

Enhancing supplier collaboration through ICT received a mean of 3.821 (0.643), reflecting agreement that digital tools facilitate communication, coordination, and trust with supply chain partners. Similarly, the reduction of paperwork and increase in operational efficiency from ICT use was acknowledged with a mean of 3.820 (0.606). The lowest-rated item was the statement concerning digital skill shortages among employees, which had a mean of 3.653 (0.419). Although still within the "agree" range, it indicates that skill gaps are a limiting factor in ICT adoption, especially in firms transitioning from manual to digital systems.

The aggregate mean score of 3.907 (SD = 0.569) places respondents' perceptions firmly in the "Agree" range, indicating that ICT integration is widely acknowledged as a value-adding factor in supply chain operations. These findings resonate strongly with Siddiqi, Rasel, and Ahmed (2025), who found that cloud-based ERP systems and AI automation improved production efficiency by 25% and reduced inventory costs by 20% in European manufacturing firms. The results also reflect findings from Omondi and Wambua (2022), who reported that ICT adoption in Kenya led to a 30% increase in order processing efficiency and a 25% reduction in production downtime. However, concerns raised about cybersecurity and digital skill shortages mirror observations by Tshuma and Dube (2023), who emphasized that inadequate ICT infrastructure and workforce preparedness hinder full adoption in some South African firms. The implication for Kenyan manufacturing firms is that while ICT tools are widely adopted and beneficial, addressing cybersecurity and human capital challenges is critical for maximizing their impact on supply chain visibility and performance.

Performance of Manufacturing firms in Nairobi City County, Kenya

This section assesses how supply chain visibility influences firm performance among manufacturing companies in Nairobi City County. The items in this section reflect key performance outcomes such as operational efficiency, profitability, competitive advantage, supplier relationship management, and informed decision-making. Respondents rated five statements on a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The descriptive statistics are summarized in Table 4.

Table 4: Descriptive Statistics for Firm Performance

Statement	Mean	Std. Dev.
Improved visibility has led to better decision-making and planning.	4.382	0.402
Our firm's profitability has increased due to enhanced supply chain visibility.	4.097	0.709
Supply chain visibility has improved our firm's operational efficiency.	3.809	0.795
Supply chain transparency has strengthened supplier relationships.	3.655	0.479
Digital transformation in supply chain visibility gives our firm a competitive edge.	3.582	0.726
Aggregate Score	**3.905**	**0.622**

Respondents expressed the highest level of agreement with the statement that improved visibility has led to better decision-making and planning, with a mean score of 4.382 (0.402). This underscores the belief that real-time access to supply chain data enables firms to respond more effectively to emerging challenges, adjust production schedules, and optimize resource allocation. The second-highest rated item was the increase in profitability due to enhanced visibility, which had a mean score of 4.097 (0.709). This reflects a strong perception that greater transparency across the supply chain contributes to cost reductions, efficiency gains, and ultimately improved bottom-line results.

Operational efficiency was also acknowledged as a key benefit, with a mean of 3.809 (0.795). While this is still within the agreement range, the relatively higher standard deviation suggests some variability in how different firms experience efficiency improvements through visibility initiatives. Strengthened supplier relationships through supply chain transparency received a mean of 3.655 (0.479). This suggests a moderately positive view of visibility's role in enhancing collaboration, trust, and coordination with suppliers, though it may not be as strongly emphasized as internal benefits. The lowest-rated item was the idea that digital transformation in supply chain visibility gives the firm a competitive edge, which scored 3.582 (0.726). Although still positive, this may imply that some firms are yet to realize or measure the external strategic benefits of digital supply chain visibility, especially in competitive positioning and market responsiveness.

With an aggregate mean score of 3.905 (SD = 0.622), the findings indicate that respondents agree that supply chain visibility contributes positively to firm performance. Notably, the highest rated aspects are improved decision-making and profitability, highlighting the value of actionable, timely information in achieving both strategic and operational goals. These findings align with those of Majumdar (2024), who found that predictive analytics tools enhanced resource planning and reduced production downtime across Asian and European firms. The slightly lower scores for competitive advantage and supplier relationship improvement suggest that while internal efficiencies are being realized, some external or strategic benefits may require more time, investment, or integration to fully materialize. For Kenyan manufacturing firms, the implication is that greater emphasis should be placed on leveraging visibility not just for internal optimization but also for long-term competitive differentiation and collaborative supply chain advancement.

Correlation Analysis

This section presents the results of a Pearson correlation analysis conducted to examine the strength and direction of the relationship between the four independent variables—real-time tracking, ICT integration—and the dependent variable, firm performance. Pearson's correlation coefficient (r) measures the degree of linear association between variables, ranging from -1 to +1, where: 0.00–0.30 = Weak correlation, 0.31–0.60 = Moderate correlation, 0.61–0.80 = Strong correlation, and 0.81–1.00 = Very strong correlation. According to Kothari (2016), correlation analysis is useful for establishing whether changes in predictor variables are associated with variations in outcome variables. A significance level (p-value) of less than 0.05 indicates that the observed relationship is statistically significant. The findings are presented in Table 5.

Table 5: Correlation Analysis

		Firm Performance	Real-Time Tracking	ICT Integration
Performance of Manufacturing firms	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	234		
Real-Time Tracking	Pearson Correlation	.631*	1	
	Sig. (2-tailed)	.048		
	N	234	234	
ICT Integration	Pearson Correlation	.756*	.024	1
	Sig. (2-tailed)	.030	.811	
	N	234	234	234

The correlation between real-time tracking and firm performance was found to be strong and positive with a coefficient of r = 0.631 (p = 0.048). This indicates that firms that utilize real-time tracking technologies tend to experience better performance outcomes, such as improved operational efficiency and customer satisfaction. This finding supports the work of Pethe, Sahu, and Kodarlikar (2024), who reported that real-time tracking led to a 30% reduction in shipment delays and a 25% improvement in supply chain coordination. It also aligns with Mwangi and Mutua (2022), who noted increased delivery efficiency and customer satisfaction from GPS and RFID adoption in Kenyan firms.

The highest correlation observed was between ICT integration and firm performance, with a coefficient of r = 0.756 (p = 0.030), indicating a strong and statistically significant relationship. This suggests that the integration of digital tools such as ERP systems, cloud computing, and AI platforms substantially contributes to improved profitability, efficiency, and decision-making. These results are consistent with Siddiqi, Rasel, and Ahmed (2025), who found that ICT-enabled firms reported significant improvements in production efficiency and forecasting accuracy. Similarly, Omondi and Wambua (2022) found that ICT adoption in Kenyan manufacturing firms led to substantial gains in order processing and supplier collaboration.

Multiple Regression Analysis

This section presents the results of the multiple regression analysis used to evaluate the combined effect of the four supply chain visibility dimensions—real-time tracking, ICT integration—on firm performance among manufacturing firms in Nairobi City County. The analysis employed the Ordinary Least Squares (OLS) method and is structured into three key parts: the model summary, analysis of variance (ANOVA), and regression coefficients with interpretation. Table 6 presents the unstandardized regression coefficients that show the individual contribution of each predictor variable to firm performance.

Table 6: Coefficients of Study Variables

Variable	Unstandardized Coefficient (B)	Std. Error	t-value	Sig. (p-value)
Constant	0.154	0.329	0.47	0.640
Real-Time Tracking	0.313	0.043	7.34	0.000
ICT Integration	0.308	0.042	7.30	0.000

Real-Time Tracking (B = 0.313, p < 0.001) emerged as a strong predictor of firm performance. This indicates that firms employing RFID, GPS, and IoT tracking systems are more likely to achieve superior coordination, fewer shipment delays, and greater customer satisfaction. This result supports studies by Pethe et al. (2024) and Mwangi and Mutua (2022), who highlighted substantial logistics improvements from real-time visibility tools.

ICT Integration (B = 0.308, p < 0.001) had the second highest impact among the predictors. A one-unit increase in ICT integration leads to a 0.308-unit increase in firm performance, holding

other variables constant. This emphasizes the role of ERP systems, cloud computing, and automation in boosting efficiency and interdepartmental coordination. These findings echo those of Siddiqi et al. (2025) and Omondi and Wambua (2022), who reported significant operational benefits from ICT tools.

Based on the coefficients, the final fitted multiple linear regression model predicting firm performance is expressed as:

$$\textit{Firm Performance} = 0.154 + 0.313(\textit{Real-Time Tracking}) + 0.308(\textit{ICT Integration}) + \varepsilon$$

Conclusions

Real-Time Tracking

The study concludes that real-time tracking technologies significantly enhance operational effectiveness within the manufacturing sector. The widespread use of GPS, RFID, and IoT systems allows firms to monitor goods in transit, identify disruptions early, and make informed routing and delivery decisions. These capabilities improve responsiveness, minimize losses during transit, and contribute to timely deliveries. Real-time tracking also supports data-driven decision-making by providing continuous, reliable visibility across the supply chain. Despite some challenges related to technological infrastructure and cost, the adoption of tracking systems is seen as a major contributor to supply chain transparency, resilience, and customer satisfaction.

ICT Integration

The research confirms that ICT integration is a pivotal driver of supply chain performance. Digital systems such as ERP, cloud computing, and AI-powered platforms are central to streamlining procurement, production, and inventory processes. ICT tools promote cross-functional collaboration, improve information accuracy, and facilitate real-time communication with suppliers and partners. Firms that have successfully implemented ICT solutions report enhanced productivity, reduced operational costs, and improved coordination across the supply chain. However, the full potential of ICT remains partially constrained by cybersecurity concerns and skill gaps among employees, suggesting that continued investment in infrastructure and training is essential for sustainable digital transformation.

Recommendations

Real-Time Tracking

Manufacturing firms are encouraged to intensify the adoption and effective use of real-time tracking systems. The study established that tools such as RFID, GPS, and IoT sensors significantly improve supply chain transparency, reduce transit-related losses, and facilitate timely delivery of goods. To maximize these benefits, firms should prioritize the integration of tracking tools across transportation, inventory, and logistics operations. Real-time tracking systems should be embedded into ERP and warehouse management systems to allow continuous flow of accurate location data, improving visibility from supplier to customer.

To address the cost barrier identified in the study, it is recommended that public-private partnerships be formed to offer financial support or subsidies, especially targeting small and medium-sized enterprises (SMEs) that lack capital to acquire advanced tracking technologies. Additionally, manufacturing firms should work closely with local ICT providers to customize affordable tracking solutions that are scalable to their operational needs. It is also essential for firms to invest in training their logistics and operations staff to interpret tracking data effectively and translate it into actionable insights that can drive efficiency, accuracy, and customer satisfaction.

ICT Integration

The study revealed that ICT integration has the strongest influence on firm performance among all supply chain visibility components. Therefore, manufacturing firms should accelerate the full adoption of integrated ICT systems such as ERP platforms, cloud computing, and AI-driven supply chain automation. These systems should span procurement, inventory, production, and distribution functions to eliminate information silos and ensure seamless coordination across departments. A shift from manual or partially digitized operations to fully automated systems will lead to improved efficiency, faster communication, and greater adaptability to disruptions.

To ensure the successful implementation and sustainability of ICT systems, firms must invest in upskilling their workforce. Digital literacy programs, continuous training workshops, and system-specific certifications should be provided to employees across all levels of management. At the same time, firms must proactively manage cybersecurity risks, which were cited as a hindrance to ICT adoption. This includes implementing secure access controls, conducting regular data protection audits, and aligning all ICT systems with Kenya's Data Protection Act. A well-integrated, secure, and digitally competent supply chain will offer firms significant competitive advantages in a rapidly evolving manufacturing environment.

Areas for further Research

While this study provided critical insights into the influence of supply chain visibility on the performance of manufacturing firms in Nairobi City County, several areas warrant further investigation to build on these findings. Future researchers could conduct longitudinal studies to examine how the adoption of visibility tools affects firm performance over time, offering a dynamic understanding of cause-effect relationships. Additionally, comparative studies across counties or sectors—such as agriculture, retail, or construction could reveal contextual differences in the adoption and effectiveness of supply chain visibility practices. A qualitative study exploring organizational culture, leadership attitudes, or resistance to digital transformation may also provide a deeper understanding of the behavioral and structural factors influencing technology adoption. Moreover, further research could explore the moderating role of firm size, digital maturity, or government policy in the relationship between visibility and performance. Finally, an in-depth examination of how emerging technologies like blockchain or digital twins intersect with supply chain visibility in the African context could open new frontiers for innovation and policy development.

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