Int Journal of Social Sciences Management and Entrepreneurship 9(3): 115-132 2025

ISSN 2411-7323

www.sagepublishers.com

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

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ABSTRACT

Manufacturing firms in Kenya face increasing exposure to supply chain disruptions driven by global shocks such as the COVID-19 pandemic, infrastructural limitations, market volatility, and policy inconsistencies. These challenges have adversely impacted operational continuity, delivery efficiency, and overall firm performance. Despite growing global interest in supply chain resilience strategies, there remains limited empirical evidence on how specific resilience capabilities influence performance outcomes within Kenya's manufacturing sector. This study sought to fill this gap by examining the effect of supply chain resilience capabilities operational flexibility and supply chain re-engineering on the performance of manufacturing firms in Nairobi City County, Kenya. The study was grounded in a multi-theoretical framework, drawing from Dynamic Capabilities Theory and Systems Theory. A pilot study involving 14 participants was first conducted to validate the research instrument. The main study adopted a descriptive cross-sectional design. Data were collected through structured, closed-ended questionnaires administered to supply chain managers from 138 manufacturing firms registered with the Kenya Association of Manufacturers (KAM), selected from a population of 210 using the Krejcie and Morgan sampling formula. Analysis was conducted using SPSS version 28, involving both descriptive and multiple regression techniques. Results showed that all four resilience capabilities had a statistically significant and positive effect on firm performance. Specifically, a unit increase in supply chain re-engineering led to a 0.306 unit increase in performance, followed by operational flexibility (B = 0.271). The study concludes that building supply chain resilience through continuous process redesign, agile operations, proactive risk management, and strategic supplier engagement is essential for enhancing firm performance. It recommends targeted investments in digital transformation, supplier diversification, employee training, and internal operational agility to foster adaptive and competitive supply chains. This study contributes both academically and practically by offering context-specific insights into how resilience-building strategies influence manufacturing performance in emerging economies. It provides actionable guidance for supply chain managers, policymakers, and institutions such as KAM, while supporting regional integration efforts like the African Continental Free Trade Area (AfCFTA). The findings are also valuable to scholars and practitioners seeking to enhance organizational agility, responsiveness, and competitiveness in the post-pandemic era.

Key Words: Supply Chain Resilience Capabilities, Operational Flexibility, Supply Chain Re-Engineering, Performance of Manufacturing Firms

Background of the Study

In the rapidly evolving global economy, manufacturing firms operate within increasingly complex and dynamic supply chain environments. Globalization, digital disruption, geopolitical conflicts, pandemics, and climate-induced disasters have heightened the frequency and impact of supply chain disruptions, exposing the vulnerability of traditional supply chain models (Dubey et al., 2021). As a result, manufacturers are under growing pressure to build responsive and resilient supply chains that not only sustain operational continuity but also drive firm performance and competitiveness.

Supply chains today are no longer linear; they are interdependent networks requiring agility, adaptability, and strategic alignment. Manufacturing firms, particularly in developing economies, face unique challenges such as inadequate infrastructure, regulatory instability, limited access to capital, and inconsistent energy supply (Odhiambo & Muathe, 2023). These challenges necessitate a shift from reactive to proactive supply chain management strategies that are grounded in flexibility, risk intelligence, collaboration, and process innovation.

One such strategic imperative is operational flexibility, which reflects a firm's ability to adjust its production processes, resource allocation, and delivery systems in response to internal and external variations. Firms that exhibit high flexibility are better able to manage demand fluctuations and reduce the impact of disruptions (Shi et al., 2025). Equally important is supply chain re-engineering, which involves the radical redesign of supply chain processes using digital technologies, lean principles, and customer-centric models. This approach allows firms to rebuild their operations for increased agility, transparency, and sustainability (Bala et al., 2023).

Firm performance, is increasingly viewed as a multidimensional construct. It extends beyond financial profitability to include operational efficiency, customer satisfaction, responsiveness, and innovation (Gong et al., 2023). In this regard, the interplay between supply chain capabilities and firm performance is a strategic concern for managers and policymakers alike.

In Kenya, the manufacturing sector is a key driver of economic development and industrialization under the government's "Big Four Agenda." However, the sector remains vulnerable to systemic shocks due to over-reliance on imported inputs, fragmented local supplier networks, and low adoption of digital technologies (Mwangi & Odhiambo, 2022). Against this backdrop, it is imperative to investigate how specific supply chain capabilities, namely operational flexibility and re-engineering, affect the performance of manufacturing firms operating in Nairobi City County and similar environments. This study therefore sought to contribute to the growing body of knowledge by empirically examining the relationship between dynamic supply chain capabilities and firm performance, providing context-specific insights that can inform managerial practices and policy interventions in emerging economies.

Statement of the Problem

The manufacturing sector in Kenya is a cornerstone of national economic growth, contributing approximately 7.6% to the country's GDP as of 2023, with Nairobi City County serving as the hub of industrial activity (Kenya National Bureau of Statistics [KNBS], 2023). Despite this strategic significance, the sector continues to operate below its potential, largely due to persistent and measurable supply chain-related inefficiencies. Specifically, manufacturing firms in Nairobi experience an average of 4.3 weeks of production downtime per year due to input delays, unreliable suppliers, traffic congestion, and power outages (Kenya Association of Manufacturers [KAM], 2023). These disruptions directly affect production lead times, customer satisfaction, and revenue stability, thereby undermining overall firm performance.

The COVID-19 pandemic exacerbated these weaknesses. According to a KEPSA (2021) survey, 65% of Nairobi-based manufacturers reported severe supply chain disruptions, 48%

experienced revenue declines exceeding 25%, and over 30% were forced to reduce output by half during the height of the crisis. This exposure revealed major disparities in firm resilience. While some large manufacturers managed to maintain continuity by rapidly adopting digital logistics systems or engaging secondary suppliers, the majority of SMEs lacked such adaptive capabilities, resulting in prolonged recovery and reduced competitiveness.

Although global and regional studies suggest that resilience mechanisms, such as operational flexibility, and supply chain re-engineering, can mitigate such shocks and enhance firm performance (Dubey et al., 2021; Odhiambo & Muathe, 2023), few empirical studies have validated these relationships in the Kenyan context. More critically, no existing study has quantitatively examined how each specific resilience capability influences distinct performance outcomes (e.g., delivery reliability, cost efficiency, customer satisfaction) among Nairobi-based manufacturers.

This knowledge gap is concerning given that Nairobi's manufacturing ecosystem is central to Kenya's Vision 2030 industrialization agenda and the African Continental Free Trade Area (AfCFTA) framework. Without robust, data-driven insights into the operational levers that enhance resilience, policy reforms and firm-level investments may fail to address the root causes of underperformance. Therefore, this study sought to fill a critical empirical void by examining the specific effects of supply chain resilience strategies on performance outcomes among manufacturing firms in Nairobi City County. The findings provided actionable insights to policymakers, manufacturing executives, and industry associations aiming to build more agile, competitive, and disruption-ready industrial systems.

Objectives of the Study

General Objective

To examine the effect of supply chain resilience and performance of manufacturing firms in Nairobi City County, Kenya

Specific Objectives

The study was guided by the following specific objectives;

i) To assess effect of operational flexibility on the performance of manufacturing firms in Nairobi City County, Kenya

ii) To find out effect of supply chain re-engineering on the performance of manufacturing firms in Nairobi City County, Kenya.

LITERATURE REVIEW

Theoretical Review

Dynamic Capabilities View

The Dynamic Capabilities View (DCV) was introduced by Teece, Pisano, and Shuen in 1997 as an evolution of the Resource-Based View (RBV), which emphasized the role of internal firm resources, those that are valuable, rare, inimitable, and non-substitutable, in achieving sustained competitive advantage. While RBV was instrumental in shaping strategic management thought, it was criticized for being static and failing to address how firms adapt to rapidly changing environments. DCV emerged to fill this gap by focusing on a firm's ability to build, integrate, and reconfigure internal and external resources in response to shifting market and technological conditions (Teece et al., 1997).

Over the years, DCV has been refined and extended to encompass a broader range of capabilities, including sensing opportunities and threats, seizing them through investment and resource mobilization, and transforming the firm's resource base to ensure long-term success (Teece, 2007). Scholars such as Eisenhardt and Martin (2000) further contributed by arguing that dynamic capabilities are especially critical in high-velocity environments where routine capabilities may no longer be effective. Unlike ordinary operational capabilities, dynamic capabilities are strategic in nature and support organizational agility, innovation, and resilience.

In the context of supply chain management, DCV has gained substantial traction as a framework for understanding how firms navigate disruption, uncertainty, and complexity. Recent applications of the theory emphasize its role in supply chain resilience, particularly through the development of flexible, adaptive, and reconfigurable systems (Singh et al., 2021). It supports the idea that firms must continuously evolve, not only by modifying their operations but by rethinking their strategies and partner interactions to ensure responsiveness to both risks and opportunities. Scholars like Dubey et al. (2021) argue that DCV underpins capabilities such as demand sensing, supply chain agility, and innovation, all of which contribute to superior firm performance during disruptions.

Critics of DCV have noted challenges in measuring dynamic capabilities and differentiating them from operational capabilities. Some also argue that the framework is overly abstract and difficult to operationalize across industries. However, these critiques have led to refinements in methodology and applications, with scholars emphasizing the role of processes, learning, and managerial cognition in building dynamic capabilities (Peteraf, Di Stefano, & Verona, 2013). Additionally, recent empirical studies have increasingly grounded DCV in sector-specific contexts such as manufacturing, where external volatility demands strategic responsiveness.

In this study, operational flexibility is anchored in the Dynamic Capabilities View. Operational flexibility refers to a firm's ability to swiftly adjust production levels, resource allocation, delivery systems, and sourcing channels in response to both anticipated and unexpected disruptions. These adaptive behaviors are emblematic of dynamic capabilities because they involve reconfiguring routines and assets to maintain continuity and efficiency under changing conditions. In manufacturing firms within Nairobi City County, where infrastructural constraints, supply shocks, and market volatility are prevalent, operational flexibility represents a core dynamic capability that enhances resilience and improves firm performance. DCV thus provides a robust theoretical lens to explain how firms can build and leverage operational flexibility as a source of sustained competitive advantage in uncertain environments.

Systems Theory

Systems Theory, originally introduced by biologist Ludwig von Bertalanffy in the 1940s, has since evolved into a foundational framework across disciplines including engineering, organizational studies, and management. At its core, the theory posits that an entity, whether biological, mechanical, or organizational, is best understood as a system composed of interrelated and interdependent components working together to achieve a common goal (Bertalanffy, 1968). The key principle is that a change in one part of the system affects the others, making it essential to manage interactions and feedback loops holistically.

In the field of organizational management, Systems Theory was popularized by scholars like Katz and Kahn (1978), who applied it to understand how organizations interact with their environments. From this perspective, organizations are seen as open systems that must constantly adapt to changes in their external environment while maintaining internal equilibrium. This theoretical lens provides a valuable foundation for studying complex,

adaptive processes such as supply chain management, where multiple actors, technologies, and flows must work synchronously for efficient operation.

In supply chain literature, Systems Theory has been widely adopted to guide the design, integration, and transformation of end-to-end supply networks. Modern supply chains are not isolated units but dynamic systems involving interconnected processes such as sourcing, production, distribution, and customer service. A re-engineering effort within such systems, whether it's changing supplier configurations, adopting new technologies, or restructuring logistics networks, can have systemic ripple effects throughout the chain. Scholars like Christopher and Peck (2004) and Ivanov and Dolgui (2020) argue that effective supply chain resilience depends on systems-level thinking that integrates responsiveness, visibility, and adaptability across all nodes.

While Systems Theory has been critiqued for its abstract nature and lack of precise predictive models (Skyttner, 2006), its strength lies in encouraging a holistic view of change and interdependence. This is particularly useful in managing supply chain disruptions, which often originate in one area (e.g., sourcing) but cascade through others (e.g., production or distribution). Therefore, re-engineering efforts must account for these systemic interdependencies to avoid unintended consequences.

In this study, Supply Chain Re-engineering is grounded in Systems Theory. This variable refers to the strategic redesign of supply chain structures and processes to achieve improved resilience, efficiency, and responsiveness. For manufacturing firms in Nairobi City County, where disruptions often span energy, transport, and supplier reliability, a systems-based approach is crucial. By understanding how various supply chain components interact, firms can re-engineer operations, such as decentralizing warehouses, digitizing procurement, or altering supplier networks, without destabilizing other parts of the value chain. Systems Theory thus provides the conceptual basis for viewing re-engineering not as isolated change, but as a coordinated transformation of interconnected processes to enhance resilience.

Conceptual Framework

A conceptual framework refers to a structured representation of the key variables in a study and the presumed relationships among them, guided by theory and empirical evidence. It provides the analytical foundation upon which the research is built, helping to explain how and why specific independent variables influence the dependent variable (Adom, Hussein, & Agyem, 2018). In this study, the conceptual framework illustrates operational flexibility, and supply chain re-engineering, are hypothesized to influence the performance of manufacturing firms.

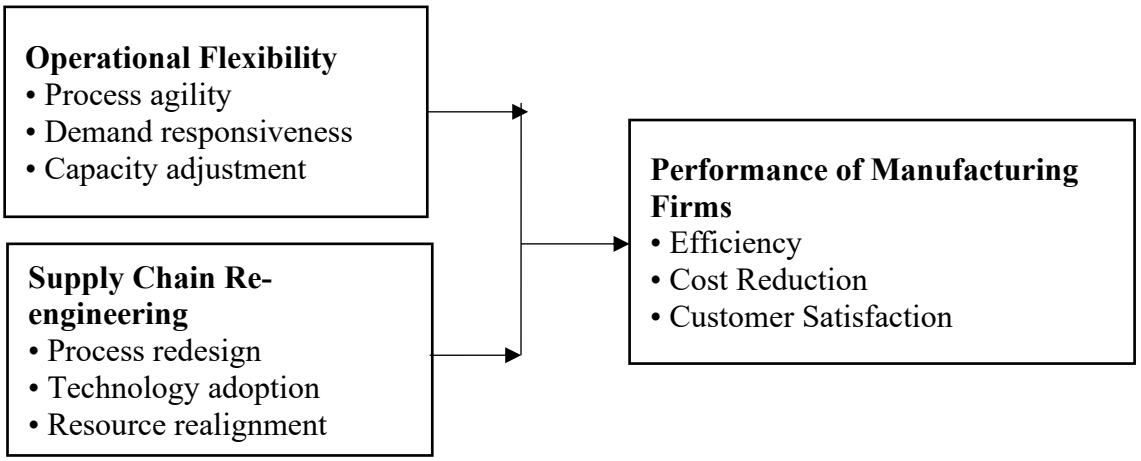

Figure 2. 1: Conceptual Framework

Operational Flexibility

Operational flexibility refers to a firm's capacity to adjust its processes, capacities, and supply chain activities in response to internal and external disruptions, while maintaining performance and service levels. It includes the ability to alter production volumes, switch product types, change delivery schedules, and modify sourcing strategies with minimal disruption and cost (Shi et al., 2025). In the supply chain context, operational flexibility is a foundational element for achieving resilience, especially in volatile environments.

In recent years, operational flexibility has gained significant attention due to its ability to help firms adapt quickly to unprecedented events such as the COVID-19 pandemic, political instability, and supply shortages. According to Thilagham et al. (2025), operational flexibility is enhanced by the adoption of Industry 4.0 technologies, such as cloud computing and the Internet of Things, which allow for real-time process visibility, decentralized decision-making, and rapid response capabilities. These technologies enable firms to monitor disruptions and implement swift changes across the supply chain.

Moreover, Aich, Sengupta, and Pasam (2025) argue that operational flexibility plays a strategic role in digital supply chain ecosystems by enabling dynamic resource allocation and scenario-based forecasting. Firms with high operational flexibility are better positioned to handle demand variability, production bottlenecks, and supplier constraints. This allows them to maintain operational continuity, improve delivery reliability, and reduce costs during disruptions.

In developing countries like Kenya, where infrastructural challenges and supply chain uncertainties are prevalent, operational flexibility is particularly crucial. Njagi (2025) emphasizes that firms in Nairobi's manufacturing sector that exhibit high levels of flexibility, such as being able to reroute logistics or switch energy sources, are more resilient and perform better during periods of disruption.

Operational flexibility is not only reactive but also proactive in nature. Firms use it to seize market opportunities, introduce new product lines quickly, or shift between customer segments in response to evolving preferences (Maqueira & Minguela-Rata, 2025). This adaptability fosters innovation, responsiveness, and long-term competitiveness. In essence, operational flexibility is a critical enabler of supply chain resilience and organizational performance. It allows manufacturing firms to absorb shocks, maintain core operations, and recover rapidly from disruptions. For firms in Nairobi and other similar regions, embedding flexibility into operational strategy is imperative to thrive in uncertain and dynamic markets.

Supply Chain Re-engineering

Supply chain re-engineering refers to the fundamental rethinking and radical redesign of supply chain processes to achieve dramatic improvements in critical performance measures such as cost, quality, speed, and service (Kumar & Luthra, 2021). Unlike incremental improvements, re-engineering is transformational in nature. It typically involves process innovation, integration of digital technologies, restructuring of sourcing and logistics, and adoption of leaner or more responsive frameworks.

The emergence of Industry 4.0, as well as the lessons learned from global supply chain shocks like COVID-19, has placed re-engineering at the forefront of supply chain strategy. According to Rane and Narvel (2022), firms that engage in proactive supply chain re-engineering, such as reshoring, digital twin modeling, or multi-modal logistics redesign, tend to show significantly improved resilience and adaptability. This has led to a paradigm shift where resilience and agility are prioritized alongside efficiency.

Re-engineering also allows for the integration of advanced technologies such as automation, blockchain, and real-time data analytics, which help break down traditional silos within supply

chains. This digital transformation enables synchronized decision-making and reduces lead times across manufacturing and distribution networks. As observed by Bala et al. (2023), supply chain re-engineering supported by digital infrastructure has helped firms create flexible fulfillment models and dynamic inventory systems that can respond to demand volatility.

In developing countries, where manufacturing firms often operate within infrastructural constraints and face demand variability, supply chain re-engineering offers a strategic pathway for performance enhancement. In Kenya, for example, re-engineering practices such as local sourcing redesign, last-mile delivery optimization, and digitization of procurement systems have proven effective in overcoming market fragmentation and reducing operational costs (Mwangi & Odhiambo, 2022).

Moreover, re-engineering encourages firms to adopt a systems-thinking approach. This involves looking beyond internal operations and considering the entire supply chain ecosystem, from suppliers to end customers. Through this approach, firms are better positioned to align strategy with execution, minimize waste, and increase responsiveness to market changes.

In summary, supply chain re-engineering empowers firms to rebuild their operational models for long-term competitiveness. It enables manufacturing firms to shift from reactive management to proactive innovation, leading to improved efficiency, customer satisfaction, and supply chain sustainability.

Firm Performance

Firm performance refers to the measurement of how effectively an organization achieves its objectives in areas such as profitability, efficiency, productivity, market share, customer satisfaction, and innovation capacity. In the context of supply chain management, firm performance often encompasses both financial and non-financial indicators that reflect a firm's competitiveness and resilience (Gunasekaran et al., 2021). Performance is influenced by internal operational strategies and external supply chain capabilities, such as flexibility, sourcing strategies, and risk management practices.

Within the manufacturing sector, firm performance is typically evaluated using multidimensional indicators. These include financial metrics such as return on investment (ROI), return on assets (ROA), and cost efficiency, as well as operational measures such as production cycle time, order fulfillment rate, and customer satisfaction (Mohammed & Baig, 2022). Modern supply chains increasingly incorporate sustainability and agility as additional dimensions of performance, recognizing that responsiveness to change and environmental responsibility contribute to long-term success.

The relationship between supply chain practices and firm performance has been the focus of numerous empirical studies. Research by Kusi-Sarpong et al. (2022) emphasizes that firms which integrate supply chain flexibility and digital sourcing practices report improved delivery performance and reduced operational costs. Technological integration also plays a central role in enhancing performance. Tools such as real-time analytics, ERP systems, and IoT sensors contribute to better decision-making, faster lead times, and improved resource allocation. Firms that digitally align their supply chain activities are better equipped to predict demand, manage inventory levels, and engage in collaborative forecasting, all of which boost firm performance (Gong et al., 2023).

In the Kenyan manufacturing context, performance remains a crucial determinant of sustainability in a competitive and often unpredictable market. Firms face challenges such as regulatory fluctuations, logistical barriers, and fluctuating input costs. According to Odhiambo and Muathe (2023), companies that embrace modern supply chain practices and maintain strategic alignment between operations and market needs are more likely to demonstrate superior performance outcomes across multiple dimensions.

In summary, firm performance is a critical dependent variable that reflects the effectiveness of supply chain management practices. It is a multidimensional construct encompassing operational, financial, and strategic outcomes. Enhancing performance requires not just efficiency in routine processes, but also the integration of flexibility, risk preparedness, and innovation within the broader supply chain strategy.

Empirical Review

Operational Flexibility and Firm Performance

Thilagham et al. (2022) conducted a quantitative study in the Indian pharmaceutical sector to examine the role of operational flexibility in mitigating supply chain disruptions during the COVID-19 pandemic. The study targeted 150 supply chain and operations managers across pharmaceutical manufacturing firms. Using structured questionnaires and Structural Equation Modeling (SEM) for data analysis, the researchers tested the influence of various operational flexibility dimensions, including production switching, supplier substitution, and logistics adaptation, on supply chain resilience. Their results demonstrated a statistically significant relationship between high operational flexibility and a firm's ability to maintain production schedules and fulfill orders during the crisis. Firms that adopted real-time inventory visibility tools, implemented shift-based labor rotations, and used backup logistics partners recovered 40% faster from disruptions compared to firms with rigid structures. The study recommended that pharmaceutical firms institutionalize agile planning processes and scenario-based simulations to enhance resilience.

In China, Shi, Zhang, and Huang (2023) applied a mixed-method research design to study 80 electronics manufacturing firms across Shenzhen and Guangdong provinces. The researchers administered structured surveys to supply chain managers and supplemented this with interviews to capture contextual nuances. Using regression analysis and thematic coding, the study revealed that operational flexibility, characterized by rapid supplier switching, modular production lines, and the ability to dynamically allocate labor, was a strong predictor of a firm's resilience to supply-side shocks. During COVID-19-induced restrictions, firms that had invested in flexible infrastructure, such as cloud-enabled supply chain systems and automated quality checks, were able to reduce their lead times by an average of 25%. Moreover, the study highlighted that the presence of decentralized decision-making enhanced the speed at which firms could respond to localized disruptions, further reinforcing the strategic value of operational flexibility.

Aich et al. (2021) conducted an in-depth longitudinal case study of a multinational automotive manufacturer based in Germany, analyzing operational performance before, during, and after the COVID-19 pandemic. The study reviewed internal reports, production records, and supplier communications spanning 2019 to 2021. Through qualitative content analysis and process mapping, the researchers found that the manufacturer’s operational flexibility, enabled by cross-trained employees, predictive maintenance technologies, and parallel production lines, allowed it to resume full-scale operations 30% faster than industry competitors. For instance, the firm was able to shift production from heavily impacted European plants to its less-affected facilities in Eastern Europe, ensuring continuity in critical component output. Aich et al. concluded that operational flexibility must be viewed as a long-term strategic investment rather than a crisis-only response mechanism.

Adegbite and Olayiwola (2021) conducted a cross-sectional survey of 112 manufacturing firms in Lagos, Nigeria, focusing on how operational flexibility contributed to supply chain resilience in the context of economic and infrastructural instability. Using a multi-stage sampling technique, the researchers distributed questionnaires to operations, procurement, and logistics managers. The data were analyzed using multiple linear regression. The results indicated that firms with a high degree of operational flexibility, such as those capable of adjusting batch

sizes, using alternative energy sources, and rerouting deliveries, had better supply continuity and customer satisfaction scores. Notably, the study identified that smaller firms that partnered with third-party logistics providers or maintained multiple sourcing contracts demonstrated stronger recovery from fuel shortages and border closures. The authors emphasized that operational flexibility was not only critical during emergencies but also contributed to long-term cost savings and agility.

In Egypt, Mahmoud and El-Baz (2022) investigated the textile manufacturing industry's operational responses to national and global disruptions. The study sampled 90 medium-sized and large textile firms across Cairo and Alexandria and employed logistic regression analysis to explore the relationship between operational flexibility and supply chain performance. The research revealed that firms with adaptive capabilities, such as adjustable loom schedules, reserve workforce pools, and digital supplier tracking systems, experienced fewer delays and cancellations during disruptions. Furthermore, firms that relied heavily on centralized operations faced greater difficulty responding to COVID-19 restrictions. By contrast, those that had diversified their raw material sources and built regional distribution hubs managed to maintain service-level agreements. The study concluded that operational flexibility needs to be embedded into supply chain strategy through capacity building, supplier collaboration, and digital investment.

Njagi (2023) explored operational flexibility in Nairobi-based small and medium-sized manufacturing enterprises (SMEs) within the food processing sector. Using a descriptive research design, the study surveyed 60 firms and applied Pearson correlation to analyze the data. The findings revealed a strong positive relationship ($r = 0.71$, $p < 0.01$) between operational flexibility and supply chain resilience. Firms that had developed capabilities such as rapid supplier substitution, flexible procurement contracts, and alternative logistics options were able to maintain production during fuel crises and public transportation strikes. For example, one firm highlighted in the study successfully transitioned from diesel-based machinery to solar-powered alternatives during a three-week blackout, showcasing adaptability. Njagi noted that most resilient SMEs practiced real-time communication with suppliers and relied on local sourcing to reduce dependency on volatile import channels. The study recommended government incentives to support SME investments in alternative technologies and flexible warehousing infrastructure.

Across all studies, operational flexibility emerges as a critical enabler of supply chain resilience in manufacturing. Whether in the context of pandemic-induced disruptions or ongoing infrastructural and logistical volatility, firms that could adapt processes, shift resources, and diversify operations demonstrated significantly better performance outcomes. The methodologies employed, from SEM and regression to in-depth case studies, consistently validate the strategic importance of operational flexibility in both global and local manufacturing contexts.

Supply Chain Re-engineering and Firm Performance

Rane and Narvel (2022) investigated the impact of supply chain re-engineering on resilience in Japanese automotive firms. Using a mixed-method approach, the study combined surveys from 95 supply chain professionals with in-depth case analyses of three leading car manufacturers. The researchers employed regression modeling to assess the effectiveness of re-engineered logistics systems, lean production adaptations, and digital twin simulations. Results showed that firms which adopted process re-engineering, particularly in inventory planning and last-mile distribution, achieved up to 30% faster recovery times after the 2020 semiconductor supply crisis. The study concluded that supply chain re-engineering is most impactful when combined with real-time visibility tools and agile planning systems.

In Germany, Bala et al. (2023) conducted a qualitative study of five large industrial machinery manufacturers that had undergone supply chain re-engineering post-COVID-19. Through semi-structured interviews and archival data analysis, the study examined how process redesign, such as supplier base restructuring, digital procurement, and modular inventory control, contributed to resilience. Firms that implemented cross-functional integration, demand-sensing analytics, and smart warehousing were able to reduce supply bottlenecks and improve order fulfillment rates during peak demand fluctuations. The research emphasized that successful re-engineering requires top-down commitment and a culture that embraces digital transformation.

Abubakar and Mohammed (2021) explored the effects of supply chain re-engineering on operational performance among 100 Nigerian manufacturing firms in Kano and Lagos. Using survey questionnaires analyzed through multiple regression analysis, the study identified that firms which had re-engineered their procurement processes, adopted mobile-based inventory systems, and relocated warehousing closer to retail hubs experienced greater supply continuity during periods of port congestion and fuel scarcity. The study found a strong positive correlation between re-engineering initiatives and reduced lead times, lower input costs, and improved delivery consistency.

In Egypt, Hassan and El-Nahas (2022) carried out a quantitative study on textile and food processing firms, focusing on re-engineering interventions aimed at building resilience during economic instability and supply constraints. Surveying 87 firms and applying path analysis, the study revealed that redesigning workflows, digitalizing supplier contracts, and regionalizing distribution networks led to measurable improvements in risk response time and inventory optimization. Firms that eliminated redundant processes and enhanced automation capacity outperformed competitors in adapting to currency shocks and raw material shortages.

Mwangi and Muthoni (2023) conducted a survey-based study on 65 mid-sized manufacturing firms in Nairobi County, assessing the relationship between supply chain re-engineering and supply chain resilience. Using descriptive and inferential statistics, the researchers found that firms that undertook radical redesigns of logistics, adopted cloud-based procurement systems, and outsourced non-core functions were better able to recover from disruptions such as transportation strikes and customs delays. One firm, for instance, shortened its average delivery time by 22% after re-engineering its internal routing and shifting from centralized to decentralized warehousing. The study emphasized that re-engineering efforts aligned with digital adoption and employee reskilling were the most effective in enhancing resilience.

Across international, regional, and local contexts, the evidence consistently demonstrates that supply chain re-engineering significantly enhances supply chain resilience. Whether through digital transformation, structural redesign, or process simplification, firms that engage in purposeful reconfiguration of supply chain functions are better positioned to adapt to dynamic environments. For manufacturing firms in Nairobi, re-engineering presents a strategic opportunity to overcome infrastructural, regulatory, and logistical bottlenecks and to achieve long-term operational stability.

RESEARCH METHODOLOGY

The study adopted a descriptive research design. According to Orodho (2012); research design refers to all the procedures selected by a researcher for studying a particular set of questions or hypothesis and a framework for the collection and analysis of data that is suited to the research question. For the purposes of this study, the target population comprises registered large and medium-sized manufacturing firms operating in Nairobi City County, Kenya. According to the Kenya Association of Manufacturers (KAM, 2024), there are 210 such firms across various

industrial sub-sectors, including food processing, chemicals, construction, pharmaceuticals, and textiles, among others

These firms were selected because they represent the formal and structured segment of Kenya's manufacturing industry, often characterized by more defined supply chain systems, documented performance metrics, and the capacity to implement strategic resilience measures. As such, they provide a reliable context for examining how supply chain resilience capabilities influence firm performance. The unit of analysis for this study is the manufacturing firm, while the unit of observation is the supply chain manager (or their equivalent). Supply chain managers are chosen because they are directly responsible for overseeing procurement, logistics, sourcing, and operational coordination. The study's sample size was reached at using Krejcie and Morgan sample size determination formula (Russell, 2013). Using this formula a representative sample was obtained. Therefore, the sample size for the study was 136 supply chain managers.

Table 1: Sample Size

Category	Population	Sample Size
Building, Mining, and Construction	5	3
Food, Tobacco, and Beverage	45	29
Chemical and Allied	29	19
Energy, Electrical, and Electronics	18	12
Plastic and Rubber	30	19
Textile and Apparels	24	16
Timber, Wood, and Furniture	12	8
Pharmaceutical and Medical Equipment	12	8
Leather and Footwear	7	5
Motor Vehicle and Accessories	8	5
Paper and Board	20	13
Total	**210**	**136**

This study adopted a stratified random sampling technique to ensure fair representation across the various sub-sectors of manufacturing firms in Nairobi City County. Stratification was necessary because the manufacturing sector is heterogeneous, comprising firms operating in diverse industries such as food processing, chemicals, textiles, and pharmaceuticals. From the target population of 210, a sample size of 136 firms was determined.

This study utilized a structured questionnaire consisting exclusively of closed-ended questions to collect primary data. To ensure reliability and clarity of the questionnaire, a pilot test was conducted on 10% of the sample size, as recommended by Mugenda and Mugenda (2019), who suggest that a pre-test involving 10% of the study sample is adequate for identifying and correcting potential weaknesses in the research instrument. The pilot study involved 14 Supply Chain managers selected from the list of manufacturing firms but were excluded in the final study. The managers completed the same questionnaire as intended for the main study within a 30-minute timeframe, during which the researcher was available to address any questions and gathered feedback on the questionnaire's format and clarity.

Data was analyzed using SPSS version 28. Data was then cleaned and analyzed using descriptive statistics such as frequencies, percentages, and mean while inferential statistics including regression and correlation was used. Correlation was used to establish the relationship between study variables. Multiple regression was used to show how changes in the independent variables would cause changes in the dependent variable.

RESEARCH FINDINGS AND DISCUSSIONS

Out of the 136 questionnaires distributed, 127 were completed and returned, yielding a response rate of 93.4%. This high response rate exceeds the generally accepted benchmark of 70% for survey-based research (Mugenda & Mugenda, 2003), thereby enhancing the reliability and representativeness of the findings. The robust participation across all sub-sectors ensured balanced insights reflective of Nairobi's diverse manufacturing landscape.

Descriptive Statistics of Study Variables

This section presents the descriptive statistical analysis of the study's main variables: operational flexibility, supply chain re-engineering, and firm performance. The analysis summarizes the central tendencies and distribution of responses using mean scores and standard deviations. All constructs were measured using a five-point Likert scale, where respondents indicated their level of agreement with various statements relating to each construct. The interpretation of the mean scores follows a standardized scale: 1.00–1.49 = Strongly Disagree, 1.50–2.49 = Disagree, 2.50–3.49 = Neutral, 3.50–4.49 = Agree, and 4.50–5.00 = Strongly Agree. These descriptive insights provide an initial understanding of how manufacturing firms in Nairobi City County perceive and implement various resilience strategies and how they relate to organizational performance.

Operational Flexibility

The first objective of the study was to assess the effect of operational flexibility on the performance of manufacturing firms in Nairobi City County, Kenya. Operational flexibility refers to a firm's ability to adjust its internal operations in response to changes in demand, supply disruptions, and resource variability. It encompasses dynamic capabilities such as shifting production schedules, using alternative suppliers, and reallocating labor with minimal disruption. Table 2 presents the descriptive statistics for eight items used to assess the extent of operational flexibility among manufacturing firms in Nairobi City County.

Table 2: Descriptive Statistics for Operational Flexibility

Statement	Mean	Standard Deviation
Ability to quickly adjust production capacity in response to demand changes	3.887	0.701
Ease of switching between product lines with minimal disruption	4.406	0.754
Use of flexible shift systems to manage labor during high or low demand periods	4.209	0.410
Availability of standby suppliers or substitute sources for critical inputs	4.089	0.885
Adaptability of production processes to raw material fluctuations	3.690	0.816
Ability to alter transport and delivery schedules on short notice	3.787	0.622
Responsiveness to sudden supply chain interruptions	3.874	0.513
Integration of operational flexibility into strategic supply chain decisions	4.091	0.589
Aggregate Score	**4.046**	**0.661**

The highest-rated indicator of operational flexibility was the ease of switching between product lines with minimal disruption (Mean = 4.406, SD = 0.754), indicating that many firms have invested in adaptive production systems that can accommodate diverse product demands. This was followed by strong agreement on the use of flexible shift systems to manage labor during demand fluctuations (Mean = 4.209, SD = 0.410), suggesting that workforce deployment is actively used as a tactical lever to balance workloads. Firms also reported high integration of

flexibility at the strategic level (Mean = 4.091, SD = 0.589), highlighting that adaptability is embedded not only operationally but also in long-term planning. The availability of standby suppliers (Mean = 4.089, SD = 0.885) received similarly high scores, though with greater variability, possibly reflecting differences in sourcing maturity or sector complexity.

The remaining indicators were rated slightly lower, though still within the "agree" range. Firms acknowledged the ability to respond to sudden supply chain interruptions (Mean = 3.874, SD = 0.513) and to adjust production capacity (Mean = 3.887, SD = 0.701), indicating core capabilities in managing operational disruptions. However, logistical flexibility, reflected in the ability to alter delivery schedules (Mean = 3.787, SD = 0.622), and adaptability to raw material changes (Mean = 3.690, SD = 0.816) were relatively less established, pointing to potential areas for development. Overall, the aggregate mean of 4.046 confirms that firms in Nairobi's manufacturing sector demonstrate a high degree of operational flexibility, though continued investment in supplier agility and raw material process adaptation could further strengthen their resilience profile.

The aggregate mean score of 4.046 confirms that operational flexibility is generally well-practiced among the sampled firms. Standard deviations ranged from 0.410 to 0.885, indicating moderate variation in implementation across organizations. These results are consistent with the literature reviewed, where operational flexibility is identified as a foundational element of supply chain resilience. Studies by Dubey et al. (2021) and Odhiambo and Muathe (2023) emphasize that firms with adaptable internal systems are more capable of maintaining continuity during disruptions. The findings in this study suggest that manufacturing firms in Nairobi have institutionalized key aspects of operational flexibility, particularly in labor management, sourcing, and product line adaptability. This reflects a strategic shift toward resilience in response to prior systemic shocks and positions these firms to better withstand future supply chain uncertainties.

Supply Chain Re-engineering

The second objective of the study was to find out effect of supply chain re-engineering on the performance of manufacturing firms in Nairobi City County, Kenya. Supply chain re-engineering involves the fundamental redesign of supply chain processes, structures, and technologies to improve performance, responsiveness, and adaptability. It includes the elimination of inefficiencies, adoption of digital tools, restructuring of facilities, and fostering cross-functional collaboration. Table 3 presents descriptive statistics for eight items measuring the extent to which re-engineering practices have been implemented among manufacturing firms in Nairobi City County.

Table 3: Descriptive Statistics for Supply Chain Re-engineering

Statement	Mean	Std.Dev.
We regularly redesign supply chain processes to improve efficiency	4.105	0.588
Our firm has adopted automation in key supply chain operations	3.703	0.795
We have relocated or redesigned warehouses for faster delivery	4.360	0.690
Digital transformation is central to our supply chain strategy	4.394	0.699
We evaluate and eliminate non-value-adding processes	4.194	0.795
There is strong cross-functional collaboration during supply chain redesign	4.083	0.472
We periodically assess our supply chain structure for redesign opportunities	4.063	0.610
Supply chain re-engineering has enhanced responsiveness and customer service	4.185	0.587
Aggregate Score	**4.136**	**0.656**

The highest-rated indicator of supply chain re-engineering was the recognition that digital transformation is central to supply chain strategy (Mean = 4.394, SD = 0.699), highlighting that firms increasingly view technology as a foundational element for achieving resilience, agility, and visibility. This was closely followed by the relocation or redesign of warehouses to improve delivery speed (Mean = 4.360, SD = 0.690), suggesting a proactive approach to optimizing logistics infrastructure in response to service-level expectations. Firms also reported strong commitment to evaluating and eliminating non-value-adding processes (Mean = 4.194, SD = 0.795), reflecting lean management principles as part of re-engineering efforts. Similarly, enhancements in responsiveness and customer service due to supply chain re-engineering received strong agreement (Mean = 4.185, SD = 0.587), confirming that these redesign initiatives are not just operational, but also customer-focused in their outcomes.

Agreement was also observed for regular redesign of supply chain processes to improve efficiency (Mean = 4.105, SD = 0.588) and cross-functional collaboration during redesign efforts (Mean = 4.083, SD = 0.472), suggesting that while redesign is practiced, coordination across departments may vary between firms. The periodic assessment of supply chain structures (Mean = 4.063, SD = 0.610) also indicates ongoing but possibly irregular re-evaluation practices. The lowest-rated item was the adoption of automation in key supply chain operations (Mean = 3.703, SD = 0.795), signalling that although digital strategy is emphasized, the practical implementation of automation technologies may still face barriers such as cost, skill gaps, or legacy systems.

Overall, the aggregate score of 4.136 confirms that supply chain re-engineering is well integrated into operational strategies among Nairobi's manufacturers, with strengths in digitization and facility optimization, but room for advancement in automation and systematic structural assessment. These results support insights presented in literature review where supply chain re-engineering is emphasized as a strategic resilience lever. Scholars such as Mandal (2012) and Dubey et al. (2021) highlight the importance of continuous redesign and digital transformation in building flexible, efficient, and disruption-ready supply chains. The strong alignment of these findings with the literature suggests that Nairobi-based manufacturers are increasingly embracing redesign strategies to boost their operational responsiveness and customer service capabilities in an unpredictable market environment.

Firm Performance

The main objective of the study was to examine the effect of supply chain resilience and performance of manufacturing firms in Nairobi City County, Kenya. Firm performance in the context of supply chain resilience refers to the organization's ability to sustain operational continuity, customer satisfaction, financial health, and competitive positioning despite external disruptions. The following statements assessed various aspects of performance linked to the implementation of resilience strategies. Table 4 presents the findings.

Table 4: Descriptive Statistics for Firm Performance

Statement	Mean	Std.Dev
Our firm has maintained consistent production levels despite disruptions	4.171	0.777
We have experienced minimal supply delays in the past year	4.015	0.442
Delivery lead times have improved due to supply chain strategies	4.302	0.702
Our firm has reduced operational costs over the last 12 months	3.627	0.694
We have increased customer satisfaction levels	4.287	0.568
Revenue has improved in part due to supply chain improvements	3.866	0.689
Our firm has gained a competitive edge in the industry	4.087	0.612
There is a noticeable improvement in supply chain responsiveness	4.118	0.590
Aggregate Score	**4.059**	**0.635**

The most highly rated indicator of firm performance was that delivery lead times have improved due to supply chain strategies (Mean = 4.302, SD = 0.702), demonstrating the effectiveness of resilience-oriented interventions in enhancing speed and service reliability. Closely following was the indication that customer satisfaction levels have increased (Mean = 4.287, SD = 0.568), underscoring that improvements in supply chain performance have translated into positive customer outcomes. Firms also acknowledged the ability to maintain consistent production despite disruptions (Mean = 4.171, SD = 0.777) and noted a noticeable improvement in supply chain responsiveness (Mean = 4.118, SD = 0.590), both of which suggest enhanced internal stability and adaptability. Additionally, the perception that firms have gained a competitive edge in the industry (Mean = 4.087, SD = 0.612) reflects the strategic advantage associated with resilient supply chain practices.

Agreement was also observed in the area of minimal supply delays experienced over the past year (Mean = 4.015, SD = 0.442), indicating generally stable inbound logistics, though with some variation. Firms also reported that revenue has improved due to supply chain enhancements (Mean = 3.866, SD = 0.689), showing that while performance improvements are being realized, financial gains may not be evenly distributed across all firms. The lowest-rated item was reduction in operational costs over the last 12 months (Mean = 3.627, SD = 0.694), suggesting that cost-efficiency gains are either modest or secondary to service improvements. Despite this, the aggregate score of 4.059 confirms that the majority of firms in Nairobi's manufacturing sector perceive strong overall performance, particularly in service delivery, responsiveness, and competitiveness, as outcomes of their supply chain resilience strategies.

These findings are consistent with studies where researchers like Christopher and Peck (2004) and Dubey et al. (2021) argue that resilience capabilities lead to better delivery performance, responsiveness, and customer service. The Nairobi-based firms in this study demonstrate how investment in flexible, aware, and re-engineered supply chains can translate into tangible performance gains especially in a post-disruption landscape. Although some financial benefits, like cost savings, appear more modest, the overall trend supports the strategic value of supply chain resilience in maintaining competitiveness and business continuity.

Correlation Analysis

Correlation analysis was conducted using Pearson's correlation coefficient to examine the strength and direction of relationships between the four dimensions of supply chain resilience: operational flexibility and supply chain re-engineering and firm performance. The results, including p-values for significance testing, are summarized in Table 5.

Table 5: Correlation Matrix

		Firm Performance	Operational Flexibility	Supply Chain Re-engineering
Firm Performance	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	127		
Operational Flexibility	Pearson Correlation	.681**	1	
	Sig. (2-tailed)	.000		
	N	127	127	
Supply Chain Re-engineering	Pearson Correlation	.792**	.087	1
	Sig. (2-tailed)	.000	. 739	
	N	127	127	127

Operational Flexibility had a Pearson correlation coefficient of r = 0.681, indicating a strong, positive, and significant relationship with firm performance. This suggests that firms capable

of quickly adjusting production schedules, reallocating resources, or adapting to supplier constraints are better positioned to maintain operational stability and responsiveness. These findings are consistent with the arguments of Dubey et al. (2021), who noted that operational flexibility enhances a firm's ability to navigate turbulence and sustain performance during supply disruptions.

Supply Chain Re-engineering demonstrated the strongest correlation with firm performance at r = 0.694, indicating that redesigning supply chain structures, eliminating inefficiencies, and adopting digital tools significantly contribute to enhanced performance. These findings reinforce the work of Mandal (2012), who emphasized the transformational value of re-engineering in driving supply chain agility, efficiency, and customer responsiveness.

Regression Analysis

The coefficients table was used to fit the regression model and assess the individual influence of each independent variable on firm performance. The results are presented in Table 6.

Table 6: Beta Coefficients of the Study Variables

Independent Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t-value	p-value
Operational Flexibility	0.271	0.062	0.318	4.371	0.000
Supply Chain Re-engineering	0.306	0.055	0.339	5.564	0.000

Operational Flexibility had a significant positive influence on firm performance (B = 0.271, $p < 0.05$). This means, a unit increase in operational flexibility results in an increase in firm performance by 0.271 units, holding other factors constant. This means that firms with greater ability to adjust production, labor, and delivery processes are more likely to achieve consistent output and service levels. This supports Zsidisin and Henke (2020), who emphasize the role of internal agility in navigating volatile supply environments and improving performance metrics such as lead times and production stability. This finding also supports the work of Braunscheidel and Suresh (2009), who emphasized the importance of internal agility in achieving supply chain resilience and sustaining competitiveness.

Supply chain re-engineering exhibited the strongest effect on performance (B = 0.306, $p < 0.05$), implying that a one-unit increase in re-engineering activities, such as automation, process redesign, and digital transformation, leads to a 0.306 unit increase in firm performance. This supports the findings of Chowdhury et al. (2021), who demonstrate that firms that continuously optimize supply chain structures through innovation and cross-functional collaboration outperform competitors in turbulent environments..

Based on the unstandardized coefficients from the regression results, the regression equation for predicting firm performance (Y) from the four independent variables is expressed as follows:

Regression Equation:

$$\text{Firm Performance (Y)} = 0.271X_1 + 0.306X_2 + \varepsilon$$

Where:

X_1 = Operational Flexibility

X_2 = Supply Chain Re-engineering

ε = Error term (residuals not explained by the model)

Conclusions

Operational Flexibility

The study concludes that operational flexibility is a foundational enabler of firm performance. Firms that demonstrated the ability to quickly shift production capacity, modify labor shifts, and source alternative inputs were better positioned to withstand supply-side shocks and maintain consistent service delivery. Flexibility was not only evident in operational adjustments but was also embedded in strategic decision-making, showing that firms view it as a long-term resilience lever. Given its significant effect on performance, operational flexibility emerges as a critical internal capability that allows firms to remain agile and responsive in uncertain environments.

Supply Chain Re-engineering

The most impactful conclusion from the study is that supply chain re-engineering has the strongest influence on firm performance. Firms that routinely redesign processes, eliminate inefficiencies, adopt digital tools, and restructure supply chain systems reported the highest performance outcomes. This demonstrates that structural adaptability and continuous improvement are essential for managing dynamic operating environments. Despite lower adoption of automation, re-engineering as a whole was well integrated into firm strategy and was strongly linked with responsiveness, customer satisfaction, and competitiveness. It can therefore be concluded that firms investing in transformative change through re-engineering are better equipped to drive sustained performance under volatile conditions.

Recommendations

Operational Flexibility

Manufacturing firms should institutionalize operational flexibility as a core element of both tactical operations and strategic planning. This includes adopting systems that allow for quick adjustment of production capacity, streamlined switching between product lines, and more agile labor management. Firms are encouraged to strengthen logistical flexibility by improving delivery scheduling tools and integrating transportation responsiveness into supply chain planning. Additionally, efforts should be made to improve process adaptability to raw material variations, especially for firms in sectors prone to input fluctuations. Managers should conduct periodic flexibility audits to identify operational bottlenecks and opportunities for dynamic reallocation of resources during supply disruptions.

Supply Chain Re-engineering

Given its strong influence on performance, firms are strongly advised to adopt a continuous improvement mindset by institutionalizing supply chain re-engineering as a recurring strategic exercise. This includes investing in automation technologies that can support scalable, efficient operations particularly in production, warehousing, and distribution. Firms should prioritize end-to-end digital transformation initiatives, integrating data across supply chain nodes to improve decision-making and responsiveness. Structural redesign of warehouse networks and logistics routes should be data-driven and regularly evaluated for performance enhancement. Finally, cross-functional collaboration must be strengthened during redesign efforts, ensuring that changes are informed by insights from procurement, production, logistics, and customer service teams.

Suggestions for Further Research

While this study provided valuable insights into the influence of supply chain resilience on firm performance in Nairobi's manufacturing sector, future research could expand the scope by including small and informal manufacturing enterprises to understand how resilience

manifests in less-structured environments. Longitudinal studies are also recommended to assess how resilience strategies evolve over time and in response to specific disruptions. Additionally, comparative studies across different counties or regions in Kenya, or even across countries, could help generalize the findings and highlight contextual variations in resilience practices and their performance outcomes.

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