Intelligent Supply Chains and Operational Efficiency in Selected FMCG Manufacturing Companies in Nigeria

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ABSTRACT

This study explores the impact of intelligent supply chains and operational efficiency within selected Fast-Moving Consumer Goods (FMCG) manufacturing companies in Nigeria. The study delves into the integration of advanced technologies such as the Internet of Things (IoT), Big Data Analytics (BDA), and Artificial Intelligence (AI) in supply chain management. These technologies have revolutionized supply chain processes, enhancing operational efficiency by streamlining workflows, reducing waste, and improving decision-making. The methodology focuses on the analysis of interconnected supply chains and intelligent supply chains, and their effects on operational performance.

The study employs a combination of quantitative and qualitative methods to gather data from various stakeholders within the FMCG sector. The findings show that interconnected and intelligent supply chains significantly contribute to operational performance, though the adoption and effectiveness of these technologies vary. The conclusion therefore emphasizes that interconnected supply chains positively influence operational performance, while intelligent supply chains show a mixed effect due to underutilization or poor implementation. The study thereby recommends strengthening the alignment between smart technology and operational performance, leveraging interconnected supply chains, and improving employee engagement and communication to foster a more efficient and responsive supply chain environment.

(Keywords: supply chain, intelligent logistics, FMCG, fast moving consumer goods, efficiency, technologies)

INTRODUCTION

Supply chain is the flow of materials, information, ideas, products and services from the right upstream supplier to the right producer in the right quality, in the right quantity, at the right time, in the right cost, to the right customer. Yang, Fu, Zhang, (2021) viewed supply chain as the improvement, controlling and management of the flows of information and materials between the initial suppliers and end users/consumers through a network of connected organizations. The supply chain is an integration process that aims to add value for the final consumer by bringing together a variety of entities, including manufacturers, distributors, sellers, and suppliers (Aliahmadi, Nozari and Ghahremani-Nahr, 2022).

For the rights parameters of supply chain to be fully effective and efficiently harnessed, supply chain has undergone series and several transformations in contemporary days and hence reflecting the integration and application of technologies in terms of intelligence and internet such as Internet of Things (IoT), Big Data Analytics (BDA) and Artificial Intelligence (AI). Coupled with this is the proliferation of information and the growing importance of the Internet in daily life, which has led to new innovations that have changed the way things are done.

A network of things that enable connection and communication between objects at any time and location has been built by linking users to the internet, sharing information, and communicating objects through sensors and tags (Nozari, Najafi, Fallah and Hosseinzadeh Lotfi, 2021).

This transformation is notably evident in all sectors including manufacturing companies, where advancements in Big Data, AI, Internet of Things (IoT) and Blockchain are reshaping operations (Shehadeh, Bani Atta, Al Barrak, Lutfi and Alrawad, 2024). Thus, the IoT has made it easier to create new applications today and enhance those that already exist in a variety of fields (De Vass, Shee, and Miah, 2021). This technological advancement has adequately reflected in supply chain intelligently and equally brought about operational efficiency.

Operational efficiency encompasses streamlining workflows, processes, and resources to reduce waste and increase productivity. It is the capacity of an organization to provide goods and services to its clients in the most economical way while preserving high standards of quality. The degree to which an organization effectively transforms inputs into outputs is known as operational efficiency, and it is a notion that is crucial for businesses undergoing digital transformation (Nadkarni and Haider, 2022; Akhtar, Alam, Khan and Shamshad, 2023). However, the use of artificial intelligence, data analytics and cloud computing as a means of an intelligent supply chain has been identified as crucial components in bolstering the operational efficiency of businesses in general and manufacturing companies in particular. This is because these technologies are perceived to streamline complex processes and guide organizations towards superior business outcomes (Kitsios and Kamariotou, 2021; Kraus, Jones, Kailer, Weinmann, Chaparro-Banegas and Roig-Tierno, 2021).

For a number of reasons, including increased organizational productivity and efficiency through intelligent supply chains based on automation technologies, advanced analytics of inventory level management, and others leading to significant cost savings and improved information access that will enable better decision-making and a quicker response to market changes, studying intelligent supply chains and technologies can be very motivating. This can also be extended and applicable in order to improve operational efficiency within companies that manufacture fast-moving consumer goods (FMCG) in Lagos and Ogun states, Nigeria.

LITERATURE REVIEW

FMCG supply chains are characterized by their fast-paced nature and high volume of products moving from manufacturers to consumers (Ali and Müller, 2023, George and George, 2023, Otieno and Maina, 2022). Key components of FMCG supply chains include procuring raw materials from suppliers to meet production demands; processing raw materials into finished goods in a timely manner; transporting finished goods to warehouses and retailers; selling products to consumers through various channels; and gathering feedback and data to understand consumer preferences and demand patterns. FMCG supply chains face several challenges that can impact operational efficiency and customer satisfaction (Adisa, 2023, Ninduwezuor-Ehiobu, *et al.*, 2023, Oguejiofor, *et al*., 2023). Fluctuations in consumer demand can lead to inventory shortages or excess stock.

FMCG products often have short shelf lives, requiring quick turnover to avoid waste. Managing multiple distribution channels and partners can be challenging. Some FMCG products experience seasonal demand variations, requiring agile supply chain planning. Ensuring product quality and safety throughout the supply chain is critical. Optimizing supply chain dynamics in FMCG is crucial for several reasons such as efficient supply chains and reduce costs associated with inventory holding, transportation, and warehousing. The responsive supply chains can meet customer demand promptly, leading to higher satisfaction levels. A well-optimized supply chain can be a source of competitive advantage in the FMCG industry (Alisaeedi, 2023, Etukudoh, *et al.*, 2024). Optimized supply chains can reduce waste and environmental impact, thereby contributing to sustainability goals.

The FMCG sector plays a vital role in the global economy, encompassing a wide range of products that are consumed on a daily basis, such as personal care products, food and beverages and household goods. FMCG firms operate in a highly competitive environment, where factors such as product quality, brand loyalty, and supply chain efficiency are critical to success (Akindote, *et al*., 2023; Okoye, *et al*., 2024).

Supply chain dynamics in the FMCG industry are multifaceted and complex involving the coordination of multiple stakeholders, including initial suppliers, manufacturers, distributors, and retailers (Gerassimidou, *et al*., 2022; Kumar and Aziz, 2023). The primary goal of FMCG supply chains is to ensure the cost-effective and timely delivery of products to customers while maintaining high levels of product quality and freshness.

FMCG supply chains face several challenges that can impact their efficiency and effectiveness.

These challenges include fluctuations in consumer demand which can lead to inventory imbalances and stockouts. FMCG products often have short shelf lives, requiring rapid turnover and efficient distribution. Some FMCG products experience seasonal fluctuations in demand, requiring agile supply chain planning and execution. Managing multiple distribution channels and partners adds complexity to FMCG supply chains.

Optimization of FMCG supply chain is essential for overcoming these challenges and improving operational efficiency and customer satisfaction (Ezeigweneme, *et al.*, 2023; Naicker, 2020). By implementing innovative technologies and strategies, FMCG companies can enhance their performance, reduce costs, and better meet customer needs (Nozari, et al., 2021; Sharma and Joshi, 2023). This paper explores a framework for integrating customer satisfaction and operational efficiency in FMCG supply chains, aiming to provide practical insights and recommendations for FMCG firms seeking to improve their supply chain operations.

The dynamic and competitive environment in which the FMCG business operates is marked by short product life cycles, fierce price competition, and quickly shifting consumer preferences (Iyadi and Itimi, 2023; Ngomane, 2023). To increase operational efficiency and improve customer satisfaction in this difficult environment, FMCG companies must optimize supply chain dynamics.

To maximize performance, FMCG supply chains must find creative solutions to their particular problems, which include short lead times, complex distribution networks, and fluctuating demand. Additionally, keeping customers loyal and gaining a competitive edge depends on matching their expectations regarding product freshness, availability and delivery time.

FMCG companies may develop a supply chain that is not only economical and efficient but also sensitive to the demands and preferences of their customers by combining operational efficiency and customer satisfaction. This paper investigates how FMCG companies might accomplish this integration by using a comprehensive approach that takes into account every step of the supply chain, from locating raw materials to shipping goods to customers.

The idea of Industry 4.0, which aims to integrate technology across the supply chain, is the foundation of the supply chain technologies (Premkumar, *et al.*, 2018). One of the most popular issues in the industry right now is supply chains digitizing, and it has a direct effect on how manufacturers, distributors, retailers, and logistics companies run their businesses, especially with regard to inventory across all sales channels (Yearling, 2018).

According to Amirkolaii, Baboli, Shahzad, and Tonadre (2017), AI efficiently assists managers in forecasting and modifying the plan in supply chain management, preventing resource waste and business hazards such as the "Bullwhip Effect." Information will be progressively distorted and amplified when it is transferred between the upstream and downstream of the supply chain without real-time information sharing. This leads to an increase in the fluctuation of supply and demand data as well as the creation of false bubble space.

Through the use of real-time data analysis, prediction model programming, historical data analysis, and other analysis techniques, artificial intelligence (AI) can assist businesses in developing dynamic operational plans and properly predicting supply and demand linkages in advance (Küfner, Uhlemann and Ziegler, 2018).

In order to preserve company continuity in turbulent and chaotic circumstances, smart supply chains use artificial intelligence (AI) and other cutting-edge technology to assist businesses in making forecasts and risk assessments. When a calamity strikes, an effective artificial intelligence-based supply chain control tower system can react swiftly, navigate around or even avoid risk with little loss or damage (Tsafarakis, Saridakis, Baltas and Matsatsinis, 2013). Similar to this, AI may be used in everyday operations through real-time omnidirectional risk monitoring, which enhances SCM's agility to react swiftly and reduce risks by anticipating supply chain interruptions and suggesting remedies. For instance, the biggest flooding in 40 years occurred overnight in August 2017 in over 30 Thai counties. The supply chain section of IBM's Singapore plant realized right away that the floods would significantly affect Thailand's hard drive manufacturers based on the purchase orders that were being processed and awaiting approval. In order to place orders, lock and prepare goods, coordinate and deploy available transportation, and ensure that a dedicated hard disk supply is in place and that the production line is not interrupted, the Singapore factory promptly selected the Singapore hard disk from the repository suppliers based on the potential risks associated with a shortage (Frederico, Garza-Reyes, Anosike, and Kumar, 2019).

Using various technological solutions to digitize supply chains is expected to have some effect on the adoption of these essential lean techniques. Adoption of these methods is facilitated and made more efficient by this impact, but it may also lead to new difficulties. According to earlier research, there are scant empirical studies that look at the connection between manufacturing companies' transition to Industry 4.0 and a successful lean implementation.

Total productive maintenance (TPM), Just-in-time (JIT), automation, kaizen/continuous improvement (CI) and value stream mapping (VSM) are some of the practices used in lean operation. These practices are thought to be the most important ones for putting the lean concept into practice (Rocha-Lona, *et al.*, 2013). Very little scientific research has been done on the relationship between supply chain digitization and the implementation of these five lean operations techniques.

The Concept of “Digital Supply Chain Management” continues to attract the interest of industry professionals and academic researchers. One of the industry's most disruptive and rapidly expanding trends is the digital supply chain (Ben-Daya, Hassini, and Bahroun, 2019). In order to make supply chains more interconnected, cooperative, and effective, digitalization entails implementing advanced and intelligent technical capabilities.

The concept of “digital supply chain” or “supply chain digitalization” is directly related to the overall concept of Industry 4.0. According to Tjahjono, *et al*. (2017), the term "industry 4.0" describes how businesses are being transformed by the advent of digitalization and the internet and the adoption of technological applications that result in revolutionary improvements in the design and manufacturing processes, operations, and services of manufacturing products and systems. The complexity of companies rises as supply chains get more digitalized, and it is critical to comprehend the advantages that this digitalization may offer the company.

METHODOLOGY, RESULTS, AND DISCUSSION

Hypothesis One of the Study

H0: Interconnected supply chains (IT) do not have a beneficial impact on operational performance (OP) of the multinational FMCG.

H1: Interconnected supply chains (IT) have a beneficial impact on operational performance (OP) of the multinational FMCG.

The effect of Interconnected Supply Chains (IT) on Operational Performance (OP) shows that there are levels of agreement (positive responses) and disagreement (negative responses) in the employee responses for both variables. This comparison provides insight into the potential relationship between these two aspects.

High Positive Correlation - Both IT and OP have a similar percentage of positive responses (~80%), suggesting that employees who view the interconnected supply chain practices favorably are likely to perceive better operational performance. This implies a strong alignment between interconnected supply chains and operational success.

Negative Responses Alignment - The percentage of employees expressing dissatisfaction with IT (16.25%) closely mirrors the dissatisfaction level for OP (15%). This correlation further supports the notion that challenges or shortcomings in interconnected supply chains may directly impact perceptions of operational performance.

Operational Efficiency through Supply Chain Integration - Interconnected supply chains can enhance real-time coordination, reduce inefficiencies, and improve decision-making. These aspects directly influence operational performance by ensuring smoother workflows and timely outputs. The strong agreement in IT likely reflects these operational benefits. The strong overlap in positive sentiment suggests that interconnected supply chains significantly enhance operational performance. If IT practices are strengthened further, OP ratings are likely to improve due to better supply chain management, increased efficiency, and alignment across operations. Interconnected supply chains (IT) positively impact operational performance (OP), with both showing strong positive employee responses. Addressing negative feedback regarding IT can potentially further enhance operational outcomes.

<u>Hypothesis Two of the Study</u>

H0: Intelligent supply chain (IC) does not have a beneficial impact on operational performance (OP) of the multinational FMCG.

H1: Intelligent supply chain (IC) has a beneficial impact on operational performance (OP) of the multinational FMCG.

Lower Positive Responses in IC Compared to OP - Only 58.75% of employees rated IC positively, compared to 78.75% for OP. This suggests that while operational performance is generally perceived as strong, the intelligent supply chain practices are not as widely accepted or effective.

Higher Negative Responses in IC - IC has a significantly higher negative response rate (35%) compared to OP (15%). This discrepancy may indicate that inefficiencies or challenges in adopting intelligent supply chain systems are limiting their ability to support operational performance.

Neutral Responses Are Consistent - Both IC and OP have similar levels of neutral responses (6.25%), indicating a small but consistent group of employees who may be undecided or unaware of how IC impacts operations.

Intelligent Supply Chains as a Driver of Operational Efficiency - IC systems involve automation, data analytics, and AI-powered decision-making, which have the potential to improve operational performance by optimizing processes and reducing waste. However, the relatively lower agreement for IC suggests that its implementation or impact is not yet fully realized across the organizations.

Impact of Negative Perception on Operational Performance - The relatively high level of dissatisfaction with IC (35%) likely affects overall employee perceptions of OP. Issues with IC, such as inadequate training, poor integration, or system inefficiencies, may hinder operational performance and limit the benefits that intelligent supply chains can bring. Addressing the challenges associated with intelligent supply chains such as increasing employee training, improving system usability, or resolving inefficiencies could positively impact operational performance by strengthening the role of IC in driving productivity and innovation.

Intelligent Supply Chains (IC) appear to have a mixed effect on Operational Performance (OP). While OP is rated highly, IC shows a more polarized perception, with significant dissatisfaction. This suggests that underutilized or poorly implemented IC systems might be hindering their full potential to enhance operational performance. To maximize the positive effect of IC on OP, organizations should focus on resolving employee concerns, improving system efficiency, and fostering better integration with operational workflows.

<u>Hypothesis Three of the Study</u>

H0: Intelligent supply chains do not have a beneficial impact on smart technology.

H1: Intelligent supply chain has a beneficial impact on smart technology.

Moderate Positive Alignment between IC and ST - IC has 58.75% positive responses, while ST has 63.75% positive responses. The similarity suggests a potential relationship, as intelligent supply chain systems often rely on smart technologies like IoT, AI, and machine learning to function effectively.

Higher Negative Responses for IC than ST - IC shows 35% negative responses compared to 21.25% for ST. This suggests that while smart technology adoption may be more positively perceived, issues with intelligent supply chain systems could hinder the full utilization or perceived value of the technology.

Higher Neutral Responses in ST - The neutral response for ST (15%) is significantly higher than that for IC (6.25%), indicating a portion of employees may be uncertain about how well smart technology has been integrated or its direct role in supply chain intelligence.

Dependency of IC on Smart Technology - Intelligent supply chains are heavily dependent on smart technology (e.g., automation tools, sensors, AI). Positive perceptions of IC likely stem from effective smart technology use. However, dissatisfaction with IC could indicate limitations in how technology is applied, scaled, or integrated into supply chain processes.

Innovation and Technology Adoption - A higher satisfaction level with ST (63.75%) compared to IC (58.75%) suggests that employees recognize the value of the technology itself but may perceive gaps in how it supports supply chain intelligence.

Barriers to Effectiveness - The 35% negative responses for IC could stem from issues such as: Poor alignment between smart technology solutions and supply chain needs. Inadequate training or understanding of the capabilities of intelligent systems. A lack of seamless integration between technology and processes.

By addressing negative perceptions of IC, such as improving system design or functionality, organizations can better leverage smart technology, enhancing both supply chain intelligence and employee satisfaction. Smart Technology (ST) positively influences Intelligent Supply Chains (IC), but IC's effectiveness is perceived as lagging ST. This indicates that while the underlying technologies are valued, their implementation in intelligent supply chains faces challenges. To strengthen the relationship, organizations should focus on improving how smart technologies are integrated into and support supply chain intelligence. Enhanced alignment and functionality could significantly improve perceptions of both IC and ST.

Hypothesis Four of the Study

H0: Interconnected supply chain does not have a benefit impact on smart technology.

H1: Interconnected supply chain has a benefit impact on smart technology.

Higher Positive Responses in IT Compared to ST - IT has a much stronger positive perception (80%) compared to ST (63.75%). This could indicate that employees recognize interconnected supply chains as effective but see gaps in how smart technology is utilized to support or enhance these systems.

Lower Negative Responses in IT - Negative feedback for IT (16.25%) is lower than for ST (21.25%). This suggests that while IT systems are generally well regarded, there may be inefficiencies or challenges in adopting smart technology to fully capitalize on interconnected supply chain benefits.

Neutral Responses for ST Are Higher - The neutral responses for ST (15%) are significantly higher than for IT (3.75%), indicating that a considerable proportion of employees may be unsure about the effectiveness or implementation of smart technology in supporting IT.

IT as a Driver of Smart Technology Adoption - Interconnected supply chains rely on smart technologies like IoT, cloud computing, and advanced communication systems to facilitate seamless coordination across networks. The high positive perception of IT indicates that smart technology is playing a crucial role in enabling these processes.

Dependency of IT on ST for Efficiency - While IT systems are viewed positively, any inefficiencies or limitations in smart technology adoption (as evidenced by lower ST ratings) could restrict IT's effectiveness. For example: Poorly integrated or outdated technology might slow down data sharing or automation within the supply chain. Gaps in employee training for smart technologies might also limit their effective use within IT frameworks.

Barriers to Perceived Impact of ST - The 21.25% negative responses for ST suggest that some employees perceive challenges in how smart technology supports IT. These could include: A lack of real-time data visibility, inefficiencies in automation or digital communication tools, insufficient investment in or scaling of smart technologies.

Opportunity for Mutual Reinforcement - Enhancing smart technology (e.g., investing in advanced IoT devices, upgrading AI systems, or improving user interfaces) could significantly boost the effectiveness of IT. Similarly, the strong foundation of IT could provide a supportive environment for further smart technology deployment.

Interconnected Supply Chains (IT) appear to positively influence the adoption and effectiveness of Smart Technology (ST), but gaps in ST implementation may limit the full realization of IT's potential. Addressing challenges with smart technology such as improving integration, scalability, and user adoption can strengthen IT systems further. By aligning IT and ST more effectively, organizations can enhance both the efficiency of supply chains and the overall technological infrastructure.

CONCLUSION

The effect of Interconnected Supply Chains (IT) on Operational Performance (OP) shows that there are levels of agreement (positive responses) and disagreement (negative responses) in the employee responses for both variables. This comparison provides insight into the potential relationship between these two aspects.

Intelligent Supply Chains (IC) appear to have a mixed effect on Operational Performance (OP). While OP is rated highly, IC shows a more polarized perception, with significant dissatisfaction. This suggests that underutilized or poorly implemented IC systems might be hindering their full potential to enhance operational performance. To maximize the positive effect of IC on OP, organizations should focus on resolving employee concerns, improving system efficiency, and fostering better integration with operational workflows.

Operational Performance (OP) positively influences the adoption and effectiveness of Smart Technology (ST), though gaps in ST's optimization may limit its perceived impact on operations. The strong operational performance suggests that smart technology plays a role in enabling efficiency, but further investments in ST, improved integration, and better employee training could close the gap between ST's and OP's perceived success. Aligning the two more effectively could lead to mutually reinforcing improvements.

RECOMMENDATIONS

Strengthen the Alignment Between Smart Technology (ST) and Operational Performance (OP) by investing in advanced and scalable smart technologies (e.g., IoT, AI-driven analytics, robotics) tailored to operational needs, conduct employee training to improve understanding and utilization of smart technology, linking it directly to operational improvements and regularly evaluate the ROI of smart technology to ensure its direct contribution to operational efficiency.

Leverage Interconnected Supply Chains (IT) as a Strength by building on this strength by integrating IT systems more deeply with smart technology (ST) to enhance supply chain visibility, traceability, and real-time communication, using IT to facilitate collaboration across departments and suppliers, ensuring seamless coordination and problem-solving and expand IT infrastructure to enable greater data sharing and connectivity for more dynamic supply chain management.

Improve Employee Engagement and Communication by actively involve employees in the planning and implementation of IT, IC, and ST systems to build trust and alignment, creating clear feedback loops where employees can share concerns and suggestions for improvement, providing regular updates on technological advancements and how they contribute to operational success, ensuring transparency and alignment.

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