Article

Optimizing Road Logistics and Global Supply Chain Integration in the Nigerian Beverage Industry: A Case Study of Bournvita Production in Lagos

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Abstract: This study investigates the influence of road infrastructure quality, freight transportation efficiency, global supply chain integration, and logistics technology on the operational performance of Cadbury Nigeria Plc. Chronic road logistics inefficiencies hinder Cadbury's global supply chain integration, limiting its ability to achieve consistent production and distribution performance. Beyond this analysis, it evaluates supply chain activities within the FMCG industry to provide broader and practical contributions. The research problem stems from persistent inefficiencies in Nigeria's FMCG sector, where poor transport infrastructure, rising logistics costs, and reliance on imported raw materials undermine efficiency. Anchored on the Theory of Constraints (TOC) and Lean Logistics Theory, the study emphasizes managing bottlenecks and minimizing waste while maximizing value creation. A population of 785 logistics and supply chain personnel was considered, with 265 respondents selected using stratified random sampling. A self-designed questionnaire was validated through expert review and pilot testing, and reliability was confirmed via Cronbach's Alpha (0.81–0.88). Multiple regression analysis revealed that freight transportation efficiency and road infrastructure quality significantly improved operational performance, while global supply chain integration and logistics technology showed no significant effect. The findings demonstrate that local infrastructural realities exert greater influence on FMCG operational performance than global integration efforts or costly digital systems, reinforcing the urgency of addressing Nigeria's infrastructural gaps. The study achieved its objective by empirically identifying the key drivers of logistics performance under constrained infrastructural conditions while also offering industry-relevant insights. Based on the findings, the study provides actionable recommendations, including targeted road infrastructure development through public–private partnerships, shared freight pooling among FMCG firms, adoption of scalable low-cost logistics visibility tools, and reducing dependence on imported raw materials through local sourcing. Overall, the study enriches academic discourse on logistics and supply chain management in constrained contexts while offering strategies for policymakers, industry stakeholders, and FMCG firms to enhance resilience and performance in Nigeria.

Keywords: road infrastructure quality; freight transportation efficiency; global supply chain integration; logistics technology; operational performance

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1. Introduction

In developed economies, the beverage manufacturing industry benefits from well-structured logistics and highly integrated supply chain systems, supported by modern infrastructure, digital technologies, and resilient freight networks. Countries such as the Netherlands, Germany, and the United States have achieved substantial efficiency in managing the road transport elements of their supply chains through strategic investments in multimodal transport, route optimization systems, and advanced supply chain visibility tools. For instance, in the Netherlands and Germany, logistics firms have successfully shifted freight loads from congested roads to inland waterways and rail networks, improving both efficiency and environmental sustainability (Pourmohammad Zia & Van Koningsveld, 2023). In the United States, AI-powered cold chain technologies are increasingly being adopted to ensure product integrity and reduce wastage in the food and beverage sector (Oriekhoe et al., 2023; Anaba et al., 2024). These advancements have enabled companies to respond more rapidly to market fluctuations, reduce lead times, and enhance supply chain resilience (Buhari et al., 2022).

Developed countries are also embracing digital twins, autonomous delivery systems, and emission-reduction technologies to optimize road logistics, reduce environmental impact, and enhance operational efficiency (Ogunmola & Arogundade, 2019). In South Africa, a leading African economy, the liquor industry has demonstrated how internal logistics synchronization and centralized control can buffer operational disruptions, reinforcing resilience during supply chain shocks (Wolmarans & Niemann, 2023; Monteiro & Barata, 2021).

In contrast, developing economies, particularly in sub-Saharan Africa, continue to struggle with inadequate logistics infrastructure, inconsistent regulatory frameworks, and operational inefficiencies. Nigeria exemplifies this situation, where the majority of the road network is in poor condition, leading to long delivery times, high operating costs, and fragile connections between production centers and consumer markets. According to Olanrewaju et al. (2023), over 70% of Nigerian roads are classified as poor or unserviceable, posing a significant risk to supply chain continuity.

This challenge is particularly critical for fast-moving consumer goods (FMCG) manufacturers such as Cadbury Nigeria Plc, which produces Bournvita, one of the country's most consumed beverages. Cadbury's manufacturing and distribution operations are centered in Lagos, Nigeria's economic capital, where the company must contend with deteriorating road infrastructure, frequent flooding, port congestion, and traffic gridlocks. These road-based limitations not only disrupt inbound logistics, especially the transportation of imported inputs like cocoa derivatives and packaging materials, but also affect outbound distribution of finished products to local markets (Onikoyi et al., 2021; Akella et al., 2023).

Compounding these challenges are global supply chain disruptions, including foreign exchange volatility, customs delays, and geopolitical shocks such as the COVID-19 pandemic and conflicts affecting international shipping routes. In the absence of robust logistics visibility systems and coordinated sourcing strategies, such challenges expose firms like Cadbury Nigeria to production delays, inventory shortages, and loss of market share (Ifekanandu & Asagba, 2025; Jang et al., 2024).

To explore these issues in greater depth, this study focuses on four key dimensions that shape logistics and supply chain performance in the Nigerian beverage industry. The first dimension is road infrastructure quality, which includes the condition of transport corridors, access to industrial zones, and the resilience of roads to weather-related disruptions. Second is freight transportation efficiency, which involves optimizing vehicle usage, reducing transit times, managing fuel costs, and coordinating delivery routes. The third dimension is global sourcing and input supply coordination, which pertains to the firm's ability to manage imports, supplier networks, and supply lead times across international borders. The fourth is logistics technology and supply chain visibility, which captures the extent to which firms deploy digital tools to track shipments, monitor inventory, and integrate supply chain operations (Niyi Anifowose et al., 2022).

The main objective of this study is to investigate how road infrastructure quality, freight transportation efficiency, global sourcing and input supply coordination, and logistics technology influence the operational performance of Cadbury Nigeria Plc's Bournvita production. Specifically, the study aims to identify the extent to which these four dimensions contribute to overcoming logistical bottlenecks and enhancing supply chain integration in the Nigerian beverage sector.

The research problem addressed in this study stems from the persistent inefficiencies and bottlenecks in Nigeria's logistics landscape. Despite the growing importance of FMCG firms, there remains limited empirical evidence on how poor road networks, inefficient freight transportation, fragile sourcing systems, and limited deployment of logistics technologies jointly undermine the performance of manufacturing firms. This study, therefore, seeks to bridge this gap by contextualizing global logistics and supply chain frameworks to the realities of Cadbury Nigeria Plc.

1.1 Identification of the Situation of the Beverage Production Sector in Nigeria

Nigeria's beverage manufacturing sector faces chronic challenges stemming from road logistics inefficiencies and unstable global supply chain dynamics. In the commercial hub of Lagos home to both the largest consumer market and the main production center of Cadbury Nigeria logistics operations are frequently interrupted by inadequate infrastructure, erratic traffic patterns, and weak institutional coordination. Cadbury's Bournvita, one of Nigeria's leading nutritional beverages, relies on a supply chain that spans both local and international sources. However, logistical problems across the entire value chain threaten its production continuity and delivery reliability.

On a practical level, poor road quality, traffic congestion, and flooding in key urban corridors in Lagos create costly delays in transporting raw materials and distributing finished goods. Trucks supplying or distributing Cadbury's products often face prolonged turnaround times, heightened fuel consumption, and increased maintenance costs. These inefficiencies, coupled with frequent disruptions at Apapa and Tin Can ports where key ingredients like cocoa, sugar, and flavoring agents are imported have a ripple effect on the company's ability to meet production targets and consumer demand (Akinbamini et al., 2025; Akazue et al., 2023; Villarreal et al., 2016).

Within the practical industry context, Cadbury also faces volatility in its global sourcing channels. Port bottlenecks, currency fluctuations, and customs inefficiencies pose a daily threat to production schedules, leading to stock-outs, underproduction, and erratic supply cycles. These weaknesses are further magnified by the lack of advanced logistics infrastructure in Nigeria, such as cold-chain systems for perishable inputs and centralized data platforms to monitor supply chain disruptions (Nwaulune, 2024; Ifekanandu, 2024; Prajogo et al., 2016). The logistics environment remains largely informal and fragmented, making it difficult for manufacturers to achieve real-time supply chain visibility or implement coordinated distribution strategies (Adu et al., 2023; Alshawabkeh et al., 2024; Tatarczak, 2024).

From a theoretical perspective, global logistics models often assume stable infrastructure and efficient institutional frameworks, which do not reflect the realities of developing economies like Nigeria. For example, the SCOR model's emphasis on process standardization and integration is hard to apply in an environment where many logistics providers lack digitized operations. Similarly, Lean Logistics Theory assumes a level of predictability and efficiency in transport systems that is rarely found in Lagos, where last-mile delivery times are subject to wide and unpredictable variance. The Theory of Constraints (TOC), which identifies system bottlenecks as performance limiters, is highly relevant in this context, but few studies have used TOC to analyze firm-level logistics performance in Nigeria's FMCG industry.

The empirical literature remains sparse when it comes to sector-specific analyses that integrate both global supply chain and local road logistics challenges. While general studies have noted Nigeria's transport and infrastructure problems (e.g., Kuteyi & Winkler, 2022; Tarigan et al., 2021), there is a lack of granular research that captures how these challenges impact specific products, firms, or operational strategies. There is little quantitative or qualitative data showing the extent to which road logistics conditions affect production timelines, input costs, or product quality in the beverage sector.

This study aims to close this gap by providing a comprehensive investigation of the relationship between road logistics and global supply chain integration in the context of Bournvita production in Lagos. It will explore how Cadbury Nigeria navigates both domestic and international logistical constraints and offer insights into how such firms can optimize their operations in an otherwise adverse logistics environment.

1.2 Hypotheses

H_{01}: There is no significant relationship between road infrastructure quality and the operational performance of Bournvita production in Lagos.

H_{02}: There is no significant relationship between freight transportation efficiency and the operational performance of Bournvita production in Lagos.

H_{03}: There is no significant relationship between global sourcing and input supply coordination and the operational performance of Bournvita production in Lagos.

H_{04}: There is no significant relationship between logistics technology and supply chain visibility and the operational performance of Bournvita production in Lagos.

2. Literature Review

2.1. Conceptual Framework

2.1.1 Optimizing Road Logistics

Optimizing road logistics involves the strategic enhancement of the efficiency, reliability, and cost-effectiveness of goods movement through road transport. This includes improving infrastructure, vehicle routing, fleet management, delivery scheduling, and digital monitoring, with the goal of reducing delays and operational costs while ensuring service excellence across the supply chain (Akazue et al., 2023). In developed nations, such optimization is achieved through intelligent transport systems (ITS), GPS tracking, predictive analytics, and transport management software, enabling real-time adjustments and seamless integration across logistics operations (Ofoegbu & Ekeh, 2023). These tools enhance delivery precision, fuel efficiency, and supply chain responsiveness (Mose et al., 2024).

However, such technological integration remains limited in developing countries like Nigeria due to infrastructural and institutional challenges (Okoduwa et al., 2024). Lagos, where Cadbury Nigeria Plc produces and distributes Bournvita, exemplifies Nigeria's logistics hurdles. The city grapples with chronic congestion, deteriorating roads, seasonal flooding, and minimal digital infrastructure (Mirabelli & Solina, 2022). Most logistics operations are still handled manually, resulting in inefficient delivery planning, high costs, and frequent delays (Ifekanandu, 2024).

For Cadbury Nigeria, road logistics optimization is vital for sustaining production and achieving market competitiveness. Efficient vehicle routing, delivery scheduling, and risk mitigation are critical in managing both inbound and outbound logistics within this challenging environment (Ifekanandu et al., 2024). This study fills key gaps by proposing context-specific logistics optimization strategies suited to Nigeria. It addresses the practical gap of unstructured logistics planning in local FMCG firms, the contextual gap where global models are poorly adapted to Nigerian conditions, and the theoretical gap in applying optimization theory to Africa's transport challenges. It also bridges the empirical gap by providing firm-level evidence from Cadbury's operations and the policy gap by offering insights that inform infrastructure planning and digital adoption (Edim & Inyang, 2022).

Ultimately, the research aims to demonstrate that, even under infrastructural limitations, effective road logistics optimization can significantly improve operational performance in Nigeria's beverage manufacturing sector.

2.1.2 Global Supply Chain Integration

Global supply chain integration refers to the coordinated alignment of processes, information, and logistics activities across international supply networks to ensure efficiency, responsiveness, and adaptability. It involves synchronizing procurement, inventory management, production planning, and delivery systems across borders to reduce lead times, enhance visibility, and improve cost-effectiveness (Zhang et al., 2024a). In advanced economies, this integration is supported by robust digital infrastructure, efficient transport systems, real-time data sharing, and strong supplier collaboration (Rejeb et al., 2020). Manufacturers in countries like Germany and Japan, for instance, rely on digitized logistics platforms and just-in-time delivery models that enable seamless coordination with global suppliers (Kopishynska et al., 2023).

In contrast, firms in developing economies such as Nigeria face significant challenges in integrating into global supply chains. Constraints such as port congestion, customs delays, unreliable IT systems, foreign exchange limitations, and poor transport connectivity hinder effective coordination (Ajayi et al., 2021). For Cadbury Nigeria Plc, which relies on imported inputs like cocoa derivatives, sugar, and packaging materials, these challenges manifest as frequent supply delays, production disruptions, and increased costs (Adu et al., 2023). Imports routed through ports like Apapa and Tin Can are often delayed due to infrastructural bottlenecks and regulatory inefficiencies (Akazue et al., 2023).

To succeed, Cadbury Nigeria must develop strategies to align global sourcing with domestic logistics realities. This requires coordinated efforts among international suppliers, freight agents, customs authorities, and local distributors (Kaur et al., 2019). The study identifies global supply chain integration as a critical operational pillar for Bournvita production, examining how supply delays, currency instability, and regulatory hurdles affect production flow (Kuteyi & Winkler, 2022).

This research addresses key gaps: operationally, by analyzing how firms align global procurement with weak local infrastructure; contextually, by adapting global models to Nigeria's realities; empirically, by offering firm-level data on supply disruptions; strategically, by uncovering risk-mitigation tactics; and in policy, by providing evidence-based recommendations for improving Nigeria's trade and logistics systems to support manufacturing competitiveness (Adu et al., 2023).

2.1.3 Freight Transportation Efficiency

Freight transportation efficiency refers to the ability to move goods in a timely, cost-effective, and resource-optimized manner across a logistics network. It encompasses not only the physical movement of freight but also how well transport systems utilize fuel, labor, capacity, and infrastructure to reduce transit times, minimize wastage, and enhance productivity (Nugroho et al., 2023). In developed logistics ecosystems, freight efficiency is driven by integrated multimodal networks, predictable transit schedules, optimized vehicle loading, reduced idle time, and advanced fleet management technologies (Adu et al., 2023). These systems support just-in-time (JIT) delivery models and enable companies to lower freight costs while maintaining high service levels (Palazzo & Vollero, 2021a).

In Nigeria, however, freight transportation efficiency is significantly constrained by infrastructural decay, unpredictable traffic flows, port congestion, and poor intermodal connectivity (Akinbamini et al., 2025). For Cadbury Nigeria Plc, which moves large volumes of raw materials into Lagos and distributes finished Bournvita products nationwide, these inefficiencies translate into longer transit times, increased fuel consumption, and higher transportation costs (Zhang et al., 2024b). Vehicles often face delays at port terminals, navigate poorly maintained roads, and lack reliable scheduling mechanisms, leading to erratic deliveries and reduced asset utilization (Bayoumi et al., 2021).

To optimize freight efficiency, Cadbury Nigeria must manage vehicle routing, truck turnaround times, loading capacity, and maintenance schedules more precisely. This study considers freight efficiency a key dimension in evaluating operational resilience and supply chain responsiveness (Adu et al., 2023). It explores how factors such as truckload optimization, backhauling, real-time dispatching, and driver performance monitoring can improve reliability and lower logistics costs (Monteiro & Barata, 2021).

The study fills key gaps by highlighting firm-level freight inefficiencies in the beverage sector, which remain under-documented in Nigerian logistics literature. It also contextualizes global best practices within Lagos's urban logistics environment and proposes cost-effective interventions such as route reconfiguration, vehicle pooling, and digital dispatch systems that align with Nigeria's infrastructural limitations while enhancing Cadbury's logistics performance.

2.1.4 Logistics Technology and Supply Chain Visibility

Logistics technology and supply chain visibility refer to the deployment of digital tools and systems that enable real-time tracking, data sharing, and performance monitoring across the logistics network. These technologies enhance transparency, coordination, and responsiveness from procurement to final delivery (Bagheri et al., 2024a). Visibility tools such as GPS tracking, RFID, transport management systems (TMS), and enterprise resource planning (ERP) allow firms to anticipate disruptions, monitor shipment progress, optimize routes, and make data-driven decisions (Zorić et al., 2023a). In mature supply chains, these technologies are foundational to agility, traceability, and service reliability (Zhang et al., 2024b).

In Nigeria, logistics operations often lack real-time visibility due to low levels of technology adoption, unreliable connectivity, and fragmented systems (Fan et al., 2023). Many firms, including those in the fast-moving consumer goods (FMCG) sector, still rely on manual processes and paper-based records. For Cadbury Nigeria Plc, this absence of digital visibility creates blind spots across the inbound and outbound supply chain especially in monitoring truck movements, predicting delivery timelines, and managing inventory fluctuations (Onikoyi et al., 2021). These inefficiencies can lead to missed deliveries, overstocks or stock outs, and increased operational uncertainty (Adebiyi et al., 2021).

This study examines how Cadbury Nigeria can leverage logistics technology to enhance supply chain visibility within the Bournvita production and distribution process. It explores the role of digital dashboards, route tracking applications, mobile delivery confirmations, and data analytics in improving control and forecasting accuracy (Mose et al., 2024). Particular attention is given to how these tools can be implemented cost-effectively in Lagos, where infrastructural and institutional challenges persist.

By doing so, the research addresses a critical technological gap in Nigeria's manufacturing logistics, demonstrating how digital innovations can be localized to overcome road congestion, uncertain delivery timelines, and fragmented communication. It also contributes to the broader discourse on digital transformation in emerging markets by offering insights into the operational impact of visibility tools on efficiency, cost reduction, and customer service in the Nigerian beverage industry (Mose et al., 2024).

2.1.5 Operational Performance

Operational performance refers to the effectiveness and efficiency with which an organization utilizes its resources to deliver products or services that meet customer expectations and business objectives. It encompasses key performance metrics such as productivity, cost control, quality, delivery timeliness, inventory turnover, equipment utilization, and customer satisfaction (Ofoegbu & Efeh, 2023). High operational performance indicates that a company is not only minimizing waste and reducing costs but also maximizing output quality, meeting demand consistently, and adapting quickly to changes in supply or market conditions.

In manufacturing and logistics, operational performance is closely tied to how well a company manages input sourcing, production planning, transportation, warehousing, and distribution. The synergy among these components determines whether the firm can achieve optimal throughput, minimize downtime, and sustain competitive advantage (Ofoegbu & Efeh, 2023). In advanced economies, firms invest heavily in lean manufacturing, process automation, total quality management (TQM), and performance benchmarking to enhance both efficiency and responsiveness.

In developing countries like Nigeria, operational performance is often undermined by infrastructure challenges, supply chain disruptions, regulatory bottlenecks, and technology limitations. According to nationwide reviews, the manufacturing sector has struggled with high unsold inventory reaching ₦1.24 trillion in H1 2024 and inconsistent raw material sourcing, reflecting troubling productivity and operational continuity issues (Akinbamini et al., 2025). Factors including port delays, erratic power supply, deteriorating road conditions, and limited supply chain visibility reduce reliability and hinder production flow for firms such as Cadbury Nigeria Plc.

This study positions operational performance as the outcome variable influenced by critical logistics dimensions like road infrastructure quality, freight transportation efficiency, global supply chain integration, and logistics technology adoption. By examining Bournvita production in Lagos, the research evaluates how disruptions in supply and delivery affect production schedules, inventory levels, and customer fulfillment. It also explores how Cadbury Nigeria employs strategies like strategic supplier partnerships, just-in-time inventory, and forward integration to bolster performance in resource-constrained environments (Onikoyi et al., 2021).

Ultimately, the research contributes practical and empirical insights into improving operational resilience and productivity in Nigeria's manufacturing landscape, illustrating how bottlenecks across logistics dimensions directly affect firm-level performance outcomes.

2.1.6 Supply Chain Disruptions

Supply chain disruptions are unplanned events that interrupt the normal flow of goods and services within global or local supply networks. They can arise from natural disasters, pandemics, geopolitical conflicts, infrastructure failures, or financial crises, and they often result in delays, shortages, and increased costs (Ivanov & Dolgui, 2021). Academic literature emphasizes that disruptions create a need for resilience strategies such as diversification, redundancy, and real-time risk monitoring (Chopra & Sodhi, 2021).

2.1.7 The Cold Chain System

The cold chain system is a temperature-controlled supply network designed to preserve the quality and safety of perishable products such as food, beverages, and pharmaceuticals. It integrates refrigerated production, storage, and transportation processes to maintain a stable environment from origin to consumer (Tiwari et al., 2020). Advances in IoT, blockchain, and AI-powered monitoring tools have strengthened cold chain visibility, minimizing spoilage and ensuring compliance with safety standards (Badia-Melis et al., 2023).

2.1.8 The SCOR Model

The Supply Chain Operations Reference (SCOR) model, developed by the Supply Chain Council, is a comprehensive framework for evaluating supply chain performance. It focuses on five core processes: Plan, Source, Make, Deliver, and Return (APICS, 2017). Scholars highlight its value in standardizing processes, benchmarking performance, and aligning supply chain strategies with organizational goals (Bolstorff & Rosenbaum, 2012). Recent studies also extend SCOR to sustainability and digital transformation contexts (Poluha, 2022).

2.1.9 Freight Transportation Efficiency

Freight transportation efficiency refers to the optimized movement of goods to reduce costs, minimize delays, and enhance resource utilization. This involves strategies such as multimodal transport, vehicle routing, load optimization, and fuel management (Palazzo & Vollero, 2021a). Efficiency is increasingly supported by digital dispatching and predictive analytics, which improve responsiveness and reduce carbon emissions (Zhang et al., 2024b).

2.1.10 Logistics Technology and Supply Chain Visibility

Logistics technology encompasses digital systems such as transport management systems (TMS), warehouse management systems (WMS), and RFID, which provide supply chain visibility. Visibility enhances transparency by enabling firms to track goods, anticipate delays, and respond to disruptions in real-time (Bagheri et al., 2024b). Studies show that visibility is strongly correlated with supply chain agility and resilience (Zorić et al., 2023a).

2.1.11 Operational Performance

Operational performance captures how effectively a firm uses resources to meet objectives such as cost efficiency, product quality, delivery timeliness, and customer satisfaction (Neely et al., 2005). In logistics and manufacturing research, operational performance is influenced by infrastructure quality, technological adoption, and supply chain coordination (Chowdhury et al., 2019).

2.1.12 Just in Time System and Just in Sequence System

The Just-in-Time (JiT) system is a lean production and logistics approach that seeks to minimize waste and improve efficiency by ensuring that materials, components, and finished goods are delivered precisely when they are needed, in the required quantities, and at the right location. Rather than maintaining large inventories, firms adopting JiT synchronize procurement and production schedules with actual demand. This reduces storage costs, prevents overproduction, and eliminates inefficiencies associated with excess handling. However, while JiT improves cost-effectiveness and operational responsiveness, it also heightens vulnerability to supply chain disruptions, as minimal inventory buffers leave little margin for delays or breakdowns in transport and supply. Successful application of JiT therefore requires accurate demand forecasting, strong supplier collaboration, and highly reliable logistics systems.

The Just-in-Sequence (JiS) system builds upon the principles of JiT by not only ensuring timely delivery but also guaranteeing that inputs arrive in the exact sequence in which they will be used in the production process. This sequencing capability is particularly important in industries where multiple product variants are assembled on a single line, such as automotive or electronics manufacturing. By ensuring that materials are pre-sequenced before reaching the assembly point, JiS eliminates the need for on-site sorting, thereby saving time and reducing operational complexity. JiS enables greater flexibility in responding to customized demand, but it also requires tighter supplier coordination, advanced digital systems for scheduling and tracking, and precise logistics execution. Any delay or disruption in the sequence can lead to significant bottlenecks, making reliability even more critical than in JiT systems.

In essence, while JiT emphasizes reducing inventory through timely delivery, JiS extends this efficiency by ensuring both timeliness and the correct order of input flows. Together, these systems highlight the strategic role of logistics efficiency, transport reliability, and technological integration in achieving operational excellence.

2.2 Theoretical Framework

This research is anchored on two interrelated theoretical foundations: The Theory of Constraints (TOC) and Lean Logistics Theory, both of which provide insights into optimizing supply chain processes to enhance operational performance. The Theory of Constraints, introduced by Goldratt (1984), posits that every complex system is limited in achieving its goals by at least one constraint. In the context of road logistics and supply chain integration, constraints such as poor infrastructure, port congestion, or delayed sourcing act as bottlenecks that impede throughput and operational efficiency. The identification and management of these constraints are essential for improving flow and ensuring timely delivery of goods.

Complementing TOC, Lean Logistics Theory emphasizes the elimination of waste (non-value-adding activities) and the continuous improvement of processes to enhance value delivery to customers (Womack & Jones, 1997). Lean principles such as just-in-time inventory, efficient routing, and synchronized supply flows are critical in managing variability and improving service levels. When applied to the Nigerian context where inefficiencies such as fuel shortages, traffic delays, and unreliable data systems abound lean logistics offers a framework for reducing redundancies, minimizing delays, and optimizing resource utilization.

The integration of these two theories enables a nuanced understanding of how firms like Cadbury Nigeria Plc can improve operational performance despite infrastructural and institutional constraints. TOC directs attention to system-wide constraints in inbound and outbound logistics, while Lean Logistics suggests practical strategies for waste reduction and process streamlining. This theoretical combination provides a robust lens through which the relationships between road infrastructure, freight efficiency, global sourcing coordination, logistics technology, and operational outcomes can be systematically analyzed.

2.3 Empirical Review

Empirical studies on road logistics optimization and global supply chain integration have highlighted varied outcomes across developed, developing, and Nigerian contexts. In developed economies, Pourmohammad-Zia and van Koningsveld (2023) conducted a logistics study in Amsterdam focusing on shifting urban freight from roadways to waterways. Though the specific sample size was not stated, their analysis, based on operational data and inferential statistics, revealed that the modal shift reduced travel distances by 80%, payload sizes by 43%, and logistics costs by nearly 28%. Similarly, Gupta et al., (2024) reviewed sustainable road freight practices across Germany and Japan, employing regression models to show that intelligent transport systems and real-time monitoring significantly improved cost-efficiency and reduced emissions in logistics networks.

In the context of developing economies, Mose et al., (2024) conducted a study in Kenya involving a sample of 228 supply chain managers in manufacturing firms. Using regression analysis, they reported a strong positive effect ($\beta = 0.769$; $p < 0.05$) of supplier visibility on operational performance. Their findings demonstrated that even in infrastructure constrained environments, strategic coordination and supply chain visibility can improve responsiveness and reduce delivery inconsistencies.

In Nigeria, several empirical studies offer localized insights. Nwaulune (2024) surveyed 519 logistics and operations managers, selected from a population of 13,782 staff across eight fast-moving consumer goods (FMCG) firms in Lagos. Utilizing multiple regression analysis (Adjusted $R^2 = 0.02$; $F(5, 496) = 3.31$; $p < 0.05$), the study found that the adoption of green logistics practices such as route optimization and eco-efficient transport planning positively affected operational sustainability.

Additionally, Onikoyi et al., (2021) examined the effect of supply chain management on performance in Nigeria's FMCG sector, using a purposive sample of 264 staff from Cadbury Nigeria Plc and Pepsi Cola Lagos. Through linear regression, the study revealed that strategic procurement, supplier partnerships, and customer engagement had statistically significant impacts on delivery efficiency, production continuity, and customer satisfaction ($p < 0.05$). These findings underscore the need for integrated sourcing and local logistics strategies to offset infrastructural limitations in Nigerian urban centers like Lagos.

Together, these empirical works highlight that while digital infrastructure and intermodal coordination drive performance in advanced economies, supply chain visibility and green logistics practices hold significant potential in developing and under-resourced settings. Specifically, Nigerian studies reveal how firms like Cadbury Nigeria Plc can enhance operational resilience through adaptive sourcing, better routing, and improved supply partnerships despite infrastructural and regulatory bottlenecks.

3. Methodology

This study utilized multiple regression analysis to investigate how four key dimensions' road infrastructure quality, freight transportation efficiency, global supply chain integration, and logistics technology affect the operational performance of Cadbury Nigeria Plc. The target population consisted of 785 logistics and supply chain personnel, including procurement officers, fleet managers, warehouse supervisors, and distribution planners engaged in Bournvita's production and distribution operations in Lagos.

To ensure proportional representation across Cadbury's functional logistics structure, a stratified random sampling technique was employed, grouping respondents into four strata: procurement, transportation, warehousing, and outbound distribution. Based on Krejcie and Morgan's (1970) sampling formula for finite populations, a sample size of 265 respondents was determined and selected accordingly.

Data were collected through a self-designed structured questionnaire specifically tailored to measure the four dimensions and their relationship with operational performance. The questionnaire also captured critical indicators of transportation efficiency such as route length, rolling stock load, and cargo box filling, which are vital parameters for evaluating freight optimization. Route length was measured in terms of average delivery distances covered during distribution, while rolling stock load assessed the degree of truck capacity utilization per trip. Cargo box filling was used to evaluate load factor efficiency by determining the extent to which available cargo space was effectively utilized during both inbound and outbound logistics movements. Collectively, these measures enabled a comprehensive evaluation of how transport resources were deployed in Cadbury's supply chain.

In addition, the study recognized the strategic relevance of lean logistics systems such as Just-in-Time (JiT**)** and Just-in-Sequence (JiS). JiT principles guided the analysis of how reduced inventory levels and synchronized deliveries influenced performance outcomes, while JiS highlighted the importance of delivering inputs not only on time but also in the precise sequence required for production. This ensured that the study accounted for the operational implications of scheduling accuracy and sequencing reliability in Cadbury's Bournvita production process.

To establish the credibility of the instrument, a pilot study involving 30 respondents (not included in the main sample) was conducted. Content validity was ensured by consulting three academic experts in transport and logistics, who reviewed the questionnaire for clarity, construct alignment, and relevance to industry practice. For reliability, Cronbach's Alpha values were computed using SPSS version 21, yielding coefficients of 0.83 for road infrastructure, 0.81 for freight transportation, 0.85 for global supply chain integration, 0.88 for logistics technology, and 0.86 for operational performance all exceeding Nunnally's (1978) 0.70 threshold for internal consistency.

After data collection, multiple linear regression analysis was employed to test the individual and combined influence of the independent variables on operational performance. The analysis incorporated transport efficiency indicators, including route length, rolling stock load, and cargo box filling, to provide nuanced insights into freight optimization and distribution efficiency. Statistical significance was tested at the 0.05 level, with interpretation focusing on R^2, Adjusted R^2, standardized coefficients, and the F-statistic to evaluate the explanatory strength of the model. This approach offered robust empirical evidence on how logistics practices, transport efficiency parameters, and lean distribution systems collectively influence Cadbury's operational performance.

As presented in Table 1**,** the model summary reveals that the regression model explains approximately 35.8% of the variance in operational performance, as indicated by the R Square value of 0.358. The Adjusted R Square of 0.348 suggests the model is appropriately fitted, with minimal inflation from the number of predictors. The R value of 0.598 shows a moderate positive relationship between the combined predictors—logistics technology, road infrastructure, freight transportation efficiency, and global supply chain integration—and operational performance. The model is statistically significant, as shown by an F-change of 36.271 and a p-value of 0.000, indicating that the independent variables collectively have a significant effect on the dependent variable. The standard error of 0.62386 is acceptable, suggesting a reasonable level of prediction accuracy. Furthermore, the Durbin-Watson statistic of 1.524 falls within an acceptable range, indicating no serious autocorrelation issues. Overall, the model is reliable and meaningful for explaining operational performance.

Table 1. Model Summary on Optimizing Road Logistics and Global Supply Chain Integration in the Nigerian Beverage Industry: A Case Study of Bournvita Production in Lagos

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.598[a]	.358	.348	.62386	.358	36.271	4	260	.000	1.524

a. Predictors: (Constant), Logistics Technology, Road Infrastructure, Freight Transportation Efficiency, Global Supply Chain Integration

Source: Field work, 2025 (SPSS V21)

As shown in Table 2**,** the ANOVA results indicate that the regression model is statistically significant in explaining variations in operational performance. The regression sum of squares is 56.467 with 4 degrees of freedom, while the residual sum of squares is 101.193 with 260 degrees of freedom. This indicates that a substantial portion of the total variation (157.660) in operational performance is explained by the model. The mean square for the regression is 14.117, and the F-statistic value of 36.271 is highly significant with a p-value of .000. This means that the combined effect of the independent variables—logistics technology, road infrastructure, freight transportation efficiency, and global supply chain integration—is statistically significant in predicting operational performance. In essence, the ANOVA confirms that the regression model fits the data well and that the predictors have a meaningful influence on the dependent variable.

Table 2. ANOVA on Optimizing Road Logistics and Global Supply Chain Integration in the Nigerian Beverage Industry: A Case Study of Bournvita Production in Lagos

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	56.467	4	14.117	36.271	.000[a]
1	Residual	101.193	260	.389		
	Total	157.660	264			

a. Predictors: (Constant), Logistics Technology, Road Infrastructure, Freight Transportation Efficiency, Global Supply Chain Integration

Source: Field work, 2025 (SPSS V21)

As presented in Table 3, the coefficients output provides further insight into the specific contributions of each predictor to operational performance. The results show the individual beta coefficients, t-values, and significance levels for logistics technology, road infrastructure, freight transportation efficiency, and global supply chain integration. Each coefficient indicates the strength and direction of the relationship between the predictor and operational performance. Variables with significant p-values demonstrate a meaningful effect on the dependent variable, confirming that improvements in these logistics components can enhance operational performance in the Nigerian beverage industry. Overall, the coefficients table complements the earlier findings by highlighting which specific factors most strongly drive performance outcomes.

Table 3. Coefficients on Optimizing Road Logistics and Global Supply Chain Integration in the Nigerian Beverage Industry: A Case Study of Bournvita Production in Lagos

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.656	.372		1.766	.079	-.076	1.388					
	Road Infrastructure	.219	.082	.146	2.690	.008	.059	.380	.343	.165	.134	.833	1.201
	Freight Transportation Efficiency	.654	.067	.534	9.755	.000	.522	.787	.583	.518	.485	.824	1.213
	Global Supply Chain Integration	-.006	.034	-.011	-.161	.872	-.073	.062	.095	-.010	-.008	.563	1.775
	Logistics Technology	-.009	.037	-.017	-.252	.801	-.083	.064	.138	-.016	-.013	.541	1.849

Source: Field work, 2025 (SPSS V21)

As indicated in Table 4, the coefficient correlation matrix presents the relationships among the independent variables in the regression model. Logistics technology has a strong negative correlation with global supply chain integration (r = –0.643), indicating a potential inverse relationship between these two variables within the context of the study. A moderate negative correlation is also observed between road infrastructure and freight transportation efficiency (r = –0.349), suggesting that as road infrastructure improves, freight efficiency may not necessarily increase proportionally—possibly due to other limiting factors. Road infrastructure has a slight positive correlation with global supply chain integration (r = 0.102), while freight transportation efficiency and logistics technology show weak negative correlations with each other and with other variables. The generally low to moderate correlations and small covariances indicate limited multicollinearity among predictors, affirming the robustness of the regression model. This supports the conclusion that each variable contributes uniquely to explaining variations in operational performance.

Table 4. Coefficient Correlations on Optimizing Road Logistics and Global Supply Chain Integration in the Nigerian Beverage Industry: A Case Study of Bournvita Production in Lagos

Model			Logistics Technology	Road Infrastructure	Freight Transportation Efficiency	Global Supply Chain Integration
1	Correlations	Logistics Technology	1.000	-.170	-.085	-.643
		Road Infrastructure	-.170	1.000	-.349	.102
		Freight Transportation Efficiency	-.085	-.349	1.000	-.082
		Global Supply Chain Integration	-.643	.102	-.082	1.000
	Covariances	Logistics Technology	.001	-.001	.000	-.001
		Road Infrastructure	-.001	.007	-.002	.000
		Freight Transportation Efficiency	.000	-.002	.005	.000
		Global Supply Chain Integration	-.001	.000	.000	.001

Source: Field work, 2025 (SPSS V21)

4. Discussion of Findings

The findings of this study reveal nuanced insights when compared with prior empirical research across both developed and developing contexts. Regarding road infrastructure quality, earlier studies from advanced economies such as Germany and China (Zhang et al., 2024b) consistently highlight its positive influence on logistics performance, citing reduced transit time and cost efficiency as core benefits. Similarly, (Kuteyi & Winkler, 2022), in a study involving 212 Kenyan logistics professionals, confirmed a strong relationship between road infrastructure and operational success in FMCG sectors. This study supports those findings, as road infrastructure quality was found to significantly influence Cadbury Nigeria's operational performance ($\beta = 0.219$, $p = 0.008$), affirming its critical role even within a constrained Nigerian context.

With respect to freight transportation efficiency, previous research emphasizes its foundational role in ensuring timely delivery and optimal inventory flow. For instance, Ifekanandu & Asagba (2025), studying 245 logistics staff in Lagos, Nigeria, found that efficient freight operations enhanced manufacturing competitiveness. The current study echoes this outcome, showing freight efficiency as the strongest predictor ($\beta = 0.654$, $p < 0.001$) of Cadbury's performance, reinforcing the centrality of optimized transport logistics.

Conversely, findings diverge on global supply chain integration. In high-income economies, integration enhances supply visibility and coordination (Dora et al., 2022). However, Adebiyi et al., (2021) reported integration challenges in Nigeria due to port congestion and regulatory delays. The present study aligns with this context-specific reality, as global supply chain integration was not statistically significant ($\beta = -0.006$, $p = 0.872$), suggesting that without reliable local infrastructure, global sourcing advantages may be undermined.

Finally, logistics technology, though transformative in developed countries (Kopishynska et al., 2023), showed no significant effect in this study ($\beta = -0.009$, $p = 0.801$). This supports Onwuchekwa and Nwanyanwu (2024) findings that technological adoption in Nigeria's logistics sector remains low due to infrastructure deficits and inadequate digital capacity.

5. Contribution to Knowledge

This research contributes significantly to the body of knowledge by contextualizing global supply chain and logistics optimization theories within a developing economy, specifically Nigeria's manufacturing sector. Unlike previous studies predominantly grounded in stable infrastructure environments, this study applies multiple regression analysis to demonstrate how road infrastructure quality and freight transportation efficiency significantly influence operational performance, while logistics technology and global supply chain integration show limited impact under infrastructural constraints. The research further introduces a practical framework that aligns international procurement with local distribution realities, offering empirical evidence from Cadbury Nigeria Plc. By bridging theoretical models with Nigeria's complex logistics terrain, it expands scholarly understanding of how firms can adapt Lean Logistics and the Theory of Constraints in fragile environments. This localized insight not only fills empirical gaps in African supply chain literature but also offers actionable strategies for manufacturers and policymakers operating in similar contexts.

6. Limitations of the Study

This study is not without limitations. First, it focuses solely on Cadbury Nigeria Plc's Bournvita operations in Lagos, which may limit the generalizability of findings to other FMCG firms or regions with different logistical challenges. Second, the study relied on self-reported data collected through structured questionnaires, which may be subject to respondent bias or misinterpretation. Additionally, while the study employed multiple regression analysis to determine causal relationships, it did not explore potential mediating or moderating variables such as regulatory influence or supply chain resilience strategies. The study also did not account for seasonal variations in road conditions or fluctuations in global supply chain disruptions. Lastly, the use of cross-sectional data restricts the ability to capture dynamic changes in logistics performance over time. Future studies could adopt longitudinal approaches or comparative multi-firm analyses to enhance the depth and applicability of the findings.

7. Conclusion and Recommendations

This study investigated the influence of four critical dimensions like road infrastructure quality, freight transportation efficiency, global supply chain integration, and logistics technology on the operational performance of Cadbury Nigeria Plc, with particular focus on the Bournvita production and distribution chain in Lagos. The findings revealed that road infrastructure quality and freight transportation efficiency had statistically significant positive impacts on operational performance, confirming their centrality to the seamless movement of goods within urban and inter-urban Nigerian contexts. Conversely, global supply chain integration and logistics technology showed no significant effect, likely due to infrastructural limitations, foreign exchange volatility, and low technological adoption within the domestic logistics ecosystem.

These findings affirm that while local logistics factors (roads and freight efficiency) are pivotal to performance, systemic and digital barriers continue to undermine the broader benefits of global integration and technological innovations.

7.1 Recommendations

1. **Develop Context-Specific Public–Private Partnerships (PPPs) for Road Maintenance**

   The Federal Government of Nigeria, in collaboration with Cadbury Nigeria and other FMCG firms, should establish PPP frameworks specifically targeting the rehabilitation of access roads around industrial zones in Lagos (e.g., Agidingbi and Ikeja industrial estates) and major transport corridors leading to Apapa and Tin Can Island Ports. Such collaborations can involve joint funding, with FMCG companies contributing maintenance levies in exchange for reduced transport bottlenecks.

2. **Implement Shared Freight-Pooling Pilot Programs**

   Cadbury Nigeria, alongside other FMCG manufacturers such as Nestlé and Unilever, should pilot freight pooling initiatives to consolidate shipments moving along similar routes, particularly from Lagos to Northern markets (e.g., Abuja and Kano). This would reduce vehicle underutilization, cut fuel costs, and ease congestion, while enhancing timely deliveries.

3. **Adopt Low-Cost, Mobile-Based Visibility Tools**

   Instead of investing heavily in enterprise-wide ERP systems, Cadbury can adopt affordable mobile logistics platforms (e.g., Kobo360, Lori Systems, or Tracklist) to provide real-time tracking, proof of delivery, and inventory updates. These digital solutions, already active in Nigeria, offer scalability without the heavy financial burden of full ERP systems.

4. **Strengthen Supply Chain Resilience through Local Sourcing and Port Coordination**

   To minimize global supply chain disruptions, Cadbury Nigeria should gradually increase local sourcing of packaging materials and inputs while maintaining strategic relationships with multiple port operators. This includes leveraging bonded terminals and inland container depots to ease Apapa port congestion.

Together, these measures can significantly improve operational resilience, cost efficiency, and delivery reliability within Nigeria's complex logistics environment.

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