Effect of Supply Chain Risk Management Strategies on the Operational Performance of Manufacturing Firms in Dangote Cement Plc, Obajana Plant, Kogi State

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ABSTRACT

The operational performance of Dangote Cement Plc, Obajana Plant, a flagship manufacturing hub in Nigeria's cement industry, is critical for sustaining productivity, reliable deliveries, and cost efficiency in an increasingly volatile operating environment. Supply Chain Risk Management (SCRM), conceptualised in this study through three core dimensions, Risk Identification, Risk Assessment, and Risk Mitigation strategies is central to cushioning the plant against high-impact disruptions in raw material sourcing, production, and outbound logistics. This study examined the effect of SCRM strategies on operational performance, measured through productivity, delivery reliability, and cost efficiency. A cross-sectional survey design was adopted, and 210 copies of questionnaires were distributed to supply chain and logistics staff, procurement and inventory officers, and production or operations supervisors using stratified proportionate allocation based on Bowley's formula. A total of 156 copies of questionnaires were retrieved and found usable, yielding a response rate of 74.3%. Data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The results revealed that Risk Identification ($\beta = 0.398$, $p = 0.000$), Risk Assessment ($\beta = 0.258$, $p = 0.002$), and Risk Mitigation strategies ($\beta = 0.289$, $p = 0.001$) each exert a positive and statistically significant effect on operational performance, with the three constructs jointly explaining 76.1% of its variance ($R^2 = 0.761$). The findings demonstrated that robust SCRM capabilities substantially enhance productivity, strengthen delivery reliability, and improve cost efficiency at the Obajana Plant. The study recommends deeper institutionalisation of systematic risk identification, analytics-driven risk assessment, and proactive mitigation measures, supported by digital technologies and strategic supplier partnerships, to consolidate operational resilience in Nigeria's cement manufacturing sector.

Keywords: Risk Identification, Risk Assessment, Risk Mitigation, Supply Chain Risk Management, Operational Performance, Dangote Cement Plc.

INTRODUCTION

The escalating complexity and interconnectedness of the contemporary global economy profoundly define modern supply chain architecture, a reality particularly pronounced within capital-intensive manufacturing sectors such as cement production, necessitating exceptional reliance on seamless global logistics and secure raw material sourcing (Golobrodska, 2024; Thomas, 2023). This interwoven complexity, while fostering specialization, simultaneously introduces profound vulnerabilities that can severely impair operational performance. Operational performacne, which is fundamentally described by Sukdeo (2017) as a firm's efficiency and effectiveness in meeting goals and customer demands, is crucial for maintaining competitiveness. Globally, leading industrial nations have long recognized the necessity of robust Supply Chain Risk Management (SCRM). Countries like the United States, China, and Germany, as major global manufacturers and distributors, pioneered sophisticated SCRM practices, integrating cutting-edge technologies like Artificial Intelligence (AI) and Big Data analytics to enhance supply chain robustness across their key sectors (Jahin et al., 2023; Hu et al., 2024). Their advanced strategies, which prioritize diversification, strategic stockpiling, and technological

investment, are empirically demonstrated to contribute significantly to their economic resilience and superior performance (Okoye et al., 2023; Um & Han, 2021). The global success in mitigating major disruptions underscores that effective Risk Identification, Risk Assessment, and Risk Mitigation directly correlate with enhanced OPP and financial stability (Alkhatib & Momani, 2023).

This global recognition of SCRM's role has significant implications for industrial operations in developing regions. In Africa, manufacturing and large-scale industrial firms operate within environments characterized by unique structural weaknesses, including infrastructure deficits, institutional instability, and security challenges, which collectively escalate the probability and impact of risks (Asikhia et al., 2022; Hatami-Marbini et al., 2024). Studies across the continent, such as those by Kiarie et al. (2017) in Kenya, have underscored the significant positive influence of proactive Risk Identification strategies on manufacturing supply chain performance. Within this challenging African landscape lies Dangote Cement Plc, one of the largest manufacturing conglomerates and cement producers in Africa, with its Obajana Plant in Kogi State being a massive, asset-intensive facility. The plant's operational performance is central to both the company's regional dominance and Nigeria's infrastructure development. However, its operations are constantly exposed to context-specific local risks, including perennial challenges such as equipment breakdown, unreliable energy supply, communal disputes affecting raw material access, and logistical bottlenecks in product distribution (Aliu Ogbaini, 2025; Enumah, 2025). Unmitigated exposure to these threats can translate directly into diminished productivity, delayed delivery reliability, and eroded cost efficiency, which are the specific measures of operational performance employed in this study (Ekpudu et al., 2022; Sulaiman & Ganiyu, 2024).

A robust, systematic approach to Supply Chain Risk Management (SCRM) is advocated as the essential mechanism for buffering the Obajana Plant against these volatilities. SCRM, broadly defined by Obi & Fadun (2025) as the systematic process of identifying, assessing, mitigating, monitoring, and controlling risks to enhance organizational performance, is investigated through its three core sequential strategies: Risk Identification is defined by Paul (2023) as the foundational, systematic process of recognizing, understanding, documenting, and communicating the likelihood and potential impact of uncertain events that may disrupt operations. Its significance lies in its capacity to preemptively address internal factors like production risks and external factors like supplier unreliability, which is critical for maintaining consistent output and enhancing long-term operational effectiveness (Renault et al., 2016). Risk Assessment, described by Kaka et al. (2024) as the systematic process of analyzing and evaluating potential hazards and their consequences in operations, is the logical next step. Its importance is underscored by its function in providing a data-driven foundation to prioritize vulnerabilities. By quantifying the probability and severity of threats such as high-impact equipment failures, managers can optimize resource allocation, which directly contributes to safeguarding Cost Efficiency (Song et al., 2025).

Risk Mitigation Strategies are conceptualized by Arndt (2025) as the deliberate, proactive implementation of actionable plans, including reduction, avoidance, transfer, and acceptance, to minimize the impact of identified and assessed threats. Tullio (2024) emphasized their significance in proactively reducing vulnerability through measures like supplier diversification and contingency planning. Effective mitigation is crucial for ensuring business continuity and bolstering Delivery Reliability amidst logistical challenges (Asikhia et al., 2022). Given the volatile operating environment of the Nigerian manufacturing sector and the strategic importance of Dangote Cement's Obajana Plant, this study seeks to empirically validate the extent to which the systematic adoption of SCRM dimensions (risk identification, risk assessment, and risk mitigation) can serve as a robust capability to enhance the firm's Operational Performance, thereby providing evidence-based insights for strategic management decisions.

Dangote Cement's Obajana Plant operates in a high-stakes, volatile environment where operational stability measured by productivity, delivery reliability, and cost efficiency is under constant threat. Locally, the plant faces equipment breakdowns, energy deficits, and logistical bottlenecks (Enumah, 2025). These issues are compounded by a collapsing macroeconomic climate. Nigeria's inflation hit a 24-year high of 31.7% in 2024, and power sector inefficiencies drain the economy of $29 billion annually (Okegbemi, 2024). For Obajana, this means hyper-inflated procurement costs and astronomical expenses for captive power generation, which directly erode profit margins and disrupt production cycles. The core problem is the empirical gap regarding how

structured Supply Chain Risk Management (SCRM) specifically Identification, Assessment, and Mitigation can actually insulate a large-scale Nigerian manufacturing firm from these specific shocks. Most research remains generic or focused on oil and gas (Asikhia et al., 2022), leaving cement producers without a data-driven roadmap. This study fills that void, providing the quantitative evidence needed to justify SCRM investments as a survival and performance strategy in a turbulent economy. The main objective of this research is to empirically assess the effect of Supply Chain Risk Management (SCRM) strategies on the Operational Performance of Dangote Cement Plc, Obajana Plant. The specific objectives are to:

i. Examine the effect of Risk Identification on the Operational Performance of Dangote Cement Plc, Obajana Plant.

ii. Assess the effect of Risk Assessment on the Operational Performance of Dangote Cement Plc, Obajana Plant.

iii. Evaluate the effect of Risk Mitigation strategies on the Operational Performance of Dangote Cement Plc, Obajana Plant.

To guide the research, the following null hypotheses are proposed:

H_{01}: Risk Identification has no significant effect on the Operational Performance of Dangote Cement Plc, Obajana Plant.

H_{02}: Risk Assessment has no significant effect on the Operational Performance of Dangote Cement Plc, Obajana Plant.

H_{03}: Risk Mitigation strategies have no significant effect on the Operational Performance of Dangote Cement Plc, Obajana Plant.

Conceptual Explanations for Variables

Operational Performance: Operational Performance is a multidimensional construct that measures how effectively and efficiently a manufacturing firm utilizes its resources, human, material, financial, and technological to execute its core activities and achieve its strategic objectives (de Oliveira, 2025; Buzinkay, 2024). It involves the management, measurement, and monitoring of key activity areas to ensure efficient execution (Al Majali, 2023). Consistent with Nigerian manufacturing evidence and focusing on post-COVID efficiency outcomes, operational performance is specifically measured through: Productivity, reflecting the optimization of processes to maximize output and minimize waste (Khosrow-Pour, 2018); Delivery Reliability, which assesses the consistency of delivering products or shipments on time and accurately (Faizal and Palaniappan, 2014); and Cost Efficiency, which evaluates the firm's ability to manage its supply chain costs within or below budget, directly reflecting the success of risk mitigation in preventing expensive operational disruptions (Nyamah et al., 2023).

Supply Chain Risk Management (SCRM): Supply Chain Risk Management (SCRM) strategies serve as the collective independent variables in this study, systematically influencing the efficiency of operations. SCRM is conceptualized as the systematic and proactive methodology employed by organizations, such as Dangote Cement Plc, to manage uncertainties throughout their value chain, ensuring operational continuity and enhanced performance (Obi & Fadun, 2025; Andeobu et al., 2015). This process is structurally divided into sequential dimensions, beginning with the identification of risks.

Risk Identification: **Risk Identification** is defined as the foundational, systematic, and proactive process of detecting, comprehending, and formally documenting all potential internal and external events that could disrupt the firm's supply chain activities (Paul, 2023; Fozia, 2022). This initial step involves pinpointing the sources, characteristics, causes, and consequences of uncertain events, thereby enabling early detection and preparation critical for robust management (Renault et al., 2016).

Risk Assessment: Following identification, risk assessment is the systematic process of analyzing and quantifying the probability and potential severity of the documented risks (Kaka et al., 2024; Tran et al., 2018). The core objective of this stage is to evaluate the magnitude of potential harm, using either qualitative or quantitative metrics, to prioritize vulnerabilities. This process provides the data-driven basis necessary for optimizing resource allocation toward the most significant threats, such as high-impact equipment failures or feedstock shortages (Kilic et al., 2023).

Risk Mitigation Strategies: risk mitigation strategies represent the deliberate, proactive implementation phase, where actionable plans are developed and executed to reduce the likelihood and negative consequences of assessed threats (Arndt, 2025). These strategies, which include avoidance, reduction (like supplier diversification or contingency planning), transfer, and acceptance, are essential countermeasures focused on ensuring business continuity and operational resilience (Tullio, 2024; Asikhia et al., 2022).

Empirical Review of Related Studies

Risk Identification and Operational Performance

Empirical evidence consistently links robust risk identification with improved operational outcomes across diverse sectors. Asika et al. (2024) show that in Nigeria's oil and gas industry, systematically identifying high-frequency risks such as vandalism, spills, fire and security incidents is foundational for targeting appropriate control measures, even though their work is largely qualitative. Extending this logic, Saptarini and Nainggolan (2022) integrate ISO 31000 and historical data to prioritize price, production and contract risks in marginal oil and gas projects, demonstrating that clear identification enables value-preserving decisions. Quantitative studies further establish performance effects: Owusu and Ihunwo (2019) report significant relationships between risk identification and sales performance among petroleum marketers, while Paul (2023) finds that procurement risk identification improves procurement performance via better project delivery and cost control. In construction and public-sector supply chains, Nurwin (2022) and Wawire et al. (2022) show that structured identification practices such as supplier screening, procurement audits and inventory forecasting explained substantial variance in supply chain performance, particularly stock replenishment and reliability. Manufacturing-focused work by Ankhi (2017) and Kiarie et al. (2017) further confirms that comprehensive mapping and prioritisation of supply chain risks enhance supply continuity and overall performance. Collectively, these studies support treating risk identification as a critical precursor to improved operational performance in high-risk, asset-intensive environments similar to cement manufacturing.

Risk Assessment and Operational Performance

Risk assessment has also been empirically validated as a key driver of operational performance, particularly when embedded in structured analytical frameworks. Arıcan and Ünal (2025) demonstrate, in LPG/LNG maritime operations, that probabilistic assessment of human, mechanical and environmental faults using Delphi and fault tree analysis allows operators to quantify explosion risks and target high-impact failure modes, thereby informing more effective mitigation and safety outcomes. At a sectoral level, Animah and Shafiee (2020) synthesize risk analysis applications in LNG plants and terminals, showing that quantitative tools such as event tree analysis, fault tree analysis, FMEA and Bayesian networks strengthen decision-making by converting complex hazard profiles into measurable risk levels, although most studies stop short of explicit performance linkages. James and Renjith (2021) add that fuzzy risk matrices and LOPA-based assessments yield more precise safety integrity levels for LNG regasification terminals, underscoring that nuanced assessment improves the reliability of protective systems. In a closer parallel to manufacturing, Onoh et al. (2025) find that risk assessment operationalized through identifying, evaluating severity, prioritising and responding to risks has a strong, positive and statistically significant effect on non-financial performance of Nigerian manufacturing firms, explaining over two-thirds of performance variation. Together, these studies justify modelling rigorous, data-driven risk assessment as a core explanatory mechanism linking supply chain risk management to enhanced operational performance.

Risk Mitigation and Operational Performance

Risk mitigation strategies are widely shown to translate identified and assessed risks into tangible operational performance gains. Aliu Ogbaini (2025) reports that in Nigerian oil and gas supply chains, mitigation through technology integration, third-party logistics and structured risk management significantly improves operational efficiency and overall supply chain performance, with risk management emerging as the most effective driver. Organisation-level evidence from logistics by Ngii (2017) shows that formal mitigation practices, including contingency plans and proactive risk registers, are strongly associated with improved organisational performance. From a broader theoretical angle, Afifa and Santoso (2022) highlight that proactive mitigation via collaboration, re-engineering, contract design and agility enhances resilience and, in turn, efficiency, responsiveness and quality in food supply chains. Empirical Nigerian work by Asikhia et al. (2022) confirms that risk mitigation, alongside identification and assessment, significantly boosts business performance in downstream oil and gas firms, with stronger effects in larger organisations. Complementary studies in IT procurement (Harju et al., 2024), public health procurement (Omoruyi and Quayson, 2023), public works (Rusliadi et al., 2024) and project-based procurement (Rahimian, 2020) consistently show that timely, well-designed mitigation actions such as collaborative risk sharing, preventive controls and process redesign reduce disruptions, improve service outcomes and align procurement and operations with organisational goals, reinforcing the performance relevance of risk mitigation in complex supply chains.

Theoretical Framework

The underpinning theory for this study is the Resource-Based View (RBV) of the firm, primarily propounded and developed by Wernerfelt (1984) and later significantly advanced by Barney (1991). The RBV suggests that a firm's sustained competitive advantage and superior performance are derived not from industry structure, but from its unique bundle of valuable, rare, inimitable, and non-substitutable (VRIN) resources and capabilities (Barney, 1991). These resources are often intangible assets, and in the context of supply chain management, this is expanded to include organizational processes. The theory's strength is underscored by its shift of strategic focus from external industry analysis to internal resource development, offering a granular explanation for performance heterogeneity among similar firms (Peteraf, 1993).

However, the RBV has been criticized for being somewhat tautological, as the definition of a "valuable" resource is often based on the observation of superior performance it is supposed to explain (Priem & Butler, 2001). Furthermore, critics caution that the theory is static, offering less guidance on how resources should be developed or dynamically adjusted over time (Teece et al., 1997). The RBV best explains the relationship in this study by treating the Supply Chain Risk Management (SCRM) strategies, Risk Identification, Risk Assessment, and Risk Mitigation—not merely as routine processes, but as unique organizational capabilities developed by Dangote Cement (Obajana Plant). These capabilities are rare and inimitable within the volatile Nigerian manufacturing context and are leveraged to secure better Operational Performance metrics like productivity, delivery reliability, and cost efficiency (Hult et al., 2007). Therefore, a successful SCRM capability is a VRIN resource that provides a defensive competitive edge, allowing the firm to avoid disruptions and maintain stable operations better than competitors, thus underpinning this study and explaining the superior performance outcomes.

METHODOLOGY

This study employed a cross-sectional survey design to examine the effect of supply chain risk management strategies on the operational performance of Dangote Cement Plc at its Obajana Plant in Kogi State, Nigeria. The cross-sectional approach was chosen because it allows for the efficient collection of quantitative data from a large number of respondents at one point in time, making it possible to test the hypothesized relationships between risk identification, risk assessment, risk mitigation, and operational performance in a real-world manufacturing setting while keeping the research feasible in terms of time and resources.

The target population comprised all staff directly involved in supply chain, procurement, inventory, and production operations at Dangote Cement Plc’s Obajana Plant in Kogi State, Nigeria. Access to the plant’s updated human-resource records (obtained through official correspondence with the Head of Human Resources and dated October, 2025) revealed a total accessible population of 420 eligible employees who met the inclusion

criteria of having at least two years of continuous involvement in supply-chain-related functions or direct supervisory responsibility over production and materials-flow processes.

This study employed stratified random sampling with proportionate allocation using Bowley's proportional allocation formula (Bowley, 1926) to determine the number of respondents from each stratum. The accessible population of 420 eligible employees was first divided into four mutually exclusive and collectively exhaustive strata based on primary job function and level of responsibility. Bowley's formula was then applied to allocate the desired sample size proportionally across the strata while rounding to the nearest whole number for practical administration, as presented in Table 1.

Table 1: Stratification and Sample Allocation

Stratum	**Description**	**Population size (N)**	**Proportion of population (%)**	**Sample Allocated (n)**
1	Supply chain and logistics staff	138	32.9	69
2	Procurement and inventory officers	102	24.3	51
3	Production and operations supervisors	124	29.5	62
4	Sectional heads/managers with direct oversight of the above functions	56	13.3	28
Total		420	100.0	210

Source: Dangote Cement Plc, Obajana Plant Human Resource Records (official data obtained from the Head of Human Resources, October 2025) and researcher's compilation, 2025.

Data were collected through a structured questionnaire that combined physical distribution during shift changes and a secure online version accessible via Google Forms to accommodate the plant's continuous operations and varying work schedules. The instrument used a five-point Likert scale ranging from Strongly Agree (5) to Strongly Disagree (1) and measured four constructs in the following sequence: Risk Identification (RIID1–RIID5), Risk Assessment (RIAS1–RIAS5), Risk Mitigation (RIMI1–RIMI5), and Operational Performance (OPPF1–OPPF5). Items for the supply chain risk management dimensions were adapted and contextualized from the established frameworks of Hallikas et al. (2004), Ritchie and Brindley (2007), and Wu et al. (2006), whereas the operational performance items, which focused on productivity, delivery reliability, and cost efficiency, were drawn from recent Nigerian manufacturing studies by Ekpudu et al. (2022) and Sulaiman and Ganiyu (2024) to reflect post-COVID realities in the cement sector. All constructs demonstrated strong internal consistency, with Cronbach's alpha values of 0.896 for Operational Performance, 0.901 for Risk Mitigation, 0.882 for Risk Assessment, and 0.863 for Risk Identification, comfortably exceeding the conventional threshold of 0.70.

Data analysis was performed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS 3 software because of its robustness with non-normal data, its effectiveness with complex predictive models, and its suitability for the achieved sample size. The analysis followed the recommended two-stage process: assessment of the measurement model for reliability and validity, followed by evaluation of the structural model through path coefficients, R^2, effect sizes, predictive relevance, and bootstrapping with 5,000 subsamples. Throughout the study, ethical standards were strictly observed, including voluntary participation, informed consent, anonymity, and confidentiality of responses, in full compliance with the guidelines of the National Health Research Ethics Committee and the researcher's institutional review board. The conceptual model tested direct paths from risk identification, risk assessment, and risk mitigation to operational performance. The model diagram of the study below:

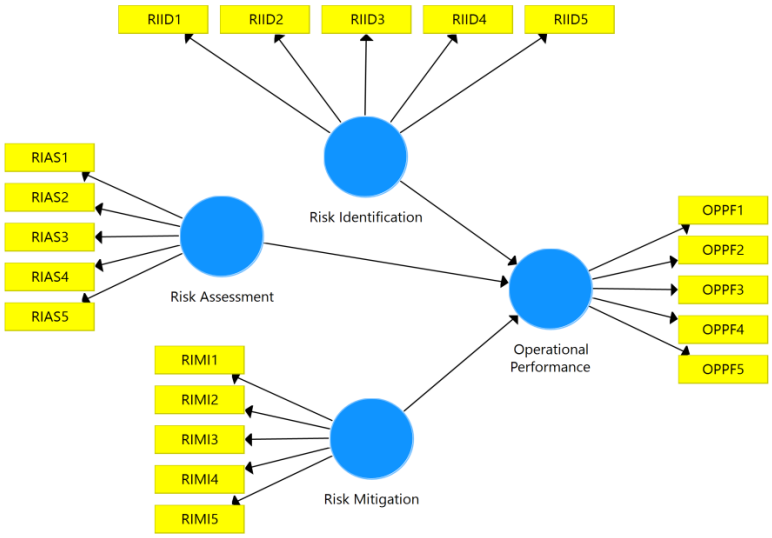

Figure 1: Model of the study

Source: SmartPLS Output, 2025.

RESULTS AND DISCUSSIONS

A total of 210 copies of questionnaires were distributed to respondents based on Bowley's proportionate allocation. Out of these, 156 copies of questionnaires were retrieved, representing a 74.3% response rate. After screening for completeness, consistency, and missing values, all 156 copies were found valid and were included in the final analysis. This provides a reliable basis for interpreting the study's results and examining the effect of Supply Chain Risk Management strategies on operational performance at Dangote Cement Plc, Obajana Plant.

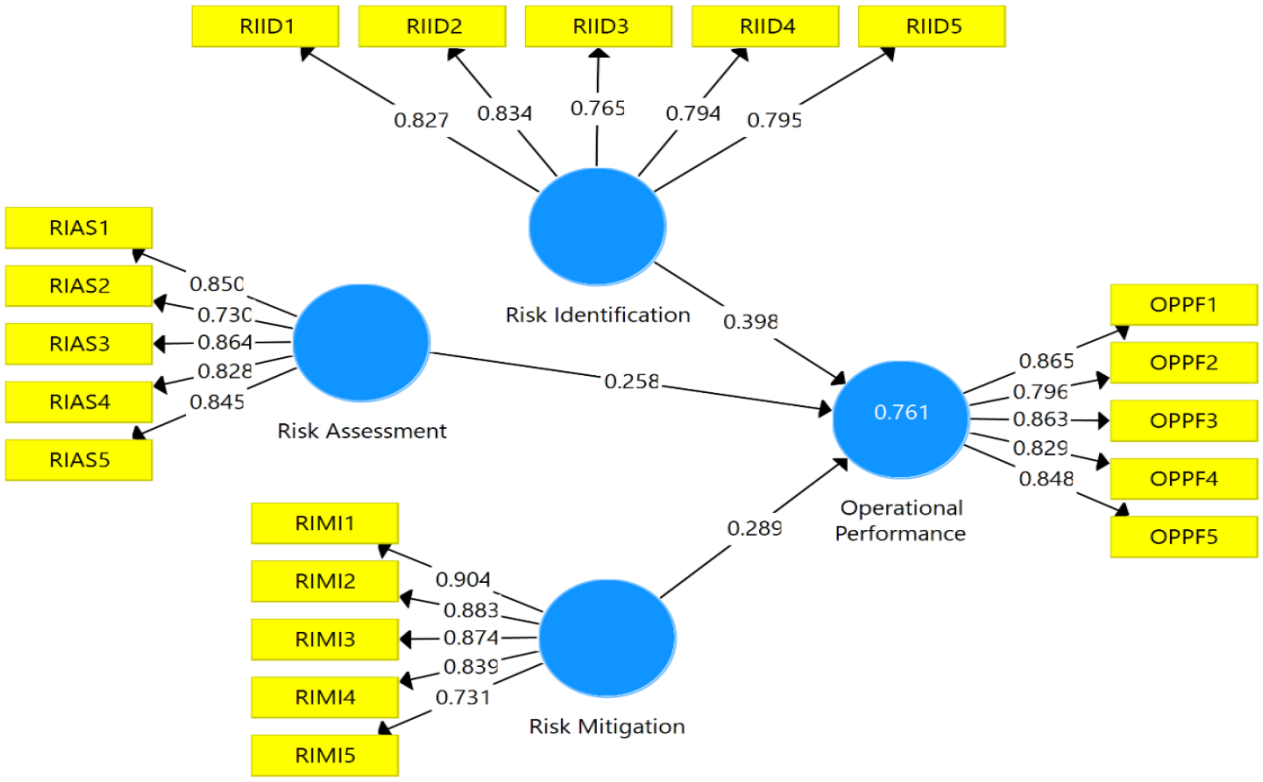

Figure 2: Factor Loadings

Source: Smart PLS Output, 2025.

Table 2: Factor Loadings

Construct	Item	Items	Factor Loading
Risk Identification (RIID)	RIID1	Our team identifies supply risks early before they affect operations.	0.827
	RIID2	Potential disruptions in material supply are clearly identified regularly.	0.834
	RIID3	Staff promptly report risks affecting production and logistics performance.	0.765
	RIID4	We apply structured methods to identify key operational supply risks.	0.794
	RIID5	Supplier risk information is consistently captured and properly documented.	0.795
Risk Assessment (RIAS)	RIAS1	Identified risks are evaluated based on likelihood and operational impact.	0.850
	RIAS2	High-priority risks are ranked clearly for management attention and response.	0.730
	RIAS3	We assess how each risk may disrupt production processes significantly.	0.864
	RIAS4	Risk assessment outcomes guide day-to-day operational decision making.	0.828
	RIAS5	Staff understand how assessed risks influence logistics and deliveries.	0.845
Risk Mitigation (RIMI)	RIMI1	We implement effective strategies to minimise major supply chain risks.	0.904
	RIMI2	Alternative sourcing or routes are activated when disruptions occur.	0.883
	RIMI3	Safety stock levels help reduce material shortages and production delays.	0.874
	RIMI4	Mitigation measures are updated after reviewing previous disruptions.	0.839
	RIMI5	Our teams respond quickly when risks begin affecting daily operations.	0.731
Operational Performance (OPPF)	OPPF1	Our production output consistently meets established operational targets.	0.865
	OPPF2	Customer deliveries are completed reliably within expected lead times.	0.796

	OPPF3	Operational costs are controlled effectively without reducing quality.	0.863
	OPPF4	Logistics disruptions have reduced significantly compared to previous years.	0.829
	OPPF5	Overall operational efficiency improved after applying risk management strategies.	0.848

Source: SmartPLS Output, 2025.

Table 2 presents the measurement model assessment for the effect of supply chain risk management strategies on the operational performance of Dangote Cement Plc, Obajana Plant. All factor loadings exceed the recommended threshold of 0.70 (Hair et al., 2019), confirming strong indicator reliability. Risk Identification (RIID) loadings range from 0.765–0.834 (>0.70; Hallikas et al., 2004), with RIID2 (0.834) reflecting regular disruption identification and RIID3 (0.765) the lowest yet acceptable loading for prompt staff reporting. Risk Assessment (RIAS) ranges from 0.730–0.864 (>0.70; Ritchie & Brindley, 2007), where RIAS3 (0.864) captures production disruption evaluation and RIAS2 (0.730) remains satisfactory for priority ranking. Risk Mitigation (RIMI) exhibits the highest loadings (0.731–0.904; Wu et al., 2006), led by RIMI1 (0.904) on strategy implementation and RIMI5 (0.731) on rapid response. Operational Performance (OPPF), measured via productivity, delivery reliability, and cost efficiency (Ekpudu et al., 2022; Sulaiman & Ganiyu, 2024), ranges from 0.796–0.865 (>0.70; Fornell & Larcker, 1981), with OPPF1 (0.865) strongly representing production target achievement and OPPF2 (0.796) delivery reliability. These consistently high and significant loadings confirm convergent validity and provide a solid foundation for subsequent structural model testing using PLS-SEM.

Table 3: Construct Reliability and Validity

Construct	**Cronbach's Alpha**	**rho_A**	**Composite Reliability**	**Average Variance Extracted (AVE)**
Risk Identification	0.863	0.870	0.901	0.645
Risk Assessment	0.882	0.893	0.914	0.680
Risk Mitigation	0.901	0.904	0.927	0.719
Operational Performance	0.896	0.900	0.923	0.706

Source: SmartPLS Output, 2025.

Table 3 presents the construct reliability and validity results for all variables in the study on the effect of supply chain risk management strategies on the operational performance of Dangote Cement Plc, Obajana Plant, Kogi State. All constructs exhibit excellent internal consistency, with Cronbach's Alpha values ranging from 0.863 to 0.901, well above the recommended threshold of 0.70 (Hair et al., 2019; Nunnally & Bernstein, 1994). Composite Reliability scores are equally strong, ranging from 0.901 (Risk Identification) to 0.927 (Risk Mitigation), confirming high reliability of the measurement scales. The Average Variance Extracted (AVE) for each construct exceeds the required minimum of 0.50 (Fornell & Larcker, 1981), ranging from 0.645 (Risk Identification) to 0.719 (Risk Mitigation). The particularly high AVE of 0.706 for Operational Performance (measured through productivity, delivery reliability, and cost efficiency) reflects strong convergent validity and aligns with established performance metrics in the Nigerian manufacturing context. Overall, these results demonstrate that the measurement instruments are highly reliable and possess strong convergent validity. The measurement model is therefore robust and trustworthy, providing a solid foundation for subsequent discriminant validity checks (e.g., Fornell-Larcker criterion and HTMT ratios) and structural model evaluation using PLS-SEM.

Table 4: Heterotrait-Monotrait Ratio (HTMT)

Construct	**RISI**	**RISA**	**RSMS**	**RSMC**	**PNLN**
Risk Identification (RISI)					
Risk Assessment (RISA)	0.761				
Risk Mitigation Strategies (RSMS)	0.741	0.824			
Risk Monitoring and Control (RSMC)	0.755	0.751	0.800		
Performance of NLNG Company (PNLN)	0.808	0.772	0.795	0.804	

Source: SmartPLS Output, 2025.

Table 4 presents the Heterotrait-Monotrait Ratio (HTMT) results. All HTMT values were below the conservative threshold of 0.90 recommended by Henseler, Ringle, and Sarstedt (2015), thereby confirming discriminant validity across all constructs. The highest correlation observed was 0.824 (between Risk Assessment and Risk Mitigation Strategies), which is well within the acceptable limit. These results affirm that the four dimensions of Supply Chain Risk Management (RISI, RISA, RSMS, RSMC) and the dependent variable (PNLN) are empirically distinct constructs. This indicates that the constructs are sufficiently independent and measure unique functional and performance dimensions of the NLNG supply chain without excessive measurement overlap.

Table 5: Heterotrait-Monotrait Ratio (HTMT)

Construct	**Operational Performance**	**Risk Assessment**	**Risk Identification**	**Risk Mitigation**
Operational Performance				
Risk Assessment	0.587			
Risk Identification	0.606	0.558		
Risk Mitigation	0.589	0.630	0.541	

Source: SmartPLS Output, 2025.

Note: All HTMT values are below the conservative threshold of 0.85 (Hair et al., 2022; Henseler et al., 2015) and even below the stricter threshold of 0.90 commonly applied in PLS-SEM studies.

Table 5 confirmed discriminant validity using the Heterotrait-Monotrait Ratio (HTMT). The highest HTMT value observed is 0.630 (between Risk Assessment and Risk Mitigation), while correlations with the dependent variable Operational Performance range from 0.587 to 0.606, all well below the 0.85 cutoff. This indicates that each construct is empirically distinct from the others, despite their conceptual relatedness within the supply chain risk management domain. The model is therefore suitable and highly trustworthy for proceeding to structural model assessment and hypothesis testing.

Table 6: Structural Model Evaluation Results

Indicator	**Value**	**Interpretation / Threshold**
Collinearity Statistics (Inner VIF Values)		

Risk Identification → Operational Performance	2.571	< 5.0 (No multicollinearity concern)
Risk Assessment → Operational Performance	3.886	< 5.0 (No multicollinearity concern)
Risk Mitigation → Operational Performance	3.823	< 5.0 (No multicollinearity concern)
Coefficient of Determination (R^2 Values)		
Operational Performance (R^2)	0.761	Substantial predictive power (explains 76.1% variance)
Adjusted R^2	0.758	Reflects strong model fit after penalisation
Effect Size (f^2 Values)		
Risk Identification → Operational Performance	0.257	Large effect (Cohen, 1988)
Risk Mitigation → Operational Performance	0.091	Small effect
Risk Assessment → Operational Performance	0.072	Small effect
Model Fit Indices	Saturated Model	Estimated Model
SRMR	0.067	0.067
d_ULS	0.955	0.955
d_G	0.534	0.534
Chi-Square	836.058	836.058
Normed Fit Index (NFI)	0.826	0.826

Source: SmartPLS Output, 2025.

Table 6 presents the evaluation results of the structural model examining the effect of supply chain risk management strategies on the operational performance of Dangote Cement Plc, Obajana Plant, Kogi State. All inner VIF values are below the conservative threshold of 5.0 (Hair et al., 2022), ranging from 2.571 (Risk Identification) to 3.886 (Risk Assessment), confirming the absence of multicollinearity and the stability of the regression coefficients. The coefficient of determination (R^2) for Operational Performance is 0.761, meaning that the three dimensions of supply chain risk management (Risk Identification, Risk Assessment, and Risk Mitigation) jointly explain 76.1% of the variance in operational performance (measured through productivity, delivery reliability, and cost efficiency). The adjusted R^2 of 0.758 remains virtually unchanged, indicating a highly robust and parsimonious model with substantial explanatory and predictive power in the Nigerian cement manufacturing context.Effect size analysis (f^2) showed that Risk Identification exerts the strongest influence, with a large effect ($f^2 = 0.257$), followed by Risk Mitigation ($f^2 = 0.091$, small) and Risk Assessment ($f^2 = 0.072$, small). This highlights Risk Identification as the most critical driver of operational performance improvements at the Obajana Plant. Model fit indices further confirm the adequacy of the structural model. The SRMR value of 0.067 falls below the 0.08 threshold, and the NFI of 0.826 exceeds the acceptable level of 0.80 (Hair et al., 2022; Henseler et al., 2015), collectively demonstrating that the proposed model exhibits good fit to the empirical data. Taken together, these results provide strong statistical evidence that the structural model is reliable, free from estimation issues, and possesses high explanatory power, thereby offering a solid basis for hypothesis testing and interpretation of path coefficients in the subsequent analysis.

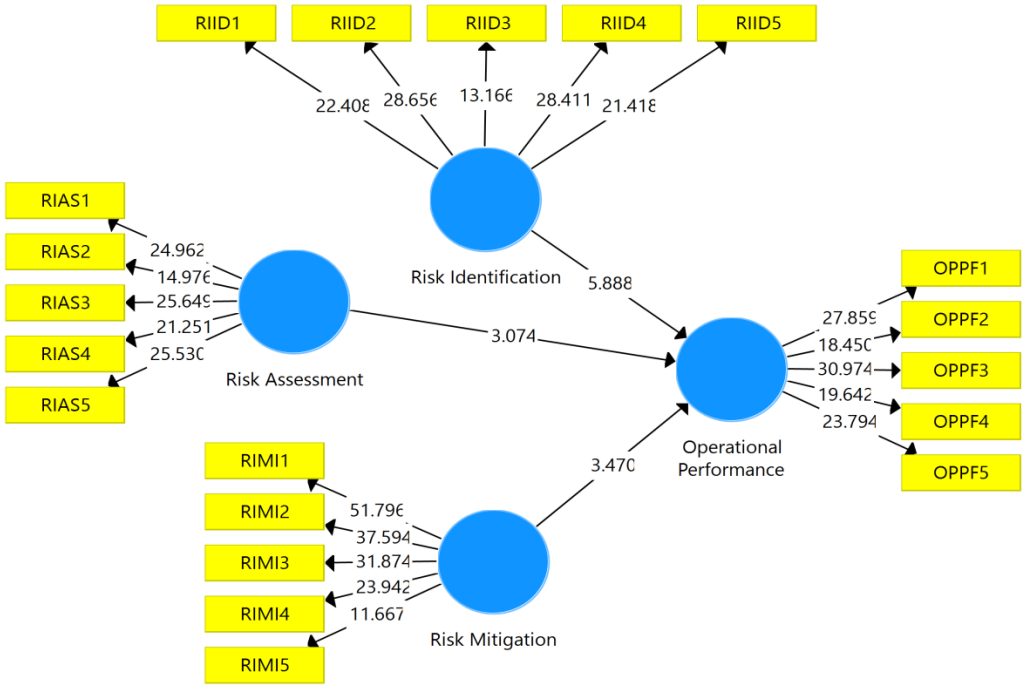

Fig. 3: Path Coefficients of the Regression Model

Source: SmartPLS Output, 2025.

Table 7: Path Coefficients and Hypothesis Testing Results

Path (Hypothesis)	Original Sample (O)	T Statistics	P Values	Decision
Risk Identification → Operational Performance	0.398	5.888	0.000	**Rejected** (significant effect)
Risk Assessment → Operational Performance	0.258	3.074	0.002	**Rejected** (significant effect)
Risk Mitigation → Operational Performance	0.289	3.470	0.001	**Rejected** (significant effect)

Source: SmartPLS 3 Output, 2025.

Key Findings

i. Risk Identification significantly and positively affects the operational performance of Dangote Cement Plc, Obajana Plant.

ii. Risk Assessment significantly and positively affects the operational performance of Dangote Cement Plc, Obajana Plant.

iii. Risk Mitigation strategies significantly and positively affect the operational performance of Dangote Cement Plc, Obajana Plant.

DISCUSSION OF FINDINGS

H_{01}: Risk Identification has no significant effect on the Operational Performance of Dangote Cement Plc, Obajana Plant.

The hypothesis was rejected, as the path coefficient of 0.398 with a t-value of 5.888 and p-value of 0.000 indicated a strong significant positive effect. This result implies that systematic and proactive identification of potential supply chain risks (e.g., raw material shortages, transportation disruptions, equipment failure, and energy supply volatility) is the most influential driver of operational performance at the Obajana Plant, directly enhancing productivity, delivery reliability, and cost efficiency. This finding aligns with empirical evidence from manufacturing and related sectors. Ankhi (2017) and Kiarie et al. (2017) confirmed that comprehensive risk identification and mapping are foundational to supply chain continuity and performance improvement. Similarly, Owusu and Ihunwo (2019) and Paul (2023) reported significant positive relationships between risk identification practices and performance outcomes in procurement and petroleum marketing in Nigeria. Nurwin (2022) and Wawire et al. (2022) further demonstrated that structured identification practices such as supplier screening and inventory forecasting significantly enhance reliability and replenishment efficiency, outcomes directly applicable to cement manufacturing operations.

H_{02}: Risk Assessment has no significant effect on the Operational Performance of Dangote Cement Plc, Obajana Plant.

The hypothesis was rejected, with a path coefficient of 0.258, t-value of 3.074, and p-value of 0.002, confirming a positive and significant effect. This suggests that rigorous evaluation and prioritization of identified risks provide management with actionable insights, enabling better resource allocation and preventive decision-making that ultimately improve productivity and cost efficiency at the Obajana Plant.These results are consistent with Onoh et al. (2025), who found that risk assessment practices (identifying, evaluating severity, and prioritizing risks) exert a strong positive influence on non-financial performance in Nigerian manufacturing firms. Arıcan and Ünal (2025) and Animah and Shafiee (2020) also showed that structured, quantitative risk assessment tools strengthen operational decision-making and reliability in asset-intensive industries, while James and Renjith (2021) highlighted improved system integrity and performance through advanced assessment techniques.

H_{03}: Risk Mitigation strategies have no significant effect on the Operational Performance of Dangote Cement Plc, Obajana Plant.

The hypothesis was rejected, with a path coefficient of 0.289, t-value of 3.470, and p-value of 0.001, indicating that well-designed mitigation actions significantly enhance operational performance. This finding underscores the importance of strategies such as alternative sourcing, inventory buffering, preventive maintenance scheduling, and collaborative supplier relationships in minimizing disruptions and sustaining high levels of productivity and delivery reliability. This outcome corroborates Aliu-Ogbaini (2025), who identified risk mitigation (through technology integration and third-party logistics) as the strongest driver of operational efficiency in Nigerian oil and gas supply chains. Asikhia et al. (2022) similarly reported significant positive effects of mitigation practices on business performance in downstream petroleum firms. Ngii (2017), Afifa and Santoso (2022), and Omoruyi and Quayson (2023) further reinforce that proactive mitigation via contingency planning, process redesign, and risk-sharing mechanisms translates into measurable gains in efficiency, responsiveness, and overall operational performance across manufacturing and logistics contexts.

CONCLUSION

In conclusion, this study found that all three dimensions of Supply Chain Risk Management (Risk Identification, Risk Assessment, and Risk Mitigation) significantly and positively affect the operational performance of Dangote Cement Plc, Obajana Plant. Risk Identification emerged as the strongest predictor, followed by Risk Mitigation and Risk Assessment. Collectively, these SCRM practices explain a substantial portion of variance in operational performance metrics (productivity, delivery reliability, and cost efficiency), highlighting the critical role of integrated risk management in achieving operational excellence in Nigeria's cement manufacturing sector.

RECOMMENDATIONS

Based on the strength and significance of the tested relationships, the following recommendations are proposed to further strengthen operational resilience and performance at Dangote Cement Plc, Obajana Plant:

i. Given that Risk Identification is the most powerful driver of operational performance, management should invest in advanced digital tools (e.g., AI-driven predictive analytics, IoT sensors, and real-time supply chain visibility platforms) to enhance early detection of risks such as raw material price volatility, logistics delays, and power outages. Establishing a centralized risk registry and conducting regular cross-functional risk workshops will further improve proactive identification.

ii. To leverage the significant role of Risk Assessment, the plant should adopt more sophisticated quantitative tools, including probabilistic risk modelling, scenario analysis, and updated risk matrices, integrated with enterprise resource planning (ERP) systems. Regular training on risk severity and likelihood evaluation will ensure assessments remain data-driven and aligned with operational priorities.

iii. Considering the strong positive impact of Risk Mitigation strategies, Dangote Cement Plc should expand and institutionalize mitigation actions such as multi-sourcing critical raw materials, building strategic inventory buffers, implementing predictive maintenance programs, and strengthening supplier partnership agreements. Exploring blockchain for supply chain transparency and automation technologies for production processes will further reduce disruption impacts and enhance cost efficiency and delivery reliability over the long term.

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