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Navigating Uncertainties: The Influence of Lean and Agile Supply Chain Strategies on Non-Financial Performance in Nigerian Manufacturing Industries

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Navigating Uncertainties: The Influence of Lean and Agile Supply Chain Strategies on Non-Financial Performance in Nigerian Manufacturing Industries

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Abstract

Purpose: This study examines how lean and agile supply chain strategies affect non-financial performance in Nigeria's manufacturing sector under uncertainty.

Methodology: Guided by RBV and TCE, the study evaluates uncertainty across upstream, midstream, and downstream activities. Data from 257 respondents (85.66% response rate) were analyzed using SPSS and SEM (SmartPLS 4).

Findings: Upstream uncertainty supports lean strategy, while midstream uncertainty drives agile strategy; downstream uncertainty has no significant effect. Lean strategy shows no significant impact on operational performance, whereas agile strategy has a strong positive effect, indicating greater effectiveness under uncertainty.

Unique Contribution to Theory, Policy and Practice: The study highlights how supply chain uncertainty shapes strategy effectiveness and underscores the importance of context-based strategic decision-making for improved performance.

Keywords: *Supply Chain, Uncertainty, Leans, Agile, Performance, Manufacturing.*

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INTRODUCTION

Nigeria's logistics and supply chain sector, though growing, remains constrained by infrastructure deficits and policy weaknesses, resulting in significant losses and heightened vulnerability due to import dependence (Oritse, 2019; IFC, 2022). MSMEs dominate the economy and drive employment, yet manufacturing performance continues to decline due to persistent structural challenges (NBS, 2023).

Supply chains link suppliers, manufacturers, and customers but face rising uncertainty from disruptions such as COVID-19, regulatory changes, and demand fluctuations. To cope, firms adopt lean and agile strategies—lean prioritizes efficiency, while agile emphasizes flexibility. However, lean systems are less effective under high uncertainty, whereas agile strategies perform better in dynamic environments (Abu Seman et al., 2022).

Supply chains operate across upstream, midstream, and downstream tiers, each exposed to distinct uncertainties. Despite prior studies, limited evidence exists on how these tier-based uncertainties influence strategy effectiveness in Nigeria. This study addresses this gap by examining their impact on lean and agile strategies and non-financial performance.

Rationale for the Study

Lean strategies enhance efficiency but struggle in uncertain conditions, while agile strategies improve responsiveness despite implementation challenges (Ramos et al., 2020). Empirical evidence on how uncertainty shapes their effectiveness remains limited, particularly in developing economies. This study therefore investigates the relationship between supply chain uncertainty, strategy choice, and performance outcomes.

Research Objectives

1. Examine upstream uncertainty and lean strategy.
2. Assess midstream uncertainty and lean strategy.
3. Evaluate midstream uncertainty and agile strategy.
4. Determine downstream uncertainty and agile strategy.
5. Analyze lean strategy and performance.
6. Examine agile strategy and performance.

LITERATURE REVIEW

A supply chain is an interconnected system of organizations coordinating flows of materials, information, and finances to deliver value to customers (Wieland, 2021). Effective management requires collaboration, alignment, and risk mitigation across all tiers to enhance performance and resilience (Richey et al., 2022).

Supply Chain Network

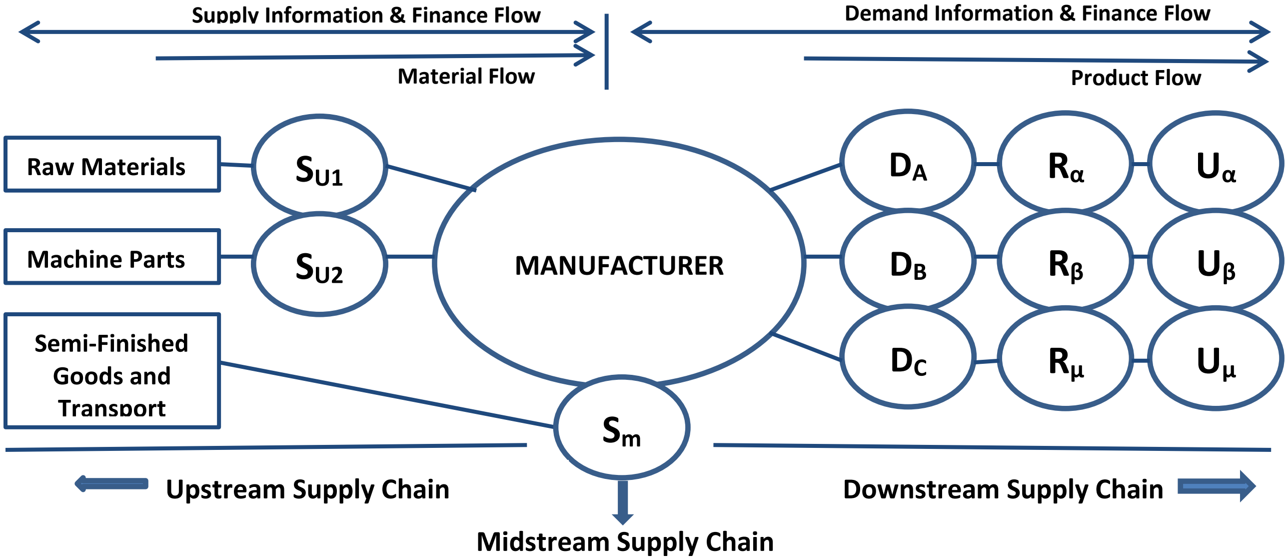

Figure 1: Supply Chain Network

Key: S_u (upstream suppliers); S_m (midstream suppliers); D (distributors); R (retailers); and U (users).

Supply chains enhance manufacturing performance but are complex, decentralized systems requiring strategic design and investment decisions that influence outcomes (Zhang et al., 2021). However, volatility, cost fluctuations, and technological disruptions increase risk and uncertainty. Effective design aligns supply and demand while managing resource flows, yet structural vulnerabilities expose supply chains to disruptions. As open systems, they require resilience strategies such as collaboration and long-term supplier relationships (Li et al., 2021).

Upstream: Focuses on sourcing and supplier coordination to ensure quality and prevent stockouts. Information sharing and technology improve visibility, forecasting, and responsiveness (Paul et al., 2022).

Midstream: Involves internal processes such as production, logistics, and transportation. Inefficiencies often arise from poor coordination and outdated systems (Abdeen & Sandanayake, 2022).

Downstream: Centers on distribution and customer fulfillment, where SMEs dominate but face financial and coordination challenges.

Risk and Uncertainty

Supply chains face frequent risks and occasional disruptions that increase costs and affect operations. Global shocks such as COVID-19 have intensified these challenges (Nagurney, 2021).

Uncertainty across all tiers complicates decision-making, making agile strategies more effective than lean approaches in dynamic environments (Alamsjah & Asrol, 2022).

Supply Chain Strategies

Supply chain strategy enhances competitiveness by balancing cost efficiency and responsiveness under uncertainty (Tarafdar & Qrunfleh, 2017). Disruptions such as COVID-19 exposed vulnerabilities, highlighting the need for resilient and well-coordinated supply chains (Raj et al., 2022). Firms increasingly combine lean and agile strategies—lean focuses on efficiency, while agile emphasizes flexibility—both improving performance and managing uncertainty (Alamsjah & Asrol, 2022).

Lean Supply Chain: Lean prioritizes waste reduction, efficiency, and value creation through practices such as JIT and TQM. It improves productivity and cost control but is less effective in highly uncertain environments due to its limited flexibility.

Agile Supply Chain: Agile enables rapid response to market changes through flexibility, collaboration, and technology. It enhances responsiveness, innovation, and customer satisfaction, though implementation can be complex.

Supply Chain Management & Performance

Supply chain management coordinates sourcing, production, and logistics to align supply with demand. Performance reflects efficiency, quality, and responsiveness, which are often reduced by uncertainty. Effective collaboration, integration, and use of digital technologies improve performance and resilience (Aslam et al., 2021).

Resilience and Responsiveness

Resilience enables adaptation and recovery from disruptions, while responsiveness reflects the ability to react quickly to changes. Both are critical for maintaining performance in uncertain environments (Wieland & Durach, 2021).

Theoretical Framework

The Resource-Based View (RBV) and Transaction Cost Economics (TCE) explain supply chain strategy and performance. RBV focuses on internal capabilities as sources of advantage, while TCE emphasizes cost efficiency and governance. Together, they explain how firms manage resources and relationships to improve performance under uncertainty.

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Conceptual Framework

The framework integrates RBV and TCE to examine how supply chain strategies mediate the relationship between uncertainty and operational performance.

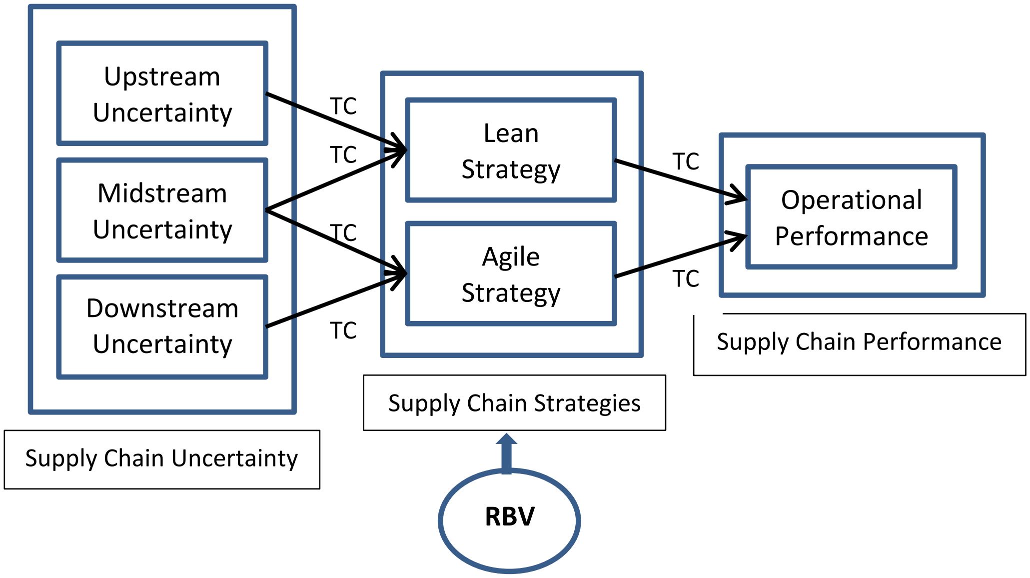

Figure 2: RBV and TCE Roles in Conceptual Model

Given below is the conceptual model showing hypothesized relationships.

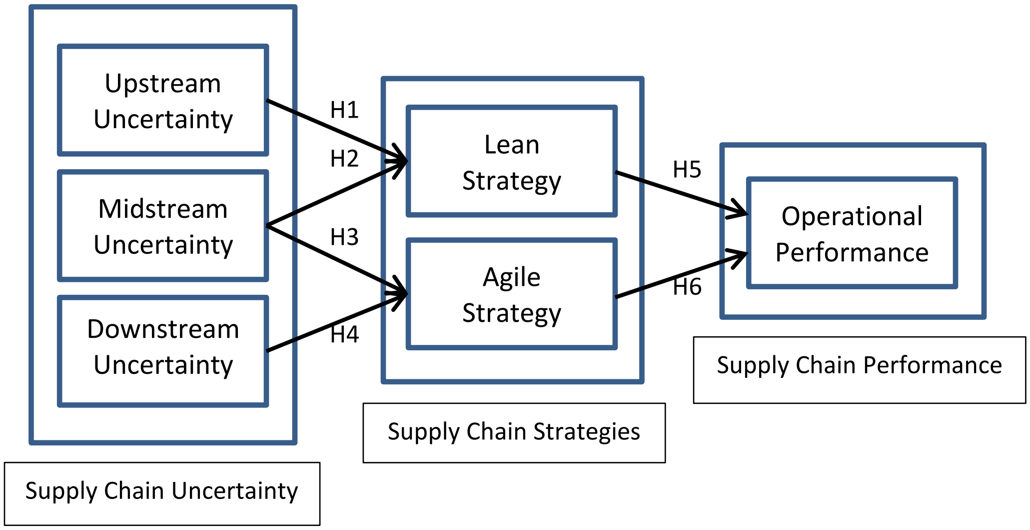

Figure 3: Hypothesized Conceptual Model

The following are the research hypotheses:

H1: Upstream uncertainty positively influences lean supply chain strategy.
H2: Midstream uncertainty positively influences lean supply chain strategy.

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H3: Midstream uncertainty positively influences agile supply chain strategy.
H4: Downstream uncertainty positively influences agile supply chain strategy.
H5: Lean supply chain strategy positively influences operational performance.
H6: Agile supply chain strategy positively influences operational performance.

METHODOLOGY

This study adopts a multi-industry survey design using a convenience sampling technique. Data were collected from 300 respondents across 15 manufacturing firms in five industries.

Measurements and Constructs' Scaling

The study's framework includes six constructs: upstream, midstream, and downstream uncertainty, lean and agile strategies, and operational performance, measured using reflective indicators from prior studies (Heo et al., 2022). A total of 20 items were used to capture these constructs, as summarized in Table 1.

Table 1: Latent Constructs and Indicators

Latent Variables	Variable Code	Indicators	Indicator Type	Indicator Code
Upstream Uncertainty	UPUN	Vendor Selection Price Change Material Scarcity	Reflective	Upun_1 Upun_2 Upun_3
Midstream Uncertainty	MIDUN	Quality Variance Production Logistics Production Processes Process Delays	Reflective	Midun_1 Midun_2 Midun_3 Midun_4
Downstream Uncertainty	DOWNUN	Product Delivery Distributor Capital Consumer Demand	Reflective	Downun_1 Downun_2 Downun_3
Lean Strategy	LEAN	Waste Generation Waste Elimination Cost Reduction	Reflective	Lean_1 Lean_2 Lean_3
Agile Strategy	AGILE	Quick Response Market Knowledge Transport Uncertainty Change Adaptation	Reflective	Agile_1 Agile_2 Agile_3 Agile_4
Operational Performance	OPPERF	Information Sharing Partner Collaboration Supplier Integration	Reflective	Opperf_1 Opperf_2 Opperf_3

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Constructs and Measures

The study employed six constructs measured with 20 indicators. The exogenous constructs include upstream uncertainty (UPUN), midstream uncertainty (MIDUN), and downstream uncertainty (DOWNUN), while the endogenous constructs comprise lean strategy (LEAN), agile strategy (AGILE), and operational performance (OPPERF). UPUN and DOWNUN were each measured using three indicators, while MIDUN was measured with four indicators. LEAN and OPPERF were each measured with three indicators, whereas AGILE was measured with four indicators. All indicators were used to assess construct reliability and validity within the measurement model.

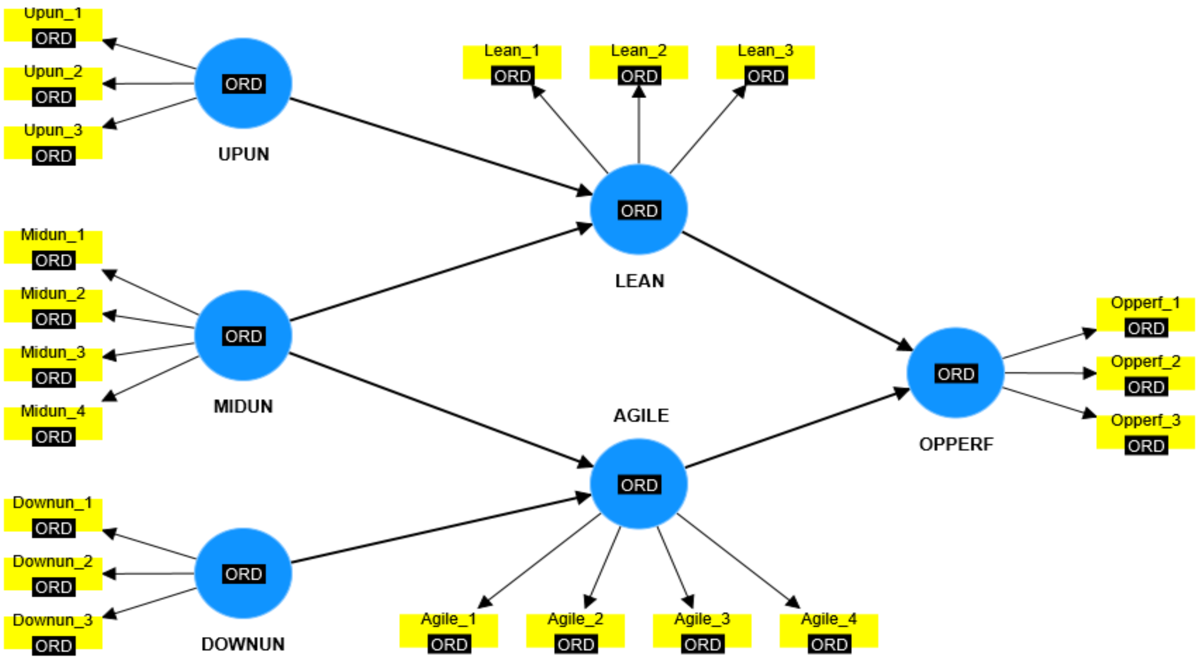

Figure 4: Latent Variables (Constructs) Vs Indicators (Reflective)

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Table 2: Indicators and Measurements

	Indicators	Measurements
1.	Upun_1	Assessed how manufacturers select their upstream suppliers and how this process leads to onboarding vendors that shared the focus-firm's vision and values.
2.	Upun_2	Evaluated price uncertainty in raw materials and other inputs sourced from upstream vendors and how this impacts on the performance of the focus-firm.
3.	Upun_3	Assessed what happens when there is scarcity of raw materials and other manufacturing inputs upstream.
4.	Midun_1	Assessed the type of materials sourced from midstream suppliers.
5.	Midun_2	Assessed the quality of these goods sourced from midstream suppliers.
6.	Midun_3	Assessed the impact of production logistics on production processes.
7.	Midun_4	Evaluated delays or lead times that trigger uncertainty in the production process.
8.	Downun_1	Evaluated how products get to end-users, if this is done directly by the manufacturer or its supply chain partners.
9.	Downun_2	Assessed if product distribution is done by SMEs.
10.	Downun_3	Evaluated order fulfillment as a determinant of supply chain effectiveness.
11.	Lean_1	Assessed the extent of waste generation of manufacturing firms.
12.	Lean_2	Assessed the impact of waste generation on quality expectations of customers.
13.	Lean_3	Evaluated cost as a determinant of process improvement.
14.	Agile_1	Assessed response speed in changing market scenarios.
15.	Agile_2	Assessed how manufacturers use market knowledge to get ahead of competitors.
16.	Agile_3	Assessed how firms maneuver transport uncertainties to deliver products on time.
17.	Agile_4	Assessed how firms adapt and sustain operations in the face of uncertainties.
18.	Opperf_1	Assessed information sharing among supply chain partners as a determinant of non-financial performance of manufacturing firms.
19.	Opperf_2	Assessed collaboration among partners as a determinant of non-financial performance of manufacturing firms.
20.	Opperf_3	Evaluated supply chain integration as a determinant of non-financial performance of manufacturing firms.

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Data Analysis

Data were analyzed using SPSS 25 for descriptive statistics and SmartPLS 4 for structural equation modeling. The measurement model was evaluated for reliability (Cronbach's alpha, composite reliability ≥ 0.7) and convergent validity (outer loadings, AVE ≥ 0.5), with discriminant validity assessed via Fornell–Larcker and cross-loadings. Indicators below thresholds were removed. The structural model was tested for collinearity (VIF < 5), explanatory power (R^2), path significance (coefficients and p-values), effect size (f^2), and predictive relevance (Q^2) to ensure robustness.

FINDINGS

Table 3: Indicators Reliability before Item Deletion

Latent Variables	Indicators	Outer Loading	Cronbach's Alpha[a]	CR[b]	AVE[c]
Upstream Uncertainty (UPUN)	Upun_1	0.859	0.667	0.801	0.575
	Upun_2	0.707			
	Upun_3	0.698			
Midstream Uncertainty (MIDUN)	Midun_1	0.594*	0.787	0.860	0.611
	Midun_2	0.797			
	Midun_3	0.830			
	Midun_4	0.876			
Downstream Uncertainty (DOWNUN)	Downun_1	0.656	0.599*	0.783	0.553
	Downun_2	0.649			
	Downun_3	0.899			
Lean Strategy (LEAN)	Lean_1	-0.022*	0.104*	0.559*	0.398*
	Lean_2	0.678			
	Lean_3	0.857			
Agile Strategy (AGILE)	Agile_1	0.089*	0.630	0.582*	0.327*
	Agile_2	0.372*			
	Agile_3	0.929			
	Agile_4	0.546*			
Operational Performance (OPPERF)	Opperf_1	0.696	0.614	0.783	0.546
	Opperf_2	0.762			
	Opperf_3	0.758			

* All items that do not meet the acceptable thresholds.

a. All indicator loadings > 0.6 are reliable.
b. All Cronbach Alphas > 0.6 shows indicator reliability.
c. All composite reliability (CR) > 0.7 show internal consistency.
d. All average variance extracted (AVE) > 0.5 shows convergent validity.

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Ten indicators met the recommended outer loading threshold, while three fell below 0.4 and seven ranged from 0.4 to 0.7. Following standard guidelines, the three low-loading indicators (Agile_1, Agile_2, Lean_1) were removed, while the seven moderate-loading indicators were retained, as deletion did not improve reliability or AVE. The final model included 15 valid indicators, ensuring robust reliability and convergent validity.

Table 4: Indicators Reliability after Item Deletion

Latent Variables	Indicators	Outer Loading	Cronbach's Alpha[a]	CR[b]	AVE[c]
Upstream Uncertainty (UPUN)	Upun_1	0.859	0.667	0.799	0.572
	Upun_2	0.707			
	Upun_3	0.698			
Midstream Uncertainty (MIDUN)	Midun_1	0.594	0.787	0.860	0.610
	Midun_2	0.797			
	Midun_3	0.830			
	Midun_4	0.876			
Downstream Uncertainty (DOWNUN)	Downun_1	0.656	0.599	0.780	0.549
	Downun_2	0.649			
	Downun_3	0.899			
Lean Strategy (LEAN)	Lean_2	0.678	0.344	0.748	0.600
	Lean_3	0.857			
Agile Strategy (AGILE)	Agile_3	0.929	0.404	0.747	0.607
	Agile_4	0.546			
Operational Performance (OPPERF)	Opperf_1	0.696	0.614	0.780	0.542
	Opperf_2	0.762			
	Opperf_3	0.758			

*Deleted indicators: Agile_1, Agile_2, and Lean_1.

Results confirmed indicator reliability, internal consistency, and convergent validity. Composite reliability (CR > 0.7) and AVE (> 0.5) criteria were met across constructs, ensuring robustness. Cronbach's Alpha varied but CR remained stable, as it is not affected by the number of indicators.

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Table 5: Fornell-Larcker Criterion Analysis for Discriminant Validity

	Agile	Downun	Lean	Midun	Opperf	Upun
Agile	**0.779**					
Downun	0.215	**0.741**				
Lean	0.285	0.18	**0.775**			
Midun	0.299	0.508	0.039	**0.781**		
Opperf	0.381	0.419	0.237	0.788	**0.736**	
Upun	0.316	0.345	0.277	0.492	0.766	**0.756**

The values given diagonally in the Fornell-Larcker criterion analysis are the square roots of the AVEs (in hold) of the latent variables. These values are the highest in each row and column indicating the establishment of discriminant validity

Table 6: Indicator Cross Loads

	Agile	Downun	Lean	Midun	Opperf	Upun
Agile_3	**0.929**	0.211	0.092	0.337	0.352	0.227
Agile_4	**0.592**	0.103	0.545	0.047	0.232	0.333
Downun_1	0.125	**0.644**	0.152	0.269	0.313	0.473
Downun_2	0.085	**0.631**	-0.108	0.524	0.289	0.032
Downun_3	0.223	**0.913**	0.228	0.419	0.349	0.245
Lean_2	0.172	0.091	**0.686**	-0.069	0.057	0.206
Lean_3	0.26	0.176	**0.855**	0.102	0.279	0.225
Midun_1	0.125	0.241	-0.09	**0.584**	0.327	0.201
Midun_2	0.266	0.463	-0.046	**0.802**	0.599	0.575
Midun_3	0.237	0.31	0.12	**0.83**	0.686	0.316
Midun_4	0.267	0.519	0.074	**0.876**	0.745	0.381
Opperf_1	0.188	0.276	0.121	0.711	**0.684**	0.252
Opperf_2	0.345	0.197	0.273	0.334	**0.776**	0.86
Opperf_3	0.267	0.519	0.074	0.876	**0.745**	0.381
Upun_1	0.345	0.197	0.273	0.334	0.776	**0.86**
Upun_2	0.232	0.464	0.071	0.469	0.508	**0.695**
Upun_3	0.111	0.303	0.19	0.426	0.377	**0.702**

The results above showed that all indicators loaded higher on their constructs when compared to other constructs. Discriminant validity was, therefore, established.

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Table 7: Summary of Reliability and Validity Measurements

Latent Variables	Indicators	Outer Loading	Cronbach's Alpha[a]	Cr[b]	Ave[c]	Discriminant Validity?
Upstream Uncertainty (UPUN)	Upun_1	0.859	0.667	0.799	0.572	Yes
	Upun_2	0.707				
	Upun_3	0.698				
Midstream Uncertainty (MIDUN)	Midun_1	0.594	0.787	0.860	0.610	Yes
	Midun_2	0.797				
	Midun_3	0.830				
	Midun_4	0.876				
Downstream Uncertainty (DOWNUN)	Downun_1	0.656	0.599	0.780	0.549	Yes
	Downun_2	0.649				
	Downun_3	0.899				
Lean Strategy (LEAN)	Lean_2	0.678	0.344	0.748	0.600	Yes
	Lean_3	0.857				
Agile Strategy (AGILE)	Agile_3	0.929	0.404	0.747	0.607	Yes
	Agile_4	0.546				
Operational Performance (OPPERF)	Opperf_1	0.696	0.614	0.780	0.542	Yes
	Opperf_2	0.762				
	Opperf_3	0.758				

After establishing indicator reliability, internal consistency, convergent validity, and discriminant validity, the next phase of analysis is the assessment of the structural model. The result of the structural analysis is presented in the next section.

Table 8: Collinearity Assessment Using VIF

	Agile	Downun	Lean	Midun	Opperf	Upun
Agile					1.088	
Downun	1.349					
Lean					1.088	
Midun	1.349		1.319			
Opperf						
Upun			1.319			

The results show that there is no collinearity issue in the variables. The next step in the structural model assessment is the evaluation of the coefficient of determination (R^2).

Table 9: R^2 of the Inner Model

	R-square	R-square Adjusted
Agile	0.095	0.088
Lean	0.089	0.082
Opperf	0.164	0.157

Agile strategy explained 9.5% of the variance in operational performance, while lean strategy accounted for 8.9%. The three operational performance indicators (Opperf_1–3) captured 16.4% of the construct's variance, indicating fair predictive power and that the exogenous constructs reasonably predict the endogenous construct.

Table 10: Path Coefficients

Hypothesis	Relationship (Path)	Path Coefficient (β)	Path Mean (M)	Std Dev	T Values	P values	Decision?
H1	UPUN -> LEAN	0.340*	0.367	0.083	4.119	0.000	Supported
H2	MIDUN -> LEAN	-0.128**	-0.120	0.126	1.017	0.309	Rejected
H3	MIDUN -> AGILE	0.255*	0.267	0.060	4.257	0.000	Supported
H4	DOWNUN -> AGILE	0.086**	0.098	0.067	1.270	0.204	Rejected
H5	LEAN -> OPPERF	0.140**	0.130	0.107	1.308	0.191	Rejected
H6	AGILE -> OPPERF	0.341*	0.351	0.053	6.406	0.000	Supported

*p < 0.001; **p > 0.05

It can be seen from Table 14 that three hypotheses are accepted and three rejected based on their significance. The path coefficient results show that AGILE (agile strategy) has the strongest effect on OPPERF, operational performance (0.341) followed by UPUN->LEAN (0.340) and MIDUN->AGILE (0.255).

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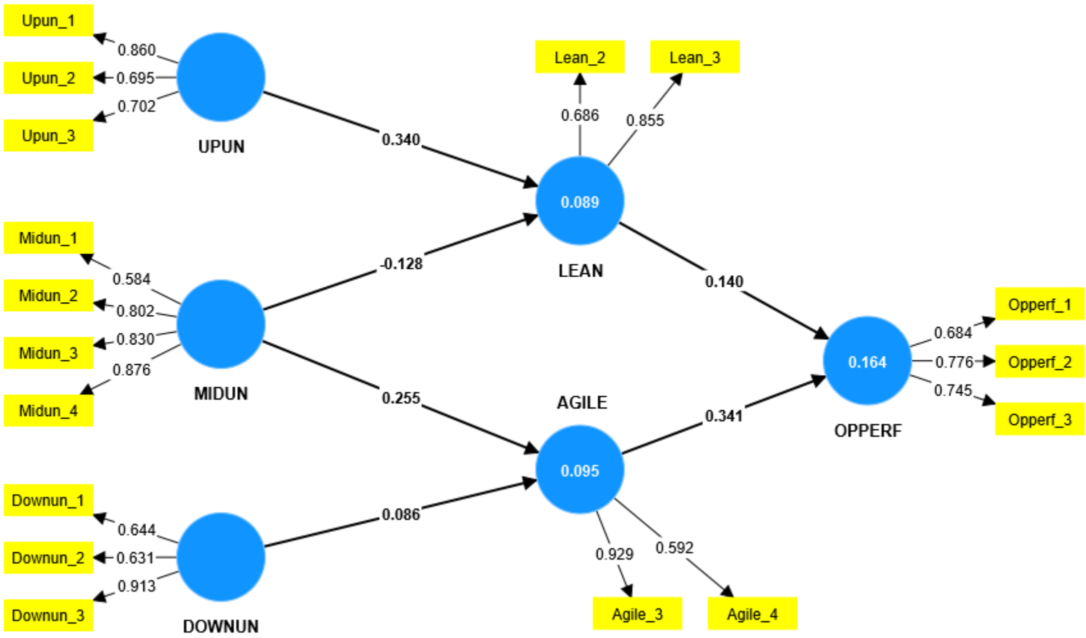

Figure 5: Path Coefficient Analysis

Table 11:Effect Sizes (f^2) of the Constructs

Relationships (Path)	f-square
UPUN -> LEAN	0.096
MIDUN -> LEAN	0.014
MIDUN -> AGILE	0.053
DOWNUN -> AGILE	0.006
LEAN -> OPPERF	0.022
AGILE -> OPPERF	0.128

AGILE has the biggest effect on OPPERF (0.128) followed by UPUN->LEAN (0.096), MIDUN-AGILE (0.053), and LEAN->OPPERF (0.022). The least effect is seen in the relationship between DOWNUN and AGILE (0.006). The outcome of the effect analysis shows that all the exogenous constructs have effects on their corresponding endogenous constructs.

Table 12: Latent Variables Prediction Relevance

	Q^2predict	RMSE	MAE
AGILE	0.071	0.970	0.796
LEAN	0.050	0.986	0.775
OPPERF	0.199	0.908	0.721

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The Q2 values of the endogenous constructs in Table 16 are larger than zero, thus confirming their predictive accuracy. The predictive relevance of OPPERF (0.199) was higher followed by AGILE (0.071) and LEAN (0.050).

Table 13: Summary of Results – Hypotheses Testing and Effect Size

Hypothesis	Relationship (Path)	Path Coefficient (β)	T Values	P Values	Effect Size (f^2)	Decision?
H1	UPUN -> LEAN	0.340*	4.119	0.000	0.096	Supported
H2	MIDUN -> LEAN	-0.128**	1.017	0.309	0.014	Rejected
H3	MIDUN -> AGILE	0.255*	4.257	0.000	0.053	Supported
H4	DOWNUN -> AGILE	0.086**	1.27	0.204	0.006	Rejected
H5	LEAN -> OPPERF	0.140**	1.308	0.191	0.022	Rejected
H6	AGILE -> OPPERF	0.341*	6.406	0.000	0.128	Supported

*p < 0.01; **p > 0.05

Table 14: Summary of Results – R^2 and Q^2

	Coefficient of Determination (R^2)		Predictive Relevance (Q^2)			
	R-square	R-square Adjusted	Q^2predict	RMSE	MAE	Decision?
AGILE	0.095	0.088	0.071	0.970	0.796	Supported
LEAN	0.089	0.082	0.050	0.986	0.775	Supported
OPPERF	0.164	0.157	0.199	0.908	0.721	Supported

Key Findings and Implications

- **H1: Upstream Uncertainty → Lean Strategy** – Supported. Lean practices like JIT and inventory management mitigate upstream risks and maintain production continuity.
- **H2: Midstream Uncertainty → Lean Strategy** – Not Supported. Lean alone is insufficient; coordination and supplier collaboration are needed.
- **H3: Midstream Uncertainty → Agile Strategy** – Supported. Agile strategies improve speed, adaptability, and midstream resilience through technology and collaboration.
- **H4: Downstream Uncertainty → Agile Strategy** – Not Supported. Agile firms can handle downstream disruptions with digital tools and proactive planning.
- **H5: Lean Strategy → Operational Performance** – Not Supported. Lean improves efficiency and cost control but does not directly enhance performance.

- **H6: Agile Strategy → Operational Performance** – Supported. Agility enhances resilience, adaptability, and competitiveness via collaboration and market intelligence.

CONCLUSIONS

Supply chain strategies should align with the type of uncertainty: lean strategies are effective upstream for efficiency and cost control, while agile strategies enhance midstream responsiveness and resilience. Integrating lean and agile approaches, supported by technology and collaboration, optimizes operational performance and mitigates risks. Sustained performance relies on partner collaboration, information sharing, and alignment of objectives to prevent disruptions from propagating across networks. Supplier integration, capability assessment, and balanced sourcing strategies strengthen both leanness and agility.

Limitations

The study focused on non-financial operational performance in Nigerian manufacturing, using convenience sampling, which limits generalizability. Findings may differ in other countries or over time. Gender imbalance and perception variability also constrained insights.

Areas for Future Research

Future studies could examine financial performance outcomes, include additional non-financial measures, use probability sampling to improve generalizability, and employ qualitative methods to gain subjective insights.

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