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MODERATING EFFECT OF SUPPLY CHAIN AGILITY ON THE RELATIONSHIP BETWEEN SUPPLY CHAIN MANAGEMENT PRACTICES AND SUSTAINABLE PERFORMANCE OF MANUFACTURING FIRM'S IN BAUCHI STATE, NIGERIA

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Abstract

Sustainable performance remains a major challenge for manufacturing firms in Nigeria, particularly in emerging industrial locations such as Bauchi State. Although the manufacturing sector contributes approximately 10% to Nigeria's GDP (National Bureau of Statistics, 2024), its growth has been inconsistent, environmentally unsustainable, and operationally inefficient. Many firms struggle to achieve the triple bottom line objectives of economic profitability, environmental responsibility, and social sustainability. This study examined the moderating effect of supply chain agility on the relationship between supply chain management practices and sustainable performance of manufacturing firms in Bauchi State, Nigeria. A cross-sectional survey design was adopted, targeting 380 registered manufacturing firms, with a final sample size of 243 determined using an a-priori calculation and adjusted for potential non-response. Stratified random sampling was employed, and data were analyzed using SPSS v30 for demographic profiling, missing value and outlier checks, and PLS-SEM 4 for structural model assessment. Findings revealed that green supply chain management, information sharing, and collaboration had significant direct effects on sustainable performance, whereas customer relationship management did not. Supply chain agility significantly moderated the effects of green supply chain management, information sharing, and customer relationship management on sustainable performance, confirming its role as a strategic enabler, but did not moderate the collaboration–performance link. Based on these results, it recommends that manufacturing firms adopt greener supply chain practices, enhance digital tools for information sharing, strengthen stakeholder collaboration, and build supply chain agility.

Keywords: Supply Chain, Green Supply Chain Management, Information Sharing, Customer Relationship Management, Sustainable Performance.

1. Introduction

Sustainable performance has become a critical measure of the long-term success of manufacturing firms, extending beyond financial profitability to encompass economic viability, environmental protection, and social responsibility (Elkington, 2022; Christopher, 2021). Globally, although manufacturing contributes significantly to economic growth, it remains a major source of environmental pollution, carbon emissions, and resource depletion, prompting increasing regulatory and stakeholder pressure for sustainable production practices. In Africa, the manufacturing sector offers substantial economic opportunities but continues to face structural challenges, including inadequate infrastructure, energy shortages, limited access to finance, and technological constraints (World Bank, 2020; McKinsey, 2023). Similarly, Nigeria's manufacturing sector, which contributes approximately 10% to national GDP, faces unreliable electricity, high production costs, supply chain disruptions, and environmental compliance pressures (NBS, 2024; World Bank, 2024). In Bauchi State, manufacturing activities such as food processing, textiles, agro-processing, and

production of construction materials contribute to employment and economic development; however, inadequate infrastructure, unreliable power supply, limited financing, and technological gaps continue to constrain productivity, competitiveness, and sustainable performance (Bauchi State Ministry of Commerce and Industry, 2024). These challenges highlight the need for effective strategic and operational practices that can strengthen the sustainability of manufacturing firms.

Supply chain management (SCM) has emerged as an important strategic approach for improving sustainable performance through efficient resource utilization, waste reduction, operational responsiveness, and stronger stakeholder relationships (Bowersox et al., 2022; Christopher, 2021). Specifically, supply chain collaboration promotes coordination among suppliers, manufacturers, and distributors; information sharing facilitates timely access to demand, inventory, and production information; customer relationship management strengthens customer engagement and demand alignment; while green supply chain management integrates environmental considerations into procurement, production, and distribution processes (Lambert et al., 2024; Van Hoek & Erasmus, 2023).

Manufacturing firms in Bauchi State face persistent challenges in achieving sustainable performance due to ineffective supply chain management practices, including poor supplier coordination, inadequate information sharing, weak customer relationship management, and limited adoption of green supply chain practices (Bowersox et al., 2022; Simatupang & Sridharan, 2020). These challenges are compounded by infrastructural deficiencies, economic uncertainties, and technological constraints, which undermine firms' economic, social, and environmental sustainability (Ogundipe et al., 2023; Adeyeye et al., 2024). Although previous studies have established that effective supply chain practices improve organisational performance and competitiveness (Adeleke et al., 2022; Ojo et al., 2023; Eze et al., 2024), limited empirical attention has been given to their effects on sustainable performance, particularly among manufacturing firms in Bauchi State. Furthermore, the moderating role of supply chain agility in strengthening the relationship between supply chain management practices and sustainable performance remains underexplored (Christopher, 2021). This study therefore seeks to address these geographical, empirical, and contextual gaps by examining the effect of supply chain management practices on the sustainable performance of manufacturing firms in Bauchi State, Nigeria, with particular emphasis on the moderating role of supply chain agility.

The study will be guided by the following research questions:

i. Does customer relationship management practice influence sustainable performance of manufacturing firms in Bauchi state?
ii. To what extent does green supply chain management practices affect sustainable performance of manufacturing firms in Bauchi state?
iii. Does information sharing practice influence sustainable performance of manufacturing firms in Bauchi state?
iv. Does supply chain collaboration practice influence sustainable performance of manufacturing firms in Bauchi state?
v. Does supply chain agility moderate the relationship between customer relationship management practice and sustainable performance of manufacturing firms in Bauchi state?
vi. How does supply chain agility moderate the relationship between green supply chain management practices and sustainable performance of manufacturing firms in Bauchi state?
vii. Does supply chain agility moderate the relationship information sharing practice and sustainable performance of manufacturing firms in Bauchi state?
viii. To what extent does supply chain agility moderate the relationship between supply chain collaboration practice and sustainable performance of manufacturing firms in Bauchi state?

The main objective of this study is to examine the moderating effect of supply chain agility on the relationship between supply chain management practices and sustainable performance of manufacturing firms while the specific objectives are to;

i. Examine the effect of customer relationship management practice on sustainable performance of manufacturing firms in Bauchi state
ii. Determine the effect of green supply chain management practices on sustainable performance of manufacturing firms in Bauchi state.
iii. Examine the effect of information sharing practice on sustainable performance of manufacturing firms in Bauchi state
iv. Determine the effect of supply chain collaboration practice on sustainable performance of manufacturing firms in Bauchi state
v. Examine the moderating effect supply chain agility on the relationship between customer relationship management practice and sustainable performance of manufacturing firms in Bauchi state
vi. Examine the moderating effect supply chain agility on the relationship between green supply chain management practices and sustainable performance of manufacturing firms in Bauchi state.
vii. Examine the moderating effect supply chain agility on the relationship between information sharing practice and sustainable performance of manufacturing firms in Bauchi state
viii. Examine the moderating effect supply chain agility on the relationship between supply chain collaboration practice and sustainable performance of manufacturing firms in Bauchi state

Research Hypothesis

Ha1: There is significant relationship between customer relationship management practice and sustainable performance of manufacturing firms in Bauchi state

Ha2: There is a significant relationship between green supply chain management practices and sustainable performance of manufacturing firms in Bauchi state

Ha3: There is significant relationship between information Sharing practice and sustainable performance of manufacturing firms in Bauchi state

Ha4: There is significant relationship between supply chain collaboration practice and sustainable performance of manufacturing firms in Bauchi state

Ha5: Supply Chain Agility significantly moderate the relationship between customer relationship management practice and sustainable performance of manufacturing firms in Bauchi state.

Ha6: Supply Chain Agility significantly moderate the relationship between green supply chain management practices and sustainable performance of manufacturing firms in Bauchi state

Ha7: Supply Chain Agility significantly moderate the relationship between information sharing practice and sustainable performance of manufacturing firms in Bauchi state

Ha8: Supply Chain Agility significantly moderate the relationship between supply chain collaboration practice and sustainable performance of manufacturing firms in Bauchi state.

2. Literature Review

2.1 Conceptual Review

Sustainable Performance

Sustainable performance refers to a firm's ability to achieve economic, social, and environmental goals simultaneously (Dyllick & Hockerts, 2002). It encompasses three dimensions: economic performance, social performance, and environmental performance (Elkington, 2023).

Concept of Supply Chain Management Practices

Supply Chain Management (SCM) practices represent the specific strategic activities and managerial approaches firms adopt to effectively manage relationships, flows, and processes across the supply chain network.

Strategic Supplier Partnership: This dimension emphasizes long-term relationships with key suppliers based on trust, joint planning, risk sharing, and collaborative problem-solving. It involves supplier

development, joint product design, and performance monitoring (Li et al., 2022).

Supply Chain Collaboration: Supply chain collaboration extends beyond supplier relationships to include coordinated activities among all supply chain members. It involves joint forecasting, synchronized production planning, shared performance goals, and mutual decision-making. Collaboration improves resource optimization, reduces duplication of efforts, and enhances supply chain visibility.

Information Sharing: Information sharing refers to the extent to which supply chain partners exchange timely, accurate, relevant, and complete information. This includes demand forecasts, inventory levels, production schedules, pricing information, and delivery updates.

Customer Relationship Management (CRM): CRM focuses on managing long-term relationships with customers to enhance satisfaction, loyalty, and demand stability. It involves understanding customer preferences, managing feedback systems, after-sales services, and customized product offerings. Customer integration ensures that supply chain activities align with market demand, reducing waste and improving revenue sustainability (Doyle & Stern, 2021).

Green Supply Chain Management (GSCM): GSCM integrates environmental considerations into supply chain activities, including green procurement, eco-design, energy-efficient production, reverse logistics, and waste reduction. It aims to minimize environmental impact while maintaining economic performance.

Supply Chain Agility as Moderator

The market environment has become more dynamic and turbulent; companies need to adopt new supply chain strategy for them to remain competitive. Supply chain management is now moving away from traditional processes to agile capability of competitive bases of speed, flexibility, innovation, quality, and profitability through the integration of reconfigurable resources and best practices in a knowledge-rich environment to provide customer-driven products and services in a fast-changing market environment (Yusuf, 2024).

2.2 Empirical Review

Information sharing is widely recognized in empirical supply chain literature as a fundamental driver of performance improvement. It refers to the extent to which supply chain partners exchange timely, accurate, relevant, and complete information regarding demand forecasts, inventory levels, production schedules, pricing, and delivery status (Mentzer, 2019; Moberg, 2022). Effective information sharing reduces uncertainty, enhances coordination, and enables evidence-based decision-making across the supply network.

Empirical studies consistently report a positive association between information sharing and operational performance. Simatupang and Sridharan (2022) found that firms engaging in structured information exchange experienced significant improvements in forecast accuracy and reductions in order cycle times. Similarly, Lee and Whang (2020) demonstrated that information visibility across supply chain partners mitigates the bullwhip effect and improves production planning efficiency.

Underpinning Theory

The study underpinning theory is Resource Base view and supported by Dynamic capability theory.

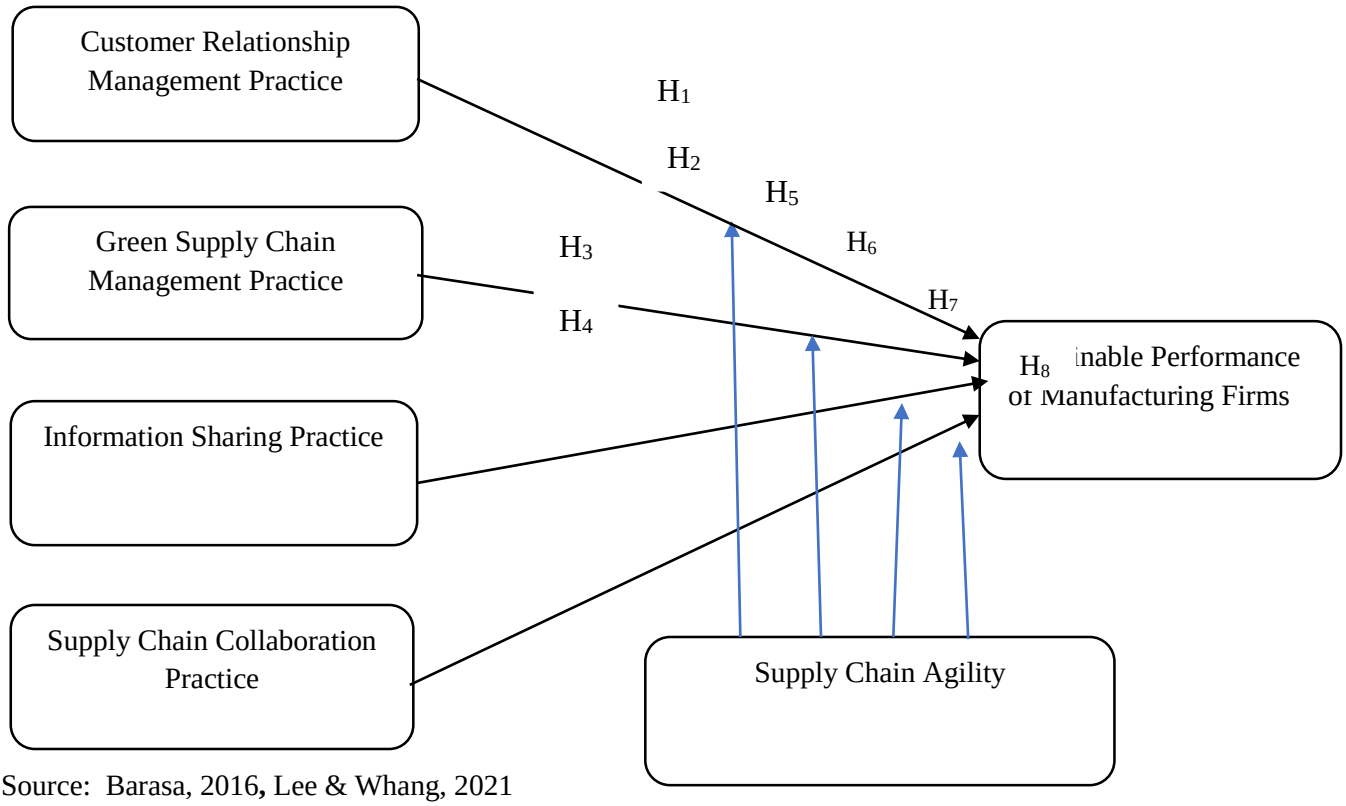
Resource-Based View

The Resource-Based View, advanced by Barney (1991), posits that firms achieve sustainable competitive advantage when they possess resources that are valuable, rare, inimitable, and non-substitutable.

Dynamic Capability Perspective

Dynamic Capability Theory, developed by Teece, Pisano, and Shuen (1997), extends the Resource-Based View by emphasizing a firm's ability to integrate, build, and reconfigure internal and external competencies in response to environmental changes.

Conceptual Framework



Source: Barasa, 2016**,** Lee & Whang, 2021

Figure 1: Conceptual Framework

3. Methodology

3.1 Research Design

This study utilized survey cross-sectional research design which according to Rindfleisch et al., (2023) is a less costly research design in comparison with other approaches. A cross-sectional research design revolves around the collection of data on multiple cases but at one specific moment of time, on a given sample of a population

3.2 Population of the Study

The target population for this study comprises 380 registered and functional manufacturing firms operating across Bauchi State as obtained from result of a Collaborative Survey by National Bureau of Statistics (NBS) and SMEDAN of 2024, MSME Survey Report (2024) and further confirmed through Bauchi state Ministry of Commerce and industry, Nigerian Association of Small and Medium Enterprises (NASME), Manufacturers Association of Nigeria (MAN) Bauchi state chapter.

3.3 Unit of Analysis

The unit of analysis for this study owners and managers.

3.4 Sample Size

Using Soper's (2020) A-priori sample size calculator, the minimum sample size was 221 respondents. An additional 10% was added to account for non-response and incomplete questionnaires, following Story and Tait (2019), resulting in a final sample size of 243 respondents

3.5 Sampling Techniques

The study adopted cluster sampling because manufacturing firms are geographically distributed across different locations and industrial clusters in Bauchi State.

Table 1: Cluster Sampling

S/N	LGAs	Operation Managers of Registered Manufacturing Firms	%	Sampling Size
1	Bauchi	101	41	100
2	Dass	23	9	22
3	Misau	32	13	32
4	Dambam	18	7	17
5	Katagum	52	21	51
6	Shira	21	9	21
	Total	247	100	243

National Bureau of Statistics (NBS) and SMEDAN of 2024, MSME Survey Report (2024)

3.6 Validity of and Reliability of the Research Instrument

Cronbach Alpha reliability coefficient of 0.70 and above was attained as presented which considered as reliably satisfactory (Streiner & Shannon, 2023).

3.7 Method of Data Collection

Data for the study was collected by means of self-administration of questionnaires to respondent which were owners and managers of selected manufacturing SMEs through systematic random sampling.

3.8 Method of Data Analysis

After collecting the necessary data, the researcher analyzed and interpret the data by using quantitative method of data analysis. The data collected were imputed by the use of statistical package for social sciences (SPSS v28) analyze demographic information and analysis of missing values as well as outliers and partial least square-structural equation model (PLS-SEM 4) was used for structural model analysis.

4. Results and Discussion

4.1 Response Rate

Table 2*: Response Rate of the Questionnaires*

Detail	Copies/Rate	Percentages
Questionnaire distributed	243	100
Questionnaire returned	168	69.14
Questionnaire not returned	75	30.86
Invalid	7	4.16
Usable questionnaire	161	66.26

Source: Field Survey, 2026

4.2 Measurement Model (Outer Model)

The result indicated that loadings of items of individual construct are shown including composite reliability (CR) for internal consistency and Average Variance extracted (AVE) for construct validity. In this study Smart-PLS4 software by Ringle, et al. 2022 was used to analyze the relationship between independent and dependent variables. The software was used to estimate the measurement model and the structural model in this study.

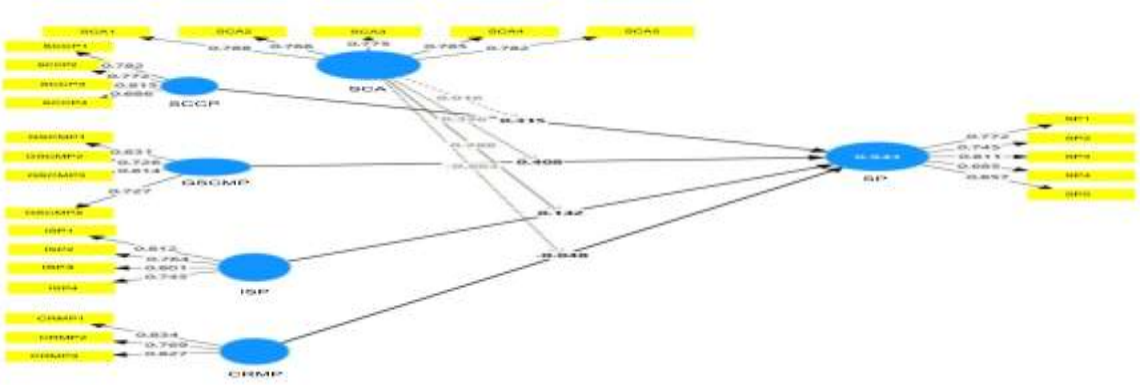


Figure 2: Measurement Model

Note that the following items were deleted ISP 1, ISP 6, SP6, CRMP4 CRMP5, GSCMP4 and SCCP5.

4.3 Structural Model (Inner model)

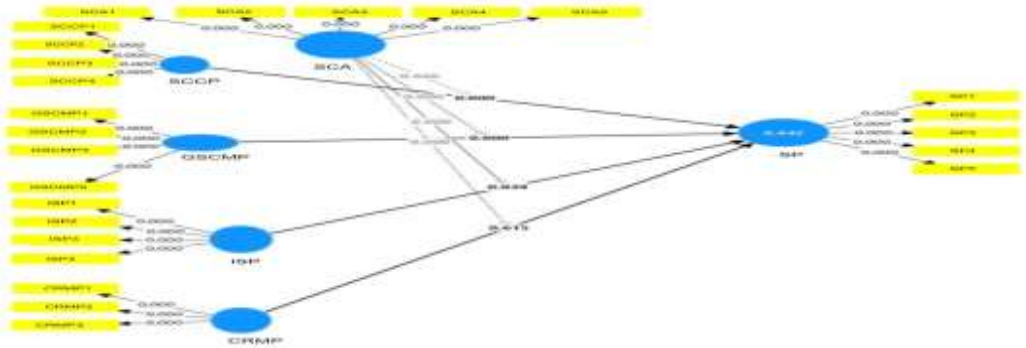


Figure 3: Structural Model: Showing the relationship between independent variables with dependent variable through moderating variable.

Coefficient of Determination Assessment (R^2)

Table 3: Coefficient of Determination (R^2)

Constructs	R^2 Value
Sustainable Performance (IP)	0.661

Source: Source: PLS-SEM Measurement model output

Effect Size (F^2)

Table 4: Effect Size (F^2)

Construct	Sustainable Performance	Effect Size
Supply Chain Collaboration Practice	0.107	Medium Effect
Information Sharing Practice	0.246	Medium Effect
Green Supply Chain Management Practices	0.044	Small Effect
Customer Relationship Management Practice	0.247	Medium Effect

Source: Extracted from SmartPLS4 output, 2025.

Assessment of Predictive Relevance (Q^2)

Table 5: Predictive Relevance (Q^2)

Endogenous Constructs	Q^2predict	RMSE	MAE	Predictive Relevance
Sustainable Performance	0.175	0.968	0.718	Yes
Supply Chain Agility	0.335	0.828	0.645	Yes

Source: Extracted from SmartPLS4 output, 2025.

4.4 Test of Hypotheses

Table 6. Path Coefficient for Direct Relationship

Hypotheses	Relationship	Beta	Stnd Error	T-value	p-value	Decision
H1	CRMP -> SP	-0.048	0.107	0.45	0.652 ***	Not Supported
H2	GSCMP -> SP	0.408	0.09	4.547	0.000***	Supported
H3	ISP -> SP	0.142	0.067	2.108	0.035 ***	Supported
H4	SCCP -> SP	0.315	0.066	4.786	0.000***	Supported

Source: PLS-SEM Measurement model output

The findings reveal that Green Supply Chain Management Practices (β = 0.408), Supply Chain Collaboration Practice (β = 0.315), and Information Sharing Practice (β = 0.142) have significant positive effects on Sustainable Performance. However, Customer Relationship Management Practice (β = -0.048) has no significant effect. Therefore, H1 was rejected, while H2, H3, and H4 were accepted. Green Supply Chain Management Practices emerged as the strongest predictor of Sustainable Performance

Table 7 Path Coefficient for Moderation Relationship

Hypotheses	Relationship	Beta	Stnd Error	T-value	p-value	Decision
H5	CRMP * SCA -> SP	-0.663	0.08	8.27	0.000***	Supported
H6	GSCMP* SCA > SP	0.326	0.064	5.066	0.000***	Supported
H7	ISP*SCA> SP	0.288	0.047	6.166	0.000***	Supported
H8	SCCP* SCA > SP	0.016	0.038	0.427	0.67***	Not Supported

Source: PLS-SEM Measurement model output

The moderating result shows that Supply Chain Agility significantly moderates the relationship between Customer Relationship Management Practice, Green Supply Chain Management Practices, Information Sharing Practice , and Sustainable Performance ($ß$ = -0.663; t = 8.27; p <0.01), ß = 0.326; t = 5.066; p <0.01), ß = 0.288 t = 6.166; p <0.01) respectively, while Supply Chain Agility does not significantly moderate the relationship between Supply Chain Collaboration Practice and Sustainable Performance ß = 0.016; t = 0.427; p <0.01).

4.5 Discussion of Findings

The study examined the effects of customer relationship management (CRM), green supply chain management

(GSCM), information sharing, and supply chain collaboration on the sustainable performance of manufacturing firms in Bauchi State, with supply chain agility as a moderating variable. The findings revealed that CRM had no significant direct relationship with sustainable performance, contradicting previous studies (Chen et al., 2022; Sin et al., 2005). However, GSCM, information sharing, and supply chain collaboration had significant positive effects on sustainable performance, supporting previous empirical studies (Zhu et al., 2023; Li et al., 2021; Cao & Zhang, 2021). These findings suggest that environmentally responsible practices, effective information exchange, and collaboration among supply chain partners are important drivers of sustainable performance.

5. Conclusion and Recommendations

This study set out to deepen the understanding of how core supply chain management practices influence the pursuit of sustainability within manufacturing firms in an emerging economy context. Grounded in the supply chain integration theory and supported by agile supply chain theory, the research explored the interplay between strategic supply chain functions and the dynamic capabilities required to adapt to sustainability demands.

Based on the findings, the following recommendations are proposed:

i. Manufacturing firms should prioritize eco-friendly initiatives such as sustainable sourcing, waste reduction, and recycling to enhance environmental and economic performance.
ii. Firms should invest in digital technologies and training to facilitate timely, accurate, and consistent information sharing across supply chain partners.
iii. Firms should engage in deeper collaborative relationships with suppliers and other stakeholders to co-create value and achieve sustainability objectives.
iv. Organizations should build agile capabilities flexibility, speed, responsiveness to better capitalize on CRM and other supply chain practices in turbulent environments.
v. Customer relationship practices should move beyond transactional engagement and focus on long-term relationships that emphasize customer-driven sustainability expectations.
vi. Since not all practices have the same impact, managers should adopt a context-specific strategy based on their operational maturity and environmental conditions.

Contribution of the Study

This study advances both theory and practice by highlighting how integrated supply chain practices, supported by agility, drive sustainable performance in emerging market contexts.

Theoretical Contribution

The theoretical contribution of the study lies in demonstrating that supply chain integration and agility are complementary but not interchangeable theoretical constructs. Integration provides the relational, informational, and process foundations through which supply chain activities can contribute to sustainability, while agility determines the firm's capacity to respond effectively to changing conditions and exploit those integrated capabilities.

Managerial Contribution

The managerial contribution of this study lies in demonstrating that the effectiveness of supply chain practices depends not only on whether firms adopt them, but also on how effectively they are supported by organisational capabilities, particularly supply chain agility.

Suggestions for Further Studies

i. **Expand the Geographic Scope**: Future studies could explore similar relationships in other states or regions of Nigeria, or in other developing countries, to increase generalizability.
ii. **Use Longitudinal Research Designs**: A time-series analysis could provide deeper insights into how supply chain practices evolve and affect sustainability over time.

iii. **Examine Additional Moderators**: Future research may investigate other moderating variables such as technological capability, leadership style, or organizational culture.

iv. **Sectoral Comparison**: Comparative studies between different industries (e.g., agriculture vs. manufacturing) could reveal sector-specific dynamics in supply chain sustainability.

v. **Qualitative Approaches**: In-depth case studies could uncover how contextual factors (e.g., local infrastructure, policy environment) influence the effectiveness of supply chain practices.

vi. **Incorporate Environmental and Social Metrics**: Future research should include specific metrics on environmental performance (e.g., carbon emissions) and social responsibility to deepen sustainability analysis

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