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Integrating Sustainable Supply Chain Practices in Agricultural Production: Evidence from Emerging Economies

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Abstract

This study explores the integration of sustainable supply chain practices (SSCP) in agricultural production within emerging economies, focusing on their impact on operational efficiency and environmental performance. Using a qualitative approach, data were collected from 150 agricultural firms in Brazil, India, and Nigeria. SPSS ANOVA analysis was employed to examine variations in SSCP adoption across firm sizes and regions. Findings reveal significant differences in adoption rates, with larger firms and those in Brazil showing higher integration of SSCP. Two hypotheses were tested: (H1) SSCP adoption enhances operational efficiency, and (H2) SSCP adoption improves environmental performance. Both hypotheses were supported, indicating that sustainable practices contribute to cost reduction and reduced environmental impact. The study underscores the need for tailored policies to promote SSCP in smaller firms and less-developed regions.

Keywords: Sustainable Supply Chain Practices; Agricultural Production; Emerging Economies; ANOVA Analysis; Operational Efficiency; Environmental Performance

1. Introduction

Sustainable supply chain practices (SSCP) have gained prominence as firms seek to balance economic profitability with environmental and social responsibility. In emerging economies, where agriculture is a cornerstone of economic development, integrating SSCP can address challenges such as resource depletion, climate change, and market competitiveness. Despite growing interest, empirical evidence on SSCP adoption in agricultural production within emerging economies remains limited. This study investigates how SSCP influences operational efficiency and environmental performance, using a sample of agricultural firms in Brazil, India,

and Nigeria. The research employs ANOVA analysis in SPSS to explore variations in SSCP adoption and tests two hypotheses to assess its impacts. The findings aim to inform policymakers and practitioners on fostering sustainable agricultural systems.

Sustainable supply chain practices (SSCP) have become a focal point in global agricultural discourse, particularly as firms in emerging economies navigate the dual imperative of economic growth and sustainable development. Agriculture plays a pivotal role in these economies, not only as a source of food and employment but also as a key contributor to GDP. However, issues such as inefficient resource use, environmental degradation, and climate-related disruptions persist. The motivation behind this study arises from the need to explore how integrating SSCP within agricultural supply chains can mitigate these challenges while enhancing firm-level performance. Specifically, this research is driven by two primary questions: (1) How does the adoption of SSCP vary across agricultural firms in emerging economies? (2) What are the effects of SSCP on operational efficiency and environmental performance within these firms? By examining these questions in the context of Brazil, India, and Nigeria—three agriculturally intensive and diverse economies—the study seeks to generate a deeper understanding of the role that sustainable practices play in shaping agricultural resilience and competitiveness. The inclusion of multiple countries offers a comparative perspective that has been underexplored in existing literature, making this study timely and relevant in light of global sustainability goals.

Preliminary findings from the study suggest that the adoption of SSCP is positively associated with improvements in both operational efficiency and environmental performance among agricultural firms. However, the extent of this relationship varies significantly across different national contexts, highlighting the influence of country-specific factors such as regulatory frameworks, access to green technology, and market maturity. Using ANOVA analysis in SPSS, this study identified statistically significant differences in SSCP adoption levels across the three countries, suggesting that external institutional and infrastructural conditions play a key role in driving sustainability efforts. Despite a growing body of research on supply chain sustainability, a critical gap remains in empirical investigations focusing specifically on agriculture in emerging economies. Most existing studies either concentrate on developed nations or offer conceptual frameworks without rigorous empirical testing. This study addresses that void by offering cross-national empirical evidence that evaluates real-world adoption patterns and their practical implications. Moreover, while previous literature often isolates environmental or economic outcomes, this study emphasizes their intersection, presenting a more integrated understanding of sustainable performance in agriculture. The evidence provided here contributes to a more granular understanding of where and how SSCP can be most effectively implemented.

This research contributes to both the theoretical and practical discourse on sustainable supply chain management in agricultural contexts. Theoretically, it extends the sustainability-performance linkage by integrating environmental and operational outcomes into a single analytical framework, thereby offering a nuanced perspective on SSCP's multifaceted impact. It also provides empirical support for institutional theory and resource-based views, suggesting that firms' ability to adopt sustainable practices is mediated by both external pressures and internal capabilities. Practically, the study offers actionable insights for policymakers, agribusiness leaders,

and development organizations. For policymakers, the findings underscore the need to create enabling environments through supportive regulations, green finance initiatives, and infrastructure investments. For practitioners, especially in developing economies, the results highlight that SSCP can drive not just ecological but also operational gains—offering a business case for sustainability. The comparative nature of the study also allows decision-makers to benchmark their progress and learn from best practices across different countries. Overall, this study moves the conversation forward by demonstrating that sustainable agriculture and competitive performance are not mutually exclusive but can be achieved concurrently through strategic supply chain interventions.

2. Literature Review and Theoretical Development

2.1. Literature Review

Sustainable supply chain management integrates environmental, social, and economic considerations into supply chain operations (Seuring & Müller, 2008). In agriculture, SSCP includes practices such as organic farming, water-efficient irrigation, and eco-friendly packaging (Zhu et al., 2018). Studies suggest that SSCP adoption enhances operational efficiency by reducing waste and costs (Pagell & Wu, 2009). Additionally, SSCP improves environmental performance by minimizing carbon footprints and resource use (Rao & Holt, 2005). However, adoption barriers, such as high initial costs and lack of expertise, are prevalent in emerging economies (Jayaraman et al., 2017). Research gaps exist regarding the extent of SSCP adoption across firm sizes and regions in these contexts.

2.2. Theoretical Framework and Variables

This study is grounded in the Resource-Based View (RBV) theory, which posits that firms gain competitive advantages by leveraging unique resources and capabilities (Barney, 1991). SSCP is conceptualized as a strategic resource that enhances operational efficiency (e.g., cost reduction, process optimization) and environmental performance (e.g., reduced emissions, sustainable resource use). The key variables are:

Independent Variable: SSCP Adoption (measured by the extent of practices like organic farming, renewable energy use, and waste management).

Dependent Variables:

- Operational Efficiency (measured by cost savings and productivity improvements).
- Environmental Performance (measured by reductions in carbon emissions and resource consumption).

Control Variables: Firm Size (small, medium, large) and Region (Brazil, India, Nigeria).

Hypotheses

Based on the literature and RBV theory, the following hypotheses are proposed:

- H1: SSCP adoption positively influences operational efficiency in agricultural firms.

- H2: SSCP adoption positively influences environmental performance in agricultural firms.

3. Methodology

3.1. Research Design

This study adopts a cross-sectional, qualitative research design to explore SSCP adoption. Data were collected through structured surveys administered to agricultural firms in Brazil, India, and Nigeria. The survey measured SSCP adoption, operational efficiency, and environmental performance using Likert-scale items (1 = strongly disagree, 5 = strongly agree).

3.2. Data and Sampling

A purposive sampling technique was used to select 150 agricultural firms (50 per country). Firms were categorized by size: small (<50 employees), medium (50–200 employees), and large (>200 employees). Data collection occurred between January and March 2025, ensuring a diverse representation of agricultural sectors (e.g., crops, livestock). The response rate was 92%, yielding 138 valid responses.

3.3. Variable Measurement

The following table outlines the measurement of key variables:

Table 1. The measurement of key variables

Variable	Measurement Items	Source
SSCP Adoption	Use of organic farming, renewable energy, waste management (3 items, Cronbach's α = 0.85)	Zhu et al. (2018)
Operational Efficiency	Cost savings, productivity improvements (2 items, Cronbach's α = 0.82)	Pagell & Wu (2009)
Environmental Performance	Reduction in carbon emissions, resource consumption (2 items, Cronbach's α = 0.87)	Rao & Holt (2005)

4. Results and Findings

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4.1. Descriptive Statistics

The sample comprised 138 firms: 46 from Brazil, 45 from India, and 47 from Nigeria. Firm sizes were distributed as follows: 40% small, 35% medium, and 25% large. The mean SSCP adoption score was 3.85 (SD = 0.62), indicating moderate adoption. Operational efficiency and

environmental performance had mean scores of 4.02 (SD = 0.58) and 3.92 (SD = 0.60), respectively.

4.2. Correlation Analysis

Pearson correlation analysis revealed significant positive relationships between SSCP adoption and both dependent variables. The results are shown below:

Table 2. Pearson correlation analysis

Variable	SSCP Adoption	Operational Efficiency	Environmental Performance
SSCP Adoption	1.000	0.682**	0.715**
Operational Efficiency		1.000	0.593**
Environmental Performance			1.000

Note: **p < 0.01

4.3. ANOVA Analysis

One-way ANOVA was conducted to examine differences in SSCP adoption across firm sizes and regions. The results are presented below:

Table 3. One-way ANOVA

Source	Sum of Squares	df	Mean Square	F	p-value
Firm Size	12.456	2	6.228	10.325	0.001
Region	15.782	2	7.891	13.467	0.000
Error	80.123	133	0.603		
Total	108.361	137			

Post-hoc Tests: Large firms (M = 4.12, SD = 0.55) exhibited higher SSCP adoption than small (M = 3.65, SD = 0.67) and medium firms (M = 3.88, SD = 0.59). Brazil (M = 4.05, SD = 0.52) showed higher adoption than India (M = 3.78, SD = 0.64) and Nigeria (M = 3.72, SD = 0.66).

H1: The correlation between SSCP adoption and operational efficiency ($r = 0.682$, $p < 0.01$) supports H1, indicating that SSCP adoption enhances operational efficiency.

H2: The correlation between SSCP adoption and environmental performance ($r = 0.715$, $p < 0.01$) supports H2, confirming that SSCP adoption improves environmental performance.

The findings align with RBV theory, suggesting that SSCP serves as a strategic resource for agricultural firms. Larger firms and those in Brazil demonstrate higher SSCP adoption, likely due to greater access to resources and supportive policies. The positive correlations between SSCP adoption and both operational efficiency and environmental performance highlight its dual benefits. However, smaller firms and regions like Nigeria face adoption barriers, such as financial

constraints and limited technical expertise. Policymakers should prioritize capacity-building programs and subsidies to bridge these gaps.

5. Conclusion

This study provides empirical evidence on the benefits of SSCP in agricultural production within emerging economies. The ANOVA results reveal significant variations in adoption, while correlation analyses support the positive impacts on operational efficiency and environmental performance. Future research should explore longitudinal designs to assess the long-term effects of SSCP and investigate additional contextual factors influencing adoption. By promoting SSCP, emerging economies can enhance the sustainability of their agricultural sectors.

This study offers several key contributions to the existing literature on sustainable supply chain practices (SSCP) within the agricultural sector, particularly in the context of emerging economies. First, it bridges a critical empirical gap by providing comparative evidence from three major agricultural economies—Brazil, India, and Nigeria—thereby capturing the heterogeneity of SSCP adoption across different institutional and economic environments. Second, it advances the theoretical discourse by linking SSCP not only to environmental outcomes but also to operational efficiency, thereby validating the dual value proposition of sustainability for agricultural firms. Through the application of ANOVA analysis using SPSS, the study uncovers statistically significant variations in the degree of SSCP implementation, suggesting that both contextual and firm-level factors play a crucial role. Notably, the findings indicate that higher levels of SSCP adoption are positively correlated with improved environmental performance (e.g., reduced waste, lower emissions) and enhanced operational metrics such as supply chain responsiveness and resource utilization. These results offer practical insights for agribusinesses seeking to enhance performance while meeting sustainability goals, and they provide policymakers with empirical grounding to support more tailored, region-specific interventions. By simultaneously addressing environmental concerns and business competitiveness, this research underscores the strategic importance of integrating sustainability into agricultural supply chains—thus contributing meaningfully to both academic literature and policy discourse.

Despite the valuable insights generated by this study, several limitations should be acknowledged. First, the data used were cross-sectional in nature, which constrains the ability to infer causal relationships between SSCP and firm performance outcomes over time. Longitudinal studies would be beneficial to assess how the sustainability-performance dynamic evolves and to capture potential lag effects of SSCP implementation. Second, the study focused on three countries, which, while diverse, may not fully represent the wide spectrum of emerging economies. Future research could expand the geographic scope to include other regions such as Southeast Asia or Eastern Europe for broader generalizability. Third, although ANOVA provided robust comparative insights, the use of more advanced econometric techniques (e.g., structural equation modeling or panel regression) could enhance the analytical depth and control for additional confounding variables. Lastly, while this study concentrated on operational efficiency and environmental performance, future work could explore other dimensions of sustainability,

such as social equity, farmer well-being, or community resilience. Integrating qualitative methods—such as interviews with supply chain stakeholders—could also offer richer contextual understanding. Addressing these limitations in future research would not only strengthen empirical rigor but also provide a more holistic view of sustainable supply chain dynamics in agriculture.

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