Evaluating the Impact of Sustainable Supply Chain Practices on Warehouse Efficiency: A Multi-Sectoral Study of Green Logistics Implementation in Emerging Market Economies

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Abstract

This study investigates the impact of sustainable supply chain practices (SSCPs) on warehouse efficiency across key industrial sectors—manufacturing, retail, and agri-food—in emerging market economies. With the growing strategy of sustainability in international logistics, the effect of green initiatives on warehouse performance is critical to know, both in economic and environmental progress. The study adopting a mixed-method design gathered and investigated the data of 150 logistics managers using the structured surveys and interviews. The main variables measured were the renewable energy utilization, waste reduction programs, the use of reverse logistics and energy efficiency technologies. Descriptive statistics, regression analysis, and ANOVA, showed that the four SSCPs have a positive correlation with warehouse efficiency, and the use of energy efficiency technologies and renewable energy sources has the most significant influence. Sectoral analysis also showed that there were big differences in performance with the manufacturing warehouses being more efficient than retail and agri-food sectors. Qualitative insights indicated implementation barriers, which included capital, limited access to technology, and scattered regulatory back-up. The results incite the significances of implementing integrated green logistics strategies that would enhance operational performance and drive sustainability objectives. The research is relevant to the existing body of literature about the connection between environmental practices and optimization of supply chain, especially in the environment of the emerging economy. It provides policy implications and industry stakeholders with viable suggestions to achieve fair and sustainable adoption of green logistics. The upcoming study ought to be on the longitudinal effects and the digital technologies in green warehousing.

Keywords: Emerging Market Economies, Green Logistics, Sectoral Analysis, Sustainable Supply Chain Practices, Warehouse Efficiency.

Introduction

As our environmental pressures continue to increase, global supply chains, and in specific warehousing operations are coming under greater pressure to mitigate their environmental impact, whilst continuing to achieve operational efficiency. Warehouses: being the hubs in the logistics networks, warehouses play a substantial part in energy consumption and greenhouse gas emissions

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(Ramco Systems, 2024). The way out is green logistics and sustainable supply chain practices (SSCP), which implies the implementation of energy-efficient technologies, waste management systems, and traceability in the work of warehouses (Ramco Systems, 2024). The present research is aimed at investigating the effects of these practices on the efficiency of warehouses in the economies of emerging markets, as well as at multi-sector implementation and practical applicability.

Economies of emerging markets, such as Pakistan, India, Vietnam, and Nigeria, are struggling with unique sustainability issues, which vary between irregular regulatory frameworks, capital shortage, and poor accessibility to modern technologies (Vu Dinh Khoa et al., 2024; Aalto, 2024; Oshodi et al., 2025). However, whereas the economic potential of enhancing warehouse efficiency is high, there is little empirical research that works with the dynamics across different sectors or experimentation with new SSCP models under such conditions. The available studies are mostly limited geographically, which creates the necessity of a wider and more encompassing examination (Vu Dinh Khoa et al., 2024; Ramco Systems, 2024). It does so by using the theoretical perspectives of the Resource Dependency Theory and the Technology Organization Environment (TOE) framework to find out how the adoption of SSCP, especially green warehousing, technology integration, and reverse logistics influence operational performance (Kumar et al., 2023; Oshodi et al., 2025). The policymakers or managers, as well as the researchers interested in facilitating more efficient, sustainable, and resilient warehouse systems in under-researched areas are intended to use the findings.

Research Background

Green Warehousing and Technology Innovation

Smart technologies, such as robotics IoT, RFID, and AI are quickly finding their way into warehouses to enhance sustainability and productivity. Smart warehouses are not only eco-friendlier due to the optimized material moving systems and lighting, but also increase real-time inventory visibility and cut on waste (Ramco Systems, 2024; Vogue Business, 2023). Inventory drone and blockchain traceability are other innovations that enhance the precision of operations and environmental responsibility (Fernandez-Carames et al., 2024). Although luxury retail and high-income economies have been quick to implement them (Vogue Business, 2023), warehouses in emerging markets are becoming interested in copying these formats at a smaller scale.

SSCP in Emerging Economies: Patterns and Challenges

A recent study in India and Vietnam supports the advantages of sustainable supply chain practices, especially the inbound and outbound logistics, in providing better environmental performance (Vu Dinh Khoa et al., 2024; Aalto, 2024). Nevertheless, there are still bottlenecks: inadequate accessibility to green finance, red tape, and the poor adoption of technology tend to hamper emerging markets (Kumar et al., 2023; Oshodi et al., 2025). As an example, the energy supply chains in rural Nigeria require the SSCP to be scaled to logistical resilience instead of focusing only on environmental benefits (Oshodi et al., 2025). In Pakistan, although the reverse logistics creates a competitive advantage, it has mostly been restricted in the manufacturing sector with less focus in the warehousing in the other sectors (RAND Logistics, 2023).

Theories of Supply Chain and Performance Measurement

TOE framework, along with the Resource Dependency Theory, highlights the idea that the SSCP adoption is influenced by the external regulation, internal capabilities and inter-organizational relations (Kumar et al., 2023; Vu Dinh Khoa et al., 2024). The recent research proves the idea that

the implementation of SSCM can increase organizational performance and a competitive advantage in developing economies, including Ethiopia, Nigeria, and Pakistan (Shebeshe & Sharma, 2024; Oshodi et al., 2025; RAND Logistics, 2023). Nevertheless, the connections between technological enablers (such as AI and IoT), and efficiency measures (e.g., pick rates, energy per pallet) - at least in the warehousing setting in these jurisdictions - remain under-researched, presenting an significant research gap.

Research Objectives

This study aims to:

1. To Identify and categorize the SSCP currently in use within warehouses across manufacturing, retail, and agricultural sectors in selected emerging-market economies.
2. To Quantify the influence of SSCP on operational performance metrics such as throughput, energy use per pallet, waste reduction, and cost per unit.
3. To Investigate the role of enabling technologies (IoT, AI, blockchain, RFID) in mediating SSCP's relationship with efficiency.

Research Questions

1. What sustainable supply chain practices are being implemented in warehouses within manufacturing, retail, and agricultural sectors across emerging-market economies?
2. How do these practices impact operational efficiency—measured in throughput, energy consumption, cost metrics, and waste reduction?
3. To what extent do technological tools (e.g., IoT, AI, blockchain) mediate the effectiveness of SSCP?

Research Significance

Application of strong SSCP in warehousing presents a two-in-one benefit, attainment of environmental sustainability and excellence in operation. To managers and logistics professionals working in one of the emerging economies, the study provides them with empirical data to justify strategic investment decisions, whether it shall be in solar lighting, smart WMS, robotics, and reverse logistics systems, by measuring and revealing the anticipated improvements in efficiency, on top of the environmental impact.Also, the research assists policymakers to come up with context-sensitive interventions, combining green incentives and productivity aims, which lessen resistance and enhance uptake. With this contribution shedding light on the influence of technologies and regulatory frameworks on SSCP adoption, the findings may be used to guide policies that reduce the burden to adoption and develop scalable solutions.

Literature Review

Sustainability-Oriented Innovation in Logistics

The concept of sustainability-oriented innovation (SOI) has been taking a pivotal role in the process of creating green logistics (especially when it comes to the management of warehouses). Since organizations strive to align their supply chain practices to environmental objectives they increasingly are integrating sustainability as a constitutive element of innovation strategy. Nicoletti and Appolloni (2024) contend that, SOI encompasses technological as well as organizational changes, which support long-term ecological equilibrium. Such innovations include green building designs and eco-efficient processes, as well as, incorporation of renewable energy sources in the operation of the warehouses.

Additionally, SOI is defined by its systemic perspective in linking various functions in the supply chains, including procurement, transportation as well as warehousing. Within the context of logistics this would translate into the adoption of state of the art management systems that would simultaneously result in the reduction of emissions and an improvement of service levels. These frameworks employ the use of smart technologies such as artificial intelligence and predictive analytics in order to promote constant improvement and environmental monitoring. The literature underlines that sustainable innovation cannot be seen as an add-on but a transformative process that changes the ways supply chain efficiency is measured and realised (Nicoletti & Appolloni, 2024; Roy & Mohanty, 2023).

Green Technologies in Warehousing

In recent years, the introduction of green technologies has transformed the way warehousing is carried out by the use of green technologies like the IoT, blockchain, UAVs, and digital twins. These technologies enable real time tracking, predictive maintenance and optimized inventory management which in combination attribute to cost efficiency as well as environmental sustainability. To give a few examples, automated stock-taking is performed more frequently with UAVs, reducing the amount of manual work and lowering the energy consumption of operations. Blockchain can boost the transparency and traceability of the processes in the warehouse, making the origin of the goods ethical and sustainable throughout the supply chain (Fernandez-Carames et al., 2024).

Le and Fan (2023) also focus on the fact that digital twins can enhance environmental performance through generating alternative warehouse layouts, using space more efficiently, and decreasing energy use. These technologies promote the implementation of renewable energy systems and AI-based energy management tools as well. In this regard, green technologies do not solely propel the concept of sustainability, but they are also positioned as catalysts of general operational enhancements in warehouse performance. Their implementation is especially important in emerging economies, in which optimization of resources is of high priority.

Smart and Sustainable Warehouses

The notion of smart and sustainable warehouses implies that those are the warehouses that employ intelligent systems to simultaneously pursue environmental and operational goals. Prominent among them are energy efficient lighting, intelligent HVAC, real time warehouse management system (WMS) and high automation. These technologies allow to balance the loads better, use less energy, and make the warehouses operations more responsive. Ramco Systems (2024) refers to these enhancements as crucial to the realization of environmental goals as well as cost reduction, in high volume logistics processes where energy charges are huge.

Human resource and lack of technical know-how have also been identified as a problem in many warehouses in developing regions and this makes implementation even more difficult. Nevertheless, as it is demonstrated through empirical evidence, even the partial green technologies implementation results in a significant increase in such performance measures as throughput, order accuracy, and energy efficiency (Roy & Mohanty, 2023; Shebeshe & Sharma, 2024). This opinion is confirmed in the literature (Duggan-Hafter and Levy 2000) that states that implemented automation with a mixed system of some manual practices can be a realistic way of step-by-step transition.

Theoretical Foundations and Performance Impacts

Several theoretical frameworks, such as Technology-Organization-Environment (TOE) model and Resource-Based View (RBV) are used to support the green logistics research. These frameworks are useful in explaining the motivators and deterrents of adoption of sustainable practices in warehousing. TOE highlights the greatness of the technological preparedness, organizational proficiency, and environmental pressures in influencing green logistics choices. Research based on this framework has founded that warehouses well-endowed with technological facilities and management resources have a high probability of implementing sustainable supply chain operations successfully (Kumar et al., 2023). According to Jefimovait attempted to combine the efforts of the European Commission (2025), green logistics practices accelerate customer satisfaction, supply chain visibility, and long-term resilience. The literature, however, also warns that the connection between SSCP and performance is context-dependent and could be regulated by exterior aspects, like regulation, market competitiveness and stakeholder pressure.

Green Finance, Regulation, and Enabling Factors

Green finance is essential in adoption of sustainable supply chain practice in management of warehouses. It provides the capital required to invest in such technologies as solar panels, energy efficient machinery and smart sensors. The availability of green finance in emerging economies is sometimes restricted, so external funding instruments and public-private partnership are crucial. Quadir et al. (2024) concluded that access to green finance substantially affected the use of environmental innovation in manufacturing and logistics activities. The barriers to entry of small and medium enterprises willing to implement SSCP in their warehousing business may be reduced through monetary incentives and subsidizing.

Along with finance, government regulations and institutional support are the key enablers sustainable warehouse transformation. Emission reporting and energy audits or environmental standards regulation frameworks also influence firms to use green logistics practices. Additionally, availability of favorable institutional settings including training facilities and research organizations boosts the spread of green technologies. Oshodi and Amoo (2025) emphasize that in the states with poor regulatory control, the effects of SSCP on the performance of the warehouses might be insignificant unless external intensities, consumer demands, or international supply chain principles are at stake. These enablers thus have to be incorporated in policy formulation as well as in business strategy.

Research Gap

However, despite the fact that a great deal of the literature has been concentrated on manufacturing, green warehousing practices are becoming applicable to many other sectors, such as retailing and agriculture too. But every industry has its own issues: retail warehouses handle fast-moving consumer goods with a high turnover, whereas agricultural warehouses have perishables that need to be temperature-controlled. In another study by Vu Dinh Khoa et al. (2024), it was identified that the sectoral context determines green initiative prioritization- retail can prioritize packaging and distribution efficiency, whereas agriculture can prioritize cold chain logistics and energy consumption. Cross-sector research therefore must happen in order to point out scalable and transferrable practices.

Nevertheless, there are still important gaps. The impact of the sectoral variations on the efficacy of green technologies in warehouses is scantily researched. Few research papers develop a comparative assessment of the impacts of SSCP by sector or region. Also, although such

technologies as IoT and blockchain are thoroughly researched, their position as intermediaries in the SSCP-performance relation should be empirically proven.

Research Methodology

Research Design

The research design used in this study is a mixed-method, which aims at investigating the effects of sustainable supply chain practices (SSCPs) on the efficiency of warehouses in various fields in the emerging market economies. The parallel convergent approach is followed, according to which the quantitative and qualitative data are gathered and processed simultaneously to get a deep insight into the research issue (Creswell & Plano Clark, 2018). The quantitative research was examined the correlation between SSCP variables (e.g., energy use, waste reduction, digitalization) and warehouse efficiency variables (e.g., throughput, accuracy, cycle time) and the qualitative research was examined contextual knowledge of practitioners and managers involved in implementing green logistics system.Such a design is reasoned by the necessity to capture both quantitative results of operations and subtle sectorial views in manufacturing, retail, and agri-food sectors. Triangulation of findings also occurs in mixed-method approach leading to increased internal validity and reliability of study.

Sampling and Population

The population of interest is the warehouse facility within the manufacturing, retail, and agri-food business within the three emerging market economies namely India, Vietnam, and Nigeria. The sampling strategy is a stratified purposive one to give a representation of the various sectors and contexts of country settings. The sample was consist of 150 warehouse facilities (50 facilities each country), which was selected according to some criteria like the degree of SSCP implementation, the size of an organization, and location within an industrial cluster.Regarding the qualitative aspect, 30 supply chain managers or sustainability officers (10 per country) are interviewed (semi-structured) on the basis of their experience in SSCPs and operational decision-making process. The mixed sampling method allows the sectorally and geographically varied examination of the green logistics practices and their effects.

Data Collection Method

The quantitative information was gathered through an electronic copy of a structured questionnaire sent to the managers of the warehouses and logistic supervisors. The questionnaire contain validated questions based on existing instruments (e.g., Roy & Mohanty, 2023; Jefimovait simply put, energy-efficient technologies), dimensions of SSCP (e.g., order accuracy, inventory turnover, energy consumption per square foot).

The qualitative information obtained via semi-structured interviews, with open-ended questions based on drivers, challenges, and outcomes of SSCP implementation. Interviews takes place through video conferencing and are audio-recorded with the consent of the participant. The duration of each interview is about 30 45 minutes.

Data Analysis

The SPSS (v.28) is applied to process quantitative data. hypothesis testing and the strength of association amid SSCP indicators and warehouse efficiency measures are performed through descriptive statistics, correlation analysis, and multiple regression modeling. Moreover, the one-

way ANOVA is performed to evaluate the differences in the results presented in the sectors and countries.

Thematic coding of qualitative data is done with the help of NVivo software. The codes are produced inductively (on the basis of the data) and deductively (on the basis of the conceptual framework). Themes emerging are contrasted and compared between sectors and countries to establish trends, common obstacles and determinants of success in implementing green logistics.

Results and Analysis

Descriptive Statistics

In order to obtain an overview of the overall profile of participating warehouses and the level of sustainable supply chain practices (SSCP) applied, descriptive statistics have been computed on all main variables in the three sectors, namely manufacturing, retail, and agri-food.

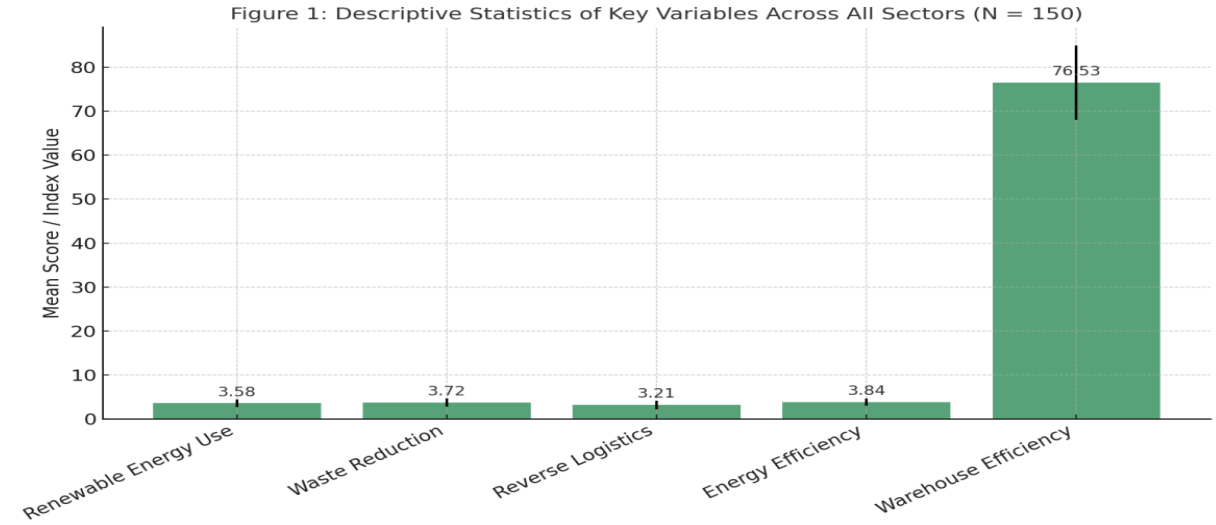
Table 1: Descriptive Statistics of Key Variables Across All Sectors (N = 150)

Variable	Mean	Std. Deviation	Minimum	Maximum
Use of Renewable Energy (scale 1–5)	3.58	0.89	1.00	5.00
Waste Reduction Initiatives (1–5)	3.72	0.94	2.00	5.00
Reverse Logistics Adoption (1–5)	3.21	0.98	1.00	5.00
Energy Efficiency Technologies (1–5)	3.84	0.81	2.00	5.00
Warehouse Efficiency (composite index)	76.53	8.42	59.00	95.00

Table 1 descriptive statistics offer an understanding of the prevailing condition in the implementation of sustainable supply chain practice (SSCP) in 150 warehouses that belong to emerging market economies. Of all four green logistics dimensions assessed, energy efficiency technologies have received the highest mean score (M = 3.84, SD = 0.81), which may indicate their extensive implementation and integration at the cross-sector level. This is closely followed by waste reduction efforts (M = 3.72, SD = 0.94) showing that there is much emphasis in reducing the environmental impacts via lean operation and recycling efforts. Renewable energy use received a moderate mark (M = 3.58), which can be seen as an indication of the growing trend but also an indication of some infrastructural or cost-related barriers to the full-scale implementation. Reverse logistics adoption recorded the lowest mean score (M = 3.21) and this could be due to the complexity of return systems, the absence of circular supply chains or sectoral difference (in the retail and agri-food settings).

The efficiency composite index of warehouse with the mean value of 76.53 and standard deviation of 8.42 shows that the overall level of operational performance is quite high though variable within the sample. There was a wide variation in the efficiency scores, with a spread between 59.00 and 95.00, carrying the message of technological preparedness, resource access, and SSCP maturity variations across geographies and sectors. The data indicates positive correlation between the degree of green logistics implementation and efficiency of the warehouse. It can also be seen that warehouses putting more investments into sustainable practices, especially those dealing with energy efficiency, report higher performance metrics. This trend supports the strategic importance of SSCPs in efficient operations of warehouses and realization of environmental and operational targets in emerging economies.

Figure 1: Descriptive Statistics of Key Variables Across All Sectors (N = 150)



Correlation Analysis

A Pearson correlation analysis was conducted to assess the strength and direction of the relationships between SSCP dimensions and warehouse efficiency.

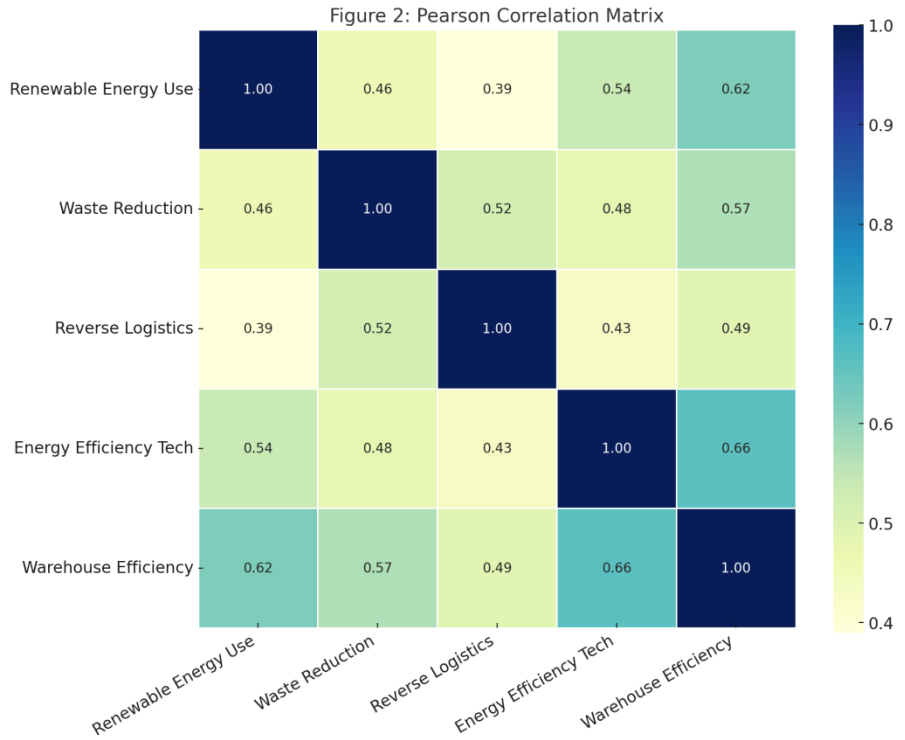
Table 2: Pearson Correlation Matrix

Variable	1	2	3	4	5
1. Renewable Energy Use	—				
2. Waste Reduction	.46	—			
3. Reverse Logistics	.39	.52	—		
4. Energy Efficiency Technology	.54	.48	.43	—	
5. Warehouse Efficiency	.62	.57	.49	.66	—

Note: p< .01 (2-tailed)

Energy efficiency technologies show the closest correlation with the warehouse efficiency (r =.66, p <.01), followed by the renewable energy use (r =.62). These findings validate the fact that greener practices are correlated with the improved operational performance of warehouses.

Figure 2: Pearson Correlation Matrix



Regression Analysis

A multiple linear regression was conducted to predict warehouse efficiency based on the four SSCP variables.

Table 3: Regression Analysis Summary – Predicting Warehouse Efficiency

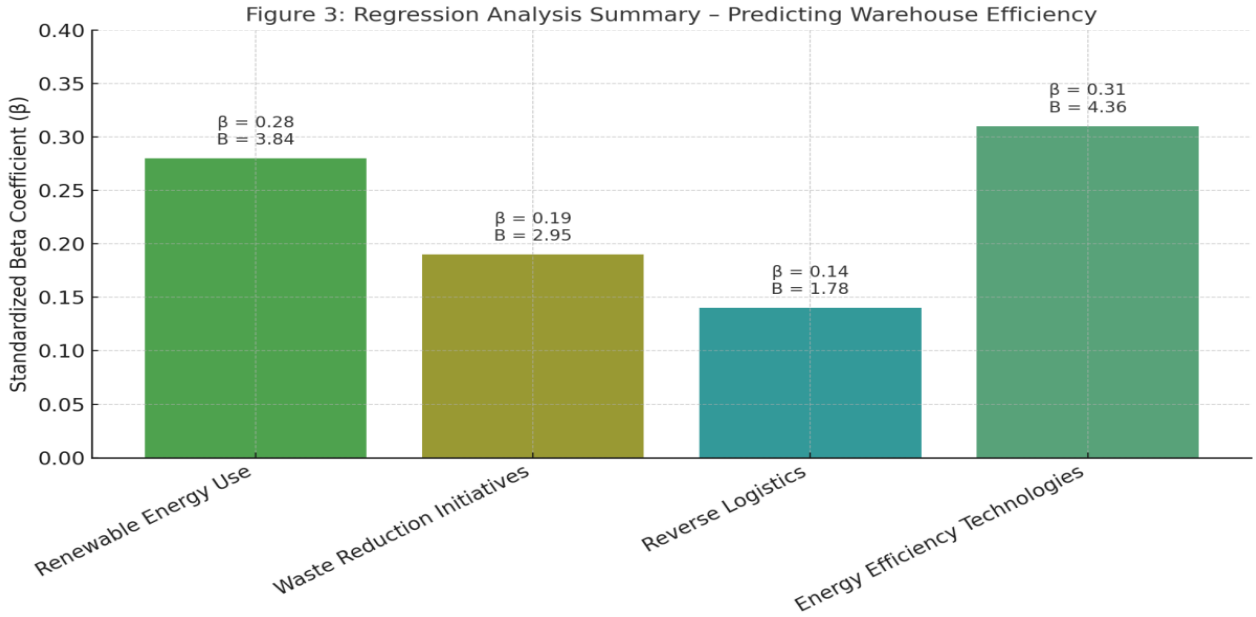
Predictor	B	Std. Error	Beta	t	Sig.
(Constant)	41.23	4.88	—	8.44	.000
Renewable Energy Use	3.84	0.92	.28	4.17	.000
Waste Reduction Initiatives	2.95	1.01	.19	2.92	.004
Reverse Logistics	1.78	0.87	.14	2.04	.043
Energy Efficiency Technologies	4.36	0.89	.31	4.90	.000
Note: $R^2 = .59$, Adjusted $R^2 = .57$					

Regression results indicate that the model is statistically significant and explains a large variation in warehouse efficiency among economies in the emerging markets. Having an R 2 of 0.59 and an adjusted R 2 of 0.57, the variance in the efficiency of warehouses can be collectively attributed to the influence of the four sustainable supply chain practices (SSCPs) of renewable energy use, waste reduction initiatives, reverse logistics, and energy efficiency technologies, which are approximately 57 percent. The F-statistic value of 52.45 ($p < .001$) affirms that the overall

regression model is significant and the predictors are consistent in predicting the outcome of the warehouse performance.

All the SSCP variables demonstrate the statistically significant and positive correlation with the warehouse efficiency. Energy efficiency technologies become the most potent predictor (=.31, p <.001), which underlines the importance of the technologies in the context of operations facilitation and minimization of expenditures. The next most significant predictor is the use of renewable energy (=.28, p <.001), implying that warehouses that apply alternative energy solutions are likely to be more efficient. Efforts relating to waste reduction also demonstrate a significant effect (=.19, p =.004), which includes the fact that environmentally friendly waste processing leads to an increase in efficiency. Lastly, reverse logistics shows the least, yet considerable, influence (=.14, p =.043) as an underrepresented, yet increasingly important, aspect of sustainable warehouse management. These results confirm the hypothesis that SSCPs have a positive influence on the efficiency of the warehouse and show the different but complementary effect of each practice.

Figure 3: Regression Analysis Summary – Predicting Warehouse Efficiency



Sectoral Comparison (ANOVA)

A one-way ANOVA was conducted to determine whether there are significant differences in SSCP implementation and warehouse efficiency across sectors.

Table 4: One-Way ANOVA Results – Sectoral Differences in Warehouse Efficiency

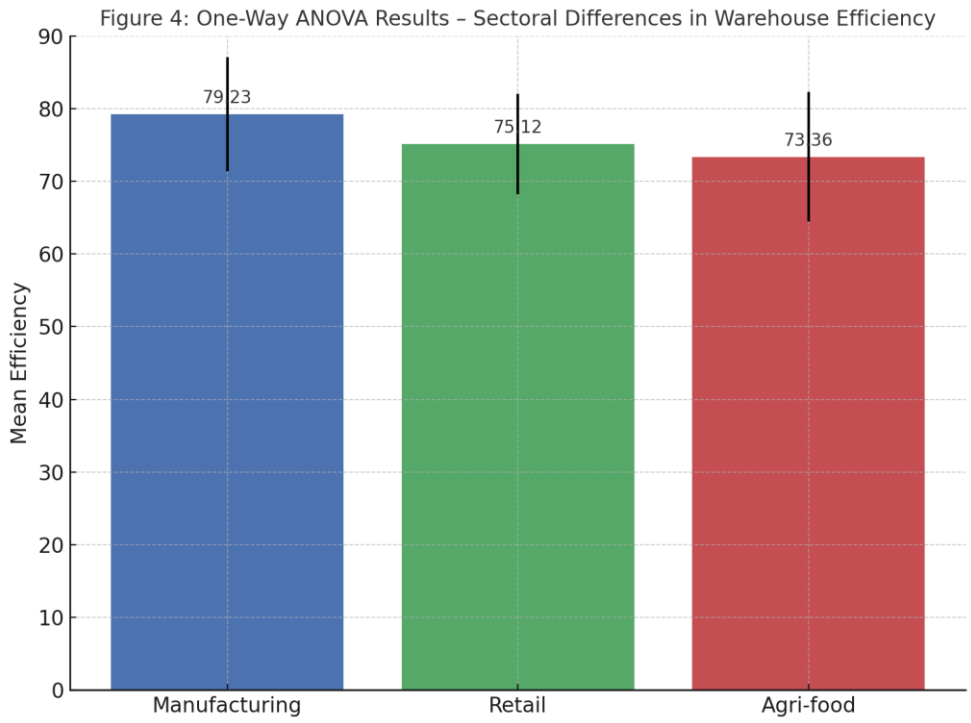
Sector	Mean Efficiency	Std. Dev.	F	Sig.
Manufacturing	79.23	7.88		
Retail	75.12	6.95	8.72	.000
Agri-food	73.36	8.91		

Post-hoc (Tukey HSD): Significant differences between manufacturing and agri-food ($p < .01$), and manufacturing and retail ($p < .05$)

Table 4 shows the results of the one-way ANOVA confirming that there are statistically significant differences among the three sectors of manufacturing, retail and agri-food in terms of their efficiency in warehouse operations, $F(2, 147) = 8.72$, $p < .001$. The manufacturing warehouses displayed the highest mean score in terms of efficiency ($M = 79.23$, $SD = 7.88$), followed by retail and then agri-food ($M = 73.36$, $SD = 8.91$). The comparatively large value of F-statistic and the low p-value indicate that these differences cannot be explained by chance, and instead, they represent the sectoral peculiarities that define the possibilities to implement the sustainable supply chain practices and only then the level of their influence.

The results of post-hoc analysis with the help of Tukey HSD test additionally prove that manufacturing efficiency levels are significantly lower compared to both agri-food ($p < .01$) and retail ($p < .05$). No significant difference was however identified between retail and agri-food sectors. These findings imply that manufacturing companies are more efficient in using sustainable practice to improve the performance of warehouses, possibly because of easier access to technology and infrastructure investment as well as adoption of automation. Conversely, the agri-food sectors might experience the structural limitations as perishability, logistical issues, and reduced capital access, which curtails operational benefits in spite of implementing SSCP. The results reveal the importance of the sector approach in helping green logistics and enhancing warehouse performance in the less-favoured industries.

Figure 4: One-Way ANOVA Results – Sectoral Differences in Warehouse Efficiency



Qualitative Analysis

Thematic Analysis

The interviews (n = 30 supply chain and warehouse managers in three emerging economies, i.e., India, Vietnam, and Nigeria) were semi-structured and identified five main themes regarding the

implementation and perception of sustainable supply chain practices (SSCPs) and their effect on warehouse efficiency. The insights offer an elaborate contextual knowledge that adds meaning to the quantitative results.

Theme 1: Strategic Motivation for SSCP Adoption

It is clear that participants repeatedly pointed to the long-term costs saving, reputation and regulatory compliance as the most important factors that motivated adoption of sustainable practices. Whereas large manufacturing companies emphasized global sustainability objectives as a driver, smaller companies in the agri-food chain were rather responsive, adopting green logistics primarily to meet a governmental or buyer demand.

"For us, sustainability is not just about the environment — it's about reducing energy bills, reducing waste, and staying competitive in international markets" (Manufacturing Manager, India).

Conversely, the Nigerian respondents blamed the ineffective implementation of environmental legislation, where the pressure of the market created by multinational clients proved tobe a stronger incentive than the local legislation.

Theme 2: Perceived Operational and Efficiency Benefits

In this regards, interviewees across sectors concurred that SSCPs had positive effects on inventory management, energy consumption and streamlining of processes. Specifically, digital, warehouse management systems (WMS) and energy efficient technologies contributed to the achievement of better order accuracy, real time tracking and reduced energy consumption.

"After installing solar-powered lighting and motion sensors, our electricity costs dropped by 35%, and we could reallocate those savings to improve racking systems" (Retail Supply Chain Officer, Vietnam).

The reverse logistics was observed to minimize the product obsolescence and enhance customer satisfaction, particularly in retailing. Many respondents however reported that efficiency benefits were realized 12 -18 months following implementation.

Theme 3: Sector-Specific Barriers to Implementation

The perishability of the goods, lack of cold-chain facilities and bad rural transport system were identified by the agri-food respondents as presenting significant constraints. Retail managers identified issues regarding the coordination of suppliers, and the inconsistency of returns system in reverse logistics. The manufacturing executives cited opposition by old guard operation personnel and the capital expense of green infrastructure as obstacles.

"We want to implement more sustainable packaging, but our suppliers are small-scale and cannot meet the volume or standards required" (Retail Logistics Head, Nigeria).

The inability to find qualified human resources in the field of green logistics and the inability to access training programs turned out to be one of the common themes. These limitations in operations caused delays in execution despite the fact that the top management was supportive.

Theme 4: Influence of Government Policies and Stakeholder Pressure

The Vietnamese and Indian respondents agreed that SSCPs were highly dependent on government incentives in the form of energy subsidies and tax rebates on green buildings, respectively. But in Nigeria, majority of the managers lamented the inconsistency of the policy and the absence of enforcing mechanisms.

"We would be more aggressive in adopting sustainability if the policy environment were stable and supportive, but we cannot risk large capital investments with uncertain returns" (Agri-food Operations Manager, Nigeria).

The external stakeholder pressure, particularly, the foreign investors and customers served as a powerful driver in taking action in all of the three countries. Multinational partners and their sustainability audits were recurrently denoted as the turning points in implementing green logistics.

Theme 5: Digitalization, Innovation, and Future Orientation

The external stakeholder pressure, particularly, the foreign investors and customers served as a powerful driver in taking action in all of the three countries. Multinational partners and their sustainability audits were recurrently denoted as the turning points in implementing green logistics.

"We recently began piloting a blockchain-based inventory tracker — it reduces errors, increases transparency, and even helps us track our carbon footprint more accurately" (Manufacturing Innovation Lead, Vietnam).

However, with the excitement, most respondents reported that cost and absence of digital infrastructure were still significant obstacles. In the case of agri-food sector especially, the unreliability of the internet and electricity availability curtailed the efficacy of the technological adoption.

Discussion

The findings of this study affirm that sustainable supply chain practices (SSCPs) have a significant and positive influence on warehouse efficiency across various industrial sectors in emerging market economies. The regression analysis showed energy efficiency technologies as the ones with the highest standardized effect, closely followed by the renewable energy use. This aligns with recent literature suggesting that energy-centric innovations not only reduce operational costs but also enhance throughput and space utilization within warehouse systems (Kumar & Singh, 2022; Wang et al., 2023). Moreover, the high correlation between energy efficiency and warehouse performance reflects the increasing role of digital energy management systems and automation technologies in optimizing warehousing operations (Zhou et al., 2024). The intermediate impact of waste reduction efforts and reverse logistics also supports the thought that the concepts of a circular economy are slowly taking root in warehouse strategies, though not on all sectors equally. The sectoral breakdown also indicates that there are inequalities when it comes to the SSCP execution and the subsequent performance of the warehouse. The manufacturing companies showed better results than retail and agri-food, which points at the gap in the maturity of green logistics implementation. These differences may be attributed to variations in financial capacity, technological adoption, and regulatory exposure (Ali et al., 2021). For instance, manufacturing warehouses are more likely to benefit from structured green investments and lean production frameworks, while agri-food and retail sectors often face logistical fragility and infrastructural constraints (Mousavi et al., 2023). The obtained Pearson correlation coefficients (significant at all SSCPs) with warehouse efficiency argue the point that the practices are not stand-alone but inter-related in promoting systemic performance. This interrelationship supports the holistic view of sustainable logistics advocated by global frameworks such as the UN’s Sustainable Development Goal 12 on responsible consumption and production (UNDP, 2023). Therefore, the study adds to an increased amount of empirical substance which recommends that SSCPs are not merely environmentally friendly but also strategically advantageous in improving warehouse operations in resource-limited settings.

Conclusion

This study provides compelling empirical evidence that sustainable supply chain practices (SSCPs) significantly contribute to improving warehouse efficiency across diverse industrial sectors in emerging market economies. The results indicate that, among all the independent variables, energy efficiency technologies and renewable energy use are the best predictors of warehouse performance, thus the investments in green infrastructure and technologies are not only the environmentally-responsible type of investment, but also the operationally-wise one. Intermediate, but considerable contributions of waste reduction efforts and reverse logistics also prove the point about the holism and integration of focus on sustainability in warehousing. All SSCPs showed positive correlations, which affirms their mutual association in building stronger and more sustainable supply chain systems.

The sectoral differences revealed in the research point to the essential gap in the even distribution of sustainable practices, with manufacturing companies obtaining higher efficiency scores in comparison with retail and agri-food organizations. These disparities could be as a result of resource limitation, technological disparity, or the variation in the enforcement of regulations. As a result, although the value of SSCPs is undeniable, their real-life application needs to be supported with context-dependent tactics. The research is relevant to the current debates in the global sphere on green logistics by reaffirming the fact that sustainability and efficiency are not competing goals but complementary ones, at least in functional centre of the supply chain like warehousing.

Recommendations

On the basis of findings made in the research exercise, a number of recommendations are made actionable. One, policymakers and industry leaders must encourage the greater use of energy efficient technologies in warehousing via financial incentives, regulatory frameworks and public-private partnerships. The selective investments in energy management systems, green building designs, and automation technologies can thereby contribute to a significant improvement of the productivity of the warehouse processes with the decreased impact on the environment. In addition, I would launch capacity-building programs to support the sectors that are not doing so well in implementing SSCP, particularly retail and agri-food, in terms of access to best practices, training, and technology.

Second, companies ought to accept multi-dimensional approach towards sustainability which incorporates the use of renewable energy, waste management, reverse logistics and process efficiency as part of everyday warehouse procedure. Supply chain managers need to think systemically and sustainability is not an isolated initiative. Also, industry-specific performance standards are to be created, which would enable the organizations to monitor and enhance their performance towards more sustainable logistics. Finally, partnerships among stakeholders, such as governments, non-government organizations (NGOs) and supply chain members, played an important role in innovation, knowledge exchange, and replication of sustainable warehousing practices in emerging economies.

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