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The Impact of Green Logistics Management on Sustainable Logistics Performance

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Abstract

A country's economic stability is greatly influenced by logistics, and logistics service providers (LSPs) are crucial to fulfilling the ever-increasing demands of business. Nonetheless, LSPs are under growing pressure to implement sustainable practices because they are one of the supply chain's most expensive and carbon-intensive operations. The significance of sustainability in logistics operations is highlighted by the need for increased energy efficiency, cost-effectiveness, and safety, in addition to stricter environmental requirements. Green innovation is essential for the logistics sector to promote sustainable development and mitigate environmental crises. Green logistics management practices (GLMPs) have become important organizational performance drivers in today's competitive market.

This study aims to investigate how sustainability performance is affected by green logistics management. Through exploratory research and employee data collection, we uncover the main characteristics and metrics that quantify sustainable logistics performance. Utilizing Structural Partial Least Squares Modeling (SPLSM), the effect of green logistics management on sustainable logistics results is examined. The results provide insightful information about how green innovation improves operational and environmental performance, setting LSPs up for long-term success in a changing market.

Keywords*: Sustainable logistics performance (SLP), Green logistics management practices (GLMPs), Logistics services providers (LSPs), Green innovation (GI), Environmental sustainability, Logistics Efficiency (EI), Logistics Differentiation (LD), Logistics Effectiveness (LE).*

INTRODUCTION

As one of the most extensive and rapidly expanding economies, India features a youthful demographic, increasing investment levels, strong domestic demand, and globally competitive enterprises. Notwithstanding the difficulties presented by recent global crises, projections indicate that India will emerge as the world's third-largest economy by 2025, following China and the USA. The transportation and logistics sector is crucial to this development, employing almost 45 million individuals. The economic expansion has heightened the demand for transportation services, underscoring the necessity for a more efficient logistics infrastructure.

Global apprehensions regarding the environmental repercussions of human activities have escalated, garnering attention from governments, academics, the media, and the public. Businesses face mounting pressure from stakeholders to assume responsibility for their environmental impacts. The logistics sector, which significantly contributes to pollution and resource depletion, has faced scrutiny.

Green logistics, which seeks to reduce the environmental impact of logistics operations, has acquired global prominence. Nonetheless, investigations exploring the impact of green logistics on India's sustainable growth still need to be made available. This study examines the notion of green logistics management practices concerning

logistics performance and active sustainability, including several tactics to minimize the environmental impact of logistical activities

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Problem Statement and Background

The transportation industry accounts for over 20% of worldwide energy use (Craig et al., 2013; Ratanavaraha & Jomnonkwao, 2015). Furthermore, it constitutes around 20% of greenhouse gas emissions within the European Union (Alises & Vassallo, 2015). The transport sector is vital for economic development, although it significantly contributes to adverse environmental effects, especially regarding climate change and energy consumption (Zuylen & Weber, 2002). In the current age of globalization, it is essential to mitigate carbon emissions from extensive worldwide transportation networks. Logistics service providers are a major threat to the sustainability of planet Earth.

In recent years, scholars and practitioners have concentrated on tackling the challenge of environmental sustainability in the logistics sector. Due to increasing expectations for flexibility, sustainability, and cost-effectiveness, there is an urgent necessity to evaluate sustainable logistics performance thoroughly. Recognizing efficient green logistics techniques is essential for harmonizing environmental sustainability with economic competitiveness in the global marketplace.

Need and Scope of the Research

Recent research on sustainability highlights the necessity for companies to transcend conventional perspectives, which frequently depend on a simplistic trade-off model (Elkington, 2019). Businesses could implement strategic sustainability strategies alongside conventional methods to get a competitive advantage (Ioannou and Serafeim, 2019). Moreover, there is an increasing focus on sustainability-driven innovation that improves societal well-being and environmental integrity (Geradts and Bocken, 2019). Given these findings, it is imperative to implement a thorough methodology for assessing sustainability performance, especially within the logistics industry.

This study concentrates on the Indian freight forwarding and logistics sector. The objective is to analyze the influence of Green Logistics Management on the Sustainable Logistics Performance of logistics service providers in India.

Research Gap

Although extensive research has investigated the benefits of Green Innovation (GI) on financial performance, more studies must address its influence on the sustainability of logistics service providers (LSPs). In recent years, there has been a heightened focus on green innovation (GI) as a strategy to mitigate environmental harm (Arfi et al., 2018; Centobelli et al., 2017), with prior research associating GI with overall corporate performance mainly through financial indicators (Tang et al., 2018). While GI has been extensively studied in the industrial sector (Seman et al., 2019), its significance in logistics is still inadequately examined.

Studies demonstrate that using GI practices is essential for LSPs to enhance their sustainability performance (Lin and Ho, 2008; Rossi et al., 2013). Centobelli et al. (2017) detect significant deficiencies in comprehending the impact of green initiatives on logistics service provider performance and evaluating sustainability outcomes. Consequently, it is essential to examine the influence of GI on Sustainable Logistics Performance (SLP) in the logistics industry.

RESEARCH METHODOLOGY

The research utilizes a quantitative design through surveys to examine Sustainable Logistics Performance (SLP) and the influence of Green Innovation on it. Constructs for SLP are delineated, and a scale is formulated by augmenting the current framework from Fugate et al. (2010). The analysis used Structural Partial Least Squares Modeling (SPLM) to investigate the link between Green Logistics Management and SLP.

The population comprises organizations and professionals from the logistics, transportation, and supply chain industries, with a sample size of 200 respondents chosen via simple random sampling. A standardized questionnaire with Likert scales is employed to gather data, assuring consistency and reliability, as validated by Cronbach's Alpha. The data undergoes processing using frequency analysis and hypothesis testing utilizing p-values to ascertain statistical significance.

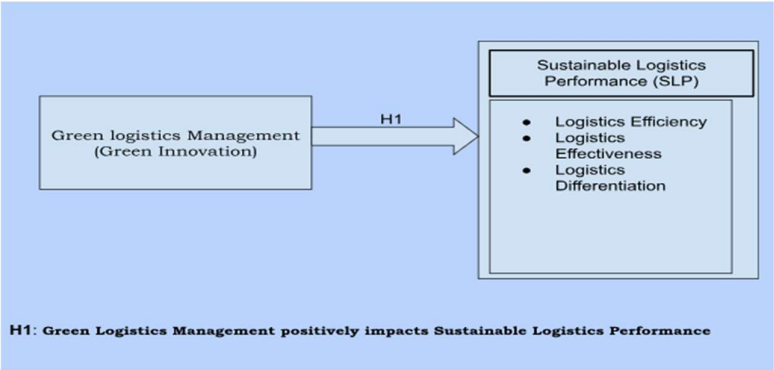

Figure 1: Proposed Conceptual Model Green Innovation (GI), Green logistics Management (GLM), Sustainable logistics performance, LE (Logistics Efficiency)

OBJECTIVE

The main aim of this study is to ascertain if Green Logistics Management effectively enhances Sustainable Logistics Performance.

This purpose will direct the investigation of the subsequent hypotheses:

H1: Green Logistics Management positively influences Sustainable Logistics Performance.

H1a: Green Innovation exerts a beneficial influence on Logistics Efficiency.

LITERATURE REVIEW

Green Logistics Management

Implementing sustainable green logistics is essential for reducing carbon emissions, achieving climate-neutral supply chains, addressing climate change, and tackling environmental challenges while enhancing transportation efficiency, decreasing energy consumption, minimizing waste, and promoting renewable energy sources (Domagala et al., 2022). Green logistics management includes green innovations, information distribution, collaboration, and transportation techniques (Trivellas et al., 2020). Over the past decade, sustainability has become increasingly significant due to rising socio-environmental issues, including climate change and health hazards linked to air pollution (Khan et al., 2020). Integrating sustainability into supply chain operations gives firms a competitive edge in the market (Akdoğan & Coşkun, 2012; Raut et al., 2019). Furthermore, the implementation of low-carbon initiatives throughout supply chains is crucial for fostering a cleaner, more sustainable future (Jira & Toffel, 2013; Klymenko & Lillebrygfjeld Halse, 2022; Oglethorpe & Heron, 2010). Green Logistics Management (GLM) includes critical components such as information distribution, freight transportation, inventory management, and material handling throughout the supply chain (Martel & Klibi, 2016; Baah et al., 2020). Research demonstrates that adopting eco-friendly practices—such as sustainable transportation, reverse logistics, effective waste management, and sustainability oversight—can significantly diminish greenhouse gas emissions and resource usage, improving operational efficiency and fostering environmental and social sustainability. These enhancements may yield enhanced market performance and increased profitability (Agyabeng-Mensah et al., 2020; Baah et al., 2020; Khan, 2019). Research indicates a strong correlation between GLM and financial performance and environmental impacts (Baah et al., 2020; Zaman & Shamsuddin, 2017). Despite multiple studies validating that green supply chain practices enhance performance, additional research is essential. Marcus Thiell (2011) delineates that a green logistics framework has numerous essential components, including eco-friendly transportation, sustainable warehousing, environmentally responsible packaging, logistics data gathering and management, and efficient waste management. Rogers (1998) emphasizes that the core of a green logistics system is the application of modern technology and equipment to minimize environmental impact while maximizing resource efficiency.

Sustainability

The notion of sustainability originated in academic discourse over two decades ago, resulting in numerous definitions by researchers and practitioners (Kumar, 2006). Linton et al. (2007) observe that sustainability varies across diverse disciplines, such as engineering, operations management, and social sciences. Carter and Rogers (2008) also emphasize the variability in definitions of sustainability seen in the current research. Sustainability has become a prominent emphasis for researchers and practitioners alike. Research indicates that it can act as a catalyst for innovation, improve efficiency, and add to sustainable company value (Appleton, 2006; Kiron et al.,

2017).

Sustainability and Logistics Performance

In recent years, escalating environmental concerns have prompted researchers and policymakers to concentrate on mitigating the adverse effects of logistical activities and advancing sustainable operations (Liu et al., 2019). Incorporating sustainability into logistics improves productivity and service quality, enabling firms to fulfill consumer requests while enhancing long-term viability (Fernando & Chukai, 2018). Liu et al. (2018) emphasize that proficient logistics performance is crucial for green supply chain management and aids environmental sustainability. LSPs should fortify community interactions and augment their social contributions to increase their reputation (Fernando & Chukai, 2018. The rising need for sustainable development has compelled logistics professionals to develop measures for assessing sustainable logistics performance (SLP). The current literature inadequately examines the roles and significance of logistics in achieving sustainability objectives (Dey et al., 2011). Fernando and Chukai (2018) characterize sustainable logistics performance (SLP) as a methodology that maximizes resource utilization and assists companies in attaining their sustainability goals. This is achieved by effective route optimization, cost minimization, heightened client happiness, augmented revenue, enhanced security, and decreased adverse social and environmental effects. Fugate et al. (2010). propose scale (i.e., logistics efficiency, logistics efficiency, and logistics differentiation) to measure logistics performance where logistics efficiency is positively related to logistics efficiency and differentiation; hence, in this paper, we find Green logistics management impact to sustainable logistics efficiency. Logistics efficiency is assessed through metrics such as the percentage of orders shipped on time, the number of shipments that require expedited handling, and the average order cycle time. Green innovation can be evaluated through several key criteria. First, using environmentally friendly materials is essential for reducing the ecological footprint of products; developing eco-friendly packaging solutions contributes to sustainability by minimizing waste. The utilization of reusable or recyclable packaging further enhances this effort. It's also important to focus on reducing the consumption of natural resources, such as water and energy, to promote resource efficiency. Implementing clean technologies can help mitigate or prevent pollution while optimizing transportation practices.

Data Analysis

The study indicates that Green Innovation (GI) has a mean of 5.085, suggesting that respondents predominantly concur that their organizations implement green innovation techniques, with modest variability in replies (standard deviation of 0.9437 and variance of 0.891). The mean of Logistics Efficiency (LE) is 4.982, indicating a favorable assessment of efficiency; however, the standard deviation of 1.050 and variance of 1.103 reveal significant variability in opinions. The mean of Sustainable Logistics Performance (SLP) is 4.840, exhibiting low variability with a standard deviation of 0.702 and a variance of 0.494, signifying uniform positive evaluations of sustainability performance among enterprises.

Table 4.1 provides a comprehensive overview of the respondents' perceptions of various aspects of their firms' logistics and sustainability practices.

Table 4.1 Descriptive Statistics of Variables

	N	Mean	Std. Deviation	Variance
Green Innovation (GI)	200	5.085	0.9437	0.891
Logistics Efficiency (LE)	200	4.982	1.050	1.103

Table 4.2 provides detailed descriptive statistics for items that measure various constructs related to Green Innovation (GI) and Logistics Efficiency (LE). 200 respondents rated each item, and the table includes data on the mean, mode, and standard deviation, giving a comprehensive overview of how respondents perceive each aspect.

Table 4.2: Provides detailed descriptive statistics for items

Acronym		N		Mean	Mode	Std. Deviation
		Valid	Missing			
GI1	Uses environmentally friendly materials like packaging:	200	0	5.35	6	1.697
GI2	Uses reusable or recyclable packaging material for consumer products:	200	0	5.14	6	1.931
GI3	Reduces the use or consumption of natural resources like electricity or water:	200	0	5.04	5	1.621
GI4	Uses clean technology to reduce/prevent pollution:	200	0	5.03	5	1.625
GI5	Optimizes transportation practices to reduce pollution:	200	0	4.89	6	1.906
LE1	Percentage of Orders Shipped on Time:	500	0	4.97	7	1.800
LE2	Percentage of Shipments Requiring Expediting:	500	0	4.94	7	1.789
LE3	Average Order Cycle Time (time	500	0	5.04	5	1.537

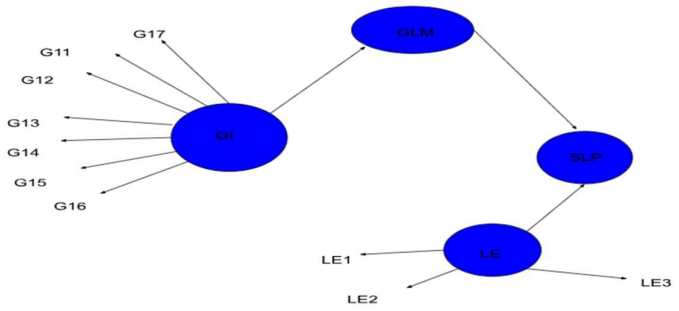

Figure 2: Proposed Smart PLSM Conceptual Model Green Innovation (GI), Green logistics Management (GLM), Sustainable logistics performance, LE (Logistics Efficiency)

Table 4.3: Internal Consistency, Reliability, and Convergent Validity of Constructs

Variable	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
GI	0.766	0.799	0.745	0.894
LE	0.769	0.817	0.744	0.776
SLP	0.745	0.708	0.703	0.839

Hypothesis Testing using Bootstrapping in Smart PLS

H1: Green Logistics Management markedly improves Sustainable Logistics Performance, evidenced by a robust path coefficient of 0.487 and a p-value <0.001, substantiating its beneficial effect.

H1a: Green innovation positively impacts logistics efficiency, evidenced by a path coefficient of 0.320 and a p-value <0.001, signifying that environmentally sustainable practices enhance resource utilization and cost-effectiveness in logistics.

Table 4.4 Hypothesis Testing

Hypothesis	Description	Path Coefficient	P-Value	Decision
H1	Green Logistics Management Positively Impacts Sustainable Logistics Performance.	0.487	<0.001	Supported
H1.2	Green innovation positively impacts logistics efficiency.	0.320	<0.001	Supported

CONCLUSION

The study shows a significant impact of Green Logistics Management on Sustainable Logistics Performance, supported by solid path coefficients. The relationship between GLM and SLP is highly significant, highlighting the critical role of adopting green practices in logistics. Additionally, Green Innovation, a vital aspect of GLM, positively affects logistics efficiency. A primary conclusion is that Green Logistics Management markedly improves Sustainable Logistics Performance. Organizations implementing green logistics strategies, including utilizing sustainable resources, eco-friendly technologies, and streamlined transportation methods, are more likely to achieve enhanced performance.

Future Implications of Study

The robust positive association between GLM and SLP suggests that organizations must prioritize integrating sustainable practices into their logistical operations. This entails investing in sustainable innovations, like environmentally appropriate packaging, greener transportation techniques, and optimized resource utilization. These initiatives yield environmental benefits while improving operational efficiency, providing a competitive market edge. The study's findings are significant for policymakers responsible for advancing sustainability in the logistics and supply chain sectors. The evident positive influence of GLM on multiple facets of logistics performance substantiates the efficacy of eco-friendly techniques in attaining overarching sustainability objectives. The study's findings create new opportunities for future research and development in sustainable logistics. Researchers and professionals leverage the findings of this study to investigate additional variables that may affect the correlation between GLM and SLP. Future research could investigate the influence of technical developments, consumer expectations, and regulatory changes on the sustainability outcomes of logistics operations.

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