

Environmental Sustainability of Logistics Operations and Its Impact on Supply Chain Sustainability: An Empirical Review

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Abstract

Recently, logistics and supply chain management have adopted environmental sustainability. Logistics, which encompasses transportation, warehousing, and distribution, affects global supply chains and the environment. This empirical review investigates logistics' environmental and supply chain sustainability. Literature and empirical studies are examined to determine how logistics sector environmental sustainability methods affect supply chain sustainability goals. This research examines important literature themes, trends, and findings to better comprehend logistics operations' environmental sustainability concerns and prospects. This review of logistics operations and supply chain sustainability informs future research and logistics environmental performance efforts. Logistics operations must cut carbon emissions, minimalize environmental impact, and strengthen supply chain resilience and competitiveness. Logistics operations' environmental sustainability and supply chain sustainability were examined in the empirical review. Summary of relevant literature, identification of research gaps, evaluation of past study methods, and analysis of supply chain resilience and competitiveness were the main goals. The technique included choosing relevant research and data sources, gathering and analyzing data, and summarizing significant conclusions. The results showed that green transportation, route optimization, and energy-efficient warehouse operations may boost logistics sustainability. These sustainability approaches boost supply chain sustainability by improving cost-effectiveness and competitiveness. Supply chain partners must collaborate to improve environmental sustainability, according to the assessment. The research stressed the significance of incorporating environmental sustainability into logistics operations to meet long-term supply chain sustainability goals.

Keywords: Environmental, Logistics, Supply Chain, Sustainability

1.0 INTRODUCTION

The growing importance of environmental sustainability in logistics operations and supply chain management is a critical aspect of contemporary business practices. As companies strive to minimize their environmental footprint and meet increasing stakeholder demands for sustainable practices, integrating environmental considerations into logistics operations has become essential (Khan et al., 2019). This shift is driven by a recognition of the significant environmental impacts of transportation, warehousing, and distribution activities, leading to the adoption of green transportation modes, route optimization, and energy-efficient warehouse operations. Empirical evidence and case studies have demonstrated the efficacy of such sustainability initiatives in reducing carbon emissions, improving operational efficiency, and enhancing corporate reputation. Analyzing these findings provides valuable insights into the challenges and

opportunities associated with achieving environmental sustainability in logistics operations and its broader implications for supply chain sustainability.

Examining environmental sustainability within logistics operations is crucial for ensuring the longevity and resilience of the entire supply chain. Environmental sustainability efforts in logistics, such as reducing carbon emissions, optimizing transportation routes, and implementing energy-efficient warehouse practices, not only minimize ecological impact but also enhance operational efficiency and cost-effectiveness. These strategies have a direct impact on the broader supply chain sustainability objectives, contributing to improved resource management, reduced waste, and increased competitiveness. Collaboration among supply chain partners further amplifies these benefits by fostering a culture of sustainability and shared responsibility. By analyzing the empirical evidence and case studies in this context, we can identify best practices, trends, and areas for improvement, ultimately paving the way for a more sustainable and resilient supply chain ecosystem (Alan McKinnon et al., 2015).

Environmental sustainability, logistics operations, and supply chain sustainability are key concepts that intersect in the realm of modern business practices. Environmental sustainability refers to the responsible use of resources and implementation of practices that minimize adverse impacts on ecosystems. Logistics operations encompass the planning, execution, and control of the movement and storage of goods, while supply chain sustainability focuses on creating long-term value while considering environmental, social, and economic impacts. By integrating environmental sustainability principles into logistics operations, businesses can enhance their supply chain sustainability by reducing carbon footprints, promoting energy efficiency, and fostering responsible resource management. This synergy between environmental sustainability, logistics operations, and supply chain sustainability is crucial for organizations seeking to achieve resilience, cost-effectiveness, and competitive advantage in today's environmentally conscious marketplace. The harmonious alignment of these concepts is essential for the long-term viability and success of businesses in a rapidly changing global environment. (Henriett Matyi et al., 2023).

This study seeks to examine existing literature, gaps, and trends in environmental sustainability practices within logistics operations. The review aims to highlight key findings and implications for supply chain management, resilience, and cost-effectiveness. Furthermore, the paper's structure will follow a clear progression from defining key concepts to discussing strategies for improving sustainability in logistics and analyzing the broader impact on supply chain sustainability. The conclusion will summarize the key findings, underscore the significance of environmental sustainability in logistics, and propose recommendations for future research and industry practice. (Diana Ridley, 2012).

2.0 LITERATURE REVIEW

2.1 Environmental Sustainability (Logistics Operations and Supply Chain Management)

Reviewing existing literature on environmental sustainability in logistics operations and supply chain management is crucial for understanding the current landscape of sustainable practices in the industry. Studies like that by (J. Wiredu, 2024) have highlighted the growing importance of reducing environmental impacts within logistics operations to enhance overall supply chain sustainability. Key themes such as green transportation modes, route optimization, and energy-efficient warehouse operations have emerged as essential strategies for improving environmental sustainability. By examining gaps in the literature and identifying areas that require further investigation, researchers can contribute to the development of more robust sustainability practices within logistics. This analysis underscores the need for continuous research and development to ensure that environmental sustainability remains a core focus in logistics operations and supply chain management, aligning with broader sustainability goals.

Examination of key themes, trends, and findings in previous empirical studies reveals a consistent focus on enhancing environmental sustainability in logistics operations and its consequent impact on overall supply chain sustainability. Through a thorough analysis of existing literature, (Da Liu, 2024) highlighted recurrent themes such as the need for green transportation modes, route optimization, and energy-efficient warehouse operations to mitigate environmental impacts. The studies underscored the importance of such strategies in improving supply chain resilience, cost-effectiveness, and competitive advantage. Additionally, collaboration among supply chain partners emerged as a pivotal factor in promoting environmental sustainability initiatives. Despite the positive outcomes reported in several case studies, the empirical evidence also revealed gaps warranting further investigation, particularly in terms of scalability and long-

term effectiveness. These findings underscore the critical nature of integrating environmental sustainability practices in logistics operations to bolster supply chain sustainability on a broader scale. Moving forward, it is essential to identify gaps in the existing literature on environmental sustainability in logistics operations and its impact on supply chain sustainability. While numerous empirical studies have addressed various aspects of this topic, certain areas remain underexplored and warrant further investigation. For instance, there is a need to delve deeper into the specific challenges and opportunities faced by different industries in implementing sustainability initiatives on overall supply chain resilience and competitiveness is crucial for shaping future strategies. Research focusing on the effectiveness of collaboration among supply chain partners in driving environmental sustainability goals could also provide valuable insights. Thus, future studies should aim to fill these gaps and contribute to a more comprehensive understanding of the complex relationship between environmental sustainability and supply chain management. (Marco Zaccagnini et al., 2024).

2.2 Environmental Sustainability in Logistics Operations

Environmental sustainability in logistics operations has significant environmental impacts across various aspects of supply chain activities. The transportation sector, a core component of logistics operations, contributes to carbon emissions, air pollution, and noise pollution (Paulina Golinska, 2014). Additionally, warehouse operations and distribution processes also have adverse effects on the environment, such as energy consumption, waste generation, and land use. To mitigate these impacts and enhance environmental sustainability in logistics, organizations have implemented strategies like using green transportation modes, optimizing routes to reduce fuel consumption, and adopting energy-efficient practices in warehouses. Empirical evidence and case studies have demonstrated the positive outcomes of these initiatives in reducing carbon footprints, minimizing waste, and promoting sustainable practices within supply chains. By addressing these environmental challenges, logistics operations can play a crucial role in enhancing overall supply chain sustainability and resilience, thereby contributing to long-term environmental stewardship and competitiveness in the market.

2.3 strategies and practices for improving environmental sustainability in logistics

Strategies and practices for enhancing environmental sustainability in logistics play a crucial role in mitigating the negative ecological impacts of transportation and warehousing activities. Green transportation modes, route optimization, and energy-efficient warehouse operations are key strategies that can significantly reduce carbon emissions and energy consumption (Alan McKinnon et al., 2015). Implementing these practices not only aligns with environmental sustainability goals but also enhances operational efficiency and reduces costs in the long run. By adopting sustainable logistics practices, organizations can achieve a competitive advantage, improve their supply chain resilience, and contribute to broader supply chain sustainability objectives. Collaboration and coordination among supply chain partners are essential in promoting environmental sustainability, as shared goals and initiatives can drive collective progress toward a more sustainable and environmentally responsible logistics ecosystem. By prioritizing environmental sustainability in logistics operations, companies can build a more resilient and sustainable supply chain network, benefiting both the environment and their bottom line.

2.4 Empirical Evidence of the Effectiveness of Sustainability Initiatives

Present empirical evidence and case studies have showcased the effectiveness of sustainability initiatives in improving environmental performance in logistics operations. For instance, studies have demonstrated that adopting green transportation modes, implementing route optimization strategies, and enhancing energy-efficient warehouse operations can significantly reduce carbon emissions and resource consumption (A. Gugkang, 2019). These initiatives not only contribute to environmental sustainability but also offer economic benefits through cost savings and improved brand reputation. By integrating sustainability practices into logistics operations, companies can enhance their supply chain sustainability, ensuring resilience, competitiveness, and long-term profitability. Collaboration among supply chain partners is essential to promote environmental sustainability effectively. These empirical findings underscore the

importance of prioritizing sustainability in logistics to achieve a more environmentally friendly and resilient supply chain ecosystem.

2.5 Impact on Supply Chain Sustainability

Environmental sustainability initiatives in logistics operations play a crucial role in promoting broader supply chain sustainability objectives. By implementing eco-friendly practices such as utilizing fuel-efficient transportation modes, optimizing routes to reduce emissions, and adopting energy-efficient warehouse operations, companies can significantly reduce their carbon footprint and environmental impact. These sustainability initiatives not only contribute to mitigating climate change but also enhance overall supply chain resilience, cost-effectiveness, and competitive advantage. Moreover, collaboration and coordination among supply chain partners are essential for the successful implementation of environmental sustainability practices, fostering a culture of shared responsibility and accountability. Through empirical evidence and case studies, it is evident that environmental sustainability initiatives in logistics operations have a substantial positive impact on supply chain sustainability, illustrating the interconnectedness of environmental and economic goals in modern business practices. Environmental sustainability initiatives not only enhance the resilience of supply chains by reducing risks associated with climate change and regulatory pressures but also contribute to cost-effectiveness through operational efficiencies and resource optimization. Moreover, a focus on environmental sustainability can provide a competitive advantage by appealing to ecoconscious consumers, improving brand reputation, and attracting environmentally responsible partners. Collaborative efforts among supply chain partners to promote sustainability further strengthen resilience, lower costs, and foster innovation, leading to a sustainable competitive advantage in the marketplace. By integrating environmentally sustainable practices into logistics operations, organizations can achieve longterm success and position themselves as industry leaders in sustainability efforts. ((Abimbola Dolapo Badmus, 2023). Collaboration among supply chain partners plays a pivotal role in promoting environmental sustainability within logistics operations. By fostering cooperation and sharing best practices, partners can collectively reduce the environmental footprint of the entire supply chain. Joint efforts in implementing sustainable transportation modes, optimizing routes, and enhancing warehouse operations can significantly mitigate the environmental impacts of logistics activities (Mei Cao et al., 2012). Furthermore, collaborative initiatives enable the sharing of resources and expertise, fostering innovation and driving continuous improvement in environmental performance. The synergistic effects of collaboration in supply chain sustainability extend beyond individual organizations, creating a ripple effect that influences industry-wide sustainable practices. Therefore, supply chain partners must align their environmental sustainability goals and work together toward achieving a more sustainable future for logistics operations and the broader supply chain ecosystem.

3.0 METHODOLOGY

3.1 Research Design

The methodology used for conducting the empirical review in this study involved a systematic approach aimed at comprehensively analyzing existing literature on environmental sustainability in logistics operations and its impact on supply chain sustainability. Initially, a comprehensive search strategy was employed to identify relevant studies and data sources using databases such as (Madeline L. Budda et al., 2020). The criteria for selecting these studies were based on their relevance to the research objectives and their empirical nature. Data collection involved extracting key information from selected studies, which was then synthesized and analyzed to identify common themes, trends, and gaps in the literature. The process ensured a rigorous and objective review of the available evidence, providing a solid foundation for the subsequent analysis of environmental sustainability initiatives in logistics operations and their broader implications for supply chain sustainability.

3.2 Data Sources

When selecting relevant studies and data sources for an empirical review of the environmental sustainability of logistics operations and its impact on supply chain sustainability, several criteria must be considered. Firstly, the credibility and validity of the studies play a crucial role in determining their relevance. According the data was sources from World Bank Logistics Performance Index (LPI) Reports.

Mode	ion Avera	1 Average CO2 Emissions (kg/km)		Total Distance Traveled (km)		d Total	Total CO2 Emissions (kg)	
Truck	0.5		1,00	00,000		500,000)	
Rail	0.1		500.	,000		50,000		
Ship 0.02 2,0			2,00	2,000,000		40,000	40,000	
able 2: Energy	Efficiency in V	Varehousi	ng					
Warehouse Type	Energy Con (kWh/sq.	sumption meter)	Total Area meter)	(sq. Con	Total Ener sumption	rgy (kWh)	Renewable Energy (%)	
Conventional	20		100,000	2,000,	000	1	0	
Energy- Efficient	15		50,000	750,00	0	5	0	
`able 3: Green T	ransportation	Adoption						
Year	Electric Vel	hicles (%)	Hybrid Veł	nicles (%)	Altern	native Fuels	(%)	
2020	5		10		15			
2021	10		15		20			
able 4: Impact	of Route Ontir	nization						
Voor Fi	uel Consumption	n (litors)	Savings Due te	Ontimiza	tion (%)	Cost Sav	ings (USD)	
2020 1 00)0 000	n (inters) 5	Savings Due to	opuniza	uon (70)	50 000	ings (USD)	
2020 1,00	000	1	0			95,000		
2022 900	,000	1	135,000					
able 5: Supply	Chain Resilien	ce and Co	mpetitiveness					
	Metric				2020	2021	2022	
Supply Ch	ain Disruptions				50	30	20	
Average L	Lead Time (days))			10	8	7	
Cost per U	Jnit Transported	(USD)			1.50	1.40	1.30	
he empirical rev ogistics operation ncreasing adopti varehouse operat ase studies demo	iew provides vans and its impa on of green to ions to reduce	aluable insi ct on overa ransportation the environ ctiveness o	ghts into the c all supply chai on modes, rou nmental footpu f these sustain	urrent land n sustaina ute optimi int of logi ability init	lscape of e bility. Key zation str stics activ iatives in a	environmen y trends id categies, a vities. Emp achieving e	ntal sustainabil entified includ nd energy-effi pirical evidence environmental	

Analysis reveals a growing recognition among supply chain stakeholders of the importance of environmental sustainability in enhancing resilience, cost-effectiveness, and competitive advantage.

However, discrepancies in empirical evidence point to the need for further research to address gaps and inconsistencies, driving continuous improvement in environmental sustainability practices within logistics operations and supply chain management. (Akkaya et al., 2021)



Graph 1: CO2 emissions by mode transportation

The bar graph that is seen above illustrates the total CO2 emissions that are produced by various modes of transportation, with trucks being the source of the largest emissions. It is the trucks that produce the most carbon dioxide emissions per km travelled. It is possible to achieve large environmental advantages by concentrating on lowering emissions from trucks via the use of alternative fuels or engines that are more economically efficient. The use of rail and ship transportation is more carbon-efficient than other modes of transportation, and it may be further used for long-distance transit to further decrease total emissions.

Energy Efficiency in Warehousing:



The combination of Graph 2 and a line graph shows the overall amount of energy used as well as the proportion of renewable energy that is utilized in traditional warehouses as opposed to energy-efficient warehouses. Not only do energy-efficient warehouses use less energy, but they also depend more on renewable energy sources, which results in a smaller carbon footprint for the warehouses. In order to achieve sustainability, it is essential to increase the use of energy-efficient warehouse designs and operations.

Green Transportation Adoption:



Graph 3: Green Technology Adoption over years

The line graph illustrating the rates of adoption of alternative fuels, hybrid automobiles, and electric vehicles over a period of three years is shown in illustration 3. There is a discernible rising trend in the deployment of hybrid and electric cars, which is indicative of a favourable transition towards more environmentally friendly logistical methods. Continuing to invest in environmentally friendly transport systems is very necessary in order to sustain this development.

Impact of Route Optimization:



Graph 4: Impact of Rout Optimization

A dual-axis graph that illustrates the decrease in fuel usage and cost savings that have occurred over the course of three years as a result of route optimisation. The relevance of modern logistics planning and technology is shown by the fact that route optimisation has demonstrated significant advantages in terms of

lowering fuel consumption and expenses. There is an expectation that there will be more reductions in environmental impact and operating expenses as optimisation methods continue to advance.

Supply Chain Resilience and Competitiveness:



Graph 5 resilient and competitive supply chain

A two-axis graph that displays the amount of interruptions that occurred in the supply chain, the average lead time, and the cost per unit that was transported over the course of three years. It is possible that environmentally sustainable logistics practices contribute to a supply chain that is more robust and competitive. This is because ecologically sustainable procedures reduce interruptions and lead times, as well as transportation costs. To maintain these advances, it is essential for partners in the supply chain to work together on collaborative projects.

3	Table Com	narison (of Supply	Chain	Resilience	Enhancement	Strategies
5.	Table. Com	parison (JI Suppry	Chain	Resilience	Emancement	Suralegies

Resilience Enhancement Strategy	Description	Implementation	Impact on Sustainability	Cost Effectiveness	Competitiveness
Diversification of Suppliers	Engaging multiple suppliers to mitigate risk	Moderate	Positive	Moderate	High
Inventory Optimization	Efficient management of inventory levels	Moderate	Positive	High	High
Adoption of Technology	Utilization of technology for supply chain monitoring	High	Positive	High	High

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Resilience Enhancement Strategy Description		Implementation	Impact on Sustainability	Cost Effectiveness	Competitiveness		
Collaboration with Partners	Collaboration with supply chain partners	High	Positive	High	High		

An analysis of the influence of environmentally responsible logistics practices on supply chain competitiveness is presented in the form of a bar graph and a table that compares different ways for improving supply chain resilience.



Graph: Impact of Green Logistics Practices on Supply Chain Competitiveness

The graph gives a quantitative representation of the competitiveness ratings for various green logistics techniques, while the table presents a qualitative comparison of the activities. The findings of the investigation provide credence to the premise that environmentally responsible logistics operations greatly improve the sustainability of supply chain operations. Green transportation, energy-efficient warehousing, and route optimisation are some of the key measures that not only decrease the impact on the environment but also increase cost-effectiveness and competitiveness. The logistics and supply chain industries should continue to be the focus of new sustainability practices, and future research should continue to investigate these practices and their larger consequences.

4.2 Implications of Logistics Operations and Supply Chain Management

Environmental sustainability in logistics operations and supply chain management has significant implications for overall sustainability efforts. By analyzing the environmental impacts of various logistics activities like transportation and warehousing, organizations can identify opportunities for improvement in areas such as green transportation modes and energy-efficient operations (Mahmoud Allahham et al., 2023). These initiatives not only reduce carbon footprint but also enhance supply chain sustainability by promoting cost-effectiveness and competitive advantage. Collaborative efforts among supply chain partners further strengthen environmental sustainability practices and foster resilience within the supply chain network. Empirical findings and analyses play a crucial role in understanding the efficacy of sustainability initiatives and guiding future strategies for environmental sustainability in logistics and supply chain management. By integrating environmental considerations into logistics operations, businesses can achieve long-term viability and minimize negative environmental effects. This underscores the importance of prioritizing sustainability in logistics and supply chain practices to ensure a greener future for all stakeholders.

4.2 Discrepancies in the Empirical Evidence and Implications

Discussing the discrepancies in empirical evidence within the context of environmental sustainability in logistics operations and its impact on supply chain sustainability is crucial for understanding the current state of research. Despite various studies highlighting the positive effects of green practices on reducing carbon emissions and enhancing operational efficiency, there are discrepancies in the magnitude of these impacts (Dr. Jayachandran). This discrepancy may arise due to differences in operational contexts, measurement methodologies, or variable definitions across studies. For instance, some studies may focus on specific regions or industries, leading to varied results. Additionally, the complexity of supply chains and interdependencies among factors make it challenging to generalize findings. To address these discrepancies, future research should adopt a more standardized approach to data collection and measurement to ensure comparability across studies and facilitate a more comprehensive understanding of the relationship between environmental sustainability in logistics operations and overall supply chain sustainability.

5.0 CONCLUSION

The empirical review of the environmental sustainability of logistics operations and its impact on supply chain sustainability has yielded several key findings and contributions. Through a comprehensive analysis of existing literature and empirical studies (Diana Ridley, 2012), the review highlighted the crucial role of environmental sustainability initiatives in enhancing the overall sustainability of supply chain operations. The review demonstrated that strategies such as green transportation modes, route optimization, and energyefficient warehouse operations can significantly mitigate the environmental footprint of logistics activities. Furthermore, the empirical evidence presented in the review showcased the efficacy of these sustainability practices through real-world case studies and data analysis. Overall, the review emphasized the importance of integrating environmental sustainability principles into logistics operations to promote a more sustainable and resilient supply chain ecosystem. The findings underscored the need for continued research and collaboration among stakeholders to advance environmental sustainability within the logistics and supply chain domain. Environmental sustainability in logistics operations plays a vital role in ensuring the longterm viability of supply chains. By minimizing waste, reducing emissions, and promoting eco-friendly practices, companies can lower their environmental footprint while simultaneously enhancing operational efficiency and resilience. Green logistics initiatives, such as the integration of renewable energy sources, the adoption of fuel-efficient transportation modes, and the implementation of sustainable packaging solutions, not only contribute to a healthier planet but also result in cost savings and improved customer perception. Collaboration among supply chain partners is essential to achieving sustainability goals collectively. Environmental sustainability in logistics is not merely a moral imperative but a strategic necessity for companies looking to thrive in a rapidly changing business landscape. Companies must invest in sustainable logistics practices to ensure the long-term success of their supply chains. (Paulina Golinska, 2014-06-10). In exploring the environmental sustainability of logistics operations and its impact on supply chain sustainability, future research should focus on several key areas. Firstly, there is a need to delve deeper into the specific strategies and technologies that can enhance sustainability within logistics operations, such as electric vehicles, green packaging, and reverse logistics systems. Additionally, examining the role of digitalization, data analytics, and IoT in promoting environmental sustainability across the supply chain would be beneficial. Furthermore, researchers should investigate the long-term implications of sustainable logistics practices on cost reduction, resilience, and overall competitive advantage. By emphasizing the importance of collaboration and information-sharing among supply chain partners, future studies can explore how collective efforts can amplify the effects of environmental sustainability initiatives. In doing so, researchers can provide actionable insights for industry practitioners and policymakers to foster a more sustainable and resilient supply chain ecosystem. (J. Jomeen et al., 2020). Highlighting opportunities for further research in environmental sustainability in logistics and supply chain management is crucial for advancing the field. One avenue for exploration could focus on the integration of emerging technologies such as blockchain, the Internet of Things (IoT), and artificial intelligence (AI) to enhance the environmental performance of logistics operations. Investigating the impact of circular economy principles on supply chain sustainability would also be valuable, especially in terms of reducing waste and promoting resource efficiency. Additionally, exploring the role of regulatory frameworks and government policies in

shaping environmental practices within logistics and supply chains could provide insights into effective governance mechanisms. Moreover, a deeper analysis of the social dimensions of sustainability within logistics, including issues of labor rights and community engagement, would contribute to a more holistic understanding of environmental sustainability in the field. By addressing these research gaps, scholars and practitioners can make meaningful strides toward achieving more sustainable and resilient supply chains. (Valeria Belvedere et al., 2017).

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