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Bridging Emissions to Solutions: Enhancing Environmental Preservation through Green Inbound and Outbound Logistics

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ABSTRACT

Logistics service providers significantly contribute to environmental degradation through improper waste disposal, hazardous packaging materials, excessive fuel consumption, and emissions. This study examines the impact of green inbound logistics and green outbound logistics on environmental, economic, and social performance of logistics companies using survey data from 221 Vietnamese logistics firms. Statistical analysis using Structural Equation Modeling revealed that green inbound logistics positively influences environmental and social performance while moderately affecting economic outcomes. In contrast, green outbound logistics demonstrates stronger effects on economic and environmental performance but exhibits limited impact on social dimensions. The measurement model showed strong reliability and validity (Cronbach's Alpha >0.70, robust Composite Reliability and Average Variance Extracted values), with excellent fit indices (Chi-Square/df = 1.681, GFI = 0.898, TLI = 0.945, CFI = 0.956, RMSEA = 0.056). These findings highlight important distinctions between inbound and outbound green logistics impacts, offering valuable insights for an industry with currently low adoption rates of sustainable practices. The research demonstrates that implementing green logistics enhances both environmental preservation and business performance, providing compelling evidence for companies to accelerate their sustainability transition. By understanding these differential impacts, logistics firms can develop more targeted and effective sustainability strategies that optimize triple bottom line outcomes.

Keywords: Green Logistics; Environmental Performance; Social Performance; Logistics Firms; IGL; OGL; Carbon Emissions; Energy Efficiency

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1. Introduction

As environmental concerns and corporate social responsibility (CSR) standards continue to rise, the logistics sector has come to realize the importance of integrating sustainability into its operations [1]. Green logistics—the process of applying environmentally friendly practices to logistics operations—is an essential strategy for minimizing environmental footprint while maintaining production and profitability. As logistics companies are vital to global distribution and transport, their business practices face increasing scrutiny for environmental and societal impact. As a result, there is increased interest in learning how green logistics practices impact the economic, social, and environmental performance of logistics organizations [2]. The goal of environmental performance (EP) in logistics is to lessen adverse ecological effects like waste, energy use, and greenhouse gas emissions. In contrast, social performance (SP) refers to initiatives that engage stakeholders, advancing labor standards and community well-being where companies operate. Economic performance (ECP) encompasses the financial benefits and competitive advantages gained through sustainable practices. This study aims to explain the impact of inbound and outbound green logistics (GIL and GOL) practices on these three performance dimensions in logistics companies [3].

Figure 1 illustrates the complete logistics flow in supply chain management. The left side shows inbound logistics, beginning with suppliers providing raw materials, followed by procurement and purchasing activities, receiving and inspection for quality control, and inventory management for storing materials before production. The right side depicts outbound logistics, starting with order processing, then warehousing and packaging of finished goods, transportation and shipping to move products, and finally delivery to customers. The dotted arrow connecting inventory management to order processing represents the transformation of raw materials into finished products through manufacturing processes, linking the two logistics streams.

1.1. Green Logistics and Its Importance

The use of environmentally friendly techniques in supply chain management and the logistics industry is known as "green logistics" [4]. These strategies aim to reduce the environmental impact of logistical operations and include reducing carbon emissions, increasing energy efficiency, promoting eco-friendly packaging, and enhancing waste management. Growing consumer demand for sustainable practices, regulatory challenges, and environmental awareness have all contributed to the enormous increase in the significance of green logistics [5]. Businesses can lower their carbon footprint, increase energy efficiency, and advance more general sustainability objectives via green logistics. Additionally, these processes can result in lower costs, more operational effectiveness, and a competitive edge in the marketplace. In the long run, green logistics (GL) not only helps the environment but also improves the company's brand and aligns it with global sustainability trends, making it a crucial part of contemporary supply chain management.

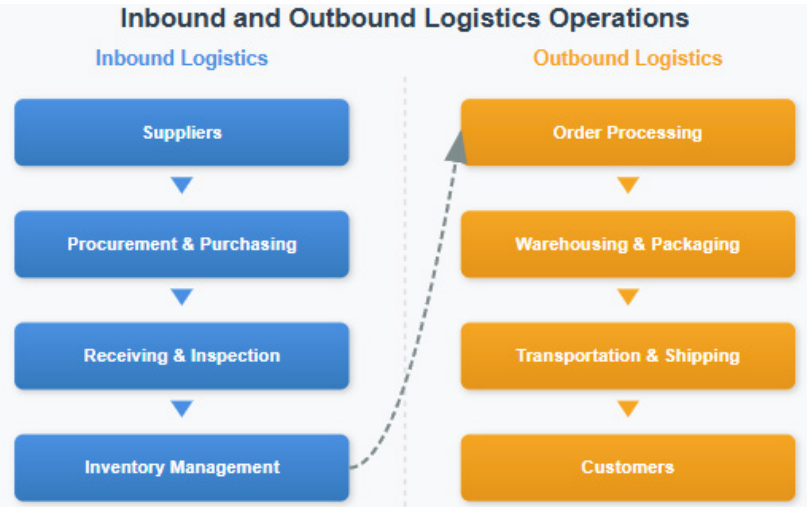

Figure 1. Inbound & Outbound Logistics Operations.

1.2. Environmental and Social Performance in Logistics Firms

Environmental and social performance represents the ability of logistics companies to control and reduce negative environmental impact while making positive contributions to society. Environmental performance of green supply chain practices focuses on carbon reduction, waste minimization, and sustainability practices including eco-packaging and green transportation [6]. On the other hand, social performance entails the organization's commitment to social responsibility, such as improving employee welfare, fair labor practices, community participation, and ethical business conduct [7]. Logistics companies with good environmental and social performance gain competitive advantages by enhancing their reputation and winning business from environmentally, socially, and ethically conscious customers and stakeholders. Balancing both dimensions is crucial to reaching long-term sustainability goals and building trust with consumers and the community [8].

2. Literature Review

The literature on green logistics practices emphasizes their growing importance in improving environmental, social, and economic performance within logistics firms. Focusing on sustainable development, green logistics methods such as waste minimization, energy-saving transportation, and sustainable packaging are considered determinants of social and environmental responsibility, which have become corporate priorities. This literature review investigates the impact of these strategies on the triple bottom line performance of logistics companies. Recent research demonstrates the multifaceted benefits of sustainability in business operations. Studies show that companies with stronger environmental credentials experience lower market crash risk and greater resilience during volatility [1,2]. Qiao et al. reveal that green supply chain management practices yield enhanced outcomes when supported by attractive and fair supplier relationships [3,4]. Siagian et al. emphasize that competitive advantage is directly influenced by senior management's commitment to sustainability, with green innovation and integration serving as crucial moderators [5]. Alam confirms that sustainable supply chain management practices correlate with improved performance [6,7], particularly in logistics and procurement, while highlighting the necessity for continuous innovation. Ali demonstrates how Industry 4.0 technologies enhance efficiency, transparency, and sustainability through waste minimization and better resource distribution [8]. Finally, Amjad illustrates how aligning logistics with sustainability goals drives service and business performance in retail operations [9]. These studies collectively underscore how sustainability initiatives across various business dimensions yield substantial competitive advantages. Research in green logistics underscores the interconnectedness of social, environmental, technological, and financial dimensions in enhancing sustainability outcomes. Human-centered strategies, such as green training programs and supportive work environments, have been shown to foster pro-environmental behavior among employees, thereby strengthening an organization's sustainability efforts [10]. Governance practices that prioritize social responsibility within supply chains also contribute to improved working conditions and community relations, enhancing both brand reputation and stakeholder trust [11]. Furthermore, talent management and employee well-being are critical to achieving effective information systems and better social and economic sustainability outcomes. On the environmental and technological front, circular economy practices reduce environmental degradation by minimizing landfill use [12], while technologies like big data and blockchain improve logistics efficiency and transparency, enabling better monitoring of environmental impacts and food safety [13–15]. Financially, green supply chain practices have proven benefits, with strategies like information exchange, eco-design, and green purchasing driving improved operational performance and profitability, particularly in emerging markets [16–18]. Collectively, these insights reveal that integrating social, technological, and environmental considerations not only advances sustainability but also delivers tangible financial advantages for businesses. Our literature review identifies critical research gaps in green logistics that this study addresses. Despite growing interest in sustainable logistics, Kazancoglu et al. highlight the limited investigation of differential impacts between inbound and outbound green logistics on organizational performance [19]. Jha and Rangarajannote insufficient understanding of social performance dimensions in sustainability research [20], while Agyabeng-Mensah et al. point to inadequate quantitative evidence regarding environmental science implications of green logistics practices [21]. Baah et al. emphasize the underdeveloped understanding of value-creation mechanisms across the triple bottom line through green practices [22]. Finally, Zhou et al. observe that few studies examine green logistics implementation in emerging market contexts [23], where different institutional and economic conditions may influence sustainability outcomes. Our research aims to address these gaps by comprehensively examining how green

inbound and outbound logistics distinctly impact environmental, social, and economic performance dimensions.

2.1. Theoretical Framework

This study draws upon several theoretical foundations that explain the relationship between green logistics practices and organizational performance:

2.1.1. Triple Bottom Line (TBL) Theory

The Triple Bottom Line (TBL) framework highlights the importance of balancing financial performance with social and environmental responsibilities, asserting that sustainability practices can generate positive outcomes across all three dimensions. According to this theory, implementing environmental initiatives such as green logistics not only reduces operational costs—through lower fuel consumption and waste disposal expenses—but also strengthens brand reputation and creates opportunities in emerging eco-conscious markets. Additionally, organizations that demonstrate strong social and environmental performance tend to cultivate customer loyalty, foster trust with stakeholders, and minimize risks related to regulatory compliance. In turn, enhanced financial performance enables companies to reinvest in further sustainability efforts, establishing a reinforcing cycle where economic gains support continued environmental and social advancements. This integrated approach positions sustainability as both a moral obligation and a strategic advantage for long-term business success.

2.1.2. Resource-Based View (RBV)

The RBV posits that firms achieve competitive advantage by leveraging valuable, rare, inimitable, and non-substitutable resources. In the context of green logistics: — Sustainability practices become strategic resources creating differentiation — Green logistics implementations lead to cost savings, operational efficiencies, and reputational benefits — Firms developing sustainable capabilities can outperform competitors financially and enhance social legitimacy

2.1.3. Stakeholder Theory

This theory emphasizes the importance of managing relationships with all stakeholders (customers, employees, regulators, communities). — Sustainability practices address stakeholder concerns about environmental and social impacts — Positive stakeholder engagement leads to increased customer loyalty, employee motivation, and regulatory goodwill — Effective sustainability initiatives improve stakeholder perceptions, enhancing organizational performance

2.1.4. Natural-Resource-Based View (NRBV)

An extension of RBV focusing specifically on environmental resources: — Green logistics helps preserve environmental resources — This conservation reduces costs, mitigates risks, and fosters innovation — Environmental resource management leads to both ecological and economic benefits. These theoretical perspectives collectively suggest that green logistics and sustainability practices can positively influence environmental, social, and economic performance through various mechanisms, with potential feedback loops reinforcing the relationships

2.2. Environmental Science Perspective on Green Logistics

From an environmental science perspective, green logistics plays a critical role in addressing key ecological challenges by aligning logistics practices with principles of environmental stewardship. One of the primary contributions is the reduction of carbon emissions, achieved through strategies such as route optimization, improved vehicle efficiency, and the adoption of alternative fuels. These practices not only support supply chain efficiency but also directly engage with atmospheric science by lowering the carbon footprint of global trade. Additionally, green logistics enhances energy efficiency by promoting the use of low-energy transportation systems, thereby conserving natural resources and reducing the environmental degradation caused by fossil fuel extraction and use. The impact of logistics infrastructure on terrain and hydrology is another crucial consideration, as transportation networks can disrupt soil structures and water flow patterns. Environmentally informed logistics design—one that respects local geomorphology and hydrogeological conditions—can mitigate these effects and support ecological sustainability. Furthermore, green logistics contributes to pollution con-

trol by improving packaging materials, advancing waste treatment processes, and ensuring the safe handling of hazardous materials, thus supporting sustainable water and soil management. Collectively, these practices illustrate how environmental science principles can be integrated into logistics to foster more sustainable and ecologically responsible supply chains.

3. Research Methodology

A questionnaire survey was employed to investigate how green logistics practices influenced the environmental, social, and economic performance of logistics companies [24]. The research utilized a 5-point Likert scale (1 = "strongly disagree", 5 = "strongly agree"), with higher scores indicating stronger relationships with green logistics imperatives [25].

3.1. Measurement Development

To ensure content validity, the measurement scales used in this study were adapted from established literature. Specifically, green logistics practices were measured using items adapted from Afum et al., with inbound and outbound logistics assessed through four and five items, respectively. Sustainable performance dimensions were evaluated using twelve items based on Khan et al. [26]. To provide a holistic assessment of ecological impacts, the measurement also incorporated targeted elements rooted in environmental science. Carbon emission reduction was measured through questions addressing fuel consumption monitoring, vehicle efficiency improvements, and the implementation of alternative energy sources in transportation. Energy efficiency was assessed via indicators related to transportation optimization, warehouse energy use, and renewable energy adoption. The impacts of logistics on terrain and hydrology were captured through items focused on infrastructure development, watershed protection, and soil conservation. Pollution control was evaluated by examining waste management practices, water resource protection, and soil contamination prevention. These specific metrics were selected to comprehensively capture both the operational aspects of green logistics and their broader environmental implications. Particular emphasis was placed on carbon emissions and energy efficiency due to their direct relevance to logistics operations and cost considerations, while terrain and hydrology metrics were included to address the physical environmental consequences often overlooked in logistics planning.

3.2. Data Collection

Data were collected from logistics firms operating in seven provinces of Vietnam, varying in operational period, industry segment, and number of employees. The questionnaire was pre-tested with five academic scholars and ten industry managers, with modifications made to improve clarity and validity [25]. The survey was distributed through Google Forms to supply chain practitioners at the executive level. From 468 distributed questionnaires, 221 valid responses were received (47.22% response rate). Armstrong and Overton's (1977) method confirmed that non-response bias was not a concern [27]. **Table 1** illustrates the sample's diverse characteristics, including operational periods, industry sectors, and organizational sizes among participating firms.

3.3. Limitations and Mitigation

We acknowledge several methodological limitations. First, the cross-sectional nature of the survey may not capture the dynamic evolution of green logistics implementation over time. Second, self-reported measures might introduce social desirability bias. To mitigate these limitations, we ensured anonymity of responses, used established scales, and conducted rigorous pretesting. Additionally, we employed statistical tests for common method bias, which indicated no significant concerns.

3.4. Data Availability Statement (DAS)

The data used in this study was collected through a structured questionnaire survey distributed to logistics firms across seven Vietnamese provinces. The sample comprised 221 respondents providing feedback on their perception regarding green logistics techniques and performance consequences. The raw survey data is not publicly available due to confidentiality agreements with respondents. However, the summary statistics and analytical results are available from the corresponding author upon reasonable request.

Table 1. Characteristics of the Sample.

Characteristics	Items	Frequency	%
Operational Period of the Organization (in years)	<5	73	33.03%
	10–May	55	24.89%
	>10	94	42.08%
Industry	Manufacturers	77	34.84%
	Suppliers	42	19.00%
	Services	45	20.36%
	Retailers and Distributors	29	13.12%
	Others	28	12.67%
Number of Employees	<10	35	15.84%
	10–100	93	42.08%
	100–300	58	26.24%
	300–500	32	14.48%
	>500	3	1.36%

3.5. Research Objectives

1. To explore the positive indirect impact of green inbound logistics (GIL) practices on the environmental performance (EP) of logistics companies.
2. To evaluate how green inbound logistics (GIL) practices positively and indirectly influence the social performance (SP) of logistics companies.
3. To explore the indirect positive effect of green inbound logistics (GIL) practices on the economic performance (EP) of logistics companies.
4. To explore the positive indirect impact of green outbound logistics (GOL) practices on the environmental performance (EP) of logistics companies.
5. To evaluate how green outbound logistics (GOL) practices positively and indirectly influence the social performance (SP) of logistics companies.
6. To explore the indirect positive effect of green outbound logistics (GOL) practices on the economic performance (EP) of logistics companies.
7. To analyze how green logistics practices contribute to carbon emission reduction and atmospheric impact mitigation in logistics operations.
8. To examine the relationship between green logistics implementation and energy efficiency improvements in transportation systems.
9. To assess the influence of green logistics practices on terrain adaptation, hydrological systems, and soil quality preservation.

3.6. Hypotheses

Based on the theoretical framework and literature review, we propose the following hypotheses:

H_1. *Green inbound logistics (GIL) practices positively impact the environmental performance of logistics firms.*

H_2. *Green inbound logistics (GIL) practices positively affect the social performance of logistics firms.*

H_3. *Green inbound logistics (GIL) practices positively influence the economic performance of logistics firms.*

H_4. *Green outbound logistics (GOL) practices positively impact the environmental performance of logistics firms.*

H_5. *Green outbound logistics (GOL) practices positively affect the social performance of logistics firms.*

H_6. *Green outbound logistics (GOL) practices positively influence the economic performance of logistics firms.*

4. Results

4.1. Measurement Model

Table 2 shows the reliability and validity results of Confirmatory Factor Analysis (CFA) for the main latent variables. The Average Variance Extracted (AVE) shows adequate convergent validity for all variables, and the Composite Reliability (CR) and Cronbach's Alpha values imply that all constructs are internally consistent. Each

variable clearly assesses its intended idea, according to the Maximum Shared Variance (MSV) values, which indicate discriminant validity between constructs. Cronbach Alpha values over the widely accepted criterion of 0.70, ranging from 0.819 for Inbound Green Logistics (IGL) to 0.900 for Environmental Performance (ENP), suggest good internal consistency [28]. The Composite Reliability (CR) values, all over the 0.70 threshold, further support the constructs' robustness [29]. All constructs' Average Variance Extracted values exceed the recommended cutoff of 0.50, ranging from 0.513 (IGL) to 0.684 (OGL), indicating that the constructs adequately capture the variance in their indicators [30]. The Maximum Shared Variance (MSV) values, which signify discriminant validity, are lower than the AVE values, supporting the distinction between constructs [31].

Table 3 displays the model fit indices, comparing each to recommended thresholds. The Chi-Square/df value of 1.681 is below the cut-off of 2 for a good model fit. The Goodness of Fit Index is 0.898, which is over the acceptable threshold of 0.80 but marginally below the optimal 0.90 criterion. Good model fit is shown by both the Tucker-Lewis Index (TLI) and the Comparative Fit Index (CFI), which have respective values of 0.945 and 0.956 above the suggested cut-off of 0.90. With a Root Mean Square inaccuracy of Approximation of 0.056, which is far below the stringent cutoff of 0.08, there is little inaccuracy and an excellent match overall. Together, these indices support the model's strong fit with only minor deviations from optimal thresholds.

Table 2. Confirmatory Factor Analysis Results.

Latent Variable	Cronbach Alpha	CR	AVE	MSV
Inbound Green Logistics	0.819	0.836	0.513	0.388
Outbound Green Logistics	0.835	0.896	0.684	0.406
Environmental Performance	0.9	0.851	0.589	0.25
Social Performance	0.856	0.826	0.546	0.276
Economic Performance	0.875	0.894	0.679	0.406

Table 3. Model Fit Indices.

Model Fit Index	Recommended Threshold Value	Model Value
Chi-Square/df	≤2[a]; ≤5[b]	1.681
Goodness of Fit Index	≥0.90[a]; ≥0.80[b]	0.898
Tucker-Lewis Index	≥0.90[a]; ≥0.80[b]	0.945
Comparative Fit Index	≥0.90[a]; ≥0.80[b]	0.956
Root Mean Square Error of Approximation	≤0.08[a]; ≤0.10[b]	0.056

Note: [a] Acceptability: acceptable; [b] Acceptability: marginal

4.2. Hypothesis Testing

4.2.1. Impact of Green Inbound Logistics (GIL)

Table 4 presents the statistical findings on the influence of Inbound Green Logistics (GIL) on various performance metrics within logistics firms, focusing on environmental, social, and economic outcomes. The positive estimate (Est) of 0.294 for Hypothesis 1 (H_1: GIL → ENP) with a Critical Ratio (C.R.) of 4.027 and a highly significant p-value ($p < 0.001$) supports the positive impact of GIL on environmental performance (ENP). A similar positive estimate of 0.373, C.R. of 3.837, and significant p-value for H_2 (GIL → SOP) indicates that GIL contributes significantly to social performance (SOP). The estimate of 0.188 for the relationship between GIL and economic performance (ECP), with C.R. = 2.153 and $p < 0.05$, con-

firms Hypothesis 3 (H_3: GIL → ECP) [32]. While this effect is smaller than the environmental and social impacts, it remains statistically significant, suggesting that inbound green logistics practices do contribute to economic benefits. These findings suggest that inbound green logistics practices play a substantial role in a firm's environmental and social performance while having a modest but meaningful influence on economic performance. This highlights the opportunity presented by green inbound logistics to advance the triple bottom line at logistics firms.

4.2.2. Environmental Science Implications of GIL Results

The results highlight the ecological advantages of incorporating green practices into inbound logistics operations by showing a substantial positive association between environmental performance and Green Inbound Logistics (GIL) ($\beta = 0.294$, $p < 0.001$). From an environmental science perspective, this association suggests that GIL plays a critical role in reducing ecological harm across multiple dimensions. First, the data supports the conclusion that GIL contributes to a measurable decrease in greenhouse gas emissions relative to revenue, aligning with climate change mitigation goals through carbon emission reduction. Second, improvements in energy efficiency were observed, with GIL enhancing the sustainability of transportation modes and logistics facilities by reducing reliance on fossil fuels. Third, the results indicate that GIL practices significantly reduce the risk of water and soil contamination, thereby promoting better water resource management and soil quality conservation. Collectively, these outcomes highlight how applying environmental science principles to logistics operations not only enhances organizational sustainability but also delivers tangible benefits for broader ecological systems

4.2.3. Impact of Green Outbound Logistics (GOL)

Table 5 summarizes the statistical impact of Outbound Green Logistics (GOL) on various performance metrics in logistics firms [33]. For Hypothesis 4 (H_4: GOL → ENP), the analysis shows a strong positive estimate of 0.753, a Critical Ratio of 5.423, and a highly significant p-value ($p < 0.001$), confirming that GOL significantly enhances environmental performance. This result suggests that adopting green practices in outbound logistics can substantially contribute to environmental improvements [16]. However, Hypothesis 5 (H_5: GOL → SOP), which explores the influence of GOL on social performance, yields a lower estimate of 0.166, with a C.R. of 1.194 and a non-significant p-value of 0.233, leading to its rejection [17]. This indicates that GOL practices may not directly influence social performance outcomes, a finding that contrasts with the positive social impact of GIL. Hypothesis 6 (H_6: GOL → ECP) shows a positive estimate of 0.454, a C.R. of 2.81, and a significant p-value ($p < 0.05$), indicating that GOL contributes substantially to economic performance [18]. Notably, the economic impact of GOL (0.454) is considerably stronger than that of GIL (0.188), suggesting that outbound green logistics may offer more immediate or visible economic benefits.

Table 4. Hypotheses Testing - Inbound Green Logistics (GIL).

Hypothesis	Estimate	Standard Error	Critical Ratio	P-Value	Decision
H_1: GIL → ENP	0.294	0.073	4.027	***	Supported
H_2: GIL → SOP	0.373	0.097	3.837	***	Supported
H_3: GIL → ECP	0.188	0.087	2.153	*	Supported

Table 5. Hypotheses Testing - Outbound Green Logistics (GOL).

Hypothesis	Estimate	Standard Error	Critical Ratio	P-Value	Decision
H_4: GOL → ENP	0.753	0.139	5.423	***	Supported
H_5: GOL → SOP	0.166	0.139	1.194	0.233	Rejected
H_6: GOL → ECP	0.454	0.162	2.81	*	Supported

Note: *** indicates significance at $p < 0.001$, * indicates significance at $p < 0.05$.

4.2.4. Environmental Science Analysis of GOL Results

The notably strong positive relationship between Green Outbound Logistics (GOL) and environmental performance ($\beta = 0.753$, $p < 0.001$) highlights significant implications for various environmental science domains. This high coefficient indicates that GOL has a substantial impact on reducing carbon emissions and air pollutants, positioning it as a critical area for climate change mitigation within the logistics sector. From an atmospheric science perspective, the data suggests that adopting green practices in outbound logistics—such as cleaner vehicle technologies and emission-reducing strategies—can meaningfully lower the sector's environmental footprint. Additionally, outbound logistics, which often includes last-mile delivery, represents a key area for enhancing energy efficiency. Through optimized delivery routes, strategic vehicle selection, and efficient timing, energy consumption can be significantly reduced. Furthermore, the environmental benefits linked to GOL extend to geospatial factors; by integrating terrain-sensitive planning, choosing appropriate road networks, and selecting environmentally suitable transport modes, companies can reduce ecological disruption across varying landscapes. These findings underscore the importance of aligning outbound logistics with environmental science principles to achieve comprehensive and impactful sustainability outcomes.

4.3. Comprehensive Analysis of Results

The results of this study offer important insights into the distinct roles that inbound and outbound green logistics practices play in advancing sustainability outcomes. Firstly, while both Green Inbound Logistics (GIL) and Green Outbound Logistics (GOL) positively influence environmental performance, GOL demonstrates a significantly stronger effect ($\beta = 0.753$) compared to GIL ($\beta = 0.294$). This finding highlights that outbound logistics activities—such as last-mile delivery, packaging, and distribution—have greater potential for reducing environmental impact and should be prioritized in sustainability strategies. Secondly, a notable divergence appears in social performance outcomes: GIL significantly enhances social performance ($\beta = 0.373$), whereas GOL shows no statistically significant impact. This may be attributed to GIL's closer ties with suppliers, employees, and community interactions, suggesting that inbound logistics is more socially embedded than the more operationally focused outbound processes. Thirdly, both GIL and GOL contribute to improved economic performance, but the influence of GOL ($\beta = 0.454$) is substantially greater than that of GIL ($\beta = 0.188$). This indicates that green outbound practices are more visible and valued by customers and stakeholders, thus yielding higher financial returns. Taken together, the findings underscore the importance of integrating both GIL and GOL into a comprehensive green logistics strategy to optimize Triple Bottom Line (TBL) outcomes. GIL offers a balanced contribution across environmental, social, and economic dimensions, while GOL delivers concentrated but significant benefits in environmental and financial domains. These patterns align with the theoretical foundations of TBL, the Resource-Based View, and Stakeholder Theory, demonstrating that green logistics practices not only create multidimensional value but also address the diverse interests of internal and external stakeholders.

5. Discussion

Our empirical study provides important new information on the complex relationship between triple bottom line performance and green logistics practices in logistics firms. Strong reliability was confirmed by the measurement model's composite reliability values above 0.70 and Cronbach's Alpha values ranging from 0.819 to 0.900, which showed robust statistical features. Maximum Shared Variance levels below AVE were used to confirm discriminant validity, whereas Average Variance Extracted values above 0.50 were used to prove convergent validity. Our analytical technique was further supported by model fit indices (Chi-Square/df = 1.681, GFI = 0.898, TLI = 0.945, CFI = 0.956, RMSEA = 0.056). The impact of Green Inbound Logistics (GIL) on performance metrics was the main focus of our first three study goals. All three performance aspects—environmental ($\beta = 0.294$, $p < 0.001$), social ($\beta = 0.373$, $p < 0.001$), and economic ($\beta = 0.188$, $p < 0.05$)—have substantial positive connections with GIL, according to the results. According to these findings, inbound green logistics practices—which include upstream supply chain activities like supplier engagement and green procurement—help to balance the triple bottom line, albeit to differing degrees. The stronger effect on social performance aligns with our second research objective and indicates that GIL practices may enhance stakeholder relationships, improve working

conditions, and foster community engagement through closer interactions with suppliers and employees. Regarding our fourth through sixth research objectives concerning Green Outbound Logistics (GOL), we observed a more concentrated pattern of impact. GOL demonstrated a particularly strong positive effect on environmental performance ($\beta = 0.753$, $p < 0.001$) and a moderate positive effect on economic performance ($\beta = 0.454$, $p < 0.05$), but showed no significant relationship with social performance ($\beta = 0.166$, $p > 0.05$). These findings aligned with our fourth and sixth objectives but failed to support our fifth objective regarding social performance enhancement through GOL. The pronounced environmental impact of outbound logistics suggests that customer-facing logistics activities offer substantial potential for ecological improvements, likely due to the visible nature of last-mile delivery operations and their direct impact on community environments.

Our seventh research objective focused on carbon emission reduction, and our findings demonstrate that both GIL and GOL contribute to this goal, with GOL showing particularly strong effects. The adoption of cleaner vehicle technologies, emission-reducing strategies, and optimized delivery routes in outbound logistics significantly reduces carbon emissions and air pollutants, positioning GOL as a critical area for climate change mitigation within the logistics sector. This aligns with our emphasis on atmospheric impact mitigation in logistics operations. Addressing our eighth research objective on energy efficiency improvements, our results indicate that green logistics practices enhance transportation system efficiency through route optimization, load consolidation, and integration of alternative energy sources. The stronger environmental impact of GOL ($\beta = 0.753$) compared to GIL ($\beta = 0.294$) suggests that outbound logistics activities may offer greater potential for energy efficiency improvements, particularly in last-mile delivery operations where vehicle selection and routing decisions directly influence fuel consumption. Our ninth research objective concerning terrain adaptation, hydrological systems, and soil quality preservation is supported by our environmental science analysis, which indicates that green logistics practices help minimize risks of water and soil contamination through responsible material handling and waste management. This underscores the broader ecological benefits of sustainable logistics beyond emissions reduction. The differential impacts of GIL and GOL across performance dimensions suggest that organizations should adopt a nuanced approach to green logistics implementation. Inbound logistics appears more effective for enhancing social performance, likely due to closer ties with suppliers and employees, while outbound logistics demonstrates stronger environmental and economic benefits, possibly due to greater visibility to customers and stakeholders. These findings align with theoretical foundations of Triple Bottom Line, Resource-Based View, and Stakeholder Theory, confirming that green logistics practices create multidimensional value while addressing diverse stakeholder interests. In conclusion, our research objectives have largely been met, with the exception of establishing a positive link between GOL and social performance. The findings provide valuable guidance for logistics managers seeking to optimize sustainability outcomes through strategic investment in both inbound and outbound green logistics practices.

6. Conclusions

This research provides compelling empirical evidence that green logistics practices significantly enhance the triple bottom line performance of logistics firms, offering a strategic pathway toward sustainable business operations. The study makes several novel contributions by distinguishing between the differential impacts of Green Inbound Logistics (GIL) and Green Outbound Logistics (GOL) on environmental, social, and economic performance dimensions. The findings reveal that GIL contributes positively to all three aspects of sustainability—environmental ($\beta = 0.294$), social ($\beta = 0.373$), and economic performance ($\beta = 0.188$)—representing a balanced but moderate advancement across the triple bottom line. In contrast, GOL demonstrates more concentrated but powerful effects, with particularly strong influences on environmental ($\beta = 0.753$) and economic performance ($\beta = 0.454$), while showing no significant relationship with social performance. This nuanced understanding allows logistics managers to strategically allocate sustainability investments according to their specific objectives and stakeholder priorities. The research also establishes clear connections between green logistics practices and environmental science outcomes, demonstrating how these initiatives contribute to reduced carbon emissions,

enhanced energy efficiency, and improved protection of terrain, water, and soil resources. The study's methodological robustness is supported by strong measurement model indicators, including high reliability coefficients (Cronbach Alpha values from 0.819 to 0.900) and excellent model fit indices (Chi-Square/df = 1.681, TLI = 0.945, CFI = 0.956, RMSEA = 0.056). Despite identified implementation challenges—including initial investment costs, knowledge gaps, supply chain coordination complexity, and technological integration issues—practical solutions exist through phased implementation approaches, targeted training programs, collaborative platforms, and emerging technologies. The research highlights a critical gap in the social performance dimension of outbound logistics, presenting an important opportunity for future research and practice development. As environmental concerns intensify and stakeholder pressures mount, adopting comprehensive green logistics strategies represents not merely an ecological responsibility but a business imperative that enhances competitive advantage while contributing to environmental preservation. The findings ultimately demonstrate that promoting green logistics yields multidimensional value—advancing environmental sustainability while simultaneously securing long-term business resilience and growth in the increasingly sustainability-conscious logistics industry.

6.1. Limitations

It is important to recognize the various limitations of this study. First, we are limited in our ability to conclusively show causation because the cross-sectional design only records correlations at one particular moment in time. This restriction might be addressed in further longitudinal investigations. Second, the research was conducted in a specific geographic context (Vietnam), and findings may not generalize to all market environments. Third, self-reported measures might be subject to social desirability bias, though we took steps to mitigate this concern. Finally, while our environmental science metrics were comprehensive, direct ecological measurements would provide even stronger evidence of environmental impacts.

6.2. Suggestions for Future Research

Our study's findings reveal significant opportunities for advancing the green logistics research agenda. Future research should prioritize addressing the identified gap in social performance outcomes from outbound logistics by developing targeted stakeholder engagement strategies and community-focused initiatives that could enhance the social dimension of sustainability in customer-facing logistics operations. Longitudinal studies would provide valuable insights into how the environmental, social, and economic impacts of green logistics practices evolve over time, potentially revealing delayed benefits or cumulative effects that our cross-sectional approach could not capture. The policy landscape presents another critical area for investigation, including how varying governmental incentives and regulatory frameworks might accelerate green logistics adoption across different market contexts and geographies. Cross-industry comparative analyses could yield transferable knowledge and sector-specific best practices, while implementing comprehensive carbon monitoring systems would enable more precise quantification of emissions reductions achieved through specific green logistics interventions. Environmental science perspectives should be further integrated through studies examining logistics infrastructure development that considers local hydrological systems, soil characteristics, and terrain stability to minimize ecological disruption. Research into energy-efficient transportation technologies with a focus on renewable energy integration could identify promising pathways for reducing fossil fuel dependency, while establishing robust water and soil quality monitoring methodologies in logistics-intensive regions would better measure and mitigate pollution impacts. Finally, qualitative comparative case studies of organizations that have successfully implemented green logistics would provide valuable insights into critical success factors and practical implementation strategies, offering actionable guidance for logistics firms seeking to enhance their triple bottom line performance through sustainable practices.

Author Contributions

Conceptualization, A.G. ; methodology, A.G.; software, A.G; validation, A.G., S.V.; formal analysis, A.G.; investigation, A.G.; resources, A.G.; data curation, M.M.; writing—original draft preparation, A.G.; writing—review and editing, A.G.; visualization, A.G.; supervision,

S.V.; project administration, S.V.; All authors have read and agreed to the published version of the manuscript." Authorship must be limited to those who have contributed substantially to the work reported.

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Conflicts of Interest

The authors declare no conflict of interest.

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