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The Impact of Collaboration on Green Innovation and Sustainable Performance: An Empirical Research of 3PL Providers in Ha Noi, Vietnam

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ABSTRACT

The primary objective of this study is to investigate the impact of collaboration (CO) on green innovation (GI) and sustainable performance (SP) among third-party logistics 3PL providers in Hanoi, Vietnam. Within the framework of a quantitative research approach, data were gathered through a field survey resulting in 86 valid responses from 3PL enterprises. The research hypotheses were rigorously tested using PLS-SEM via SmartPLS 4 software. The empirical findings demonstrate that collaboration acts as a direct and significant catalyst for both green innovation capabilities and long-term sustainable performance. Notably, green innovation is identified as a vital mediating mechanism that effectively converts collaborative resources into sustainable organizational value. Although geographically constrained to the Hanoi area, this research provides significant empirical evidence to the literature on green supply chain management within newly industrialized contexts. Consequently, the study suggests that 3PL managers should prioritize cultivating high-trust partnership networks and proactively investing in eco-logistics solutions to secure a competitive advantage in an increasingly environmentally conscious market.

Keywords: Collaboration, Green innovation, Sustainable performance, 3PL.

INTRODUCTION

The global economy is undergoing a paradigm shift toward sustainable growth, where logistics is no longer merely the "backbone" of trade but a focal point for national decarbonization strategies. According to the International Energy Agency **[1]**, transport and logistics activities account for nearly 24% of global CO2 emissions, necessitating an urgent integration of operational excellence with environmental responsibility. In emerging markets like Vietnam, the convergence of international climate commitments and evolving market demands is compelling Third-Party Logistics (3PL) providers to transition from a purely profit-driven mindset to a sustainable performance framework - the intersection of economic growth, environmental protection, and social responsibility **[2]**.

However, the roadmap to "greening" logistics operations is fraught with substantial barriers, including high capital requirements and technological complexities, which often exceed the capabilities of individual firms. Consequently, collaboration has emerged as a decisive strategic catalyst. Scholars argue that extensive collaboration between supply chain actors is fundamental to fostering

sustainable initiatives [3]. In the 3PL sector, collaboration is increasingly manifested through collaborative R&D activities, where the pooling of knowledge, big data, and joint pilot programs allows firms to overcome resource constraints and achieve technological breakthroughs [4].

Deep-seated collaboration creates a direct lever for green innovation - the implementation of novel processes and technologies designed to mitigate ecological footprints, such as AI-driven route optimization and smart warehousing powered by renewable energy[5]. Within this framework, green innovation acts as a critical mediating variable, translating collaboration efforts into tangible outcomes. Empirical evidence suggests that green innovation not only mitigates carbon footprints but also delivers direct economic benefits, with expected operational cost reductions of 10% to 15% through optimized asset sharing [6]. Crucially, a report from the World Bank [2] indicates that 75% of shippers are now actively seeking logistics partners with eco-friendly solutions. This underscores that enhancing sustainable performance is no longer an option but a prerequisite for survival and market expansion in global supply chains [7].

Despite a rich body of literature on collaboration and individual green practices, significant research gaps remain. Internationally, studies have explored various angles of this phenomenon. For instance, Ardito et al. [8] highlighted that inter-firm R&D collaboration is a primary driver for green innovation value, though its effectiveness may be limited by geographical and technological proximity. Within the service-oriented industry, Asadi et al. [9] demonstrated the potential of green innovation in driving sustainable performance within the hospitality industry. Furthermore, research by Ardakani et al.[10] and Han and Huo [11] emphasized how institutional pressures and supply chain integration foster collaboration, significantly impacting environmental and economic efficiency. Notwithstanding these advancements, current empirical evidence remains disproportionately centered on manufacturing or hospitality sectors, leaving the 3PL industry—characterized by its asset-heavy and coordination-intensive nature—relatively under-explored.

In Vietnam, while domestic research has begun to address green management—such as the work of Nguyen and Hoang [12] in tourism or Thanh Tiep Le et al. [13] regarding SMEs— there remains a noticeable deficit of empirical evidence illustrating the logical pathway from collaboration to sustainable performance through the mediation of green innovation. Specifically, although Nguyen Thi Mai Anh et al. [14] recently explored green logistics practices among LSPs in Vietnam, the specific mechanism of forming initiatives through collaboration remains unanalyzed. Therefore, this study is essential to address these theoretical gaps and provide a practical basis for Vietnam's 3PL sector amidst the current green transition pressures.

To resolve these limitations, the present research explores the influence of collaboration on green innovation and sustainable performance among 3PL providers in Vietnam. The present study utilizes a quantitative methodology, utilizing survey data processed via SEM through SmartPLS 4 to evaluate the research hypotheses and establish a conceptual framework. The findings aim to provide timely insights for 3PL managers and policymakers, offering a strategic roadmap for navigating the dual pressures of operational excellence and environmental stewardship in an increasingly competitive global landscape.

LITERATURE REVIEW

Construct

Collaboration

Collaboration is primarily seen as a strategic organizational mechanism where independent businesses voluntarily connect to perform joint activities, aiming to achieve better results than they could on their own[15]. In this sense, it is more than just a

surface-level interaction; it is a co-creation process where partners break down organizational barriers to set common goals and share benefits fairly[16]. The core of this relationship lies in the effective collaboration of information and resource flows, which helps minimize redundancies and optimize transaction costs within the network [17]. Trust and commitment act as essential lubricants, making partners willing to share sensitive data and reducing the need for rigid contractual terms[18]. This collaboration is also shown through the ability to integrate processes and synchronize decision-making, creating a smooth link from demand forecasting to actual supply chain execution[19].

From a management theory perspective, collaboration is a key strategy for improving competitive advantage. From the perspective of the Resource-Based View (RBV), it functions as a dynamic capability which allows firms to access and combine valuable external assets that they do not own internally [20]. Meanwhile, Transaction Cost Economics (TCE) views collaboration as a form of hybrid governance, where long-term relational commitments replace simple market transactions to create more total value[21]. Maintaining these deep-seated linkages helps firms truly understand their partners' capabilities, building a flexible ecosystem that can adapt well to market changes [22]. Altogether, these perspectives confirm that collaboration is beyond a mere operational decision, serving as a crucial strategic catalyst [23].

Green innovation

Green innovation refers to the execution of new products, processes, services, or management methods aimed at minimizing environmental impacts while optimizing resource efficiency throughout the product life cycle [24]. This concept goes beyond simple technical solutions to include a fundamental shift in strategic mindset, balancing economic objectives with ecological responsibility [25]. From a management perspective, it is a core component of sustainable development strategies, helping firms comply with strict environmental regulations and meet rising community expectations [26]. These innovations enable businesses to transition from reactive problem-solving models to proactive systems that control emissions at the source [27].

In terms of classification, green innovation is categorized into two primary dimensions: green product innovation and green process innovation. Green product innovation concentrates on designing and developing items with eco-friendly features, from the sourcing of raw inputs to post-consumer recovery [28]. Meanwhile, green process innovation aims to improve production and operational technologies to save energy, reduce emissions, and limit toxic waste [29]. According to the Porter Hypothesis, strict environmental regulations can actually stimulate creativity and improve operational efficiency [30]. Thus, Green innovation functions as a strategic catalyst instead of a financial strain for firms to enhance technological capabilities and build a distinct competitive advantage in the market [5,31].

Sustainable performance

Sustainable performance is conceptualized as a holistic measure of operational success that transcends traditional financial metrics by integrating environmental and social impacts [32]. This framework evaluates the extent to which supply chain activities generate value for stakeholders while managing extensive ecological consequences [33]. Theoretically, it requires a shift toward the Triple bottom line (TBL) framework, evaluating results based on economic, environmental, and social performance [34]. Within this context, environmental performance reflects an organization's success in mitigating negative ecosystem impacts through resource optimization and carbon footprint control [35]. Beyond technical pollution-reduction metrics, it serves as a strategic component for establishing environmental legitimacy and positioning a green brand image [36].

Integrating these standards into the value network also functions as a risk management mechanism, ensuring regulatory compliance and preventing operational disruptions caused by environmental volatility **[11]**.

On the other hand, economic performance in a sustainability context is defined as the equilibrium between financial growth objectives and the efficient utilization of inputs **[37]**. It encompasses cost structure optimization and the enhancement of sustainable productivity through modern technological applications. This dimension goes beyond net profit to reflect the maintenance of asset value and the mitigation of financial risks arising from resource waste**[38]**. It is a multidimensional concept covering cash flow stability and the capacity to restructure supply chains to meet the rigorous standards of green markets**[39]**. Complementing this, social performance focuses on non-financial values, reflecting ethical compliance and corporate responsibility toward the community**[33]**. This involves integrating professional ethics into management systems to build organizational reputation and fairness in labor environments, ensuring that community engagement remains an inseparable part of overall operational effectiveness**[36]**.

Hypothesis development

Collaboration and Sustainable performance

In modern supply chain management, collaboration between enterprises is considered a primary driver for transforming strategic goals into tangible sustainability outcomes. According to the relational view, inter-organizational partnerships and joint knowledge-sharing processes generate relational rents **[40].** These processes contribute to superior performance compared to firms operating in isolation **[3]**. From a resource-based view (RBV) perspective, collaboration allows firms to access and leverage complementary resources from partners that they do not possess internally **[20]**. Specifically, fostering trust with partners through information exchange is crucial for enhancing radical innovation and maintaining a stable competitive position in transition economies like Vietnam **[41]**.

Regarding the economic and environmental dimensions, collaboration directly improves firm performance through cost optimization and green integration. From an economic perspective, real-time data sharing between partners significantly reduces the bullwhip effect **[18]**. Furthermore, the integration of digital transformation within these collaborative frameworks enables firms to improve their supply chain capabilities, directly leading to superior competitive performance **[42]**. This practice leads to a substantial reduction in inventory waste and enhanced financial health **[16]**. Furthermore, close coordination with logistics partners maximizes infrastructure capacity and reduces fuel costs **[43]**. From an environmental perspective, collaboration enables parties to engage in joint problem-solving, such as eco-friendly product design **[44]**. By establishing shared green agreements, firms collectively minimize their carbon footprint and meet strict environmental regulations **[45]**.

Finally, in terms of the social dimension, strong collaborative relationships foster the implementation of ethical standards and community responsibility. Interactions based on trust and mutual respect encourage transparent communication **[4]**. This environment helps focal firms support partners in improving working conditions and occupational safety **[36]**. Sharing common commitments toward social responsibility reduces operational misunderstandings **[33]**. It also builds a business ecosystem that earns firm trust from stakeholders **[34]**. Combined, these multifaceted outcomes demonstrate that collaboration is a vital driver of sustainable performance **[39]**. Thus, we propose the hypothesis:

Hypothesis H1: Collaboration has a positive impact on sustainable performance.

Collaboration and Green innovation

Collaboration is a decisive driver in developing eco-friendly technological solutions by allowing firms to overcome capital barriers and shared technical risks during the research process [46]. Specifically, collaboration plays a vital role in fostering both incremental and radical innovations by establishing cognitive proximity and relationship learning mechanisms [47]. Through inter-organizational coordination, parties can leverage complementary resources to accelerate the adoption of new technologies [48]. Moreover, trusted partnerships and tight network linkages enable effective knowledge exchange with stakeholders, driving the implementation of rigorous environmental standards and ecological initiatives [49]. These stable relationships facilitate long-term knowledge transfer along with collaborative issue-resolution, both of which are vital to the complex and time-consuming nature of green innovation [29].

Furthermore, collaboration helps firms reconcile the trade-off between high initial investment costs and proactive environmental orientations [4]. By committing to strategic partnerships, enterprises can move beyond short-term opportunistic behaviors to execute more ambitious environmental strategies [8]. Working directly with suppliers and R&D partners allows firms to integrate specialized expertise to co-create cleaner production processes, directly boosting the organization's green innovation capabilities [50]. This collaborative interaction transforms technical skills into high-value innovation outcomes that remain sensitive to both social needs and environmental concerns [51]. Based on these arguments, the following hypothesis is proposed:

Hypothesis H2: Collaboration in the supply chain has a positive impact on green innovation.

Green innovation and Sustainable performance

Green innovation directly impacts sustainable performance by optimizing economic, environmental, and social benefits through value repositioning. Rather than a mere compliance cost, it serves as a strategic tool to create a sustainable cost advantage. Process optimization through green innovation significantly cuts operational costs by saving energy and reducing waste [52]. This transformation enhances long-term profitability and creates new economic value [53]. Furthermore, green innovation allows firms to manage risks from volatile resource prices and secure a distinct competitive advantage within strict international marketplace [54]. By capitalizing on technical environmental barriers, proactive firms can establish a unique market position and outperform traditional competitors who still operate under legacy models [30].

From a broader perspective, green innovation mitigates legal and financial risks while improving ecological and social standing. In the face of tightening carbon regulations, it helps firms avoid penalties and access "green credit" with preferential interest rates [55]. Environmentally, by redesigning products and using recycled materials, enterprises reduce greenhouse gas emissions and ecosystem damage [56]. These initiatives lead to international sustainability certifications, establishing a distinct competitive advantage [5]. Socially, proactive eco-solutions strengthen trust from stakeholders, enhancing corporate reputation and opening doors to premium, environmentally conscious customer segments [57] Thus, green innovation is a comprehensive strategy to realize long-term sustainability goals [39]. Therefore, the following hypothesis is proposed:

Hypothesis H3: Green innovation has a positive impact on the sustainable performance of the firm.

The mediating role of green innovation

Green innovation acts as an essential internal absorption mechanism that empowers companies to fully capture the potential of external flows of knowledge gained via collaboration [20]. Without proactive green

innovation activities, the shared resources and complementary technologies gained from collaboration cannot be effectively transformed into tangible environmental solutions [57]. By leveraging advantages from partner networks, green innovation creates a solid platform to simultaneously improve environmental and economic performance. In this sense, green innovation serves as a concrete tool that transforms collaboration commitments into actual competitive advantages through the improvement of eco-friendly products and processes [5]. Such innovative efforts help firms cope more effectively with legal challenges and drive the ability to restructure operational systems to achieve better outcomes [54].

Furthermore, The execution of green innovation is directly driven by the synchronization of information and resources among partners within the collaboration framework [53]. This mediating process aims to optimize material usage and minimize waste, thereby reducing operational costs through innovative solutions [53]. These green innovation activities also strengthen brand positioning and the ability to serve premium customer segments, which are critical components of a firm's success [57]. Therefore, green innovation constitutes the vital link that converts the synergistic power of inter-organizational collaboration into comprehensive sustainable performance [12]. Thus, we propose the hypothesis:

Hypothesis H4: Green innovation mediates the relationship between collaboration and the sustainable performance of the firm.

In light of these hypotheses, the theoretical model is illustrated in Figure 1.

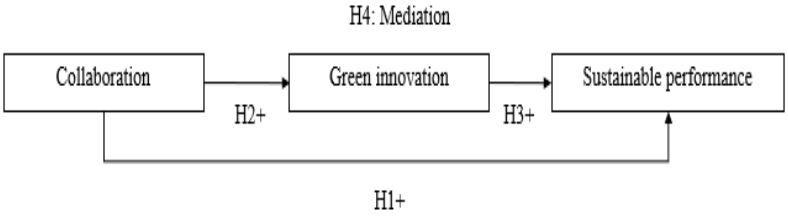

Figure 1: Theoretical model

MATERIALS & METHODS

Measurement model

In the supply chain, collaboration adopts the set of observed variables from [41,42,47] with six variable scales. Green innovation uses five scales utilized based on the study of [47,56]. Finally, sustainable performance incorporates six variable scales synthesized from the study of [9,14]. All items are measured utilizing a 5-point Likert scale to capture insights from the target participants

Data collection

The research is conducted based on a questionnaire-based survey. The target respondents are firm managers or executives specialized in supply chain management, who are responsible for formulating and implementing strategies to enhance the sustainable performance of the organization.

RESULT

The current study utilizes the PLS-SEM technique. Statistical evaluation was performed through the application of SmartPLS 4 statistical software to test the conceptual model. Upon gathering the distributed questionnaires and their subsequent responses, through a process of validation and filtration for validity, 86 survey forms with complete and usable information were collected for the final analysis.

Statistic result

The author analyzed the characteristics of the survey subjects based on three main criteria:

the operational period of the organization, firm size (number of employees), and annual revenue. These indicators illustrate the fundamental background and organizational characteristics of the profile of the surveyed logistics enterprises. Table 1 presents the detailed descriptive statistical results of the sample.

Table 1 presents the descriptive statistics of the survey respondents (N=86). Regarding operational period, 52.3% of firms had been operating for fewer than 5 years, 37.2% for 5 to 10 years, and 10.5% for more than 10 years, indicating that the sample comprises a mix of both new and established firms. In terms of firm size, the distribution shows that 36.0% of the surveyed firms had 0–50 employees, and 31.4% had 51–100 employees. Firms with 101–300 employees accounted for 18.6%, while larger enterprises with 301–500 employees and more than 500 employees represented 8.1% and 5.8%, respectively. This distribution indicates that the majority of the 3PL providers in this study are small-to-medium-sized enterprises (SMEs), which reflects the authentic structure of the logistics service industry in the Hanoi region. With respect to annual revenue, 5.8% reported revenues under 10 billion VND, 25.5% between 11–50 billion VND, 24.4% between 51–100 billion VND, 38.4% between 101–300 billion VND, and 5.8% above 300 billion VND. The sample composition reflects a diverse structure within the supply chain sector, providing a robust basis for further analysis.

Table 1: Descriptive statistics of the sample

Characteristics	Frequency %		
Operational period of the organization (unit: years)	< 5	9	52.3
	5-10	32	37.2
	> 10	45	10.5
Firm size (unit: employees)	0-50	31	36.0
	51-100	27	31.4
	101-300	16	18.6
	301-500	7	8.1
	> 500	5	5.9
Annual revenue (unit: Billion VND)	<10	5	5.8
	11-50	22	25.5
	51-100	21	24.4
	101-300	33	38.4
	> 300	5	5.8

Source: Calculated by authors

Measurement Model Assessment

Indicator Reliability and Convergent Validity

Table 2 demonstrates the quality of the measurement model by reporting the outer loadings, Cronbach's alpha, C.R, and AVE for the three constructs. All indicator loadings fall within the interval of 0.703 and 0.845, surpassing the suggested cutoff point of 0.70 **[58]**, thereby confirming adequate indicator reliability. The internal consistency of all constructs, as measured by Cronbach's alpha, exceeded the 0.70 (CO = 0.901; GI = 0.829; SP = 0.872). Similarly, composite reliability (C.R) values ranged from 0.880 to 0.923 (CO = 0.923; GI = 0.880; SP = 0.904), confirming satisfactory internal consistency. Finally, the convergent validity was confirmed as the AVE values for all constructs surpassed the 0.50 mark. (CO = 0.667; GI = 0.595; SP = 0.612), establishing strong convergent validity for the measurement model.

Table 1: Outer loading, Cronbach's Alpha, CE, and AVE value

Variables	Items	Outer Loadings	Cronbach's Alpha	C.R	AVE
CO	CO1	0.811	0.901	0.923	0.667
	CO2	0.824			
	CO3	0.820			
	CO4	0.817			
	CO5	0.845			
	CO6	0.782			
GI	GI1	0.805	0.829	0.880	0.595
	GI2	0.759			
	GI3	0.703			
	GI4	0.744			
	GI5	0.838			
SP	SP1	0.725	0.872	0.904	0.612
	SP2	0.822			
	SP3	0.819			
	SP4	0.753			
	SP5	0.754			
	SP6	0.813			

Source: Calculated by authors

Discriminant Validity

To evaluate discriminant validity, the study employed a dual approach involving the HTMT ratio and the Fornell-Larcker criterion. According to the data in Table 3, all HTMT coefficients remain strictly under the stringent 0.85 limit [59], reaching a peak of 0.654 in the relationship between GI and SP. Furthermore, the Fornell-Larcker analysis in Table 4 reveals that each construct's square root of the AVE (presented as diagonal elements) surpasses its correlation with any other latent variable. These coherent findings suggest that the three constructs are conceptually unique, thus validating the discriminant integrity of the measurement model.

Table 2: HTMT Discriminant Validity Matrix

	CO	GI	SP
CO	—		
GI	0.440	—	
SP	0.629	0.654	—

Source: Calculated by authors

Table 3: Fornell-Larcker Criterion

	CO	GI	SP
CO	0.817		
GI	0.391	0.771	
SP	0.574	0.567	0.782

Source: Calculated by authors

Collinearity Assessment

All inner model VIF coefficients stayed comfortably under the 3.0 benchmark (CO→GI: 1.000; CO→SP: 1.180; GI×SP→GI: 1.180), confirming the absence of multicollinearity.

Table 5: Inner VIF

	CO	GI	SP
CO		1.000	1.180
GI			1.180
SP			

Source: Calculated by authors

Structural Model Assessment

The assessment of the structural model was performed through the bootstrapping procedure to test the significance of the proposed hypotheses. As demonstrated by the empirical findings in Table 5, it is evident that all four hypotheses are statistically supported at the 99.9% confidence level. Specifically, CO has a positive and significant direct impact on SP ($\beta = 0.415$, $t = 5.344$, $p < 0.05$), supporting H1. Similarly, the relationship between CO and GI is validated with $\beta = 0.391$ ($t = 4.509$, $p < 0.05$), confirming H2. For H3, GI is found to be a significant driver of SP ($\beta = 0.405$, $t = 5.281$, $p < 0.05$). Finally, the indirect effect analysis reveals that GI plays a crucial mediating role in the link between CO and SP ($\beta = 0.158$, $t = 2.954$, $p = 0.000<0.05$), thereby providing

support for H4. In conclusion, the results demonstrate that all paths in the conceptual model are significant, highlighting the critical roles of both collaboration and green innovation in driving sustainable outcomes.

Table 6: Hypothesis testing results

Hypotheses	Relationship	β	t	p	Decision
H1	CO → SP	0.415	5.344	0.000	Supported
H2	CO → GI	0.391	4.509	0.000	Supported
H3	GI → SP	0.405	5.281	0.000	Supported
H4	CO → GI → SP	0.158	2.954	0.000	Supported

Source: Calculated by authors

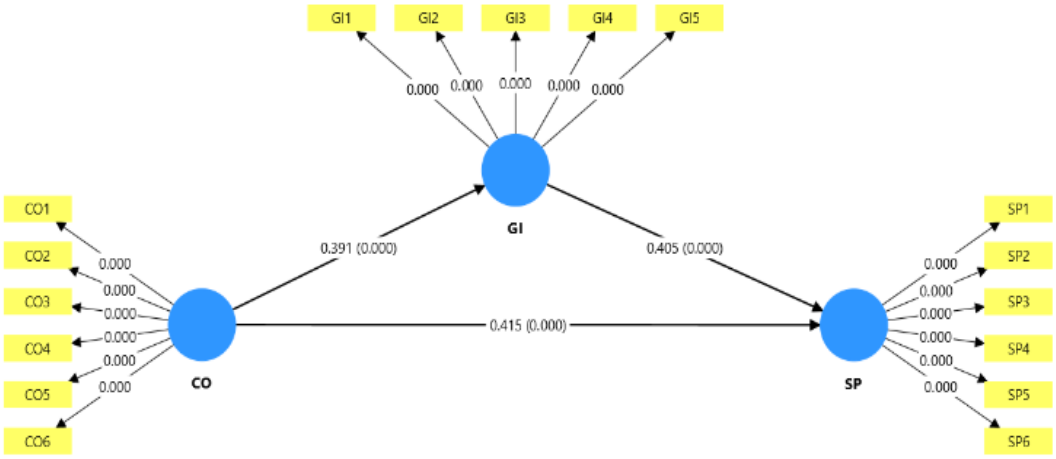

Figure 2: SEM model result

DISCUSSION

Discussion of Result

The data analysis yields strong empirical evidence that validates each of the four proposed hypotheses, offering theoretically grounded and contextually situated insights into the drivers of sustainable performance among 3PL providers in Vietnam.

Hypothesis H1 was strongly supported, confirming that collaboration (CO) is a significant positive driver of sustainable performance (SP). This evidence substantiates the Relational View perspective which posits that firms derive competitive advantages from inter-organizational resource sharing [40]. It corroborates the findings of [3] who demonstrated that collaborative ties are essential for enhancing operational outcomes. In the Vietnamese logistics context, where sustainability expectations are rapidly evolving [2], this result underscores the critical role of partnership quality as a primary catalyst for long-term success.

Hypothesis H2 was validated with high statistical significance, demonstrating that CO directly stimulates Green Innovation (GI). This result aligns with the assertions of [4], who emphasize that collaborative capabilities are pivotal for fostering continuous innovation. It suggests that when 3PL firms in Hanoi engage in deep coordination with partners, they gain the necessary knowledge and resources to adopt eco-friendly technologies, confirming that collaboration is a prerequisite for environmental innovation.

Hypothesis H3 was confirmed, establishing that Green Innovation (GI) significantly enhances Sustainable Performance (SP). Consistent with the Resource-Based View [20], these findings frame green innovation capabilities as valuable and strategic resources. This is in line with the work of [13] and [9] who confirmed that

sustainability initiatives translate into significant improvements across financial and operational dimensions for logistics firms in emerging economies.

Hypothesis H4, which explores the mediating role of GI in the CO–SP relationship, was statistically confirmed through a significant indirect effect. This mediation pattern is consistent with the logic of **[25]**, demonstrating that for 3PL providers in Hanoi, green innovation constitutes a critical internal mechanism that governs how effectively external collaborative resources are converted into sustainable value. This finding underscores that green innovation operates beyond a simple act of regulatory compliance, but as a strategically mediated outcome that drives organizational performance.

Taken together, these findings confirm an integrated value chain from inter-firm collaboration through internal green innovation to ultimate organizational sustainability. They highlight that achieving high-level performance in the Vietnamese logistics sector requires a holistic approach that combines external partnership quality with internal innovative capacity.

Managerial Implications

In terms of practical implications, the results offer actionable insights and strategic guidance for logistics service providers (3PLs) in Hanoi seeking to enhance their sustainable performance. Firstly, managers should recognize that Collaboration (CO) is the foundational driver for achieving environmental goals. Rather than acting in isolation, firms should prioritize building high-trust partnerships and seamless information-sharing mechanisms with their clients and suppliers. Collaborative efforts are essential for mobilizing the collective resources needed for complex environmental transitions **[3,41]**.

In particular, the results underscore that to achieve superior sustainable performance (SP), it is insufficient to rely solely on traditional collaboration; firms must actively channel these partnerships into green innovation (GI). Managers are encouraged to invest in green logistics innovations, such as Sustainable storage infrastructure and green transportation modes, as these innovative capabilities act as the primary bridge converting collaborative inputs into long-term organizational value **[25]**. "Going green" is no longer just a compliance task but a strategic necessity for logistics firms to secure a strategic edge within the increasingly green Vietnamese market **[13]**.

Limitations and Future Research Directions

While this research offers valuable insights, certain constraints exist that pave the way for future scholarly inquiries. To begin with, the adoption of a cross-sectional approach implies that observations were captured at a specific moment, thereby limiting the capacity to establish rigorous causal linkages over time. Future studies should consider longitudinal methods to track how the relationship between collaboration and green innovation evolves over several years. Secondly, the sample size of 86 firms is relatively small and focused exclusively on the Hanoi area. Future research could expand the sample size or conduct comparative studies across different regions of Vietnam (e.g., Ho Chi Minh City or Da Nang) to enhance the generalizability of the findings.

Thirdly, this model only includes three main constructs: CO, GI, and SP. Other potential variables such as organizational culture, government support, or digital transformation could also significantly influence the green innovation process. Future models could incorporate these to achieve a more comprehensive understanding of the sustainable supply chain. Lastly, the subjective nature of self-reported responses could potentially lead to subjective bias. Cross-verifying the results with objective secondary data, such as firm financial reports or environmental certificate, could further bolster the empirical credibility of the study outcomes.

CONCLUSION

In summary, this investigation highlights the essential contribution of collaboration (CO) in driving green innovation (GI) and enhancing sustainable performance (SP) within the Hanoi 3PL sector. While collaboration provides the necessary foundation of resources and information, its ultimate impact on organizational sustainability is significantly realized through the mediating mechanism of green innovation. These findings add significant value to both academic theory and practical management, particularly in highlighting the requirement for logistics firms to go beyond traditional partnership models and focus on strategic environmental innovation.

The theoretical implications underscore the strategic value of the Relational View and Resource-Based View in understanding how external partnerships are converted into internal green capabilities. From a managerial perspective, the results suggest that 3PL providers in Hanoi should prioritize investments in eco-friendly technologies and sustainable practices within an increasingly dynamic business environment, "green-conscious" business setting. Future investigations are encouraged to explore additional mediators, such as digital transformation or government regulatory pressure, to provide further insights into how logistics firms can further leverage their collaborative networks for enhanced sustainability.

Declaration by Authors

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