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IMPACTS OF LOGISTICS PERFORMANCE ON GREEN EXPORTS OF VIET NAM DURING 2007-2022: A GRAVITY MODEL APPROACH

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Abstract

This study examines the influence of logistics performance on Vietnam's green exports during 2007-2022, thereby contributing to the literature by linking subcomponents of the World Bank's Logistics Performance Index (LPI) to green trade outcomes in a developing country. Using bilateral trade data and a gravity model estimated with robust OLS, this study examines three dimensions of green exports: total export value, product diversification, and average export value per product. The results show that shipment competitiveness and delivery timeliness exert the strongest positive effects, while logistics quality, tracking, infrastructure, and customs efficiency also contribute positively but to a lesser magnitude. These findings advance the current understanding that operational efficiency and predictability in logistics are critical determinants of green export performance, beyond aggregate infrastructure measures. Practically, the study highlights that targeted logistics reforms, especially those related to transport reliability and delivery speed, are essential for promoting the sustainable growth of Vietnam's green exports.

Keywords: *Green exports, gravity model, logistics performance, Vietnam.*

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TÁC ĐỘNG CỦA HIỆU QUẢ LOGISTICS ĐẾN XUẤT KHẨU XANH CỦA VIỆT NAM GIAI ĐOẠN 2007-2022: CÁCH TIẾP CẬN TỪ MÔ HÌNH TRỌNG LỰC

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Tóm tắt

Nghiên cứu này xem xét ảnh hưởng của hiệu quả logistics đến xuất khẩu xanh của Việt Nam giai đoạn 2007-2022, qua đó đóng góp vào các tài liệu hiện có bằng cách liên kết các thành phần của Chỉ số hiệu quả logistics (LPI) của Ngân hàng Thế giới với hiệu quả thương mại xanh ở một quốc gia đang phát triển. Sử dụng dữ liệu thương mại song phương và mô hình trọng lực được ước lượng bằng phương pháp OLS với sai số hiệu chỉnh, chúng tôi xem xét ba khía cạnh của xuất khẩu xanh: tổng giá trị xuất khẩu, số lượng mặt hàng xuất khẩu và giá trị xuất khẩu trung bình trên mỗi sản phẩm. Kết quả cho thấy hiệu quả logistics, đặc biệt trong khâu vận chuyển và độ đúng hẹn, có ảnh hưởng lớn nhất đến cả ba khía cạnh của xuất khẩu xanh. Các thành phần khác của LPI như hiệu quả thủ tục hải quan, chất lượng dịch vụ logistics, cơ sở hạ tầng và khả năng theo dõi hàng hóa cũng có tác động tích cực nhưng ở mức độ thấp hơn. Những phát hiện này bổ sung sự hiểu biết về mặt lý thuyết, chứng minh rằng hiệu quả hoạt động và khả năng dự đoán trong logistics là những yếu tố quyết định quan trọng đến hiệu quả xuất khẩu xanh, vượt ra ngoài các biện pháp cơ sở hạ tầng tổng hợp. Về mặt thực tiễn, nghiên cứu nhấn mạnh rằng các cải cách có mục tiêu trong hệ thống logistics, đặc biệt là về độ tin cậy trong vận tải và tốc độ giao hàng, là yếu tố then chốt để thúc đẩy tăng trưởng bền vững trong xuất khẩu xanh của Việt Nam.

Từ khóa: *Hiệu quả logistics, mô hình trọng lực, xuất khẩu xanh, Việt Nam.*

1. Introduction

Logistics plays a pivotal role in facilitating international trade, serving as the backbone that ensures the smooth, timely, and cost-effective movement of goods and information across borders (Gani, 2017). It encompasses a wide range of interconnected activities from transportation, warehousing, and inventory control to customs procedures and data management, which together enable the seamless operation of global supply chains. As international trade becomes increasingly complex in a globalized economy, the importance of efficient logistics systems has grown significantly. Well-functioning logistics not only reduce transaction and delivery costs but also enhance trade connectivity, streamline cross-border flows, and improve a nation's competitiveness in the global market (Arvis et al., 2018).

At the same time, the rise of environmental concerns and sustainability standards has brought green exports to the forefront of international trade. These are goods produced with minimal environmental impact and aligned with ecological standards demanded by environmentally conscious markets. Green exports offer dual benefits: they contribute to addressing global environmental challenges while unlocking access to markets where regulations and consumer preferences increasingly favor eco-friendly products (United Nations, 2002). However, entering and succeeding in these markets requires more than just green production. It demands a logistics system capable of meeting stringent environmental, safety, and transparency requirements.

In this context, logistics performance can become a key driver of green export success. Efficient logistics reduce energy consumption, limit emissions through optimized transport routes, and enable real-time monitoring of supply chain factors, which are crucial for compliance with environmental regulations (Thaller et al., 2022). Furthermore, a high-performing logistics sector helps exporters respond quickly to shifting demand, maintain product quality, and ensure traceability. All these are essential in environmentally sensitive markets. Thus, it is clear that investing in logistics is not merely an economic imperative but a strategic approach to promote sustainable and competitive trade.

While the existing literature has extensively explored the role of logistics in enhancing overall trade performance (Ma et al., 2021; Morita et al., 2022), research examining its specific influence on green exports, particularly in developing countries like Vietnam, still remains limited. This study addresses that gap by investigating how logistics performance affects Vietnam's green exports, both at the extensive margin (diversification of products and destinations) and the intensive margin (export value per product). Accordingly, the key research question is: *How does logistics performance influence the breadth and depth of Vietnam's green exports?* Approaching both margins, the study offers a comprehensive view of the logistics–green trade nexus. It provides practical insights for policymakers and businesses aiming to align economic growth with environmental sustainability.

The rest of this paper is structured as follows. Section 2 reviews the relevant literature, while Section 3 outlines the data and research methodology. Section 4 presents and discusses the empirical findings before concluding remarks are displayed in Section 5.

2. Literature review

Numerous studies have investigated the link between logistics performance and trade efficiency. Hoekman and Nicita (2011) and Shepherd and Wilson (2007) indicated that improvements in logistics can lower trade costs, reduce delivery times, and enhance competitiveness, thereby stimulating exports. Similarly, the World Bank (2023) highlighted that in developing economies, improvements in logistics not only facilitate trade flows but also foster long-term economic integration and growth. Bougheas et al. (1999) demonstrated that

infrastructure investment strengthens trade performance through its impact on logistical capacity and connectivity. While these studies all underscore the importance of logistics, they primarily focus on aggregate trade flows. What remains underexplored is whether, and how, logistics performance shapes specific categories of exports, particularly environmentally sustainable trade.

Several studies have recognized the crucial role of green exports in sustainable development and investigated its determinants. Hamwey (2018) emphasized that green exports offer a dual opportunity for developing countries. They act as a climate response and a path to economic diversification and job creation. The United Nations (2002) underscored that green trade advances the three pillars of sustainability: economic growth, social inclusion, and environmental protection. Empirical evidence has linked green export performance to factors such as R&D investment and access to green finance (Li & Lu, 2018; Zhou et al., 2023), institutional pressures and supply chain coordination (Do et al., 2022), and the adoption of digital technology (Wang et al., 2023). In Europe, Fabrizi et al. (2024) demonstrated that green innovation and participation in environmental research programs promote green trade, while Huong and Ngoc (2024) found that Vietnam's green exports are significantly influenced by macroeconomic conditions in partner countries. These studies collectively indicate that multiple factors influence green trade. However, logistics as a crucial component of trade activities has been largely neglected in the analysis of green exports.

The Melitz-style model of trade posits that reductions in trade costs affect the extensive margin and the intensive margin in different ways (Melitz, 2003). Studies such as Lawless (2010) and Dutt et al. (2013) further show that distance and other proxies for trade costs have larger effects on the extensive margin than on the intensive margin. Building on these theoretical and empirical insights, this study contributes to the literature by explicitly examining how logistics performance shapes Vietnam's green export performance, distinguishing between the extensive and intensive margins of exports. Unlike prior research, which has typically treated logistics as an aggregated index, this study disaggregates the World Bank's Logistics Performance Index (LPI) into its six subcomponents: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness. This multidimensional approach provides a novel evidence on which aspects of logistics matter more for upgrading green exports. By applying this approach to Vietnam, an emerging economy with significant growth in both logistics capacity and green trade, the study not only fills a notable empirical gap but also offers theoretical and political insights into how targeted improvements in logistics can facilitate sustainable export development.

3. Data and research methods

3.1. Data

Green exports refer to the export of environmentally beneficial products and services that comply with sustainable environmental standards and minimize carbon emissions. As countries seek to decouple economic growth from environmental degradation, green exports - especially low-carbon or environmentally safe products - have gained strategic importance, and Vietnam is no exception (OECD, 2014). Although it is challenging to define a fixed list of green products due to the evolution of technologies, several organizations have developed classifications. The OECD proposed a list of 257 green products (Sauvage, 2014), and earlier, in 1999, created a list of 121 environmental products with Eurostat. The WTO (2011) compiled a list of 408 potential green products and a core list of 26 items widely supported by member states. APEC (2012) also issued a list of 54 products with a commitment to reduce tariffs to 5% or lower by 2015. Following Mealy and Teytelboym (2022), this study uses HS codes from OECD, WTO, and APEC to construct a comprehensive dataset of 485 green products at

the 6-digit HS2002 level. After that, the list is merged with the BACI database of Centre d'Études Prospectives et d'Informations Internationales (CEPII) to track Vietnam's green exports to 198 countries and territories from 2007 to 2022.

The Logistics Performance Index (LPI) data used in this study were collected from the World Bank. This data source provides an assessment of trade logistics performance for over 160 countries during the period from 2007 to 2022. The index is measured on a scale from 1 to 5, with higher scores indicating better logistics performance (Arvis et al., 2018; World Bank, 2023). The LPI dataset consists of two main components. First, the overall LPI score represents the general efficiency of logistics. Second, the LPI sub-indicators provide detailed insights into specific aspects of logistics performance. These include the ability to track and trace consignments, ease of arranging competitively priced shipments, efficiency of customs clearance process, frequency with which shipments reach consignee within scheduled or expected time, competence and quality of logistics services, and quality of trade and transport-related infrastructure (Arvis et al., 2018). From the original dataset, data specific to Vietnam were extracted and filtered to evaluate the impact of logistics performance on the total green export value of the country during the period from 2007 to 2022.

3.2. Model specification

The gravity model is one of the most widely used frameworks for analyzing international trade flows, rooted in Newton's law of universal gravitation (Tinbergen, 1962; Deardorff, 1998). This model suggests that the trade volume between two countries is positively correlated with their economic sizes and negatively correlated with the distance between them (Bergstrand, 1985). Expanding upon the gravity model, this study incorporates logistics performance as a key determinant of Vietnam's green exports. The empirical equation is specified as follows:

$$ln(green\_exp)_{VN,j,t} = \beta_0 + \beta_1 \ln(LPI)_{VN,j,t} + \beta_2 \ln(GDP)_{VN,j,t} + \beta_3 \ln(DIST)_{VN,j} + \beta_4 RTA_{VN,j,t} + COL_{VN,j} + \varepsilon_{VN,j,t} \quad (1)$$

where $ln(green\_exp)_{VN,j,t}$ represents the logarithm of Vietnam's green exports to country *j* in year *t*. This study considers three dimensions of green exports, including: total green export value in million US Dollars to each partner (denoted by "*total_green_exp"*), the number of green export products to each partner (denoted by "*num_product"*), and the average export value per product to each partner (denoted by "*exp_per_product"*).

The variable $ln(LPI)_{VN,j,t}$ denotes the logarithm of the bilateral Logistics Performance Index between Vietnam and partner *j* in year *t*. This study constructs the bilateral indices by simply averaging the indices of Vietnam and partner *j* in each year. As a result, we have overall bilateral Logistics Performance Indices (denoted by "$LPI_{VN,j,t}$") and its six sub-components, namely ability to track and trace consignments (denoted by "$track\_trace_{VN,j,t}$"), ease of arranging competitively priced shipments (denoted by "$shipment_{VN,j,}$"), efficiency of customs clearance process (denoted by "$customs\_efficiency_{VN,j,t}$"), frequency with which shipments reach consignee within scheduled or expected time (denoted by "$timeliness_{VN,j,t}$"), competence and quality of logistics services (denoted by "$logistics\_quality_{VN,j,t}$"), and quality of trade and transport-related infrastructure (denoted by "$infrastructure_{VN,j,t}$"). The rationale for this approach is that logistics performance in bilateral trade is jointly determined by the capabilities of both the exporter and the importer. Averaging the two indices provides a balanced indicator of the overall logistics environment faced by trade flows, ensuring that neither country's performance is disproportionately weighted.

$ln(GDP)_{VN,j,t}$ captures the logarithm of the GDPs of both Vietnam and its trading partner *j* in year *t*. It is calculated by averaging the data of Vietnam and each partner in each year. The data for GDP (thousand US Dollars) is taken from the World Development Indicators of the World Bank database.

$ln(DIST)_{VN,j}$ refers to the logarithm of the geographical distance between the two countries. $RTA_{VN,j,t}$ is a dummy variable equal to 1 if Vietnam and country *j* are members of a regional trade agreement in year *t*, and 0 otherwise. Similarly, $COL_{VN,j}$ is a dummy variable equal to 1 if Vietnam and its trading partner *j* have ever had a colonial or dependency relationship. Data for those variables is downloaded from the Gravity data of the CEPII database. Finally, $\varepsilon_{VN,j,t}$ denotes the error term. Table 1 shows the statistical summary of variables used in the regressions.

Table 1. Basic Statistics of Variables

Variables	Obs	Mean	Std. Dev.	Min	Max
$ln(total\_green\_exp)_{VN,j,t}$	960	8.611	3.113	-1.826	16.678
$ln(num\_product)_{VN,j,t}$	960	3.57	1.414	0	5.756
$ln(exp\_per\_product)_{VN,j,t}$	960	5.041	1.967	-2.198	10.922
$ln(LPI)_{VN,j,t}$	960	1.787	.101	1.521	2.028
$ln(track\_trace)_{VN,j,t}$	960	1.801	.113	1.478	2.054
$ln(shipment)_{VN,j,t}$	960	.582	.05	.406	.694
$ln(timeliness)_{VN,j,t}$	960	1.912	.088	1.652	2.116
$ln(infrastructure)_{VN,j,t}$	960	1.716	.136	1.361	2.054
$ln(logistics\_quality)_{VN,j,t}$	960	1.763	.115	1.413	2.043
$ln(customs\_efficiency)_{VN,j,t}$	960	1.707	.113	1.351	1.988
$ln(GDP)_{VN,j,t}$	939	19.699	.968	18.171	23.874
$ln(DIST)_{VN,j}$	960	8.976	.715	5.352	9.883
$RTA_{VN,j,t}$	960	.135	.342	0	1
$COL_{VN,j}$	960	.125	.331	0	1

Source: The authors' calculation using Stata14

3.3. Tests for the model's suitability

This study employs Ordinary Least Squares (OLS) to estimate the gravity model, with data processing and analysis conducted using Stata 14. To ensure the validity and reliability of the regression results, several diagnostic tests consistent with the OLS framework were run.

First, the F-test was performed to check whether all regression coefficients in model (1) are simultaneously equal to 0. The result obtained was F(5.933) = 349.20 with P-value = 0.0000 < 0.01, indicating that the model is statistically significant.

Next, the Breusch-Pagan Lagrange multiplier (LM) test was performed to determine whether heteroskedasticity exists in the model. The result obtained was χ^2 (1) = 56.13 with P-value = 0.000< 0.1, indicating that there is heteroskedasticity in the model. To deal with this problem, we follow Wooldridge (2010) to use robust options when running regressions.

Table 2 presents the results of the VIF test of the baseline model (1) to detect multicollinearity in panel data. The results show that all variables have VIF values less than 10, indicating that there is no multicollinearity in the model.

Table 2. VIF test for multicollinearity

Variables	VIF	1/VIF
$ln(LPI)_{VN,j,t}$	2.04	0.490765
$ln(GDP)_{VN,j,t}$	2	0.50108
$RTA_{VN,j,t}$	1.72	0.579939
$ln(DIST)_{VN,j}$	1.53	0.65564
$COL_{VN,j}$	1.11	0.899774
Mean VIF	1.68	

Source: The authors' calculation using Stata 14

We recognize that OLS has limitations in the presence of heteroskedasticity. To address this issue, the researcher followed Wooldridge (2010) to use robust options when running regressions. Moreover, the dataset does not contain zero trade flows since the focus is on Vietnam's actual bilateral exports, which reduces the bias typically associated with log-linearized OLS when zeros are present. Additionally, the Poisson Pseudo Maximum Likelihood (PPML) estimator was run to check the robustness of our benchmark results (see Appendix 1). The PPML results confirm the robustness of our main findings on the positive role of logistics performance. However, the coefficient of the RTA variable is unexpected. This outcome may be due to the relatively small and unbalanced nature of our sample, as noted in previous studies that highlight potential limitations of PPML in such circumstances (Pfaffermayr, 2019). Therefore, OLS with robust standard errors is a reasonable choice for our study.

4. Results and discussions

4.1. Description of Vietnam's green exports

Figure 1 provides a comprehensive visual representation of Vietnam's remarkable growth in green exports from 2007 to 2022, with a line graph indicating the value of Vietnam's green exports in thousands of US dollars and a bar graph illustrating their percentage share in the nation's total exports. As the figure clearly demonstrates, although green exports initially represented a relatively small fraction of Vietnam's overall export portfolio, their volume experienced a pronounced and consistent upward trend throughout the entire study period. More specifically, the value of green exports rose gradually in the early years before increasing more rapidly after 2011, reaching a peak of over 55 billion USD by 2022. This upward trend becomes even more evident after 2015, indicating a stronger role of environmentally friendly products in Vietnam's export activities. At the same time, the share of green exports in total exports also increased consistently, despite some minor fluctuations in the earlier years. Starting from a relatively low level of about 5-7% during 2007-2010, this proportion grew steadily to approximately 13-14% by the end of the period. The similar upward trends in both export value and export share suggest not only an expansion in the scale of green exports but also a gradual shift in Vietnam's export structure toward more sustainable products. This

pattern indicates that green exports are becoming an increasingly important component of the country's overall trade performance and long-term development strategy.

Figure 1. Trend of Vietnam's green exports from 2007 to 2022

Source: The authors' calculations based on data from the BACI-CEPII database

Table 3 displays the top 10 countries importing the highest value of green products from Vietnam in 2007 and 2022. The data reflects clear changes in market structure and export scale over time. In 2007, the United States was the largest importer, followed by Japan, with both countries together accounting for nearly 33 percent of Vietnam's total green export value. Other major markets included the Netherlands, Singapore, China, Germany, Hong Kong, Australia, and the Philippines, showing the early presence of both developed economies and regional partners. That year, the top 10 countries accounted for around 2.3 billion USD, making up 65.52 percent of total green exports. By 2022, the composition of top importers had shifted significantly. The United States remained the leading market with a much larger import value of 17.5 billion USD, representing 31.59 percent of total exports. China moved up to second place, overtaking Japan, while South Korea rose to third, reflecting rising demand for green products in East Asia. Japan dropped to fourth place, and although the Netherlands and Germany continued to appear in the top rankings, their shares grew more slowly than those of Asian markets. New names such as India, Thailand, Taiwan, and Indonesia entered the list, signaling the successful expansion of Vietnam's green exports into South Asia and Southeast Asia. By the end of 2022, the total export value to the top 10 countries reached 40.44 billion USD, accounting for 73 percent of green exports. This demonstrates the strong growth and diversification of Vietnam's green export markets over the past 15 years.

Table 3. Top 10 countries with the highest green product import value from Vietnam in 2007-2022

Rank	2007			2022		
	Country name	Value (Thousand USD)	%	Country name	Value (Thousand USD)	%
1	USA	627013.5	17.89	USA	17500000	31.59
2	Japan	524599.6	14.97	China	6895127	12.45

Rank	2007			2022		
	Country name	Value (Thousand USD)	%	Country name	Value (Thousand USD)	%
3	Netherlands	224519.1	6.41	Korea	4340246	7.83
4	Singapore	162598.3	4.64	Japan	2705004	4.88
5	China	153438.3	4.38	Netherlands	2162300	3.90
6	Germany	140610.9	4.01	India	1815134	3.28
7	Hong Kong	131011.6	3.74	Germany	1779787	3.21
8	Australia	113711	3.24	Thailand	1285027	2.32
9	Other Asia	113378.2	3.23	Taiwan	1005141	1.81
10	Philippines	105854.2	3.02	Indonesia	953033	1.72
	Top 10	2296735	65.52	**Top 10**	40440799	73
	Total	3505292	100	**Total**	55400000	100

Source: The authors' calculations based on data from the BACI-CEPII database

4.2. Regression results and discussions

4.2.1. Impacts of overall logistics performance on different dimensions of Vietnam's green exports

Table 4 presents regression results of the model (1) with $ln(total\_green\_exp)_{VN,j,t}$, $ln(num\_product)_{VN,j,t}$, and $ln(exp\_per\_product)_{VN,j,t}$ being the dependent variables, respectively. The key independent variable is the overall logistics performance index ($ln(LPI)_{VN,j,t}$). As shown in Table 4, the Logistics Performance Index (LPI) shows a strong positive effect at the 1% level across all Columns of Table 4. To be more specific, a 1% increase in LPI leads to 8.286% growth in total green exports, 4.901% in product count, and 3.386% in average export value. The magnitude of these elasticities suggests that logistics efficiency acts as a powerful engine for trade expansion. It not only scales up overall export volumes but also lowers entry barriers for new products (extensive margin) and enhances the exported value of existing exports (intensive margin). These effects underscore that improvements in logistics substantially strengthen Vietnam's green trade competitiveness by enabling both diversification and increased value of existing products. The findings are consistent with previous studies. For example, Arvis et al. (2018) document that lower logistics costs and more efficient transport systems can enhance firms' participation in international trade, particularly in developing countries. In the case of Turkey, Töngür et al. (2020) indicate that better logistics infrastructure significantly increases export variety more than the intensive margin.

$ln(GDP)_{VN,j,t}$ also shows significant positive effects (1% level). This result is in line with the logic of Tinbergen's gravity model (Tinbergen, 1962). In contrast, geographical distance has a negative impact on all dimensions of Vietnam's green exports, consistent with traditional gravity theory (Anderson & van Wincoop, 2003). Regional Trade Agreements (RTAs) are found to have positive and statistically significant impacts on all dependent variables. This result supports the findings of Baier and Bergstrand (2007), who demonstrated

that RTAs not only reduce tariff barriers but also foster a more stable institutional environment, thereby facilitating trade among member countries. Consistent with the expectation, colonial ties (COL) are found to have a positive and significant impact on trade flow.

Table 4. Impacts of overall logistics performance on different dimensions of Vietnam's green exports (2007-2022)

Variables	$ln(total\_green\_exp)$	$ln(num\_product)$	$ln(exp\_per\_product)$
	(1)	(2)	(3)
$ln(LPI)_{VN,j,t}$	8.286***	4.901***	3.386***
	(0.813)	(0.381)	(0.621)
$ln(GDP)_{VN,j,t}$	1.679***	0.582***	1.097***
	(0.0815)	(0.0390)	(0.0570)
$ln(DIST)_{VN,j}$	-0.744***	-0.402***	-0.342***
	(0.0941)	(0.0452)	(0.0674)
$RTA_{VN,j,t}$	1.001***	0.459***	0.542***
	(0.185)	(0.0760)	(0.143)
$COL_{VN,j}$	0.408*	-0.0332	0.441**
	(0.237)	(0.105)	(0.182)
Constant	-32.78***	-13.10***	-19.69***
	(1.543)	(0.757)	(1.098)
Observations	939	939	939
R-squared	0.652	0.630	0.515

*Notes: Robust standard errors are in parentheses. *, **, and *** reflect statistical significance at the 10%, 5% and 1% level, respectively.*

Source: The authors' calculation using Stata 14

4.2.2. Impacts of logistics performance components on different dimensions of Vietnam's green exports

This section examines the impact of each component of logistics performance on different dimensions of Vietnam's green exports. Tables 5-7 present the regression results with dependent variable being the value of green exports from Vietnam to each partner (denoted by "$total\_green\_exp_{VN,j,t}$"), the number of green products exported from Vietnam to each partner (denoted by "$num\_product_{VN,j,t}$"), and the average value per product of Vietnam's green exports to each partner (denoted by "$exp\_per\_product_{VN,j,t}$"), respectively. The key independent variables in each specification are six subcomponents of Logistics Performance Index, including ability to track and trace consignments (denoted by "$track\_trace_{VN,j,t}$"), ease of arranging competitively priced shipments (denoted by "$shipment_{VN,j,t}$"), frequency with which shipments reach consignee within scheduled or expected time (denoted by "$timeliness_{VN,j,t}$"), and quality of trade and transport-related infrastructure (denoted by "$infrastructure_{VN,j,t}$"), competence and quality of logistics services (denoted by "$logistics\_quality_{VN,j,t}$"), and efficiency of customs clearance process (denoted by "$customs\_efficiency_{VN,j,t}$").

The outcomes in Table 5-7 consistently indicate that among the six components of Logistics Performance Index, "*shipment*" and "*timeliness*" show the most potent positive effects, followed by "*logistics_quality*", "*track_trace*", "*infrastructure*", and "*customs_efficiency*". These results imply that Vietnam's primary logistical constraints are not

rooted in its physical infrastructure or customs processes, but rather in the operational efficiency and cost predictability in logistics. These findings align with evidence from other emerging countries. For instance, in Bangladesh, Dappe et al. (2019) highlight that high shipping costs and frequent delays in port clearance are primary barriers preventing garment exporters from upgrading and diversifying. Focusing on determinants of South African maize exports, Geyser et al. (2024) show that rising domestic transport costs have a statistically significant negative effect on export volumes.

The findings suggest that logistics providers and exporting firms in Vietnam should prioritize operational efficiency and timeliness rather than focusing solely on infrastructure or customs reforms. Firms can achieve this by adopting advanced logistics management systems (e.g., real-time tracking, digital platforms for coordination with carriers and freight forwarders) to reduce delays and improve shipment reliability. Besides, Vietnam's exporting firms should collaborate with logistics providers that have established networks and historical track records of on-time delivery. In addition, exporters and logistics providers should collaborate to design training programs that enhance workforce skills in logistics operations, documentation accuracy, and compliance with international standards. By emphasizing these areas, firms can better leverage logistics performance to enhance Vietnam's green export competitiveness.

Table 5. Impact of different dimensions of logistics performance on the total value of Vietnam's green exports (2007-2022)

Variables	$ln(total\_green\_exp)$					
	(1)	(2)	(3)	(4)	(5)	(6)
$ln(track\_trace)_{VN,j,t}$	6.102***					
	(0.695)					
$ln(shipment)_{VN,j,t}$		8.942***				
		(0.892)				
$ln(timeliness)_{VN,j,t}$			7.022***			
			(0.873)			
$ln(infrastructure)_{VN,j,t}$				5.611***		
				(0.611)		
$ln(logistics\_quality)_{VN,j,t}$					6.441***	
					(0.686)	
$ln(customs\_efficiency)_{VN,j,t}$						5.416***
						(0.661)
Constant	-30.94***	-36.15***	-35.92***	-28.19***	-30.23***	-31.22***
	(1.536)	(1.690)	(1.770)	(1.480)	(1.493)	(1.572)
Observations	939	939	939	939	939	939
R-squared	0.642	0.655	0.642	0.646	0.645	0.639

*Notes: Robust standard errors are in parentheses; *, **, and *** reflect statistical significance at the 10%, 5% and 1% level, respectively.*

Source: The authors' calculation using Stata 14

Table 6. Impact of different dimensions of logistics performance on the number products of Vietnam's green exports (2007-2022)

Variables	$ln(num\_product)$					
	(1)	(2)	(3)	(4)	(5)	(6)
$ln(track\_trace)_{VN,j,t}$	3.549***					
	(0.354)					
$ln(shipment)_{VN,j,t}$		4.860***				
		(0.403)				
$ln(timeliness)_{VN,j,t}$			4.157***			
			(0.416)			
$ln(infrastructure)_{VN,j,t}$				3.386***		
				(0.288)		
$ln(logistics\_quality)_{VN,j,t}$					3.912***	
					(0.332)	
$ln(customs\_efficiency)_{VN,j,t}$						3.317***
						(0.312)
Constant	-11.98***	-14.73***	-14.95***	-10.37***	-11.61***	-12.23***
	(0.766)	(0.834)	(0.861)	(0.729)	(0.738)	(0.794)
Observations	939	939	939	939	939	939
R-squared	0.613	0.625	0.614	0.622	0.621	0.612

*Notes: Robust standard errors are in parentheses; *, **, and *** reflect statistical significance at the 10%, 5% and 1% level, respectively.*

Source: The authors' calculation using Stata 14

Table 7. Impact of different dimensions of logistics performance on the average value per product of Vietnam's green exports (2007-2022)

Variables	$ln(exp\_per\_product)$					
	(1)	(2)	(3)	(4)	(5)	(6)
$ln(track\_trace)_{VN,j,t}$	2.554***					
	(0.521)					
$ln(shipment)_{VN,j,t}$		4.082***				
		(0.679)				
$ln(timeliness)_{VN,j,t}$			2.865***			
			(0.658)			
$ln(infrastructure)_{VN,j,t}$				2.225***		
				(0.464)		
$ln(logistics\_quality)_{VN,j,t}$					2.529***	
					(0.531)	
$ln(customs\_efficiency)_{VN,j,t}$						2.099***
						(0.496)
Constant	-18.96***	-21.42***	-20.96***	-17.82***	-18.62***	-19.00***
	(1.061)	(1.214)	(1.269)	(1.017)	(1.043)	(1.072)
Observations	939	939	939	939	939	939
R-squared	0.511	0.520	0.511	0.512	0.511	0.509

*Notes: Robust standard errors are in parentheses; *, **, and *** reflect statistical significance at the 10%, 5% and 1% level, respectively.*

Source: The authors' calculation using Stata 14

5. Conclusion and policy implications

This study analyzes the impact of logistics performance as well as its subcomponents on green export performance in a developing country context, using Vietnam as a case, between 2007 and 2022. The results confirm that improvements in logistics significantly enhance Vietnam's green export performance, not only in terms of total export value but also through product diversification (extensive margin) and higher average export value per product (intensive margin).

Among the six components of the Logistics Performance Index (LPI), ease of arranging competitively priced shipments and frequency with which shipments reach the consignee within the scheduled or expected time exert the strongest influence, underlining the importance of efficient and reliable transport systems in meeting the demands of environmentally conscious markets. Although logistics service quality, tracking and tracing capabilities, quality of trade and transport-related infrastructure, and efficiency of customs clearance process are relatively less influential in the regression results, they remain critical drivers boosting Vietnam's green export performance.

The findings from this study offer important implications. To promote green trade, Vietnam should prioritize the digitalization of customs procedures, the adoption of smart transport and real-time tracking systems, and investments in multimodal transport infrastructure to better serve time-sensitive green products. Digitalizing customs procedures can reduce clearance delays, thereby enhancing timeliness through faster and more predictable border processing. The adoption of smart transport and real-time tracking systems increases transparency and operational reliability, which directly strengthens shipment capacity and reduces the risks of unexpected disruptions. Investments in multimodal infrastructure expand the ability to improve the speed and consistency of delivery. Furthermore, logistics upgrading should be integrated into trade strategy, including targeted negotiations in regional trade agreements (RTAs) to reduce logistics costs and harmonize standards. These actions would not only reduce inefficiencies but also signal Vietnam's commitment to sustainable trade, thereby strengthening its position in green global value chains.

Although this study provides valuable insights, its limitations are present. The analysis is conducted at the country level, which restricts the ability to capture heterogeneity across firms. Firm-level data can reveal how exporters with different sizes, ownership structures, or product portfolios experience logistics constraints differently. Future research could address this gap by combining firm-level trade data with logistics performance indicators to provide deeper insights.

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Appendix 1. Impacts of overall logistics performance on different dimensions of Vietnam's green exports (PPML estimator)

Variables	$ln(total\_green\_exp)$	$ln(num\_product)$	$ln(expper\_product)$
	(1)	(2)	(3)
$\ln(LPI)_{VN,j,t}$	8.202***	3.479***	4.624***
	(0.997)	(0.284)	(0.677)
$\ln(GDP)_{VN,j,t}$	1.008***	0.342***	0.799***
	(0.110)	(0.0262)	(0.0842)
$\ln(DIST)_{VN,j}$	-0.532***	-0.384***	-0.272***
	(0.0873)	(0.0222)	(0.0706)
$RTA_{VN,j,t}$	0.190	0.341***	0.127
	(0.259)	(0.0444)	(0.185)
$COL_{VN,j}$	0.804**	0.100	0.778***
	(0.318)	(0.0845)	(0.264)
Constant	-19.72***	-5.598***	-15.84***
	(3.009)	(0.452)	(1.802)
Observations	939	939	939
R-squared	0.538	0.727	0.559

Source: The authors' calculation using Stata 14.