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Assessing the impact of green logistics performance on vietnam's export trade to regional comprehensive economic partnership countries

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Abstract

This article uses a gravity model framework to examine the impact of green logistics on Vietnam's exports to countries participating in the Regional Comprehensive Economic Partnership (RCEP). The study uses a generalized least squares (GLS) estimation method based on panel data for the period 2010-2018 and has reliable sources. The results of empirical research have found the following main findings: (i) Logistics performance, encompassing cost, reliability, and time-related factors, significantly and positively influence Vietnam's exports; (ii) The interaction effects between supply chain input components (customs, infrastructure, and services) and CO2 emissions from the transportation sector have a positive impact on Vietnam's exports; (iii) The supply chain input components demonstrate direct and positive effects on exports when implemented in conjunction with their interaction effects with CO2 emissions from the transportation sector; (iv) The emissions of CO2 from Vietnam's transportation sector exert a negative influence on exports; (v) Adopting a green logistics approach that focuses on reducing CO2 emissions from the transportation sector demonstrates a positive influence on Vietnam's exports. This influence is observed through direct and moderating effects, indicating the potential for sustainable practices to foster export growth. These research findings provide valuable insights for managers and policymakers in the formulation of informed decisions related to the development and promotion of green logistics. By embracing sustainable practices and aligning export growth with environmental goals, Vietnam can enhance its competitiveness while contributing to a greener future.

Keywords: Export, Gravity model, Green logistics, Logistics performance index, RCEP, Vietnam.

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1. Introduction

Research on the impact of green logistics on exports is a topic that has drawn considerable attention from scholars and managers, particularly in the current context in which climate change poses significant challenges globally. Logistics, as a major industry for national economic development, plays a pivotal role in determining the competitiveness of international trade [1]. Extensive research has consistently shown that the performance of logistics, encompassing factors such as logistics infrastructure, logistics quality, and competence, among others, exerts a positive influence on international trade Puertas, et al. [2] and Bensassi, et al. [1]. Hausman, et al. [3] and D'Aleo and Sergi [4] emphasized in their studies that the development of logistics, combined with economic liberalization, contributes to trade growth, thereby positively affecting the economic scale, distribution capabilities, production activities, and ultimately promoting economic growth. Undeniably, the significance of logistics operations for economic growth cannot be overlooked. Hence, enhancing logistics activities through sustainable logistics, or green logistics, holds the key to economic growth and competitiveness for all countries worldwide, including Vietnam.

In recent years, Vietnam's logistics sector has experienced significant development, consistently climbing in international rankings. In the 2021 Emerging Markets Logistics Index by Agility, Vietnam secured the 8th position among the top 10 emerging markets, advancing 3 places from 2020, with a logistics industry growth rate of 14-16%. Despite these achievements, logistics remains one of the major contributors to environmental pollution, accounting for up to 8% of the global CO_2 emissions from freight transport. In Vietnam, the lack of synchronized and modern infrastructure leads to higher fuel consumption, resulting in increased CO_2 emissions. Consequently, the country is striving to pursue sustainable economic development, wherein green logistics practices are emphasized through specific objectives and initiatives, such as green packaging, eco-friendly transportation, and sustainable warehouses. These efforts aim to conserve energy and mitigate environmental hazards and pollution.

Environmental regulations serve the purpose of promoting the sustainable development of green logistics and addressing environmental concerns. However, these regulations can also function as new non-tariff trade barriers manifested through measures such as the Restriction of Hazardous Substances (RoHS), the End of Life Vehicle Directive (ELV), and eco-labeling. Many countries, particularly developed ones, implement these regulations to safeguard the ecological environment, human health, and the well-being of animals and plants. Such regulations can restrict or prohibit the entry of products and services from foreign regions, potentially leading to adverse effects on international trade. To our knowledge, there are very few studies on the impact of green logistics on international trade, especially no studies looking at Vietnam, a developing country that does not have the conditions to heavily focus on environmental factors. Given the crucial role of logistics in international trade and the significant greenhouse gas emissions associated with logistics activities, conducting an empirical study to investigate the impact of green logistics on international trade is both worthwhile and urgent.

This study focused on examining the influence of logistics and green logistics on Vietnam's commodity exports to member countries of the Regional Comprehensive Economic Partnership (RCEP). RCEP is a free trade agreement betweenthe Association of Southeast Asian Nations (ASEAN)and 5 partner countries, including China, South Korea, Japan, Australia, and New Zealand. The combined Gross Domestic Product (GDP) of the countries in the agreement accounts for approximately 30% of the global GDP, making it the largest trading bloc in history.

The primary objective is to answer the following research questions: How does green logistics impact Vietnam's commodity exports to RCEP member countries? And can logistics performance moderate the effect of emissions on exports? The study also aims to provide recommendations for green logistics practices to promote sustainable exports, strike a balance between economic interests and environmental protection, and foster economic growth for both Vietnam and RCEP member countries.

Following this introduction, the subsequent content of the paper includes four sections. Section 2 is devoted to Literature Review. Section 3 outlines the approach and methods utilized in this study, including data sources, analytical techniques, and variables considered. Section 4 is for findings and discussion. Section 5 includes a conclusion and some implications.

2. Literature Review

2.1. An Overview of Green Logistics and the Logistics Performance Index

Since the 1980s, the concept of Green Logistics has emerged within the framework of global sustainable development. Green Logistics encompasses a range of sustainable strategies and practices designed to reduce the ecological footprint associated with logistics operations. This approach entails reconfiguring processes, structures, and equipment systems in transportation, distribution, and warehousing to align with environmental objectives [5]. The primary goal of Green Logistics is to achieve a harmonious balance between efficient logistics operations, including warehouse management, goods distribution, and transportation, and the preservation of natural resources and the environment. Consequently, Green Logistics has become a critical determinant of trade competitiveness [6, 7].

Since 2007, the Logistics Performance Index (LPI), published by the World Bank, has become a criterion for evaluating and ranking the efficiency and operational capabilities of logistics activities in countries. This index is based on standardized questionnaires and utilizes statistical techniques to synthesize data into a single indicator, facilitating comparisons of logistics performance among countries, regions, and different income groups [8]. Experts in logistics, multinational freight forwarders, express delivery companies, and individuals responsible for transporting goods worldwide participate in answering the questionnaire, and their choices regarding transportation routes influence decisions related to production locations, supplier selection, and target market preferences. In the LPI questionnaire, respondents evaluate eight foreign markets that are the most important import-export markets for the country where they reside [8].

The Logistics Performance Index (LPI), developed by the World Bank, assesses countries based on six key components:

1. Customs and border management clearance efficiency (CUST).
2. Trade and transport-related infrastructure quality (INFR).
3. Competence and quality of logistics services (LOGS).
4. Competitively priced international shipment arrangements (ITRN).
5. Consignment tracking and tracing capabilities (TRAC).
6. Timeliness of shipments reaching consignees(TIME).

The six LPI indicators can be categorized into two main groups: (i) areas for policy regulation that signify the primary inputs to the supply chain, including customs, infrastructure, and services (indicators 1, 2, and 3); (ii) supply chain performance outcomes that encompass cost, reliability, and time (indicators 4, 5, and 6).

This comprehensive selection of indicators allows for a comprehensive analysis of logistics performance, enabling meaningful comparisons between different countries and regions.

Although the Logistics Performance Index (LPI) provides comprehensive data on logistics at the national level, it has two main limitations. First, the experiences of international freight forwarders may not represent the logistics environment in poorer countries. Second, the LPI may reflect issues related to external access for landlocked countries, such as difficulties and disadvantages during transit. However, low LPI rankings in these countries may not fully reflect their efforts to improve trade and logistics in general.

2.2. Impact of Logistics and Green Logistics on Exports

2.2.1. Logistics Affects Exports

2.2.1.1. Logistics Affects Exports Through Trade Facilitation

Trade facilitation refers to the streamlining and harmonization of international trade procedures [9]. The Organization for Economic Cooperation and Development (OECD) defines trade facilitation as the simplification and standardization of procedures and information flows necessary for the transportation of goods from the seller to the buyer, as well as facilitating payment transactions in the opposite direction. The World Bank takes a broader approach by incorporating customs reforms, regulatory frameworks, standards, and considerations related to logistics and infrastructure.

According to the World Trade Organization (WTO), efficient transportation of goods is essential for robust trade development, with logistics playing a crucial role in this process [10]. Logistics is a critical factor in efficiently transporting goods from production centers to export markets. The quality of transportation infrastructure, the availability of skilled labor, and the capacity of the logistics sector can significantly influence the speed and cost of goods transportation.

A study by Arvis, et al. [8] found a positive correlation between logistics activities and export performance, with countries with more developed logistics tending to have higher export levels. Tang and Abosedra [11] demonstrated that the export-led growth hypothesis stayed true in all the countries analyzed. Moreover, a crucial and noteworthy finding was that the performance of the logistics sector played a significant role in facilitating trade. Further, economic growth in Asia depended on the level of logistics performance in examined countries. Therefore, from a policy standpoint, it was advisable to prioritize investment in logistics infrastructure because it brought substantial benefits and yielded the highest returns for growth in the future in the selected countries. Finally, the results showed that the different logistics capabilities of the countries that were looked at might explain the mixed results found in earlier studies that tested the export-led growth (ELG) hypothesis in Asian countries.

Barriers such as inadequate infrastructure, inefficient customs procedures, corruption in customs, and the lack of appropriate and coherent transport strategies from government agencies prevent countries from competing globally, especially in the export sector. Analyzing logistics as a determinant factor for export activities to various regions, Marti, et al. [12] concluded that implementing measures to facilitate trade through improved logistics activities over five years yielded favorable results in export growth, particularly in regions like Africa, South America, and Eastern Europe. The study also highlighted that developing countries needed to further improve infrastructure, logistics services, and the efficiency of customs and national agencies to compete fairly and boost exports in a complex international trade network.

2.2.1.2. Logistics Affect Exports Through Absolute Advantage and Competitive Advantage

The theories of absolute advantage and comparative advantage of a country have described a clear relationship between logistics and trade flows. However, measuring logistics efficiency is not straightforward due to the diverse nature of logistics activities, such as transportation, multimodal transportation, warehousing, customs, information technology, communication, etc. Therefore, researchers often rely on alternative indicators for logistics activities [13]. Many studies have evaluated the impact of one or more logistics activities on a country's trade performance.

In the context of the increasingly diverse and complex international business environment, logistics plays a crucial role in determining the performance of international trade, including the exports of countries [14]. Among countries with similar income levels, those taking part better in logistics activities achieved GDP growth and trade growth rising by 1% and 2%, respectively [8]. Thus, enhancing logistics activities, such as developing transportation infrastructure, logistics services, and ports, enhancing logistics centers' efficiency, and continuously improving information systems, is crucial to the development of a country's import-export operations Arvis, et al. [8]. Bensassi, et al. [1] also demonstrated a positive correlation between logistics activities and trade, highlighting the positive impact of logistics facilities' quality on export flows.

Töngür, et al. [15] studied the influence of logistics activities on Turkish exports using a gravity model. Their empirical findings showed a significant impact of logistics activities on export value. This impact was stronger in emerging marketsthan in other ones [16]. Similarly, Çelebi [17] investigated the influence of different logistics indicators on trade in a comparative analysis. Empirical results revealed that logistics created several advantages to the export performance in the situation of low and lower-middle-income countries, while for medium and high-income economies it was the opposite effect.Logistics activities play a crucial role in determining a country's competitiveness in international trade. Sergi, et al. [18] found that there was a relationship between the Logistics Performance Index and factors selected in the Global Competitiveness Index. Cedillo-Campos, et al. [19] showed that the significance of transportation infrastructure for enhancing the competitiveness of both companies and nations was widely recognized, particularly in terms of increasing the logistics value of supply chains. For example, companies based in emerging countries face significant challenges in effectively participating in global supply chains due to the lack or insufficiency of transportation infrastructure. This issue is often considered a major obstacle they encounter. Costs associated with input and finished product transportation have an impact on the opportunity cost of producing goods. Inefficient logistics operations can increase the opportunity cost of producing goods, making them less competitive in the global market. Conversely, efficient logistics can reduce the opportunity cost of production and enhance product quality, thereby increasing competitiveness in the global market [8]. Similarly, Hoekman and Nicita [9] found that logistics influencedgeneral trade, especially exports, and trade activities among countries. Thus, it is evident that logistics efficiency and export value have a positive and mutually supportive relationship.Logistics efficiency not only promotes export activities and international trade but also leads to economic growth and enhances a country's competitive capacity in the market.

In summary, by reducing transportation costs, improving delivery times, enhancing sustainability, and reducing costs, a country can gain an absolute advantage in the production and export of goods to improve economic welfare.

2.2.2. Green Logistics Affect Exports

In the context of sustainable development, the focus of logistics has shifted from cost-effectiveness and efficiency to environmental friendliness and resource conservation. Green logistics efficiency considers factors such as greenhouse gas emissions intensity and fossil fuel consumption in addition to traditional logistics efficiency indexes. The Green Logistics Performance Index (GLPI) builds upon the six components of the traditional LPI.

Both logistics and green logistics are crucial for a country's comparative advantage in production and export. Wang, et al. [20] conducted a study using an augmented gravity model and data from 113 countries and regions to analyze the relationship between logistics, green logistics, and trade. The findings revealed several important insights. The LPI and GLPI of both exporting and importing countries were positively correlated with trading volume. However, for different country groups, the green logistics performance of importing countries had a negative effect on the export volume of exporting countries. In the case of trade between developing and developed countries, the green logistics performance of importing countries negatively affected export probability but positively impacted export volume.

Improved logistics and green logistics can reduce trade costs, including variable and fixed costs. Variable trade costs fluctuate with export volume, while fixed costs, such as port operations, remain constant. Reducing variable trade costs has a positive impact on both export and import markets, as it lowers the export threshold. Reducing fixed trade costs encourages small and less productive firms to participate in the export market, with minimal impact on the import market. Studies by Melitz [21] and Chaney [22] have examined the sensitivity of export and import markets to trade barriers, extending the understanding of trade costs about productivity and market participation. In exports, green logistics demonstrates significant benefits, enabling the country and its export businesses not only to protect the environment and natural resources but also to enhance competitiveness and reputation in the market. This is because green logistics exhibits its superiority in reducing industrial waste. Export activities following this green orientation will necessitate changes in production and operations, such as using eco-friendly packaging made from recyclable and biodegradable materials, practicing green transportation, green warehouses, etc. These measures contribute to reducing CO_2 emissions, optimizing supply chains, and enhancing brand value for goods, thereby increasing the export capacity of businesses and countries in the market.

In their study, Ekici, et al. [23] demonstrated the positive impact of logistics activities, particularly green logistics, on international trade, including exports, with the assistance of the logistics performance index. Accordingly, green logistics promotes exports by first reducing transportation costs, as it differs from traditional logistics by prioritizing the use of clean fuels and fuel-efficient means of transport. Additionally, green logistics applies management measures and techniques to reduce vehicle and equipment energy consumption while still meeting the set goals for the production process.

In line with this perspective, Zhang, et al. [24] addressed the policy aspects of green logistics, green growth, and sustainable growthwhile also discovering several factors that help improve exports when pursuing green logistics. These factors include building and operating a freight transport network that employs multimodal transportation, distribution centers, and selected transportation routes to maximize the use of existing infrastructure and warehouses. As a result, import-export activities among countries are conducted conveniently at optimized costs while ensuring delivery schedules and, especially, minimizing harmful impacts on the environment.

Studies have shown that logistics companies can implement sustainable activities to reduce their environmental impact while improving their reputation and competitiveness in the market [25]. Efficient transportation is one of the ways logistics companies can reduce emissions significantly. Logistics companies need to consider leveraging green logistics knowledge and the regulatory impact of green knowledge capital on the relationship between green logistics knowledge and green logistics management practices [26]. The use of more efficient transportation methods, such as rail or sea, instead of road or air transport can also significantly reduce emissions [25]. Moreover, collaboration between logistics companies and their customers is another approach to reducing emissions. Logistics companies should negotiate with their customers to optimize their supply chains by consolidating shipments, reducing packaging, and using more sustaina ble materials. This can helpreduce the carbon footprint of customers and improve their perception of the company's sustainability [27]. Thereby, logistics can play a role as a regulatory factor to lessen the negative impact of emissions from the transportation industry. By applying sustainable practices and collaborating with customers to optimize their supply chains, logistics companies can improve their reputation, enhance competitiveness, and contribute to a more sustainable future.

In recent years, studies on the impact of logistics on international trade have attracted significant attention from researchers. Particularly since 2007, when the World Bank first published the LPI for over 160 countries, there have been numerous studies examining the impact of logistics efficiency on the exports of countries on various continents [15, 17, 28, 29]. However, these studies mainly focus on examining logistics efficiency without considering green logistics, or if they investigate green logistics, they approach it from the perspective of emissions reduction across all sectors.

However, to date, we have not found any articles that study the moderating role of logistics efficiency in the relationship between emissions and exports. This is the research gap that we aim to address in this article. In addition to investigating the impact of green logistics efficiency from the perspective of CO2 emissions reduction in the transportation sector, which is closely related to logistics activities, we will examine the moderating role of logistics efficiency on the impact of emissions from the transportation sector on the export value of Vietnamese goods to RCEP countries during the period 2010-2018.

Thus, we formulate the hypotheses in this study as follows:

Hypothesis H_1. Logistics performance in Vietnam has a positive effect on the value of Vietnamese goods exported to partners participating in RCEP.

Hypothesis H_2. CO2 emissions from Vietnam's transportation industry have a negative impact on Vietnam's exports to RCEP countries.

Hypothesis H_3. Logistics performance plays a role as a moderation variable and reduces the negative impact of CO2 emissions from Vietnam's transport industry on the value of Vietnamese goods exported to RCEP countries.

3. Materials and Methods

3.1. Gravity Model in International Trade

The gravity model is a commonly employed framework in international trade that explains trade patterns between countries based on their economic size and geographical distance. It has been extensively utilized in empirical studies of international trade, particularly for analyzing aggregate-level trade flows [30].

The fundamental tenet of the gravity model is that the economic size of the two countires-typically expressed as their GDP has a positive impact on bilateral trade flow. At the same time, the distance between trading partners exerts a negative impact. Geographical distance serves as a proxy for transport costs, and it can be quantified by calculating the distance between capital cities [31]. Consequently, the gravity model can be mathematically represented as follows:

$$E_{ij} = A\frac{Y_iY_j}{D_{ij}}$$

Where E_{ij} is the trade flow between countries i and j, $Y_i$andY_j is the GDP of countries i and j, and D_{ij} is the distance between them. A is a constant representing the effects of other factors that affect trade flows, such as trade policies, cultural similarities, and historical ties.

The gravity model has been extended and modified in various ways to account for other factors that affect trade flows. For example, some studies have incorporated institutional quality [32], language [33], and colonial relationships [34] into the model. These extensions improved the predictive power of the gravity model, making it a useful tool for analyzing the determinants of international trade.

Additionally, the model can incorporate other variables as supplements. A gravity model will be applied to identify the factors that influence international trade in selected countries, with particular emphasis on logistics performance, as part of the following equation representing the trade facilitation factor.

In empirical studies, the gravity model is often converted to a linear form by taking the logarithm of both sides to the following form:

$$lnE_{ij} = lnA + lnY_i + lnY_j - lnD_{ij}$$

3.2. Empirical Research Model

The gravity model of trade is widely employed as a theoretical framework to analyze the impact of logistics performance on international trade flows.

Figure 1illustrates a research model.

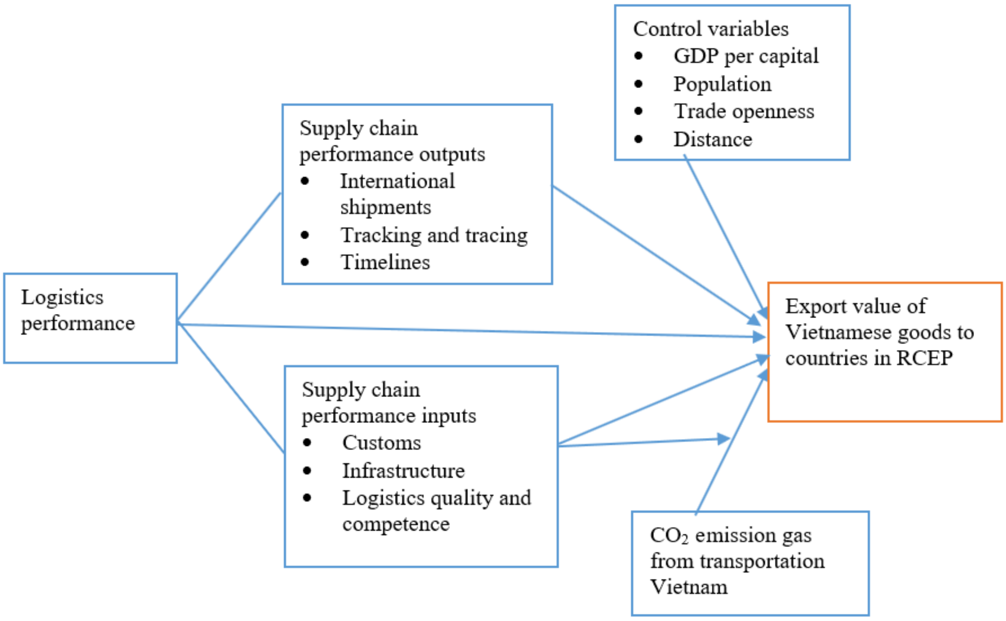

Figure 1.
Research model.

The linear regression models are built in log-log form based on the extended gravity model.

$$lnEX_{ijt} = \beta_0 + \beta_1 lnGDPPCV_{it} + \beta_2 lnGDPPC_{jt} + \beta_3 lnOPEN_{jt} + \beta_4 lnPOP_{jt} + \beta_5 lnDIST_{ij} + \beta_6 lnLPI_{it} + \beta_7 lnCOPC_{it} + \varepsilon_{ijt} \quad (1)$$

In which, i is the index referring to the exporting country of Vietnam, j is the index referring to the 14 RCEP countries that import goods from Vietnam, t signifies the study period, specifically, even years. The survey results on the logistics efficiency index in the period from 2010 to 2018; are as follows: the dependent variable, denoted as *lnEX*, represents the natural logarithm of the export value of Vietnamese goods to RCEP partners; Table 1 provides a detailed explanation of the independent variables, which consistof variables derived from the gravity model and additional extended variables.

These extended variables are employed to test hypotheses H1 and H2, which are as follows:

lnLPI is the natural logarithm of Vietnam's logistics efficiency index, which includes the general logistics efficiency index *(lnOVRL)*and 6 component indexes: *lnCUST; lnINFR; lnINTR; lnLOGS; lnTRAC; lnTIME.*

lnCOPC is the natural logarithm of carbon dioxide (CO2) per capita from the Vietnamese transportation sector.

ε_{ijt} is the random error in the regression model.

In our empirical research model, we extend the gravity model by including two additional variables: the Exporter's Logistics Performance Index and emissions from logistics activities. The LPI reflects trade facilitation, while emissions represent the environmental impact of logistics. We anticipate a negative coefficient for emissions, indicating that higher emissions can adversely affect exports. Exporting countries should focus on reducing emissions and complying with environmental regulations to maintain and enhance their export competitiveness.

To test hypothesis H3, the interaction variable between *lnLPI* and *lnCOPC*is added to Model (1).

$$lnEX_{ijt} = \beta_0 + \beta_1 lnGDPPCV_{it} + \beta_2 lnGDPPC_{jt} + \beta_3 lnOPEN_{jt} + \beta_4 lnPOP_{jt} + \beta_5 lnDIST_{ij} + \beta_6 lnLPI_{it} + \beta_7 lnCOPC_{it} + \beta_8 (lnLPI_{it} * lnCOPC_{it}) + \varepsilon_{ijt} \quad (2)$$

Unlike most previous studies, in model 2, there is an additional interaction variable between logistics performance and CO2 emissions from the transport industry. The sign of the coefficients β_7, β_8 helps us to assess the moderating role of logistics performance on the influence of emissions on exports, and that impact is calculated by the formula:

$$\frac{\partial lnEX_{ijt}}{\partial lnCOPC_{it}} = \beta_7 + \beta_8 lnLPI_{it}.$$

3.3. Data, Variables, and Model Estimation Procedures

3.3.1. Data and Variables

The data used in this study were collected in the period 2010-2018from the websites of reputable and reliable organizations such as Comtrade, World Bank, Centre for Prospective Studies and International Information(CEPII), and Climate Watch. Data was collected in the years 2010, 2012, 2014, 2016, and 2018,because the logistics performance index was surveyed and reported by the World Bank during this time.

The variables, source of data, andexpected sign of the coefficients are explained in Table 1.

Table 1.
Explain the variables in the empirical research model.

Variables	Variable explanations	Expected sign	Data sources
lnEX	The natural logarithm of the value of Vietnam's exports to RCEP countries each even year was calculated at constant prices in 2015.		Trade Data [35]
lnGDPPCV	The natural logarithm of Vietnam's GDP per capita each year was calculated at constant prices in 2015.	+	World Bank [36]
lnGDPPC	The natural logarithm of RCEP countries' GDP per capita each even year, was calculated at constant prices in 2015.	+	World Bank [36]
lnPOP	The natural logarithm of the population of a country in RCEP each even year.	(+)/(–)	World Bank [36]
lnOPEN	The natural logarithm of trade openness of a country in RCEP each even year (measured by the ratio of import and export value to GDP).	(+)	World Bank [36]
lnDIST	The natural logarithm of the distance between the capital of Vietnam and the capital of a country in RCEP.	(–)	GeoDist [37]
lnLPI	The natural logarithm of Vietnam's logistics performance index, in which LPI consists of one common index (OVRL) and six sub-indices (TRAC, INFR, CUST, INTR, TIME, LOGS).	(+)	World Bank [36]
lnCOPC	The natural logarithm of CO2 emissions per capita of the Vietnamese transportation sector each even year.	(–)	Climate [38]

3.3.2. Model Estimation Procedures

According to Wooldridge [39], the process of estimating the array model is as follows:
(1) Estimating the pooled model (POLS).
(2) Estimating the random effects model (REM).
(3) Taking the Breusch and Pagan test to choose between POLS or REM.
(4) Estimating the fixed effects model (FEM).
(5) Taking the Hausman test to choose between FEM or REM.
(6) Detecting the model's defects.
(7) Repairing defects in the model.

If the model satisfies the basic assumptions, it can be concluded that the research model is reliable in estimating the impact of each independent variable on the dependent variable. If the model has multicollinearity, then we will proceed to remove one of the highly correlated variables from the model. If the model encounters other defects, the Feasible Generalized Least Squares (FGLS) method can be used to estimate the model.

4. Results and Discussions

4.1. Impact of Green Logistics Performance on Vietnamese Goods Exports

Correlation analysis between variables aims to eliminate variables that can cause multicollinearity in the regression model. The pairwise correlation coefficients between the variables in Table 2 show that the independent variables in the models have low correlation, so models containing these variables are less likely to have multicollinearity.

Table 2.
Correlation coefficients between variables.

Variables	*lnEX*	*lnGDPPCV*	*lnGDPPC*	*lnOPEN*	*lnPOP*	*lnDIST*	*lnOVRL*	*lnCOPC*
lnEX	1.000							
lnGDPPCV	0.189	1.000						
lnGDPPC	-0.032	0.061	1.000					
lnOPEN	-0.024	0.013	-0.084	1.000				
lnPOP	0.498	0.014	-0.427	0.045	1.000			
lnDIST	0.093	0.000	0.609	-0.269	0.124	1.000		
lnOVRL	0.159	0.703	0.043	0.043	0.009	0.000	1.000	
lnCOPC	0.094	0.746	0.042	-0.008	0.009	0.000	0.402	1.000

Following the estimation procedure outlined in Section 3.3, we used Pooled Ordinary Least Squares (POLS) and Random Effects Model (REM) methods for panel data to estimate Model(1). Besides, the Breusch and Pagan Lagrangian multiplier test was applied to detect heteroscedasticity in REM. The test result showed a P-value of 0.0000, which was less than 1%. It indicates that, although there is heteroscedasticity in REM, this model is better than POLS. The Fixed Effects Model (FEM) was then employed to estimate Model (1), and the Hausman test was taken to choose between FEM and REM. The test result showed a P-value of 0.4079, which was greater than 10%. Therefore, REM is chosen because it is the most suitable for the data (see Appendix Tables A1 and A2). The same procedure was applied to Models (1) and (2), with variables representing LPI and CO2. In addition, to account for heteroscedasticity, the Generalized Least Squares (GLS) method was utilized to estimate both Models (1) and (2) using REM for panel data.

Table 3.
Estimationresults of model (1) with representative variables of green logistics including supply chain performance inputs.

Variable	OVRL	CUST	INFR	LOGS
Cons	-38.489*** (14.206)	-40.816*** (13.513)	-37.797** (14.738)	-40.860*** (13.680)
lnGDPPCV	1.977*** (0.445)	2.160*** (0.511)	2.063*** (0.564)	2.197*** (0.429)
lnGDPPC	1.316*** (0.339)	1.304*** (0.349)	1.307*** (0.347)	1.302*** (0.350)
lnOPEN	0.768*** (0.063)	0.785*** (0.061)	0.780*** (0.061)	0.789*** (0.061)
lnPOP	0.731*** (0.283)	0.724** (0.287)	0.726** (0.286)	0.723** (0.288)
lnDIST	-1.217* (0.660)	-1.196* (0.654)	-1.202* (0.656)	-1.193* (0.653)
lnCOPC	-1.657*** (0.548)	-1.775*** (0.521)	-1.618*** (0.627)	-1.769*** (0.530)
lnOVRL	0.874* (0.498)			
lnCUST		0.132 (1.014)		
lnINFR			0.199 (0.428)	
lnLOGS				-0.026 (0.384)

Notes: *, **, and *** indicate statistical significance at p-value levels 0.1, 0.05, and 0.01 respectively; standard errors are in parentheses.

Table 4.
EstimationResults of Model (1) with representative variables of green logistics including supply chain performance outcomes.

Variable	INTR	TRAC	TIME
Cons	-7.986 (24.813)	-41.362*** (13.514)	-42.031*** (13.224)
lnGDPPCV	0.981 (0.798)	2.124 (0.358)	1.991*** (0.352)
lnGDPPC	1.094*** (0.363)	1.324*** (0.332)	1.315*** (0.332)
lnOPEN	0.747*** (0.085)	0.762*** (0.067)	0.786*** (0.070)
lnPOP	0.687** (0.287)	0.735*** (0.280)	0.728*** (0.281)
lnDIST	-0.975 (0.658)	-1.229* (0.662)	-1.211* (0.652)
lnCOPC	0.320 (1.217)	-1.792*** (0.516)	-1.764*** (0.523)
lnINTR	7.563** (2.961)		
lnTRAC		0.601** (0.234)	
lnTIME			2.188* (1.281)

Notes: *, **, and *** indicate statistical significance at p-value levels 0.1, 0.05, and 0.01 respectively; standard errors are in parentheses.

The results show that the signs of the coefficients in both models are the same as the expectations of the researcher.

Estimation results of Model (1) in Tables 3 and 4 have shown the following points:

(i) For the control variables in the gravity model: GDP per capita of Vietnam *(lnGDPPCV)*; GDP per capita of countries in RCEP *(lnGDPPC);* The trade openness and population of countries in RCEP *(lnOPEN;lnPOP)* all have positive and statistically significant coefficients at 1% or 5%. These suggest that the above factors all positively affect Vietnam's export value to RCEP countries. Meanwhile, the distance between Vietnam and each of the RCEP countries *(lnDIST)* has a negative coefficient in all models and low statistical significance at 10%. Thus, it can be concluded that the distance between Vietnam and partner countries has a negative effect on export value. These results are also similar to those of Çelebi [17]and Fan, et al. [28].

(ii) Considering the logistics performance variables of Vietnam, the general logistics efficiency index (*lnOVRL*) and its six component indexes are divided into two groups. In Model (1), shown in the first column (OVRL) of Table 3, the estimation results indicate that the overall logistics performance variable (*lnOVRL*) has 0.87363 coefficients and statistical significance at 1%. These findings support hypothesis H1, suggesting that Vietnam's general logistics efficiency (OVRL) has a positive influence on its export value to RCEP partners, consistent with studies by Bensassi, et al. [1];Töngür, et al. [15] and Fan, et al. [28].

Regarding the six component indicators measuring logistics efficiency, in Table 4, three variables measuring supply chain output efficiency *(lnINTR, lnTRAC, lnTIME)* exhibit positive coefficients that are statistically significant at below 5%. This indicates that competitively priced international shipment arrangements (INTR), consignment tracking and tracing capabilities (TRAC), and timeliness of shipments reaching consignees(TIME) positively affect Vietnam's export value to other RCEP countries. These conclusions align with the findings of Çelebi [17] and Hoekman and Nicita [9], suggesting that logistics significantly influences trade and exports. However, in Table 3, three variables representing supply chain input performance *(lnCUST, lnINFR, lnLOGS)* do not show statistical significance. This implies that the quality the efficiency of customs (CUST), trade and transport-related infrastructure quality (INFR), andlogistics services (LOGS) do not impact Vietnam's export value to RCEP partners.

The research results indicate that logistics efficiency indexes related to Vietnam's supply chain output have a positive effect on exports, while those related to supply chain input do not play a significant role in improving exports. These findings are suitable for a developing country like Vietnam, which may not have sufficient resources to invest synchronously in logistics infrastructure. Despite efforts to improve customs efficiency and logistics services to promote export activities, the results are not as positive as expected. Vietnam's transportation infrastructure has not yet met the demand for fast and cost-effective goods transportation. Additionally, customs procedures and logistics services in Vietnam are time-consuming, making it challenging for businesses to transport goods efficiently. Furthermore, transportation costs in Vietnam remain higher compared to other countries in the region and the world, reducing the competitiveness of Vietnamese goods in the international market.

(iii) Regarding the emission variables (*lnCOPC*) obtained from the Vietnamese transportation sector, theyhave a negative regression coefficient and statistical significance at 1% in almost all models. In general, it can be confirmed that the amount of emissions per capita released from the transportation industry has a negative impact on exports of goods from Vietnam to RCEP countries. It means that if the amount of emissions from the transportation sector decreases, the average export value will increase. On the other hand, hypothesis H2 is supported. Specifically, the results of the models containing the overall logistic index variable *(lnOVRL)*, in the first columns in Table 3 indicate that if the amount of CO2 per capita from the transportation industry decreases by 1% and other factors remain unchanged, the average export value of Vietnam increases by 1.65673%. Similarly, in the models including one of the six component indexes representing logistics efficiency, the direction of impact of the amount of these emissions on the export value of Vietnam is still downward, and the amount of CO2affects this value most seriously. These results are similar to the conclusion of Fan, et al. [28] in the study on the impact of green logistics on China's exports to RCEP countries. Therefore, improving logistics efficiency by reducing emissions generated from the transportation of goods can have positive effects on exports.

The results also indicate variations in the degree of influence of logistics performance indexes on Vietnam's export value to RCEP countries. Moreover, the degree of influence of each index on Vietnam's export value depends on the emission variable included in the model. To further understand these effects, the study explores the moderating relationship between logistics efficiency and the impact of emissions on Vietnam's export value to RCEP countries by introducing interaction variables between logistics efficiency and emissions generated from the transportation industry into the model.

4.2. Logistics Efficiency Moderates the Degree of Impact of Emissions on Export Value

Table 5 shows the results of estimating Model (2), which added an interaction variable between logistics performance and CO2 emissions to Model (1). These results indicate that variables measuring supply chain output efficiency (*lnINTR, lnTRAC, lnTIME*) and interaction variables between them and the amount of emissions released from the transportation industry are not statistically significant. Meanwhile, variables measuring supply chain input efficiency (*lnCUST, lnINFR, lnLOGS*) and interaction variables between them and the amount of emissions have statistical significance at 5% or 10%.

Table 5.
Estimation results of model (2) with interaction variables between logistics efficiency of supply chain inputs and CO2 emissions per capita of the Vietnamese transportation sector.

Variable	CUST	INFR	LOGS
Cons	-350.010** (159.856)	-242.614** (115.138)	-182.878*** (64.766)
lnGDPPCV	2.261*** (0.537)	2.342*** (0.647)	2.204*** (0.433)
lnGDPPC	1.316*** (0.336)	1.316*** (0.336)	1.316*** (0.336)
lnOPEN	0.777*** (0.080)	0.777*** (0.080)	0.777*** (0.080)
lnPOP	0.730** (0.285)	0.730** (0.285)	0.730** (0.285)
lnDIST	-1.214* (0.660)	-1.21434* (0.660)	-1.21434* (0.660)
lnCOPC	-22.599** (11.094)	-15.274* (7.928)	-11.340** (4.692)
lnCUST	295.042* (160.168)		
lnCUST*lnCOPC	19.920* (10.866)		
lnINFR		181.837* (105.347)	
lnINFR*lnCOPC		12.245* (7.120)	
lnLOGS			123.794* (64.326)
lnLOGS*lnCOPC			8.353* (4.358)

Notes: *, **, and *** indicate statistical significance at p-value levels 0.1, 0.05, and 0.01 respectively; standard errors are in parentheses.

Results in Table 5 reveal several unanimous conclusions. Firstly, the sign and significance level of regression coefficients corresponding to variables in the gravity model *(lnGDPPCV, lnGDPPC, lnPOP, lnOPEN,lnDIST)*do not change compared to the estimation results of Model (1). It indicates that the impact of the above factors on Vietnam's goods export value is preserved in the models containing interaction variables between logistics efficiency and the amount of emissions released from the transportation sector. Secondly, considering the influence of green logistics efficiency, in most of the models, logistics efficiency variables (*lnCUST, lnINFR, lnLOGS)* and interaction variables between them and CO2 emissions have a positive influence with statistical significance at 5% and 10% on Vietnam's export value. This means that increasing the logistics efficiency of supply chain inputs (customs, infrastructure, and services) towards green transportation (reducing CO2) not only reduces the negative impact of emissions but also increases the positive effect of logistics efficiency on Vietnam's goods export value to RCEP countries. Hence, we can confirm that logistics performance plays a role as a moderation variable that reduces the negative impact of CO2 emissions generated from Vietnam's transportation industry on Vietnam’s goods export value to countries participating in RCEP. It means that hypothesis H3 is supported. This finding is really meaningful for Vietnam’s managers and policymakers in making decisions related to developing green logistics by concentrating on resources for greening supply inputs, including infrastructure, customs clearance, and logistics services.

In summary, the results of estimating Models (1) and (2) and the above analysis show that the overall logistics performance index and efficiency indicators of Vietnam's supply chain inputs (customs, infrastructure, and transportation services) not only directly affect Vietnam's export value but also play a role in moderating the negative relationship between emissions and goods export value from Vietnam to partners in RCEP. Meanwhile, three logistics efficiency indicators measuring supply chain outputs (cost, reliability, and time) only have a direct and positive impact on the export value of Vietnam without a moderate relationship between the amount of emission and Vietnam's export value.

5. Conclusions and Implications

In this research, the gravity model in international trade was used to build empirical research models. Besides, to test the hypotheses proposed in the research model, the generalized least squares (GLS) method was worked out to estimate panel data models with random effects. In particular, the study investigated the impact of green logistics on Vietnam’s goods export value to countries participating in RCEP in the period 2010-2018 and found several empirical research results as follows:

- Factors such as the GDP per capita of Vietnam and partner countries, trade openness, and population of partner countries positively influenced the goods export value, aligning with the gravity model theory.
- The distance between Vietnam and partner countries participating in RCEP is a barrier that negatively affects the export value of Vietnam. This is also suitable for expectations and the theory of the gravity model in international trade.
- Overall logistics performance and the three components measuring supply chain output efficiency in cost, reliability, and time all have a direct and positive influence on export value. This result is in line with expectations and many previous studies.

Meanwhile, three components representing Vietnam's supply chain input efficiency, such as customs, infrastructure, and transportation services, do not have a direct impact on the export value of Vietnam. However, if we consider the interaction between these variables and emission variables, both increasing the efficiency of supply chain inputs in the direction of greening and reducing emissions released from the transportation sector lead to an improvement in export value, including both direct and regulatory effects. In particular, unlike previous studies, in this study, we have found empirical evidence that logistics efficiency can moderate the impact of emissions on Vietnam's exports to partners participating in RCEP.

- Vietnam's transportation sector produces a lot of CO2 per person, which lowers the value of its exports of goods. Specifically, if the efficiency of green logistics in the direction of reducing emissions released from the transportation of goods is promoted, it will have a positive impact both directly and indirectly (through the impact of emissions) on Vietnam’s goods export value.

Consequently, the research results show that improving Vietnam's logistics efficiency and green logistics efficiency will contribute to promoting sustainable exports from Vietnam to RCEP partners in particular and countries around the world in general. To enhance the positive influence of green logistics on Vietnam's goods export value to countries in the RCEP, the study proposes the following recommendations:

Improve green logistics performance indicators: The Vietnamese government needs to promote LPI indicators, especially supply chain input indicators (customs procedures, quality of infrastructure, and services), because these are the strongest promoters of goods exports to RCEP countries. Currently, customs clearance procedures in Vietnam are still quite cumbersome and manual; hence, it takes logistics businesses a lot of time and money. Therefore, it is necessary to optimize the customs clearance process, apply electronic customs, and diversify customs clearance to shorten time and save costs for businesses. At the same time, it is also essential to invest in upgrading logistics and transport infrastructure to reduce CO2 emissions from the transportation industry. Consequently, the cost of the logistics industry will decrease significantly, contributing to the promotion of export activities in general and exporting goods to RCEP countries in particular.

Establish a dialogue mechanism with RCEP countries: Vietnam needs to establish a dialogue mechanism with RCEP countries to maximize the flexibility of this organization, rationalize logistics flows among RCEP participating countries, harmonize green logistics standards, and improve the responsiveness of green logistics services in the region. This mechanism can help logistics providers reduce complexity, save time and costs, and improve the efficiency of green logistics throughout the region, thereby further boosting Vietnam's exports to the RCEP region.

The conclusions drawn from this study are similar to the findings of Fan, et al. [28] in their research on the impact of green logistics on China's exports to RCEP participating countries and Tang and Abosedra [11] in their study on the influence of logistic efficiency on ASEAN countries' exports. Differing from these previous studies, our research model introduces additional variables of per capita emissions from Vietnam's transportation sector and the interaction between logistics efficiency indices and emissions. This investigation aims to assess the impact of green logistics on Vietnam's exports to RCEP partners.

Contributions to Literature:

(i) Per capita emissions from Vietnam's transportation sector represent emissions from logistics activities that have a negative impact on Vietnam's exports to participating partners RCEP.

(ii) Overall logistics performance and the three components constituting output performance in the supply chain have a positive and direct influence on Vietnam's exports to RCEP partners.

(iii) Unlike previous studies, in this study, we use green logistics in the sense of logistics performance along with low emissions from the transport industry. The study shows empirical evidence that logistics performance plays a role in moderating the impact of emissions on exports.

6. Limitations and Future Research

This study has a number of limitations, such as:

(i) The research timeframe covers 2010-2018, and due to the disruption caused by the COVID-19 pandemic, data on the World Bank's Logistics Performance Index is not updated.

(ii) The study does not construct a comprehensive green logistics measurement index.

This limitation opens the way for further research on related green logistics topics, such as (i) expanding the spatial and temporal scope with updated dataand (ii) further research methods to build a green logistics performance index.

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Appendix

Table A1.
Estimation of POLS, FEM, REM.

Variable	POLS	FEM	REM
lnGDPPCV	2.491	2.488***	1.977***
lnGDPPC	0.609*	1.697***	1.316***
lnOPEN	-0.253	0.885***	0.768***
lnPOP	0.587***	-2.430	0.731**
lnDIST	-0.618	(Omitted)	-1.217
lnOVRL	0.925	0.589	0.874
lnCOPC	-2.413	-1.744**	-1.657**
_Cons	-44.927	-3.226	-38.488***

Note: * p<0.05; ** p<0.01; *** p<0.001.
Breusch and Pagan Lagrangian multiplier test for random effects.
lnExj[id,t] = Xb + u[id] + e[id,t].
Test: Var(u) = 0.
Chibar2(01) = 120.20.
Prob > chibar2 = 0.0000.

Table A2.
Hausman test to choose FEM or REM.

Variable	Coefficients		Difference	Std. err.
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	FEM	REM		
lnGDPPCV	2.488	1.977	0.511	0.436
lnGDPPC	1.697	1.316	0.381	0.182
lnOPEN	0.885	0.768	0.118	0.026
lnPOP	-2.430	0.731	-3.161	1.884
lnOVRL	0.589	0.874	-0.285	.
lnCOPC	-1.744	-1.657	-0.088	.

Note: b = Consistent under H0 and Ha; obtained from xtreg.
B = Inconsistent under Ha, efficient under H0; obtained from xtreg.
Test of H0: Difference in coefficients not systematic.
chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B).
= 6.14.
Prob > chi2 = 0.4079.
(V_b-V_B is not positive definite).