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Effects of logistics performance on Vietnam's exports: a quantitative analysis using the PPML method

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Abstract

This study aims to analyze the effects of logistics performance on Vietnam's exports at both the overall level and in specific aspects. We investigate the linkage between logistics performance and Vietnam's exports based on a panel of bilateral trade from Vietnam to 158 trading partners from 2007 to 2018. Using the Poisson pseudo-maximum likelihood method, the positive and significant effects of Vietnam's and importing countries' logistics performance on exports are identified. Our estimates become highly consistent after controlling for both time-specific effects and time-invariant country-fixed effects and remain robust to changes in the model specification, contributing reliable empirical evidence to the literature. Considering the specific aspects of logistics performance, we find the significant roles of the ability to track and trace consignments, the quality of logistics services, the customs clearance efficiency, and the timeliness of shipments in trade. From Vietnam's perspective, improvements in tracking and tracing ability and timeliness can enhance exports to other countries, with larger effects than those of trading partners. Based on these findings, this study provides evidence for policymakers to effectively enhance trade with other countries by developing the national logistics system alongside further logistics cooperation with trading partners and with a greater focus on tracking and tracing ability and timeliness.

Keywords: Logistics performance, Vietnam's exports, Gravity model, Poisson pseudo-maximum likelihood

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1. Introduction

Export is one of the crucial drivers of economic growth in Vietnam (Anwar and Nguyen, 2010). As the country's economy becomes increasingly open to the world market, exports play a significant role. From 26.5% in 1995, the value added (both direct and indirect types) in exports has increased to 49.2% of the whole economy's value added in 2020. Among the ASEAN countries, only Singapore has the higher ratio, at about 62.2% (World Bank Vietnam Office, 2023). Considering the importance of exports, the Vietnamese government has put much effort into facilitating international trade with foreign trading partners, such as participation in different free trade agreements (Huynh, 2021).

In recent years, logistics has been widely recognized as one of the effective trade facilitation factors in the international trade literature (Puertas *et al.*, 2014; Song and Lee, 2022; Zaninovic *et al.*, 2021). Logistics is a part of supply chain management (CSCMP, n.d.), and refers to the optimizing management process which involves procurement, goods transportation, inventory, etc. from the point of production to the point of consumption (Christopher, 2016). Due to the revolutionary advances in logistics and supply chain management, such as containerization and the development of logistics information systems, logistics has transformed from a secondary factor to one of the vital pillars of the global economy (Song and Lee, 2022). While the positive effect of logistics performance on Vietnam's exports has been found in some empirical studies (Huynh, 2021; Le, 2021; Le, 2022; Le, 2023; Tran *et al.*, 2023), most of them only considered the overall logistics performance and covered limited trading partners of Vietnam. In addition, there are concerns about estimation shortcomings. Therefore, the main objective of this study is to capture the effects of logistics performance on Vietnam's exports at both the overall level and specific logistics aspects, considering all of Vietnam's trading partners.

Using the Poisson pseudo-maximum likelihood estimator with a two-way error component model, our study can provide reliable estimates of the relationship between logistics and Vietnam's exports. Based on an unbalanced panel covering bilateral trade between Vietnam and 158 trading partners in 2007, 2010, 2012, 2014, 2016, and 2018, we find the statistically significant and positive effects of Vietnam's and importing countries' logistics on trade. As the latter's effect is more significant, the results imply the importance of logistics cooperation in the country of destination, while development in Vietnam's logistics system can enhance exports. Considering the logistics components' effects, our study suggests further improvement efforts should focus on tracking and tracing ability, and timeliness.

The rest of this study is organized as follows. Section 2 provides an overview of the empirical studies on the relationship between logistics performance and Vietnam's exports. Section 3 explains the methodological framework, data, and analysis strategy. Section 4 discusses the empirical results. Section 5 presents the conclusion and implications.

2. Literature review

Inspired by Newton's law of universal gravitation, the gravity model of trade is the most used approach to explain international trade flows (Allen *et al.*, 2020). In the simplest form,

it predicts that the bilateral trade between two countries, like the gravitational force between two objects, is proportional to the economic sizes and diminishes with the distance (Krugman *et al.*, 2018). Although the initial applications were in the mid of the 20th century, such as Tinbergen (1962), only after the seminal work of Anderson (1979) and Anderson and van Wincoop (2003) wherein the general equilibrium effects of trade costs were introduced and formulated, the gravity model of trade has evolved and become the workhorse in international trade. With concrete theoretical foundations and high flexibility, the gravity framework is appropriate to analyze the relationships between bilateral trade and various factors, including investment, labor, the environment, etc.

In the international economics literature, logistics is one of the most important factors facilitating trade flows and enhancing national competitiveness (Zaninovic *et al.*, 2021). Logistics can directly affect trade flows by improving the efficiency of goods' movement and reducing transport costs. The other logistics factors, such as infrastructure quality, customs procedure, transport and storage security, and other value-added services, can indirectly influence the trade flows. Hence, some studies have investigated this linkage and found the positive effects of logistics on trade. Wilson *et al.* (2003) reported that enhancements in port efficiency and liberalization of border regulation significantly and positively affected trade among the Asia Pacific Economic Cooperation members. Hummels (2007) argued that the declines in rapid transportation exerted by technological advancements essentially enabled the fast-growing world trade from 1950 to 2004. As logistics is multifaceted per se, analyzing the relationship between logistics and trade should focus on the overall effect and the specific effects exerted by the particular logistics components. Marti *et al.* (2014) found that both the overall logistics performance and the six logistics components significantly affected trade flows among 140 countries in 2005 and 2010. However, the corresponding magnitudes and significances varied across the geographical group of countries. Their results also suggested that the effects of logistics of the exporters were larger than those of the importers. Zaninovic *et al.* (2021) concluded that differences in logistics performance affected trade of the EU15 and the Central and Eastern European EU members with the rest of the world in the period 2010-2018. Similarly, Song and Lee (2022) found the different effects of logistics performance on South Korean international trade from 2010 to 2018. Particularly, customs efficiency had no significant impact on Korean trade, while transport-related infrastructure quality only significantly affected the machinery and transport equipment trade. The statistically significant effects of timeliness were limited to the miscellaneous manufactured articles exports and the imports of chemicals and related products, minerals, fuels, and related materials.

There are some empirical studies on the effect of logistics performance on Vietnam's exports, however, this relationship is still not fully developed (Le, 2021). Most of the studies on this topic are based on the trade gravity model and only cover selected sets of Vietnam's trading partners. Huynh (2021) examined the importance of logistics to aggregate revenues of Vietnam's exports, using panel data from 48 major importing countries in the period between 2010 and 2018. The author employed pooled ordinary least squares and random effects

estimators and found that the overall logistics performances of Vietnam and the destination country positively and significantly affected trade flows. Because time-specific effects were not controlled in the study, the findings might be biased by common shocks in certain years during the sampling period.

Le (2021) and Le (2022) studied the effects of logistics performance in tandem with some other factors on Vietnam's aquaculture and agriculture products exports at sector and sub-sectoral levels. Various estimation techniques were used to address different issues in the trade gravity model separately, such as zero trade and reverse causality, wherein bilateral trade can also affect logistics performance; however, the findings were inconsistent and depended on the choice of estimators. When the system generalized method of moments technique was used, both Vietnam's and the importing country's logistics performances significantly affected the bilateral trade. Using other methods, at most, only the effect of the logistics performance of the destination was found to be significant. While the system generalized method of moments technique can be considered an effective countermeasure to reverse causality, it is not perfect (Leszczensky and Wolbring, 2022) and particularly, is prone to zero trade issues.

Tran *et al.* (2023) applied the trade gravity model to analyze the effects of green logistics on Vietnam's exports to Regional Comprehensive Economic Partnership (RCEP) countries. The study only covered bilateral trade from Vietnam to 13 member countries in the period between 2012 and 2018. Based on the random effect estimator, the authors found a positive effect of green logistics on Vietnam's exports without control of time-specific effects. Additionally, the importing country's economic size, which is included in the theoretical trade gravity model and consistently found to be significant in empirical studies, was omitted from their model specifications, hence seriously challenging the unbiasedness of the findings.

Regarding the research gaps in the extant literature, this study aims to capture the effects of logistics on Vietnam's exports, considering both the overall performance level and the specific performance criteria. Details of the model specifications, data, and methodology are presented in the next section.

3. Research model and data

3.1 Model specifications

In this study, we apply a gravity model to investigate the linkage between logistics performance and Vietnam's exports. Following Abreo *et al.* (2021), Anderson and van Wincoop (2003), the research model is defined with augmented specifications as the following equation:

$$EX_{ij,t} = exp(\beta_0 + \beta_1 lnLP_{i,t} + \beta_2 lnLP_{j,t} + \beta_3 lnDIST_{ij} + \beta_4 lnGDP_{i,t} + \beta_5 lnGDP_{j,t} + \beta_6 CBOR_{ij} + \beta_7 RTA_{ij,t}) * \varepsilon_{ij,t} . \quad (1)$$

Subscripts *i, j*, and *t* indicate country of origin (only Vietnam), country of destination, and year, respectively. The annual value of Vietnam's gross exports to country *j* in year *t*, the dependent variable, is denoted by $EX_{ij,t}$. Our key independent variables are $LP_{i,t}$ and $LP_{j,t}$ that denote Vietnam's logistics performance and the importing country *j's* logistics performance in

year *t*. In addition to the main regressors, we specify other control variables to elicit unbiased effects on the regressand (Soh *et al.*, 2021). The included controls are the geographical distance between the two trading countries, the GDPs of the country of origin and the country of destination, the common border, and the regional trade agreement. Denoted by $GDP_{i,t}$, $GDP_{j,t}$, and $DIST_{ij}$ respectively, GDPs of exporting and importing countries, and the distance between the two are standard variables in the gravity model of trade. $GDP_{i,t}$ and $GDP_{j,t}$ represent the economic size of bilateral trading partners, while $DIST_{ij}$ reflects associated transport costs. $CBOR_{ij}$ is a dummy variable of common border, taking the value of 1 if countries i and j share a common land border, and 0 otherwise. Because the only exporter in this study is Vietnam, the only three countries with shared borders are China, Laos, and Cambodia. Following the previous empirical studies of Vietnam's exports (Huynh, 2021; Le, 2021; Le, 2022; Le, 2023; Le and Nguyen, 2022), we specify a dummy variable of regional trade agreement, denoted by $RTA_{ij,t}$. It equals 1 if both trading countries *i* and *j* are members of a regional trade agreement in year *t*, and 0 otherwise. As Vietnam does not share a common language with any trading partners, the respective dummy is excluded from the current study.

Taking natural logarithm of equation (1), we have the following linear equation:

$$lnEX_{ij,t} = \beta_0 + \beta_1 lnLP_{i,t} + \beta_2 lnLP_{j,t} + \beta_3 lnDIST_{ij} + \beta_4 lnGDP_{i,t} + \beta_5 lnGDP_{j,t} + \beta_6 CBOR_{ij} + \beta_7 RTA_{ij,t} + \varepsilon_{ij,t}. \quad (2)$$

ln indicates to the natural logarithm, while β_0 is the intercept of equation (2). The other βs refer to the coefficients of the specified variables on the right-hand side of the equation. β_1 and β_2 are our main interests in this study, representing the elasticity of the log-log relationship between logistics performance and Vietnam's exports.

Lastly, $\varepsilon_{ij,t}$ is the error term and is assumed to be normally distributed with a zero-mean, homoscedastic, uncorrelated with the specified explanatory variables and without serial correlation (Wooldridge, 2020). However, in the international trade literature, common unobserved time-specific shocks, multilateral resistance terms, and endogeneity are likely to present and potentially bias the estimates. To counter the endogenous issue, Egger and Nigai (2015) suggested controlling for country-pair fixed effects. Abeliansky *et al.* (2021) included importer-year fixed effects to control for multilateral resistance terms. In this study, as there is only one exporter, Vietnam, we decompose the error term into exporter-importer fixed effects (or equivalent to the importer-fixed effects in the current model specification) and year-specific effects. Therefore, we change equation (2) as follows:

$$lnEX_{ij,t} = \beta_0 + \beta_1 lnLP_{i,t} + \beta_2 lnLP_{j,t} + \beta_3 lnDIST_{ij} + \beta_4 lnGDP_{i,t} + \beta_5 lnGDP_{j,t} + \beta_6 CBOR_{ij} + \beta_7 RTA_{ij,t} + \mu_{ij} + \lambda_t + \upsilon_{ij,t} \quad (3)$$

where μ_{ij} refers to exporter-importer fixed effects, λ_t is time-specific effects. After disentangling the above-mentioned effects from $\varepsilon_{ij,t}$, the remainder is stochastic disturbance term (Baltagi, 2021).

3.2 Analysis strategy

Initially, we estimate equation (2) using pooled ordinary least squares (POLS) and Poisson pseudo-maximum likelihood (PPML). POLS can provide the most efficient and unbiased estimates if all the assumptions hold. The alternative approach, PPML (Santos Silva and Tenreyro, 2011; Silva and Tenreyro, 2006), is widely used in trade gravity models (Abreo *et al.*, 2021) for the following important reasons. First, the results of PPML are consistent (Egger and Nigai, 2015). Second, it is an effective estimator against potential endogeneity and some econometric shortcomings, including multicollinearity, heteroscedasticity, and serial correlation (Alvarez *et al.*, 2018). PPML can address the presence of numerous zeros in bilateral trade data and country-time dummies (Head and Mayer, 2014). Motta (2019) found that PPML estimators with robust standard errors performed better than log-linear OLS, as well as Tobit and two-part models, and experimented on the health expenditure dataset. Even when observations of dependent variables are greater than zero, OLS estimators are still inconsistent and inferior to PPML.

Moreover, we use PPML to estimate equation (3) partially with the inclusion of year dummies and importer's region-fixed effects. We fully estimate the equation, specifying both year-specific effects and exporter-importer fixed effects. Our approach is to observe changes in results when we gradually apply all the countermeasures to the sources of endogeneity.

We change the model specification by adding other explanatory variables suggested by the related empirical studies to further investigate the estimates' robustness. Three additional variables included in equation (3) are the economic size similarity index, the importing country's membership of the World Trade Organization (WTO), and institutional quality. Finally, we look for the differential effects exerted by different aspects of logistics on Vietnam's exports.

3.3 Data

This study employs data on Vietnam's exports to 158 trading partners from 2007 to 2018. We collect data from well-recognized sources, including the World Bank (WB), World Trade Organization (WTO), and Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). The sampling panel is unbalanced because bilateral trade data from CEPII BACI (Conte *et al.*, 2022) contain missing values, and we use the WB's Logistics Performance Index (LPI) and its subindices as proxies for logistics performance. Particularly, data on LPI is only available in 2007 and biennial from 2010 to 2018. In this study, our approach is to gather all available trade data in contrast with the previous studies (Huynh, 2021; Le, 2021; Le, 2022; Le, 2023; Le and Nguyen, 2022; Tran *et al.*, 2023) that only covered smaller collections of trading countries with Vietnam. Regarding control variables, we obtain GDP data from the WB's World Development Indicators (WDI), geographical distance from CEPII, and regional trade agreements from WTO. Tables 1 and 2 exhibit data description and correlation matrix, respectively.

Table 1. Descriptive statistics of the data

	Obs.	Mean	Std. Dev	Min	Max	Data sources
$lnEX_{ij,t}$	1084	10.542	2.829	-1.795	17.685	CEPII
$lnLP_{i,t}$	1303	1.111	0.042	1.061	1.184	WB
$lnLP_{j,t}$	925	1.026	0.202	0.190	1.441	WB
$lnDIST_{ij}$	1303	8.984	0.646	6.173	9.856	CEPII
$lnGDP_{i,t}$	1303	26.076	0.223	25.731	26.404	WB
$lnGDP_{j,t}$	1203	24.016	2.386	17.141	30.600	WB
$CBOR_{ij}$	1303	0.013	0.116	0	1	CEPII
$RTA_{ij,t}$	1303	0.071	0.257	0	1	WTO

Source: Authors' calculation

There are no zero trade values in this study since we use the annual total export values in contrast with sectoral and sub-sectoral data, as presented in Table 1. We also observe that the minimum value of the exporter's logistics performance is higher than that of the importers, while the maximum value of the exporter's logistics performance is lower than the level of the importers', indicating that Vietnam exported to countries either higher or lower than its logistics performance. Except for geographical distance, the rest of the explanatory variables are positively correlated with the dependent variables in Table 2. The pair correlation of the importer's logistics performance is higher than that of the exporter's logistics performance.

Table 2. Correlation matrix

	$lnEX_{ij,t}$	$lnLP_{i,t}$	$lnLP_{j,t}$	$lnDIST_{ij}$	$lnGDP_{i,t}$	$lnGDP_{j,t}$	$CBOR_{ij}$	$RTA_{ij,t}$
$lnEX_{ij,t}$	1.000							
$lnLP_{i,t}$	0.155	1.000						
$lnLP_{j,t}$	0.672	0.078	1.000					
$lnDIST_{ij}$	-0.274	-0.003	-0.070	1.000				
$lnGDP_{i,t}$	0.193	0.790	0.090	0.002	1.000			
$lnGDP_{j,t}$	0.839	0.040	0.710	-0.112	0.046	1.000		
$CBOR_{ij}$	0.201	0.000	-0.013	-0.434	-0.001	0.047	1.000	
$RTA_{ij,t}$	0.422	0.069	0.181	-0.588	0.074	0.263	0.430	1.000

Source: Authors' calculation

To investigate the effects of each specific aspect of logistics performance on Vietnam's exports, we employ six LPI-subindices to replace the LPI overall score in equation (3), including tracking and tracing (denoted by *trac*), logistics service quality (denoted by *logs*), international shipments (denoted by *ints*), efficiency of customs clearance (denoted by *cust*), timeliness (denoted by *time*), and transport infrastructure (denoted by *infr*). Table 3 shows the descriptive statistics of these subindices. We find that the exporter's LPI-subindices also have smaller maximum values than the importers', while the mean and minimum values are higher.

Table 3. LPI-subindices description

	Mean	Std. Dev	Min	Max
Tracking and tracing				
$trac_{i,t}$	3.11	0.20	2.84	3.45
$trac_{j,t}$	2.86	0.64	1.00	4.38
Logistics services				
$logs_{i,t}$	2.96	0.23	2.68	3.40
$logs_{j,t}$	2.79	0.62	1.25	4.32
International shipments				
$ints_{i,t}$	3.11	0.07	3.00	3.22
$ints_{j,t}$	2.82	0.53	1.22	4.24
Customs clearance				
$cust_{i,t}$	2.79	0.11	2.65	2.95
$cust_{j,t}$	2.65	0.61	1.11	4.21
Timeliness				
$time_{i,t}$	3.49	0.15	3.22	3.67
$time_{j,t}$	3.26	0.60	1.38	4.80
Infrastructure				
$infr_{i,t}$	2.76	0.23	2.50	3.11
$infr_{j,t}$	2.70	0.70	1.10	4.44

Source: Authors' calculation based on the WB Logistics Performance Reports

4. Empirical analysis

4.1 Baseline regressions

We analyze equations (2) and (3), using POLS and PPML estimators. The results are presented in Table 4. Columns (1) and (2) of the table show estimates of coefficients of equation (2) without controls of time-specific and time-invariant effects. The results estimated by POLS in column (1) and by PPML in column (2) indicate a significantly positive effect of the importing country's logistics performance on trade. The maximum variance inflation factor (VIF) in the POLS estimation is 2.67, below the common threshold of 10, indicating that multicollinearity is not a problem in our model (Wooldridge, 2020). Common border is found to influence significantly Vietnam's exports but with a negative coefficient. This estimate is likely biased and encourages necessary controls for unobserved common shocks in specific years and time-invariant effects. Therefore, we add year dummies and estimate again, using the PPML method. While time-invariant effects are partially controlled in column (3) by importer's region dummies, we specify country-specific effects and fully include two-way error components in column (4).

Table 4. Baseline regressions

VARIABLES	POLS	PPML	PPML	PPML
	(1)	(2)	(3)	(4)
$lnLP_{i,t}$	-0.258	1.074	1.166	1.018*
	(1.496)	(1.676)	(1.021)	(0.544)
$lnLP_{j,t}$	1.846***	2.157***	2.147***	1.339**
	(0.280)	(0.283)	(0.309)	(0.547)
$lnDIST_{ij}$	-0.287***	-0.618***	-0.684***	
	(0.0774)	(0.0402)	(0.0810)	
$lnGDP_{i,t}$	1.556***	1.559***	1.321***	1.300***
	(0.283)	(0.323)	(0.315)	(0.175)
$lnGDP_{j,t}$	0.827***	0.835***	0.703***	0.871***
	(0.0312)	(0.0508)	(0.0455)	(0.265)
$CBOR_{ij}$	1.410***	-0.558***	-0.385**	
	(0.416)	(0.172)	(0.169)	
$RTA_{ij,t}$	0.992***	0.165*	0.261**	-0.0346
	(0.130)	(0.0962)	(0.121)	(0.197)
Time-specific effects			Yes	Yes
Time-invariant effects			Region	Country
Max VIF	2.67			
Observations	861	861	861	857
R-squared	0.788			
Pseudo R-squared		0.916	0.938	0.987

Notes: Dependent variable: $lnEX_{ij,t}$. Robust standard errors are in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Authors' calculation

After including year dummies and importing country dummies, we do not obtain any abnormal signs of significant explanatory variables, and we find that the logistics performances of both exporting and importing countries have significantly positive effects on bilateral trade at 10% and 1%, respectively. The magnitude of the effect of Vietnam's logistics performance on its exports is smaller than that of the importing country. Compared with columns (1) - (3), the two time-invariant variables, geographical distance, and common border are canceled out, while region trade agreements become insignificant. This is analogous to Le (2021), in which the effects of specific RTAs were inconsistent and varied with the choice of estimators, and only a few of Vietnam's RTAs were found significant. By contrast, the GDPs of exporting and importing countries have consistently significant impacts on trade across the table. The

coefficient of determination improves after we change the estimator from POLS to PPML and add further controls for error components.

4.2 Robustness check

We re-estimate with the inclusion of additional variables to investigate whether our previous findings are sensitive to model specifications. Three added variables are the importing country's WTO membership, institutional quality, and the similarity between the two trading countries. The calculation of the similarity index is provided in the following equation and previously applied by Kahouli (2016):

$$SIML_{ij,t}=1-\left(\frac{GDP_{i,t}}{GDP_{i,t}+GDP_{j,t}}\right)^2-\left(\frac{GDP_{j,t}}{GDP_{i,t}+GDP_{j,t}}\right)^2. \quad (4)$$

Table 5. Robustness check

VARIABLES	POLS	PPML	PPML	PPML
	(1)	(2)	(3)	(4)
$lnLP_{i,t}$	1.020*	1.019*	1.032*	1.022*
	(0.543)	(0.539)	(0.539)	(0.535)
$lnLP_{j,t}$	1.349**	1.344**	1.494***	1.507***
	(0.548)	(0.549)	(0.572)	(0.576)
$lnGDP_{i,t}$	1.300***	1.355***	1.283***	1.368***
	(0.175)	(0.191)	(0.182)	(0.214)
$lnGDP_{j,t}$	0.870***	0.819***	0.773***	0.678**
	(0.264)	(0.281)	(0.268)	(0.307)
$RTA_{ij,t}$	-0.0314	-0.0301	-0.0395	-0.0338
	(0.199)	(0.194)	(0.201)	(0.201)
$WTO_{j,t}$	-0.0861			-0.0863
	(0.100)			(0.106)
$SIML_{ij,t}$		-0.658		-0.965
		(1.259)		(1.416)
$INST_{j,t}$			0.00776	0.00912
			(0.0107)	(0.0111)
Observations	857	857	825	825
Pseudo R-squared	0.987	0.987	0.987	0.987

Notes: Dependent variable: $lnEX_{ij,t}$. Both time-specific effects and time-invariant effects are controlled. Robust standard errors are in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Authors' calculation

The other two variables added for robustness evaluation, the importer's WTO membership and institutional quality, are denoted by $WTO_{j,t}$ and $INST_{j,t}$. The former is also collected from WTO, and the latter is extracted from the Heritage Foundation's economic freedom index. Table 5 shows the results of robustness investigations.

We include each of the additional variables to the models in columns (1) - (3) of Table 5, while column (4) presents the results when all of them are specified. Because we continue to control for country-specific time-invariant effects, geographic distance and common border variables that do not vary across time dimensions, are omitted and excluded from the table. Our estimates are highly consistent; both exporting and importing countries' logistics performances remain positive and have significant effects on bilateral trade at the 10% and 1% levels. We also observe limited deviations of the coefficient magnitudes from the estimates in column (4) of Table 4. The coefficient of determination stays the same across the table and equals that of the previous estimation when both time-specific effects and time-invariant country-specific effects are controlled. While regardless of model specifications and choice of estimators, GDPs of the trading countries significantly and positively affect bilateral trade hitherto, the newly added variables are insignificant in all scenarios. Therefore, the estimates are not sensitive to the model specifications, and our findings of significant and positive effects of logistics performance on Vietnam's exports are confirmed consistently.

4.3 Effects of LPI-subindices

We replace the overall LPI in equation (3) and use the subindices instead to analyze different effects exerted by each specific aspect of logistics performance on bilateral trade. The six LPI-subindices are tracking and tracing ability, logistics competence, international shipment, customs clearance, timeliness, and trade and transport-related infrastructure quality. The estimated results using each of the subindices are exhibited in columns (1) - (6) of Table 6. We continue to use PPML estimators with two-way error components and robust standard errors in these estimations.

Table 6. Effects of LPI-subindices

VARIABLES	POLS	PPML	PPML	PPML	PPML	PPML
	(1)	(2)	(3)	(4)	(5)	(6)
$lntrac_{i,t}$	0.506*					
	(0.267)					
$lntrac_{j,t}$	1.345***					
	(0.388)					
$lnlogs_{i,t}$		0.541				
		(0.350)				
$lnlogs_{j,t}$		0.708*				
		(0.391)				

Table 6. Effects of LPI-subindices (*continued*)

VARIABLES	POLS	PPML	PPML	PPML	PPML	PPML
	(1)	(2)	(3)	(4)	(5)	(6)
$lnints_{i,t}$			3.173			
			(1.960)			
$lnints_{j,t}$			0.327			
			(0.382)			
$lncust_{i,t}$				1.400		
				(0.948)		
$lncust_{j,t}$				0.754**		
				(0.348)		
$lntime_{i,t}$					3.032*	
					(1.815)	
$lntime_{j,t}$					0.906**	
					(0.428)	
$lninfr_{i,t}$						0.447
						(0.327)
$lninfr_{j,t}$						0.500
						(0.380)
$lnGDP_{i,t}$	1.272***	1.223***	1.618***	1.163***	0.868**	1.507***
	(0.172)	(0.197)	(0.209)	(0.227)	(0.364)	(0.181)
$lnGDP_{j,t}$	0.851***	0.920***	0.917***	0.938***	0.935***	0.896***
	(0.259)	(0.264)	(0.276)	(0.261)	(0.263)	(0.266)
$RTA_{ij,t}$	-0.0135	-0.0194	-0.0300	-0.0512	-0.0372	-0.0488
	(0.193)	(0.205)	(0.202)	(0.201)	(0.198)	(0.203)
Observations	857	857	857	857	857	857
Pseudo R^2	0.987	0.986	0.986	0.987	0.987	0.986

Notes: Dependent variable: $lnEX_{ij,t}$. Both time-specific effects and time-invariant effects are controlled. Robust standard errors are in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Authors' calculation

Diverse results of LPI-subindices are found in comparison with the overall LPI score. Not all subindices have significant effects on trade. Particularly, either exporting or importing countries' international shipment and infrastructure are found insignificant. Regarding logistics competence and customs clearance, only impacts from the side of the importing country are statistically significant and positively influence bilateral trade. We consider the prolonged export-oriented policy of Vietnam and the popular choice of delivery terms that favors the

importer's decision in the practice of Vietnam's exports are the reasons for the results. While both tracking and tracing ability and timeliness are found bilaterally important to trading countries, their comparative magnitudes are different. The coefficient of tracking and tracing of the importing country is higher than that of the exporting country. By contrast, Vietnam's timeliness has a much greater magnitude of effect than that of its importer on exports.

The current research further confirms the significance of both exporting and importing countries' logistics performance on trade, in accordance with the previous empirical studies (Marti *et al.*, 2014; Zaninovic *et al.*, 2021). Given that the only exporter is Vietnam, we find similar results with Huynh (2021). Specifically, both Vietnam's and importing partners' logistics significantly affect bilateral trade, while the effects of the import side are larger. This indicates that there is still room for export enhancements by persistently improving Vietnam's logistics system. However, additional cooperation and integration to strengthen the logistics stages in the destination country is equally important and may realize considerable gains. The finding contrasts with Marti *et al.* (2014) in which the authors' results showed the larger effects of exporting countries' logistics. The difference may be explained by the fact that Vietnam's logistics performance is above the world average level. According to the WB's LPI ranking 2018, Vietnam ranked 39th out of 160 countries.

Targeting the specific effects of logistics components, from Vietnam's perspective, we find only tracking and tracing ability and timeliness significantly affect the exports. Our results mostly contradict Tran *et al.* (2023) in which the significant impacts of international shipments, logistics services, customs efficiency, and timeliness were found. As the authors considered only bilateral trade between Vietnam and other RCEP countries, the differences in the estimates are expected. The insignificances of logistics service competence, customs efficiency, international shipments, and transport-related infrastructure quality indicate those factors do not statistically constrain Vietnam's exports. In addition, the significant effects of tracking and tracing ability and timeliness on both trading sides may highlight the importance of reliability and integration from the importers' perspective. Particularly, foreign buyers need to update the shipping progress and expect to receive their shipments timely to synchronize their operations and business plans. On the import side, the significance of customs efficiency implies that the clearance procedure in the country of destination is still a barrier to Vietnam's exports. Logistics service competence also matters more in the importing countries.

5. Conclusion

In the current study, we aim to investigate the linkage between logistics performance and Vietnam's exports. Using PPML estimators with two-way error components, we find a significant and positive effect of overall logistics performance on Vietnam's exports in the 2007-2018 period. Explicitly, both Vietnam and its importing countries' logistics performance positively influence bilateral trade flows with a notion that the destination side has a higher magnitude. The finding remains consistent when the model specifications are modified, thus implying that if the trading countries' logistics performances are improved further, a larger bilateral trade volume is expected. It shows that the recent effort of the Vietnamese government

to enhance the national logistics system is the proper development policy and is expected to promote its exports, hence contributing more to economic growth.

When analyzing the subindices of logistics performance, we only find significant effects of tracking and tracing ability, logistics competence, customs clearance efficiency, and timeliness. From Vietnam's perspective, tracking and tracing ability and timeliness can significantly affect exports. Therefore, concentration on improvement in these two specific aspects is more efficient than sparse investment in all aspects of logistics performance, especially timeliness. Application of advanced information and telecommunication technologies may effectively improve abilities to track and trace shipments, and to manage shipments to reach consignees on time, hence, it is a viable measure to promote Vietnam's exports through logistics performance.

Our study contributes reliable empirical evidence of the relationship between logistics and Vietnam's exports, affirming that logistics development in either Vietnam or the importing countries can enhance trade flows, given the significant effect on the import side. It also provides new insights into the specific effects of logistics components and emphasizes the importance of tracking and tracing ability, and timeliness while suggesting that trading partners' customs efficiency and logistics service competence still constrain Vietnam's exports. Therefore, the Vietnamese government should not only focus on developing the national logistics system but also put more effort into cooperation with trading partners, with an emphasis on tracking and tracing ability and timeliness.

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