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Impact of logistics performance and trade facilitation on China-ASEAN trade flows

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ABSTRACT

The Association of Southeast Asian Nations (ASEAN) has grown to be China's biggest trading partner since 2019. Trade flows between China and ASEAN are becoming increasingly significant in fostering economic expansion in both China and ASEAN nations. This research aims to analyze the impact of logistics performance and trade facilitation improvements on bilateral trade flows between China and ASEAN countries. We use a panel data set of six ASEAN countries from 2009 to 2019. We use feasible generalized least squares estimation to do the data regression based on the heteroskedasticity and Wooldridge autocorrelation test results to make sure the results are correct. The empirical results indicate that the logistics performance improvement of ASEAN countries significantly promotes China-ASEAN bilateral trade flows. Trade facilitation measures implemented in ASEAN countries also play a crucial role in boosting the bilateral trade flows between China and ASEAN. Trade facilitation shows a higher impact on China's exports to ASEAN than on China's imports from ASEAN. The findings of this research imply that policymakers in ASEAN countries still need to prioritize improving their logistics performance and trade facilitation to enhance their bilateral trade flows. This research also provides valuable insights for other developing countries to promote their trade flows by improving their logistics performance and trade facilitation.

Contribution/ Originality: This research stands out by specifically examining the influence of logistics performance and trade facilitation on trade flows between China and ASEAN. It employs FGLS estimation to tackle heteroskedasticity and autocorrelation issues.

1. INTRODUCTION

Many factors affect trade flows. Some researchers show growing interest in the effects of logistics performance and trade facilitation measures on promoting international trade flows. Having a logistics system that works efficiently can boost trade and make a company more competitive in global marketplaces (Hausman, Lee, & Subramanian, 2013). Reliability, efficiency, and responsiveness in logistics promote smooth supply chain management and trade transactions (Gani, 2017). According to Çelebi (2019), effective logistics practices facilitate trade facilitation, timely delivery, and seamless cargo transportation, all of which increase trade activity and economic growth. To assess logistical performance metrics that can determine supply chain efficiency, trade competitiveness, and the overall impact on trade dynamics in global marketplaces, the World Bank provides the Logistics Performance Index (LPI) (Martí, Puertas, & García, 2014). Variations in logistics performance can impact market access, trade integration, and trade patterns (Adelajda Zaninović, Zaninović, & Pavlić Skender, 2021).

The term "trade facilitation" describes policies intended to lower trade costs, streamline and simplify trade processes, and increase the effectiveness of cross-border transactions (Zaki, 2015). Trade flows and trade facilitation have a complex relationship. Changes in a nation's trade flow are influenced by both its trade policy revisions and those of its trading partners. Trade flows can be encouraged by trade facilitation policies and reforms that increase trade competitiveness, reduce trade costs, and enhance trade efficiency (Sakyi & Afesorgbor, 2019). As shown by the fact that good trade procedures are needed to encourage trade growth (Ali & Shakoor, 2020) trade facilitation policies may have an effect on trade flows, market access, and trade dynamics. Good trade procedures can impact the choice of transportation means, the efficiency of logistics, and overall trade flows (Avetisyan & Hertel, 2021). Improving trade infrastructure and streamlining customs procedures can boost trade volumes, promote trade diversity, and enhance overall trade performance (Sá Porto, Canuto, & Morini, 2015). Trade facilitation initiatives support increased trade efficiency, reduced trade barriers, and trade integration with regional and global markets (Yu & Luu, 2020).

This research applies the theory of transaction cost to explain the effects of logistics performance and trade facilitation in promoting trade flows. The idea of transaction cost theory is first proposed by Coase (1937), which aims to explain why firms exist in an exchange economy (Benkler, 2006; Williamson, 1985). Transaction costs play a significant role in shaping the pattern of international trade. Countries with larger domestic markets tend to be net exporters of goods subject to scale economies, as firms prefer to locate production near larger markets to minimize transaction costs (Holzhey, 2003). High transaction costs can act as barriers to trade, affecting the competitiveness of countries. Reducing these costs can enhance trade integration and economic cooperation (De, 2006). The improvement in logistics performance and trade facilitation reduces trade costs and then promotes trade flows.

Several studies (Ali & Shakoor, 2020; Avetisyan & Hertel, 2021; Bugarčić, Skvarciany, & Stanišić, 2020; Çelebi, 2019; Gani, 2017; Song & Lee, 2022; Yu & Luu, 2020) have shown how important logistics performance and trade facilitation are in international trade. Studies on how trade facilitation and logistics performance affect the rapidly expanding trade flows between China and ASEAN are few. China is the biggest developing economy. Trade flows with ASEAN countries significantly influence China's economic growth. Studying the trade flows between China and ASEAN and identifying the key variables influencing these flows is therefore essential. The purpose of this study is to examine the effects of improved trade facilitation and logistics performance on the bilateral trade flows between China and ASEAN nations. Six ASEAN nations—Indonesia, the Philippines, Thailand, Vietnam, Malaysia, and Singapore—are selected in the study sample. The study time is from 2009 to 2019. The findings of this research can help policymakers in ASEAN countries to understand more about their trade flows and prioritize improving their logistics performance and trade facilitation to enhance their bilateral trade flows. This research also provides valuable insights for other developing countries to promote their trade flows by improving their logistics performance and trade facilitation.

2. LITERATURE REVIEW

2.1. Theory of Transaction Cost

The idea of transaction cost theory is firstly proposed by Coase (1937), which aims to explain why firms exist in an exchange economy (Benkler, 2006; Williamson, 1985). According to Coase (1937), there appears to be a cost associated with using the price mechanism, which is the primary reason why it is profitable to establish a firm. The basic idea behind Coase's theory was that market transactions involve a set of costs that can be minimized if they occur within a company (Rindfleisch, 2020). While Coase gave birth to transaction cost theory, Williamson further developed the transaction cost theory in 1970s and 1980s. Williamson (1979) emphasizes the role of opportunism and bounded rationality in economic transactions. In his book "The Economic Institutions of Capitalism", Williamson (1985) introduced key dimensions of transactions such as asset specificity, frequency, and uncertainty. He maintained that, because of the possibility of opportunistic behavior and the limitations of human reason, transactions that involve particular assets, occur frequently, or are fraught with uncertainty, are more expensive.

Transaction cost theory has been widely applied in many fields, such as economics, public policy, international business, operations, management, and marketing. Transaction cost theory is a useful way to look at institutions that make global interdependencies possible through the lens of multinational corporations (MNEs) (Cuypers, Hennart, Silverman, & Ertug, 2021; Hennart, 2010).

The transaction cost hypothesis is used by Hennart (1977) to describe the nature of MNEs' operations and the reasons behind their existence. Transaction cost theory helps explain why companies choose different ways to enter foreign markets, such as equity joint ventures and hybrids, by taking into account both the costs of doing business in the foreign market and the costs of running the business itself. Additionally, it explains why information asymmetry and asset specificity are critical to MNE survival (Hennart, 1989).

Transaction costs significantly shape the pattern of international trade. Because businesses want to put manufacturing close to larger markets to minimize transaction costs, countries with larger domestic markets typically have net exporters of goods susceptible to scale economies (Holzhey, 2003). Transaction costs hinder trade and reduce a nation's ability to compete in the global market. Lowering transaction expenses can improve economic cooperation and trade integration (De, 2006). Geographic distance increases transportation costs and affects the possibility of face-to-face interactions between buyers and sellers, leading to extra transaction costs that may deter long-distance trade (Håkanson & Dow, 2012). Improving trade facilitation and logistics effectiveness can significantly lower international trade costs, which encourages trade flows.

2.2. Logistics Performance and Trade Flows

The improvement of logistics performance can reduce trade costs and raise trade efficiency, which promotes trade growth in turn. There are abundant studies that have examined the impact of logistics performance on trade growth. For instance, Hoekman and Nicita (2011) find that trade intensity and logistical performance are significantly positively correlated. Logistics performance has a positive effect on expanding developing country trade. They suggest that raising a low-income nation's logistics performance index (LPI) to the average for middle-income nations would increase trade flows by about 15%. Korinek and Sourdin (2011) find that better trade logistics are strongly, significantly, and positively linked to more trade between two countries. They also find that better trade logistics have a bigger effect on goods that are shipped by air than on goods that are shipped by sea, and middle-income countries benefit more from improvements in port and air transport infrastructure than low-income countries. The study of Martí et al. (2014) indicates that every aspect of logistics performance is significantly and positively correlated with trade flows in developing countries, and components of the logistics performance index are becoming more and more significant for nations in Eastern Europe, South America, and Africa. Puertas, Martí, and García (2014) reveal that strong logistics performance and increased export competitiveness are positively correlated, and efficient logistics systems can help European exporters compete more successfully in global markets.

Bensassi, Márquez-Ramos, Martínez-Zarzoso, and Suárez-Burguet (2015) show investments in logistics infrastructure can boost export capacities, promote trade growth, and stimulate regional economic development in Spain. Gani (2017) investigates how logistics performance affects global trade and discovers that it has a noteworthy and favorable impact on imports and exports. He emphasizes the role of logistics efficiency, reliability, and responsiveness in promoting smooth trade transactions and supply chain coordination. Çelebi (2019) finds that logistics performance positively and significantly influences trade flows, with components like infrastructure, timeliness, and quality showing the greatest impact; the impact of logistics performance is higher in exports than in imports in low-and-middle income countries. Buvik and Takele (2019) indicate that logistics performance, particularly in customs efficiency, infrastructure, and quality of logistics services, significantly impacts trade flows in African economies. Landlocked African countries face additional challenges, with lower LPI scores correlating with diminished trade performance. Katrakylidis and Madas (2019) conclude that the performance of logistics and global trade both act as catalysts for economic expansion; there is a long-run bidirectional causal relationship between LPI

and trade. Adelajda Zaninović et al. (2021) reveal that logistics performance significantly boosts trade in European Union 15 (EU15) countries with Central and Eastern European countries (CEMS), with EU15 countries showing a stronger correlation due to advanced logistics systems. Barakat, Madkour, and Moussa (2023) find that higher logistics performance, particularly in infrastructure and international shipments, significantly enhances trade flows in EU countries; improving logistics systems strengthens regional trade and economic integration and improves European trade competitiveness.

2.3. Trade Facilitation and Trade Flows

The promotion effect of trade facilitation on trade flows has also been examined and verified by abundant research. Shepherd and Wilson (2009) find that improving port infrastructure for trade facilitation alone could expand intra-regional trade by 7.5% in ASEAN. Based on a gravity model of trade, Felipe and Kumar (2012) indicate that effective trade facilitation is crucial for promoting regional trade cooperation in Central Asian countries. Yadav (2014) shows that trade facilitation reforms can lower transaction costs, increase the efficiency of global value chains, promote the movement of parts and components, and finally improve export and manufacturing competitiveness in international market. Zaki (2015) looks at how trade facilitation affects international trade. He looks at how trade facilitation measures affect trade efficiency, market access, and trade volume. He discovers that making trade processes easier is good for promoting international trade. Sá Porto et al. (2015) demonstrate that trade facilitation significantly enhances trade performance and improves trade diversification by reducing transaction costs and simplifying customs processes. They suggest that trade facilitation measures play a crucial role in improving international trade competitiveness when countries' tariff reductions have met limitations or are stable.

Sakyi and Afesorgbor (2019) show that the higher trade facilitation, the better trade performance in African countries, and reductions in the real cost to export and import across borders to improve trade facilitation promote intra-trade in African countries. They argue it is necessary to improve Africa's trade facilitation to reduce trade costs within African countries because, compared to other regions, Africa's trade facilitation is at a low level. Ali and Shakoor (2020) explore the impact of trade facilitation on trade flows in Asian countries and find that tariff reduction, documentation requirements, trade costs, and time, as well as Information and Communication Technology (ICT) and infrastructure, significantly increase trade flows. Yu and Luu (2020) indicate that trade facilitation improvements, especially in customs efficiency, infrastructure, and trade-related logistics, significantly boost Vietnam's import and export volumes. Kurul (2023) shows that both hard factors and soft factors affect countries' export diversification; border efficiency promotes product and market diversity broadly, while ICT infrastructure is particularly significant for least developed countries. Reddy and Sasidharan (2024) demonstrate that while customs regulations discourage businesses from participating in global value chains, loan availability and the use of digital communication promote businesses' supply chain integration. Kumari (2024) utilizes Organization for Economic Cooperation and Development (OECD) Trade Facilitation Indicators (TFIs) and finds that trade facilitation has significant positive effects on agriculture and manufacturing trade and helps to maximize global trade benefits.

The above empirical studies fully show the importance of logistics performance and trade facilitation in international trade flows. Yet, how logistics and trade facilitation measures affect China-ASEAN bilateral trade flows has not been studied. Therefore, this research aims to analyze the impact of logistics performance and trade facilitation on the bilateral trade flows between China and ASEAN countries.

3. RESEARCH METHODOLOGY

The aim of this research is to examine the impact of logistics performance and trade facilitation on China-ASEAN bilateral trade flows. The two primary explanatory variables in this study are trade facilitation and logistical performance. The China-ASEAN bilateral trade flow value is selected as the dependent variable. Based on the gravity model of trade (Anderson & Van Wincoop, 2003; Isard, 1954), Gross Domestic Product (GDP) per capita, population,

and distance are selected as the control variables in the model. Since high import tariff rates slow down trade between countries and low import tariff rates speed it up (Cheong & Tang, 2018; Saygili, Peters, & Knebel, 2018), the tariff rate was also chosen as a control variable in the model. The Logistics Performance Index (LPI) from the World Bank is used to indicate logistics performance. The trade facilitation index is calculated based on the study of Wilson, Mann, and Otsuki (2005), who proposed four aspects to measure trade facilitation, namely, port infrastructure, customs environment, regulatory environment, and e-business infrastructures. Table 1 reports the trade facilitation index used in this research. A total of 11 indicators are used to calculate the trade facilitation index. This research employs the entropy method (Jaynes, 1982) to standardize the data and calculate the final trade facilitation index.

Table 1. Trade facilitation index.

First-level indicator	Second-level indicator	Value range
Institution	Government corruption index	0%-100%, 0%==Extremely corrupted, 100%==Extremely in corrupted
	Jurisdiction independence	Value range 1-7, 1==Extremely dependent, 7==Extremely independent
	Government supervision burden	Value range 1-7, 1==Extremely burden, 7==Extremely unburden
	Jurisdiction efficiency	Value range 1-7, 1==Extremely low, 7==Extremely high
Port efficiency	Road infrastructure	Value range 1-7, 1==Extremely low, 7==Extremely high
	Railway infrastructure	Value range 1-7, 1==Extremely low, 7==Extremely high
	Seaport infrastructure	Value range 1-7, 1==Extremely low, 7==Extremely high
	Airport infrastructure	Value range 1-7, 1==Extremely low, 7==Extremely high
Customs environment	Trade barriers	Value range 1-7, 1==Extremely high, 7==Extremely low
	Customs burden	Value range 1-7, 1==Extremely low, 7==Extremely high
	Tariff	0%-100%, 0%==No tariff, 100%==High tariff
E-commerce	Usage of mobile phones	%, Percentage
	Broadband accession	%, Percentage
	Internet penetration	%, Percentage

Source: From the global competitiveness report provided by the World Economic Forum; https://www.weforum.org.

Because logistics performance is a part of trade facilitation and trade facilitation and logistics performance are very similar, this study looks at the effects of trade facilitation and logistics performance on trade flows separately.

Additionally, we use China's total trade value with ASEAN, its exports to ASEAN, and its imports from ASEAN as the dependent variables.

Model 1: Impact of logistics performance on China-ASEAN total trade value.

$$TV_{ijt} = \beta_0 + \beta_1 LPIP_{jt} + \beta_2 CP_{it} + \beta_3 TP_{jt} + \beta_4 CG_{it} + \beta_5 TG_{jt} + \beta_6 DISC_{ijt} + \beta_7 TFRC_{it} + \beta_8 TFRP_{jt} + \epsilon_{ijt} \quad (1)$$

Model 2: Impact of logistics performance on China's export value to ASEAN.

$$EX_{ijt} = \beta_0 + \beta_1 LPIP_{jt} + \beta_2 CP_{it} + \beta_3 TP_{jt} + \beta_4 CG_{it} + \beta_5 TG_{jt} + \beta_6 DISC_{ijt} + \beta_7 TFRP_{it} + \epsilon_{ijt} \quad (2)$$

Model 3: impact of logistics performance on China's import value from ASEAN.

$$IM_{ijt} = \beta_0 + \beta_1 LPIP_{jt} + \beta_2 CP_{it} + \beta_3 TP_{jt} + \beta_4 CG_{it} + \beta_5 TG_{jt} + \beta_6 DISC_{ijt} + \beta_7 TFRC_{it} + \epsilon_{ijt} \quad (3)$$

Model 4: Impact of trade facilitation on China-ASEAN total trade value.

$$TV_{ijt} = \beta_0 + \beta_1 TFS_{jt} + \beta_2 CP_{it} + \beta_3 TP_{jt} + \beta_4 CG_{it} + \beta_5 TG_{jt} + \beta_6 DISC_{ijt} + \beta_7 TFRC_{it} + \beta_8 TFRP_{jt} + \epsilon_{ijt} \quad (4)$$

Model 5: Impact of trade facilitation on China's export value to ASEAN.

$$EX_{ijt} = \beta_0 + \beta_1 TFS_{jt} + \beta_2 CP_{it} + \beta_3 TP_{jt} + \beta_4 CG_{it} + \beta_5 TG_{jt} + \beta_6 DISC_{ijt} + \beta_7 TFRP_{it} + \epsilon_{ijt} \quad (5)$$

Model 6: Impact of trade facilitation on China's import value from ASEAN.

$$IM_{ijt} = \beta_0 + \beta_1 TFS_{jt} + \beta_2 CP_{it} + \beta_3 TP_{jt} + \beta_4 CG_{it} + \beta_5 TG_{jt} + \beta_6 DISC_{ijt} + \beta_7 TFRC_{it} + \epsilon_{ijt} \quad (6)$$

In model 1, i, j and t refer to China, China's trade partner in ASEAN countries, and year respectively. TV indicates the total bilateral trade value between China and its trade partner - ASEAN. LPIP is the core explanatory variable in

the model, and it denotes the logistics performance index of trade partner j. CP and TP stand for China's population and the trade partner's population. CG and TG refer to China's GDP per capita and the trade partner's GDP per capita. DISC represents the capital distance between China and its trade partner. TFRC is China's import tariff rate on its trade partner's products, and TFRP is the trade partner's import tariff rate on China's products.

In model 2 and model 3, EX refers to China's exports to its trade partner (ASEAN), and IM refers to China's imports from its trade partner (ASEAN). The meanings of other abbreviations in Model 2 and Model 3 are in line with those in Model 1. In model 4, model 5, and model 6, the abbreviation TFS indicates the trade partner's trade facilitation index. The meanings of other abbreviations in these models are the same as that above.

For the above models, this research employs data of each variable from 2009 to 2019 because the data for trade facilitation are only reported for 2009-2019 by the World Economic Forum. Due to a data shortage in some countries, this research only uses the trade panel data between China and six ASEAN countries. That is Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. The other four ASEAN countries, namely, Brunei Darussalam, Cambodia, Lao People's Democratic Republic (PDR), and Myanmar, are excluded from the panel data set due to some data shortage.

The positive effects of logistics performance, trade facilitation, population, and GDP per capita on China's total trade flows with ASEAN, as well as on China's exports to and imports from ASEAN, are expected. We anticipate a negative relationship between China's trade flows with ASEAN countries and the import tariff rate and distance. The data on total trade value, export value, and import value are sourced from the UNCTAD database. The logistics performance data comes from the World Bank database. The data on trade facilitation are from the Global Competitiveness Report provided by the World Economic Forum. The data on population and GDP per capita are from the World Bank. The average tariff rate is from the World Bank. The distance data comes from the CEPII database. We conduct the research data analysis using the software STATA 17.0. The details of each variable are listed in Table 2.

Table 2. Details of variables.

Variables	Specific meaning	Expectation	Time span	Source
Dependent variable				
TV	Total trade value between China and its partners - ASEAN.		2009-2019	UNCTAD
EX	China's total export value to its trade partner - ASEAN		2009-2019	UNCTAD
IM	China's total import value from its trade partner - ASEAN		2009-2019	UNCTAD
Independent variable				
LPIP	Logistics performance of China's trade partners	Positive	2009-2019	World bank
TFS	Trade facilitation index of China's trade partner	Positive	2009-2019	World Economic Forum
CP	China's population	Positive	2009-2019	World bank
TP	Trade partner's population	Positive	2009-2019	World bank
CG	China's GDP per capita	Positive	2009-2019	World bank
TG	Trade partner's GDP per capita	Positive	2009-2019	World bank
DISC	Capital distance between China and its partners	Negative	2009-2019	The CEPII database
TFRC	China's import tariff rate on its trade partners	Negative	2009-2019	World bank
TFRP	Trade partner's import tariff rate on China's products	Negative	2009-2019	World bank

Note: Only six ASEAN countries are included in the panel data set, namely Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. The data for Brunei, Laos, Myanmar, and Cambodia are excluded from this objective due to a shortage of some variables. Time period: 2009-2019.

4. EMPIRICAL RESULTS

4.1. Descriptive Statistics

Table 3 reports the descriptive statistics of the panel data set in this research. The average total trade value (TV) between China and the six ASEAN countries amounts to $70.346 billion, with a relatively high standard deviation of $28.108 billion, a maximum value of $161.986 billion, and a minimum value of $20.531 billion. It indicates large variability in trade volumes among different observations. China's export value (EX) to the six ASEAN countries averages $37.572 billion, and China's import value from ASEAN countries (IM) averages $32.774 billion. The core explanatory variables are the logistics performance index and the trade facilitation index. The Logistics Performance Index (LPIP) ranges between 0 and 5, which captures the overall efficiency and quality of logistics services. It has an average value of 3.314 with a standard deviation of 0.396, a minimum value of 2.668, and a maximum value of 4.144. Similarly, the trade facilitation index (TFS) ranges between 0 and 1.0, which measures the effectiveness of customs and other border procedures. It has an average value of 0.447, with a standard deviation of 0.251, a minimum value of 0.144, and a maximum value of 0.936. This measurement implies that there are notable differences in the six ASEAN countries' trade facilitation status.

Table 3. Descriptive statistics.

Variables	Specific meaning	Obs.	Mean	Std. dev.	Min	Max
TV	Trade value in billion US$	66	70.346	28.108	20.531	161.986
EX	Export value in billion US$	66	37.572	16.368	8.585	97.869
IM	Import value in billion US$	66	32.774	15.668	4.747	71.91
LPIP	Logistics performance index of partner	66	3.314	0.396	2.668	4.144
TFS	Trade facilitation index of partner	66	0.447	0.251	0.114	0.936
CP	China's population in millions	66	1367.459	25.362	1331.26	1407.745
TP	Trade partners' population in millions	66	91.438	80.656	4.988	270.626
CG	China's GDP per capita in US$	66	7206.455	2025.795	3749	10144
TG	Trade partner's GDP per capita in US$	66	13197	19259.132	1232	66859
DISC	Physical distance between capitals in km.	66	3741.5	1010.014	2322	5200
TFRC	China's tariff rate towards its trade partners.	66	1.004	0.804	0.031	3.324
TFRP	Trade partner's tariff rate towards China	66	2.112	2.598	0	11.888

4.2. Correlation Matrix

The correlation matrices are presented in Table 4 and Table 5. In Table 4, it can be seen that the correlation between trade value (lnTV) and the logistics performance index (LPIP) is positive with a coefficient of 0.350. It indicates that higher logistics performance is associated with increased trade flows between China and ASEAN countries. In Table 5, the correlation between trade value (lnTV) and the trade facilitation index (TFS) is 0.429, showing a moderate to high correlation between trade flows and trade facilitation. The result indicates that improved trade facilitation—such as streamlined customs procedures and more efficient border management—has a meaningful impact on trade volumes between China and ASEAN countries. In both Table 4 and Table 5, the correlation coefficients are below 0.8, indicating no collinearity issue in the model.

Table 4. Correlation matrix (Impact of logistics performance on trade flows).

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) lnTV	1.000								
(2) LPIP	0.350	1.000							
(3) lnCP	0.627	0.043	1.000						
(4) lnCG	0.682	0.053	0.946	1.000					
(5) lnTP	-0.252	-0.935	0.032	0.032	1.000				
(6) lnTG	0.400	0.940	0.149	0.155	-0.900	1.000			
(7)lnDISC	0.165	0.355	-0.000	-0.000	-0.211	0.546	1.000		
(8) TFRC	-0.188	-0.306	-0.354	-0.399	0.343	-0.335	-0.022	1.000	
(9) TFRP	0.039	-0.133	-0.109	-0.161	0.042	-0.090	0.047	0.187	1.000

Table 5. Correlation matrix (Impact of trade facilitation on trade flows).

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) lnTV	1.000								
(2) TFS	0.429	1.000							
(3) lnCP	0.627	0.111	1.000						
(4) lnCG	0.682	0.111	0.946	1.000					
(5) lnTP	-0.252	-0.909	0.032	0.032	1.000				
(6) lnTG	0.400	0.977	0.149	0.155	-0.900	1.000			
(7) lnDISC	0.165	0.530	-0.000	-0.000	-0.211	0.546	1.000		
(8) TFRC	-0.188	-0.279	-0.354	-0.399	0.343	-0.335	-0.022	1.000	
(9) TFRP	0.039	-0.067	-0.109	-0.161	0.042	-0.090	0.047	0.187	1.000

4.3. Heteroskedasticity Test Results

Heteroskedasticity is the condition in which the variance of the error components in a regression model is not constant across all observations. Ignoring this condition could lead to inaccurate hypothesis testing and inefficient estimations (Baltagi & Baltagi, 2021). The heteroskedasticity test results presented in Table 6 are essential for assessing the reliability of the regression models used in evaluating the impact of logistics performance and trade facilitation on China-ASEAN trade flows. The results in Table 6 show the existence of a heteroskedasticity problem, which needs to be addressed.

Table 6. Heteroskedasticity test results.

Null hypothesis: Homoskedasticity (Constant variance of errors)	The impact of logistics performance			The impact of trade facilitation		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Chi2	45.77	77.91	369.77	22.66	23.98	240.98
Prob>Chi2	0.0000	0.0000	0.0000	0.0009	0.0005	0.0000

4.4. Wooldridge Test Results for Autocorrelation

The Wooldridge test results for autocorrelation in Table 7 provide key insights into the presence of autocorrelation in the models. The Wooldridge test for autocorrelation is used to detect whether the residuals (error terms) of the regression models are serially correlated. Autocorrelation in panel data leads to inefficient estimates and inaccurate standard errors, distorting hypothesis testing and resulting in unreliable conclusions if left uncorrected (Griffith, 2000). Here, the results indicate the rejection of the null hypothesis of no autocorrelation, confirming the presence of an autocorrelation issue in the model. If this issue is not addressed in regression, the results may be biased.

Table 7. Wooldridge test results for autocorrelation.

Null hypothesis: No first-order autocorrelation	Logistics performance			Trade facilitation		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	lnTV	lnEX	lnIM	lnTV	lnEX	lnIM
F	20.657	57.469	21.390	16.086	57.351	20.831
Prob>F	0.0061	0.0006	0.0057	0.0102	0.0006	0.0060

4.5. Regression Results

Table 8 reports the regression results of models 1-6. In this part, the feasible generalized least squares (FGLS) estimation method is used to address heteroskedasticity and autocorrelation issues, making the estimation results more accurate and useful (Menke, 2015). Models 1-3 examine the impact of logistics performance on China's total trade value with ASEAN countries, China's exports to ASEAN countries, and China's imports from ASEAN

countries. Models 4-6 analyze the impact of trade facilitation on China's total trade value with ASEAN countries, China's exports to ASEAN countries, and China's imports from ASEAN countries.

Model 1's regression results show that ASEAN's logistics performance coefficient is positive and statistically significant at the 10% level (0.590, $p < 0.1$). This means that better logistics infrastructure and services are linked to more trade between China and ASEAN. Better logistics performance reduces transportation expenses, improves reliability, and enhances trade efficiency, leading to increased trade volumes. In model 2, China's exports to ASEAN nations are positively (0.469) but not statistically significantly impacted by ASEAN's logistics performance. Also, model 3 shows that the amount of goods China buys from ASEAN countries is positively related to how well ASEAN handles logistics, but the relationship is not statistically significant (correlation coefficient = 0.341).

Also, model 4 shows that the trade facilitation index (TFS) is significantly positive, with a coefficient of 3.534 at 1% significance. This means that better border controls, regulatory frameworks, and customs processes lead to more trade. This finding demonstrates how important effective trade facilitation is to lowering trade barriers and encouraging more seamless cross-border transactions. In model 5, results demonstrate that trade facilitation significantly and favorably affects China's exports to ASEAN nations with a coefficient of 4.239 at 1% significance. It suggests that enhancing trade facilitation among ASEAN nations lowers costs and delays, increasing the competitiveness of Chinese exports in ASEAN markets. Finally, model 6 reveals that China's imports from ASEAN nations are positively and significantly impacted by trade facilitation from ASEAN nations, with a coefficient of 0.595 at 10% significance. It suggests that increased import volumes from ASEAN nations are linked to advancements in trade facilitation of ASEAN nations, such as more efficient customs processes and fewer border waits. This data demonstrates how crucial trade facilitation is to promoting ASEAN imports into China.

Table 8. Regression results.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	lnTV	lnEX	lnIM	lnTV	lnEX	lnIM
LPIP	0.599*	0.469	0.341	--------	--------	--------
	(1.896)	(1.427)	(0.682)	--------	--------	--------
TFS	--------	--------	--------	3.534***	4.239***	0.595*
	--------	--------	--------	(5.219)	(7.919)	(1.814)
lnCP	-5.975	-4.536	-1.945	-9.483**	-8.875**	-3.456*
	(-1.110)	(-0.808)	(-0.227)	(-2.036)	(-2.167)	(-1.783)
lnCG	1.438***	1.431***	0.994*	1.161***	1.338***	0.669***
	(4.192)	(4.146)	(1.801)	(3.862)	(5.334)	(4.742)
lnTP	0.00232	-0.0803	0.0515	0.515***	0.421***	0.351***
	(0.0150)	(-0.527)	(0.219)	(3.057)	(3.282)	(4.317)
lnTG	-0.0718	-0.164	0.0751	-0.000796	-0.287*	0.436***
	(-0.326)	(-0.724)	(0.216)	(-0.00468)	(-1.953)	(3.588)
lnDISC	0.103	0.0867	0.326	-0.960***	-0.954***	-0.131
	(0.323)	(0.265)	(0.656)	(-3.002)	(-3.717)	(-0.854)
TFRC	0.109**	--------	0.120	0.0101	--------	0.0403*
	(2.221)	--------	(1.555)	(0.215)	--------	(1.699)
TFRP	0.0318**	-0.0179	--------	0.0381***	-0.0147	--------
	(2.358)	(-1.294)	--------	(3.268)	(-1.478)	--------
Constant	135.5	107.6	50.73	211.1**	200.1**	81.57**
	(1.226)	(0.933)	(0.288)	(2.208)	(2.381)	(2.050)
Observations	66	66	66	66	66	66
Number of ID	6	6	6	6	6	6

Note: z-statistics in parentheses; N=6, T=11 (2009-2019); estimation method: FGLS.
*** p<0.01, ** p<0.05, * p<0.1.

5. CONCLUSION

The purpose of this study is to examine how China's imports and exports to ASEAN are affected by improvements in trade facilitation and logistics performance. The variables under investigation are China's exports to ASEAN,

imports from ASEAN, and trade flows with ASEAN. The trade facilitation index and the logistics performance index are the primary explanatory factors. We employ a panel data collection for the analysis, which spans six ASEAN nations—Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam—from 2009 to 2019. Due to data shortages for certain variables, Brunei, Laos, Myanmar, and Cambodia are not included in this target. The feasible generalized least squares (FGLS) estimation method is used to deal with heteroskedasticity and autocorrelation in panel data sets.

According to the study's empirical findings, countries' effective logistics processes can influence trade flows between China and ASEAN by lowering transportation expenses, speeding up deliveries, and boosting supply chain dependability. Logistics performance, which includes things like infrastructure quality, customs efficiency, and logistical services, is important to make trade easier and more competitive (Hausman et al., 2013; Shikur, 2022). The study findings of Martí et al. (2014), Gani (2017), Çelebi (2019), Bugarčić et al. (2020), Adelajda Zaninović et al. (2021), and Song and Lee (2022) also support the favorable effect of logistics performance on trade flows in this study. Additionally, this study indicates that trade facilitation improves trade flows between China and ASEAN. According to Zaki (2015), effective trade facilitation policies can boost trade volumes, open up new markets, and make companies more competitive. Trade facilitation can foster a climate that is favorable to economic growth and trade expansion by lowering trade obstacles, improving customs processes, and encouraging transparency in trade rules. This study's findings are also in line with earlier research by Avetisyan and Hertel (2021); Ali and Shakoor (2020); Yu and Luu (2020); Sakyi and Afesorgbor (2019); Zaki (2015); and Sá Porto et al. (2015).

The results of this study indicate that further steps should be taken by China and other developing ASEAN nations to enhance their trade facilitation and logistical capabilities. By encouraging the building of roads and railroads connecting China and ASEAN nations and bolstering the development of air and sea transportation infrastructure, China and ASEAN may collaborate on logistics infrastructure and increase transportation efficiency. A regional customs database and administration system can also be established, and customs cooperation between China and ASEAN nations can be strengthened.

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