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The influence of trade facilitation on agricultural product exports of China: empirical evidence from ASEAN countries

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ABSTRACT

The trade of agricultural products plays an essential role in agricultural development. Agricultural trade is more complicated and diversified than other industrial products, influenced by product characteristics for perishable. The Association of Southeast Asian Nations (ASEAN) is one of the most important markets for China's agricultural exports. This study aimed to analyze the impact of trade facilitation indicators on China's agricultural exports to ASEAN countries. A gravity model was adopted by taking the volume of Chinese agricultural exports to ASEAN countries from 2006–2020 as the dependent variable. Indicators such as economic freedom (EF), trade across borders (TAB), and infrastructure quality (Infra) were introduced that were representing trade facilitation as the core independent variable. Also, an empirical analysis was carried out using a mixed regression model. The results show that the three proxy indicators of trade facilitation had a significantly positive impact on the scale of China's agricultural exports to the ASEAN market. The results could play a guiding role in strengthening the cooperation between China and the ASEAN regarding trade facilitation and expansion of the scale of agricultural trade.

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1. Introduction

China is a significant global agricultural producer, consumer, and exporter of agricultural products. In 2020, the trade volume of China's agricultural products reached $246.83 billion, which was 8% up year on year. Its exports totaled $76.03 billion, down by 3.2% year on year, and its imports totaled $170.08 billion, up by 14% year on year; therefore, the overall trade deficit was $94.77 billion, which was 32.9% high year on year. Stable exports of agricultural products from China are of great significance to China's agricultural development and greatly value alleviating the trade

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deficit, changing the trade structure, boosting farmers' incomes, and realizing rural revitalization. However, even though China is a traditionally agricultural country, China's agricultural exports do not harness the scale effect, so it is not easy for the country to form a competitive advantage. Exports are mainly affected by Non-self factors, such as tariff agreements (Lyu et al., 2021, Ming & Man, 2021), the business environment (Castellano-Álvarez et al., 2021), infrastructure (Camisón-Haba & Clemente-Almendros, 2020), and customs clearance efficiency (Kumanayake, 2022). Therefore, trade facilitation is one of the important factors. Trade facilitation is a comprehensive index that reflects a country's economic freedom, customs clearance efficiency, and infrastructure construction level. Since Regional Comprehensive Economic Partnership (RCEP) came into effect on January 1, 2022, the trade between China and ASEAN has entered a new era of development. Under the influence of COVID-19 and the conflict between Russia and Ukraine, what factors affect the export of Chinese agricultural products to ASEAN countries? how China and ASEAN should start to promote the development of agricultural trade? and how to make breakthroughs in trade facilitation are the main objectives of our study.

Despite being China's most important agricultural trade partner, few studies have focused on the trade impact of China's agricultural exports to ASEAN countries that focused on trade facilitation (Gera, 2004, Alleyne et al., 2020, Bouet et al., 2022). Furthermore, agricultural products are sensitive to trade facilitation due to their perishable characteristics. However, at present, the selection of trade facilitation indicators is generally based on the empirical analysis of four indicators—port environment, customs efficiency, regulations, and e-commerce as proposed by Wilson Mann (Wilson et al., 2003), which makes it challenging to provide more effective analysis results for the characteristics of agricultural products.Moreover, these indicators are mainly non-quantifiable policy indicators and existing research has not greatly considered policy indicators and has lacked comprehensive indicators (Beckman, 2021, Borojo et al., 2022). Since the outbreak of COVID-19 and the conflict between Ukraine and Russia in 2022, the global agricultural trade supply chain has been greatly impacted (Zhang et al., 2022). In this context, policy factors, including lowering tariff barriers, enhancing economic freedom, improving customs clearance efficiency and strengthening infrastructure cooperation play an important role in promoting agricultural trade and maintaining the security and stability of the world situation. Therefore, taking agricultural products as the research object, determining the trade facilitation index system suitable for agricultural products, and clarifying the policy direction are the current research topics that need to be solved on priority.

Given this, to overcome the limitations of current research. The contribution of this paper lies in the following aspects:First, this study optimizes the statistical methods to provide data on agricultural trade more accurately and comprehensively. By combining the characteristics of agricultural trade between China and ASEAN countries, we used HS codes to subdivide, summarize, and define the scope of agricultural products. This provides a more realistic and accurate definition and makes up for the deficiencies of the existing statistical methods. Second, based on previous studies, this paper tries to break through the limitation of simply taking some secondary indicators of GCR as the core variable, and further subdivided trade facilitation into three categories, including economic freedom (EF) from 'Heritage Foundation and the Wall Street Journal', trade across borders (TAB) from World Bank Doing Business, and infrastructure quality (Infra) from GCR, which can fully represent non-quantitative indicators such as policy indicators and comprehensive indicators. To establish an indicator system for the impact of trade facilitation that is more in line with the reality of ASEAN countries.Third, this paper incorporated the impact of COVID-19 into the research framework and used the correction coefficients of the Stringency Index (SI) to quantitatively evaluate the impact of China's agricultural exports to ASEAN countries on trade facilitation before and after the outbreak of the epidemic, which made a useful attempt to study agricultural trade in the epidemic era. In addition, agricultural products have the characteristics of perishability and deterioration and are more affected by trade facilitation. ASEAN is a major agricultural export market for China, and this study is an effective supplement to existing research findings.

The remainder of this paper is organized as follows. We review the current research literature and explain the research methods used briefly in the second part. The third part introduces the research methods and establishes the gravity model. The results of regression analysis are presented in section 4. The fifth part discusses the research results from the perspective of theory and practice. Finally, the sixth part is the conclusion and direction of further research.

2. Literature review

The choice of the statistical classification of agricultural products will significantly affect the results of any related analysis. At present, there are two major definitions of agricultural products, one each from the World Trade Organization (WTO) and the United Nations Food and Agriculture Organization (FAO) (Hiemstra & Mackie, 1986). According to the Standard International Trade Classification (SITC) codes, the WTO defines agricultural products. Specifically, this includes 0 (food and live animals), 1 (beverages and tobacco), 2 (non-edible raw materials, which do not include fuel), and 4 (animal and vegetable oils, fats, and waxes). WTO statistics include the main agricultural products, aquatic products, and primary forest products. Therefore, they are available for the analysis of agricultural production statistics. However, the main problem is that this bank of statistics is relatively broad and contains some non-agricultural products that are difficult to eliminate; therefore, achieving precision is cumbersome.

Meanwhile, the FAO divides agricultural products into 540 specific products based on their SITC codes. This is a relatively small number when compared with the statistical range of the WTO since it excludes aquatic products and forest products, such as cork and pulp. The advantage of the FAO statistics is that the time series is long, i.e., the earliest date can be traced back to 1987. However, such statistics do not include forestry and fishing; therefore, the statistical scope is relatively narrow.

Research on trade facilitation was initially applied to improve the efficiency of customs declaration and the transportation of goods. Yet, with further development of economic globalization and information technology, the connotations that are associated with trade facilitation are constantly expanding (Liang et al., 2021), and different indicator systems of trade facilitation were formed (Vorontsova & Klimova, 2021, Ibrahim & Ajide, 2022). The WTO focuses on the index selection of customs clearance efficiency. The Organization for Economic Cooperation and Development's (OECD) index system focuses on e-commerce and the regulatory environment. The Asia-Pacific Economic Cooperation's (APEC) index system focuses on policy behavior. The World Bank mainly adopted Wilson Mann's index system to build a trade facilitation index system that is based on four indicators: port environment, customs efficiency, regulations, and e-commerce (Wilson et al., 2003). At present, scholars in China and abroad primarily draw on this indicator and select different secondary indicators to measure the level of trade facilitation of a country or region in combination with different research priorities. For example, Petrevski et al. (2015) used this indicator to measure and analyze the trade facilitation between eastern and southern European countries. Based on this index, Safaeimanesh & Jenkins (2020) constructed different secondary index systems, which were combined with the characteristics of goods trade and measured the trade facilitation levels of African countries. Zaninović et al. (2021) state that The Central and Eastern European (EU) member countries should make changes in infrastructure, border procedures, regulatory environment, and transport regulations. That way, it will have more chances of increasing participation in global supply chains.

Regarding the research methods used to investigate the impact of trade facilitation on international trade, scholars in China and abroad mainly used the following three models: First, there is the Computable General Equilibrium (CGE) model. Hertel et al. (2001), Zaki (2014), and Cui (2019) respectively, adopted the CGE model to analyze the impacts of different indicators on trade costs and the trade scale of developed countries, such as Singapore and Japan and some developing countries. Thomas, Hertel et al. (2007) combined the CGE framework with a probit model to study the substitution relationship between customs clearance simplification and tariffs. The second model, which Hertel and Huff (2001) constructed, is the Global Trade Analysis Project (GTAP) model, which explores the improvement of trade facilitation that was brought about by the free trade agreement between Japan and Singapore. The results of the model show that trade facilitation measures significantly promoted trade benefits and social welfare on both sides. Saini (2012), and Jain (2019) analyzed relevant data for Bangladesh, India, and Nepal through the GTAP model and concluded that the trade facilitation level of South Asian countries lagged far behind those at the global forefront. Therefore, the suggestion was that improving trade facilitation could effectively boost the innovative capacity of South Asian countries. The third model is the gravity model. Many domestic and foreign experts and scholars adopt the gravity model from different perspectives to analyze the effects of trade facilitation on APEC countries (Wilson et al., 2003), with studies spanning 124 major industrial (Iwanow & Kirkpatrick, 2009), developing countries (Alberto Portugal-Perez, Alberto Portugal-Perez, 2012), African countries (Sakyi & Afesorgbor, 2019), and Central Asia Regional Economic Cooperation.

To summarize, the current trade facilitation and trade impact measurement models are relatively effective and lay the foundation for the research that was conducted in this study (Shepherd, 2022). At present, the CGE model, GTAP model and gravity model are all important methods in regional economic research. The CEG model and

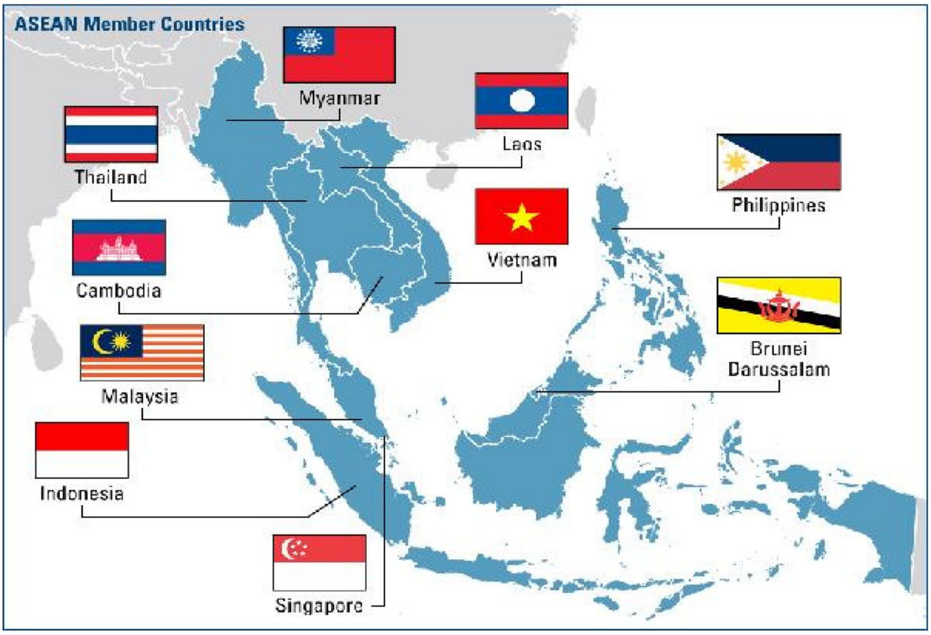

Figure 1. ASEAN member countries.
Source: https://blogs.nottingham.ac.uk.

GTAP are mainly used for pre-simulation evaluation studies and are supported by the GTAP database. Gravity models are more suitable for post-hoc evaluation studies. This paper mainly studies the influence of trade facilitation indicators on China's agricultural products exported to ASEAN countries. Most of the data needed to be calculated by authors, and the research is more focused on post-evaluation, thus, in this study, we chose the gravity model as the experimental research method due to its suitability for the research objective.

3. Materials and methods

3.1. The study area

The Association of Southeast Asian Nations (ASEAN) includes ten countries (namely, Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam (Figure 1).

The ASEAN is an important trading partner of China and represents the largest export market and second-largest import market for China's agricultural products (Table 1).

Among the ten ASEAN countries, Vietnam is China's largest export recipient country in terms of agricultural products, showing an increasing trend year on year. In 2020, the total imports of agricultural products reached 8.8 billion USD. Thailand, the Philippines, Indonesia, and Malaysia are in the second tier, with the Philippines growing from 2006 to reach second place in 2017 but then declining after 2018. Meanwhile, the export scale of Indonesia and Malaysia is in the range of 3 billion to

Table 1. China's agricultural exports to ASEAN countries from 2006 to 2020, Million.

	2006	2008	2010	2012	2014	2016	2018	2020
Brunei	4.90	8.98	25.18	73.33	37.94	35.00	39.52	31.80
Indonesia	689.81	962.47	2676.63	3051.25	3114.97	2969.57	3420.63	3102.94
Cambodia	290.33	245.97	218.55	392.14	562.98	611.63	948.00	1480.38
Laos	17.80	26.17	20.44	34.59	36.29	39.16	83.19	62.05
Myanmar	161.53	129.88	271.21	429.45	734.03	726.33	1022.28	1188.52
Malaysia	923.46	1456.68	2227.62	2991.94	3629.69	3254.33	3247.79	4540.18
Philippines	943.98	1146.69	1149.88	2069.12	2479.83	4103.84	4043.63	3877.25
Singapore	812.79	1553.77	910.26	1094.82	1473.37	1259.99	1333.63	1449.72
Thailand	850.42	1655.42	1834.91	2891.61	3572.52	4251.87	4204.83	5197.50
Vietnam	827.03	1631.34	3005.77	4030.28	6197.44	6587.20	8744.82	8885.44

Source of data: United Nations Comtrade Database.

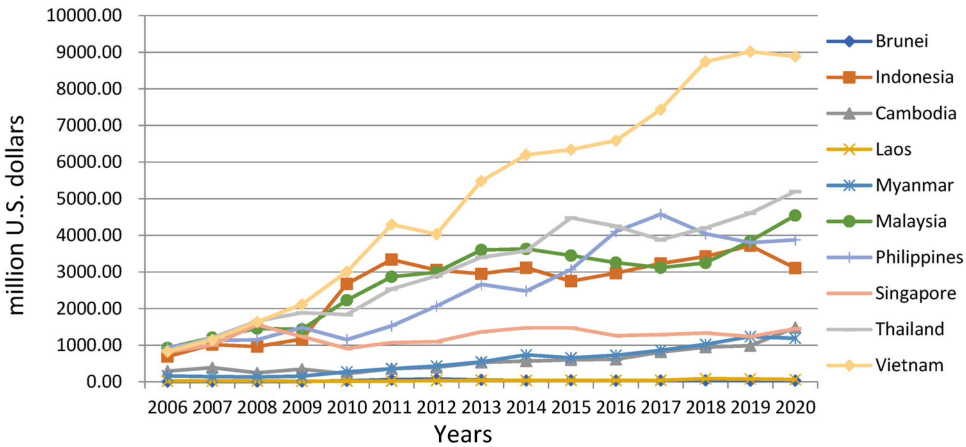

Figure 2. Trends of China's agricultural exports to ASEAN countries from 2006 to 2020.
Source: Authors' calculations.

4 billion USD individually. Thailand is currently the second-largest target country for China's agricultural exports among the ASEAN countries. In 2020, Thailand imported 5.1 billion USD of agricultural products from China. Singapore, Myanmar, and Cambodia are then in the third tier, with their imports from China being stable at around 1 billion USD individually. The annual import volume of Laos and Brunei was less than 100 million USD individually. Brunei imported less than 60 million USD of agricultural products from China in 2011, which was its all-time highest import level. Since 2016, Brunei has maintained imports in the range of 30 million to 40 million USD, ranking in last place among the ASEAN countries (Figure 2).

Due to the outbreak of COVID-19, the international trade pattern in 2020 has undergone huge changes, and the dislocation of supply and demand has also had a great impact on agricultural trade. China's agricultural exports to ASEAN countries have also undergone certain structural changes. Laos and Indonesia saw the biggest drop of 19.29% and 16.58%, respectively, while Myanmar, Brunei, and Vietnam displayed a slight drop. Cambodia, Malaysia, Singapore, and Thailand had huge increases of 49.86%, 18%, 17.57%, and 12.88%, respectively. The Philippines edged up 2.03%. On the whole, due to China's early epidemic prevention and control efforts, agricultural exports to ASEAN countries increased slightly by 4.14%.

Due to bilateral and multilateral agreements, the tariffs on agricultural trade between China and the ASEAN were reduced from 95% to 0%. The scale of bilateral trade is now more influenced by its non-tariff efficiency. Looking ahead, by reducing trade costs and improving trade efficiency, trade facilitation will become a new driving force for the development of China-ASEAN agricultural trade and will provide support for the formation of a stable global agricultural market pattern. Under these circumstances, this study investigated the relationship between trade facilitation and the scale of China's agricultural exports and determined the main factors that affect China's agricultural exports and their degrees of influence. We then verified our research findings through empirical analysis. This research is important for further stimulating the internal trade potential of agricultural products for both China and the ASEAN and clarifying the policy direction.

3.2. Methods

3.2.1. Model setting and variable selection

The gravity model is based on the law of universal gravitation, which states that the force of gravity between two objects is proportional to their masses and inversely proportional to the distance between them. Later, economists applied this idea to the study of international trade. Tinbergen (1962) and Pyhnen (1963) concluded that the scale of bilateral trade between two countries is proportional to their GDPs and inversely proportional to the distance between them. Linnemann and John A. Sawyer (1967) introduced the population variable into the gravity model and believed that the bilateral trade scale of the two countries was proportional to the populations of the two countries. Subsequently, many scholars introduced different explanatory variables according to different research priorities to expand the gravity model (Jacimovic et al., 2018, Peternel & Grešš, 2021, Liao et al., 2022), and thus, the gravity model became applied more widely (Mendes dos Reis et al., 2020).

In recent years, many scholars try to apply the gravity model to study bilateral or multilateral agricultural trade facilitation. Based on the extended gravity model, Huang et al. (2020) studied the impact of trade facilitation in developed countries on China's agricultural exports. It is pointed out that due to the existence of technical trade barriers, trade facilitation between developed and developing countries has a heterogeneous influence on China's agricultural exports. Mendes dos Reis et al. (2020) used the extended gravity model to test soybean export facilitation in the United States, Brazil and Argentina from the perspective of logistics performance and proposed that logistics performance had a positive impact on soybean export. Hendy and Zaki (2021) employed Egypt customs data and the World Bank Doing Business data, and the gravity model was used to analyze the impact of administrative barriers on export trade. Agricultural products were perishable and seasonal, which were more sensitive to administrative barriers. All these studies show that the gravity model had a very good application effect on agricultural trade facilitation research. Therefore, this study also uses the extended gravity model to test the impact of trade facilitation on China's agricultural exports to ASEAN countries.

Many factors affect export trade. This study took trade facilitation as the core independent variable and other factors as control variables, in combination with the characteristics of agricultural trade (Kumar et al., 2021). Referring to the study of Zhu (2018), based on the traditional gravity model, this study introduced control variables, such as a country's trade facilitation level, distance, whether it bordered China, whether it was a landlocked country, the exchange rate, and the net terms of trade, to study the impacts of trade facilitation on the scale of agricultural exports.

As trade facilitation is not uniform, the corresponding statistical data and quantitative indicators also differ. Therefore, after considering the availability of data and the coverage of influence, we referred to the quantitative index system of trade facilitation and chose the Index of Economic Freedom (EF), trade across borders (TAB), and infrastructure quality (Infra) as proxy variables of trade facilitation.

We selected EF as a proxy variable for market access and the business operating environment. The promotion of a country's level of economic freedom depends on the improvement of relevant international trade rules. Improving the freedom of investment, currency, and legal rights can provide standardized, transparent, and orderly trade conditions for the countries participating in trade, reducing trade costs and promoting trade development (Kumanayake, 2022, Nadeem et al., 2021).

The impact of border management on trade is mainly reflected in the efficiency of customs clearance (Do & Sang, 2020, Nestoryshen et al., 2020, Bang, 2022). We chose TAB as the proxy variable of the border management level since it is an essential index that considers both the efficiency and cost of customs clearance (Beverelli & Ticku, 2022). It represents the distance of each country or region from the world's 'frontier level' in this respect. The time panel can effectively track the development and change in the related economies regarding border management. The score for each economy regarding the distance to trade across borders represents a simple average of the time and costs of imports and exports, document compliance, and border compliance (Zaki, 2014). Among them, document compliance indicators represent the government's requirements for document processing time and cost; border compliance rules represent the time and cost required for the mandatory inspection and supervision of goods crossing the border of a country or region. In addition, the loading and unloading times at ports and the associated costs are also included within this indicator. Overall, a higher score indicates better trade convenience for an economy. Therefore, this indicator can effectively represent the level of border management.

We chose the infrastructure quality score in the Global Competitiveness Report (GCR) as a proxy variable for a country's infrastructure level. The infrastructure quality (Infra) includes the railways, roads, ports, aviation, power, communications, and internet within a country or region. These factors can effectively reduce transportation and information communication times and improve logistics and information flow speed (Hussain et al., 2020, Vidya et al., 2021).

The control variables are mainly reflected by the geographical distance to China (Dis), whether the country borders China (Bor), whether it is a landlocked country (Land), the exchange rate cost (ER), the net barter terms of trade (NBTT), and other similar indicators. Geographical distance significantly affects the trade scale; the

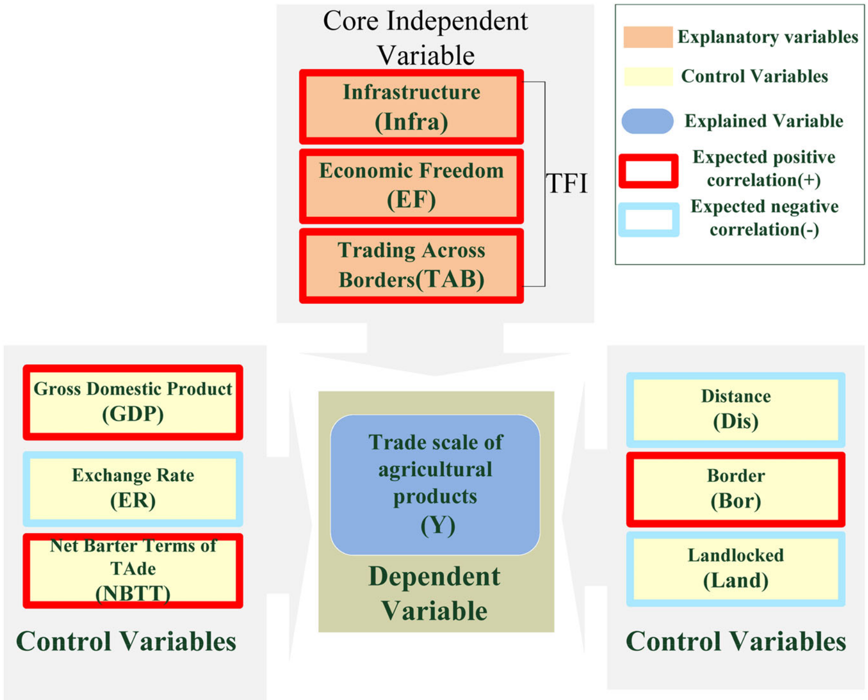

Figure 3. Selection of impact factors and expected direction of China's agricultural exports to ASEAN countries.
Source: Authors.

farther the geographical distance, the smaller the trade scale (Hummels, 1999). The distance is a determining factor in the cost of transport, notwithstanding the infrastructure coverage and improvements in quality (Camisón-Haba & Clemente-Almendros, 2020). The exchange rate cost is reflected by the indirect quotation in a certain period, while the net barter terms of trade represent a country's export price index ratio to its import price index; this factor mainly measure a country's foreign trade profitability. Only good profitability can lay the foundation for enhancing trade facilitation and reducing trade costs. The selection of significant variables and the expected direction of exports is shown in Figure 3.

This study investigated China's agricultural product export trade with ASEAN countries. China's GDP and population variables were constants, leading to multicollinearity problems, therefore, these two variables were not introduced into the model. The languages of all ASEAN countries and China are different. thus, the language cost was not considered. All ASEAN countries are members of the WTO, and the ASEAN as a whole has signed multilateral trade agreements with China. A country that is a member of the WTO and it signed trade agreements with China also excluded. To facilitate the regression, the model was set as follows after logarithmic processing:

$$\ln Y_{ijt} = \alpha_0 + \alpha_1 \ln GDP_{jt} + \alpha_2 \ln EF_{jt} + \alpha_3 \ln TAB_{jt} + \alpha_4 \ln Infra_{jt} + \alpha_5 \ln Dis_{ij} + \alpha_6 Bor_{ij} + \alpha_7 Land_j + \alpha_8 \ln ER_{ijt} + \alpha_9 \ln NBTT_{ijt} + \varepsilon \quad (1)$$

where i represents China, j represents the importing country, t represents the year, and the trade scale (Y_{ijt}) represents the total trade volume of agricultural products exported by China to ASEAN country j in period t, which was the explained variable in the model.

The index of trade facilitation level was the core variable in the model, which was expressed using EF, TAB, and Infra, while EF_{jt} represents the economic freedom index of ASEAN country j in period t. The range of this index is 0–100. The higher the value is, the freer the economy of a country.

TAB_{jt} represents the 'trade across borders' distance of ASEAN country j in period t. As a proxy variable of the border management level in trade facilitation, it represents the efficiency and cost of customs clearance of a country. The higher the score of this index, the closer it is to the frontier level, and the higher the corresponding customs clearance efficiency, the lower the cost. Therefore, this indicator was expected to be positively correlated with trade volumes.

$Infra_{jt}$ represents the infrastructure quality of ASEAN country j in period t, with values ranging from 1 to 7. As a proxy variable of the transportation infrastructure and information network technology in trade facilitation, it represents the logistics and information costs. A higher value indicates a higher level of infrastructure, which was expected to be positively correlated with the trade volume. GDP_{jt} represents the GDP of ASEAN country j in period t, respectively. The distance from China (Dis_{ij}), exchange rate level with China in period t (ER_{ijt}), and net barter terms of trade between ASEAN country j and China in period t ($NBTT_{ijt}$) were also expected to have an impact on the trade scale and were used as control variables in the model. Whether a country was landlocked ($Land_j$), whether the country bordered China (Bor_{ij}), and so on, were signified using 1 for yes and 0 for no. α_0 is the constant term. $\alpha_1,\alpha_2,\alpha_3,\alpha_4,\alpha_5,\alpha_6,\alpha_7,\alpha_8$, and α_9 are the coefficients to be estimated. ε is the random error term.

3.2.2. Data sources and processing

The trade scale data of China's exports to ASEAN countries came from the UN Comtrade International Trade Statistics Databases. As WTO statistics include non-agricultural projects, eliminating them and studying only agricultural products is not easy. Meanwhile, the FAO statistics were too narrow to be accurate. To make up for these problems, this study chose the classifications and summaries according to the Harmonized Commodity and Coding System(HS code), and defined the agricultural product as 'Uruguay-round agricultural agreement + aquatic products + part of the primary forest products'. The range of agricultural products was determined as shown in Table 2.

This study chose ten countries as cross-section samples and 2006 to 2020 as the period of interest. The Index of Economic Freedom (2006–2020) was published by the Heritage Foundation and the Wall Street Journal. Meanwhile, the trade across borders index came from The World Bank Doing Business, while infrastructure quality as a measure came from The Global Competitiveness Report (GCR), which is published annually by The World Economic Forum. The distance, landlocked factor, and border with China data were from the research and expertise on the world economy database (CEPII). Finally, the exchange rate index and the net barter trade cost index of

Table 2. Statistical range of agricultural products that were determined in this study.

Code	Commodity	Code	Commodity
1	Live animals	18	Cocoa and cocoa preparations
2	Meat and edible meat offal	19	Cereal,flour, starch, milk preparations and products
3	Fish, crustaceans, molluscs, aquatic invertebrates nes	20	Vegetable, fruit, nut, etc food preparations
4	Dairy products, eggs, honey, edible animal product nes	21	Miscellaneous edible preparations
5	Products of animal origin, nes	22	Beverages, spirits and vinegar
6	Live trees, plants, bulbs, roots, cut flowers etc	23	Residues, wastes of food industry, animal fodder
7	Edible vegetables and certain roots and tubers	24	Tobacco and manufactured tobacco substitutes
8	Edible fruit, nuts, peel of citrus fruit, melons	4001	Natural rubber, balata, gutta-percha, guayule, chicle and similar gums; in primary forms or in plates, sheets or strip
9	Coffee, tea, mate and spices	41	Raw hides and skins (other than furskins) and leather
10	Cereals	44	Wood and articles of wood, wood charcoal
11	Milling products, malt, starches, inulin, wheat gluten	45	Cork and articles of cork
12	Oil seed, oleagic fruits, grain, seed, fruit, etc, nes	46	Manufactures of plaiting material, basketwork, etc.
13	Lac, gums, resins, vegetable saps and extracts nes	47	Pulp of wood, fibrous cellulosic material, waste etc
14	Vegetable plaiting materials, vegetable products nes	50	Silk
15	Animal,vegetable fats and oils, cleavage products, etc	51	Wool, animal hair, horsehair yarn and fabric thereof
16	Meat, fish and seafood food preparations nes	5201 5202 5203	Cotton; not carded or combed Cotton waste (including yarn waste and garnetted stock) Cotton, carded or combed
17	Sugars and sugar confectionery	53	Vegetable textile fibres nes, paper yarn, woven fabric

Data sources: Harmonized Commodity and Coding System.

China and the ASEAN countries came from the United Nations Conference on Trade and Development (UNCTAD) database, in which the exchange rate cost is expressed using an indirect quotation method. The net barter trade cost index is defined by the ratio of the export unit value index to the import unit value index (Tables 3 and 4).

3.2.3. Summary statistics

This study used Stata15.0 to conduct descriptive statistics on the main variables and predicts the influence trend from the perspective of economics.

Table 4 shows the statistical descriptions of the variables. It can be seen that there is heterogeneity among core variables of core sample countries.

4. Results

4.1. Stationarity test

Stationary data is an important basis for establishing regression analysis models. If the data is not stationary, a spurious regression phenomenon may occur, which may affect the accuracy of the empirical analysis. Therefore, time series image analysis of log-processed variables was carried out first. Dis, Land, and Bor represent distance, land-locked country, and the border with China, respectively. These variables are constant and do not change with time trends, so a stationarity test is not needed. (Figure 4)

Table 3. Data sources of major variables.

Variable	Data sources
Y	United Nations Comtrade Database
GDP	World Bank WDI
EF	Heritage Foundation and the Wall Street Journal - 《Index of Economic Freedom》
TAB	World Bank 《Doing Business》
Infra	World Economic Forum GCR
Dis	CEPII
Land	CEPII
Bor	CEPII
ER	UNCTAD
NBTT	UNCTAD

Y, Import scale; GDP, gross domestic product; EF, Economic Freedom; TAB, trade across borders; Infra, infrastructure quality; Dis, distance to China; Land, landlocked country; Bor, borders; ER, exchange rate; NBTT, the net barter terms of trade.
Source: Authors.

Table 4. Descriptions of the variables used.

Variable	Mean	SD	Max	Min	Expected direction
Y (million US dollars)	1987.21	1985.90	9014.37	4.90	/
GDP (million US dollars)	251,772	241,011	1049,330	7,323	+
EF (0–100)	63.15	10.95	89.40	49.80	+
TAB (0–100)	73.72	14.86	96.8	18.40	+
Infra (1–7)	4.30	1.11	6.6	2.24	+
Dis(Kilometer)	3619.08	889.09	5220.88	2330.80	−
Land (0 or 1)	0.11	0.32	1	0	−
Bor (0 or 1)	0.22	0.42	1	0	+
ER	1.33	2.01	5.14	0.00029	±
NBTT	102.48	13.55	180.00	79.60	+

Y, Import scale; GDP, gross domestic product; EF, Economic Freedom; TAB, trade across borders; Infra, infrastructure quality; Dis, distance to China; Land, landlocked country; Bor, borders; ER, exchange rate; NBTT, the net barter terms of trade.
Source: Authors' calculations.

As can be seen from the time series plot of ASEAN member countries (except Myanmar), some variables may have trends, and the outbreak of COVID-19 in 2020 also has a certain impact on the stationarity of some data, so it is necessary to further carry out stationarity test for these variables.

The most common method of stationarity test is the unit root tests. At present, unit root tests include LLC (Levin et al., 2002), IPS (Im et al., 2003), Fisher type (Maddala & Wu, 1999, Choi, 2001), and Breitung (Breitung, 2001). LLC and Breitung are mainly suitable for the common root, while IPS and Fisher Type are mainly suitable for the individual unit root. To ensure the accuracy of the test, the current study mainly adopts a combination of various tests(Gu, An-ping et al. 2009, Westerlund & Breitung, 2013, Onakoya et al., 2019, Yameogo & Omojolaibi, 2021). This study mainly used balanced panel data, so we used LLC and IPS to test the main variables.If the null hypothesis is rejected, it indicates that the data are stationary and can be used for regression analysis.

In the LLC test, all variables passed the significance test at the 5% level, and the series was stable. However, in the IPS test, only the lnTAB variable passed the significance test at the 5% level. LnY, lnGDP, lnEF, lnInfra, lnER, and lnNBTT all had unit roots. Therefore, the variables DlnY, D lnGDP, DlnEF, DlnInfra, DlnER and DlnNBTT are obtained at first difference. All the variables passed the significance test of LLC and IPS at 5% level, and all the variables were stationary as shown in Table 5.

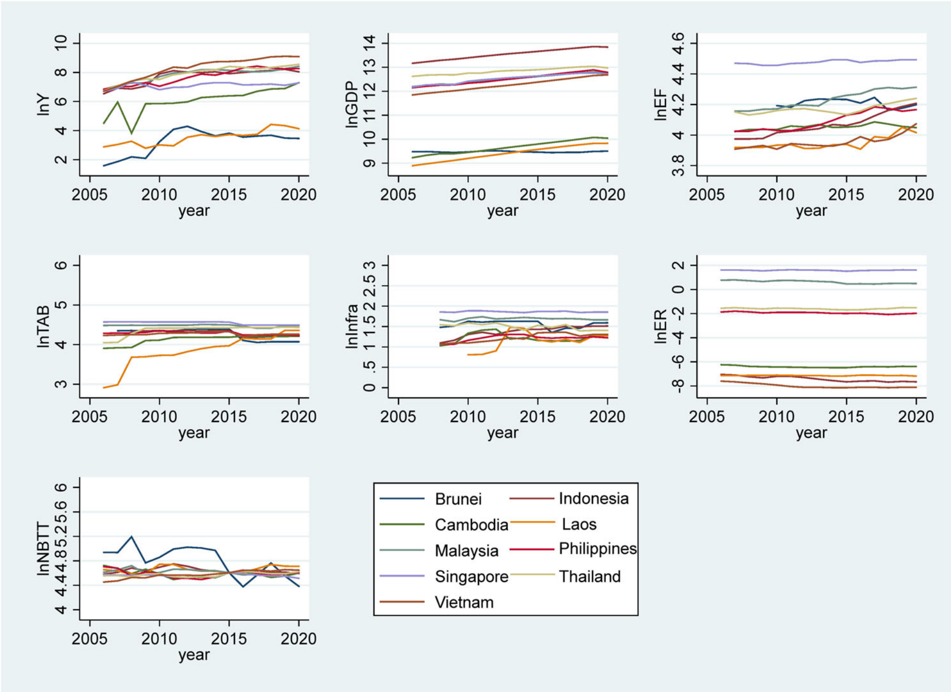

Figure 4. Time series plot of main variables in ASEAN member countries.
Source: Authors' computation using Stata15.0 software.

Table 5. Result of the unit root tests.

	LLC test		IPS test		
Variables	Statistic	*p*-value	Statistic	*p*-value	Unit root (Yes or NO)
lnY	−6.4751	0.0000	−1.1388	0.1274	Y
lnGDP	−5.2017	0.0000	0.2352	0.5930	Y
lnEF	−2.5375	0.0056	1.3833	0.9167	Y
lnTAB	−1.9973	0.0257	−2.0401	0.0207	N
lnInfra	−5.1058	0.0000	−0.6384	0.2616	Y
lnER	−3.5099	0.0002	0.6149	0.7307	Y
lnNBTT	−4.1077	0.0000	0.1701	0.5675	Y
D lnY	−3.9787	0.0000	−2.9479	0.0016	N
D lnGDP	−6.8450	0.0000	−1.8519	0.0320	N
D lnEF	−9.6463	0.0000	−2.2810	0.0113	N
DlnInfra	−8.8643	0.0000	−21.3051	0.0000	N
D lnER	−6.7631	0.0000	−2.1824	0.0145	N
D lnNBTT	−7.8094	0.0000	−1.7535	0.0398	N

Note: D expresses First Difference.
Data source: Authors' computation using Stata15.0 software.

4.2. Multicollinearity test

Multicollinearity refers to the existence of an approximately linear correlation between explanatory variables, which results in the loss of accuracy of model estimates.The Pearson Correlation Coefficient, as shown in Table 6 conforms the hypothesis mentioned above in terms of coefficient direction. There is no high correlation coefficient between variables, indicating that there is no serious multicollinearity problem.

Table 6. Correlation matrix for coefficient estimates.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) lnY	1.000									
(2) lnGDP	0.136	1.000								
(3) lnEF	−0.033	0.232	1.000							
(4) lnDis	−0.235	−0.421	−0.004	1.000						
(5) lnTAB	−0.048	−0.368	0.012	0.396	1.000					
(6) lnInfra	−0.203	−0.061	0.184	0.016	0.053	1.000				
(7) lnER	−0.090	−0.064	−0.039	−0.038	−0.122	0.057	1.000			
(8) lnNBTT	0.162	−0.156	−0.129	−0.063	−0.150	−0.012	0.061	1.000		
(9) Land	0.040	0.248	0.156	−0.274	−0.417	−0.152	0.063	0.054	1.000	
(10)Bor	0.105	0.388	0.122	−0.693	−0.375	−0.006	−0.039	0.066	0.585	1.000

Source: Authors' calculations.
Note: Y, Import scale; GDP, gross domestic product; EF, Economic Freedom; TAB, trade across borders; Infra, infrastructure quality; Dis, distance to China; Land, landlocked country; Bor, borders; ER, exchange rate; NBTT, the net barter terms of trade.

Table 7. Result of the variance inflation factor (VIF) test.

Variable	VIF	1/VIF
lnGDP	1.50	0.667604
lnEF	1.18	0.849298
lnTAB	1.51	0.664002
lnInfra	1.10	0.905100
lnER	1.06	0.945634
lnNBTT	1.10	0.912287
lnDis	2.34	0.427592
Bor	3.00	0.333021
Land	1.91	0.522571
Mean VIF	1.63	

Source: Authors' calculations.

Table 8. The results of F test and LM test.

	Option	Standard	*p*-value	Test result
F test	fixed effects model vs random effects model	0.53	Prob > F = 0.8284	mixed effects model
LM test	mixed effects model vs random effects mode	10.19	Prob > chibar2 = 0.9822	mixed effects model

Source: Authors' calculations.

In this paper, the multicollinearity of the model is further tested by the variance inflation coefficient (VIF). If VIF $\leq$ 10 indicates that there is no serious collinearity between explanatory variables or control variables and other variables, which could not affect or interfere with the accuracy and scientific nature of regression analysis results. Through the variance inflation coefficient test, the VIF of variables in this study is all less than 3, which can be used for regression analysis (Table 7).

4.3. Regression results

To determine the panel data model, this study used F-test to determine the fixed effects model or random effects model. LM test was used to determine the mixed effects model or random effects model, and the Hausman test was used to determine the choice between the random effects model and the fixed effects model. (Table 8)

With the F-test, the null hypothesis was not rejected, so the mixed effects model was chosen between the fixed effects model and the random effects model. Through the LM test, Prob > Chibar2 = 0.9822, the null hypothesis was not rejected, and the

Table 9. Results of the mixed regression analysis.

lnY1	Coef.	St.Err.	t-value	*p*-value	[95% Conf	Interval]	Sig
lnGDP	0.7965128	0.0497179	16.02	0.000	0.698	0.895	***
lnEF	0.3362891	0.8306655	0.40	0.087	−1.316	1.988	*
lnTAB	2.369033	0.5664509	4.18	0.000	1.243	3.495	***
lnInfra	0.0176892	0.5585722	0.03	0.075	−1.093	1.128	*
lnER	−0.1674102	0.0313038	−5.35	0.000	−0.23	−0.105	***
lnNBTT	−0.8828571	0.5580939	−1.58	0.017	−1.993	0.227	**
lnDis	−2.120102	0.5304654	−4.00	0.000	−3.175	−1.065	***
Bor	0.5861954	0.3105644	1.89	0.063	−1.204	0.031	*
Land	−1.531482	0.2761039	−5.55	0.000	−2.081	−0.982	***
_cons	7.080118	5.157945	1.37	0.074	−3.177	17.337	*
Mean dependent var		6.848	SD dependent var		1.873		
Adj R-squared =		0.928	Number of obs		113.000		
F-test		134.693	Prob > F		0.000		
Akaike crit. (AIC)		146.524	Bayesian crit. (BIC)		171.957		

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Source: Authors' calculations.

mixed effect model was finally adopted in the fixed effect model and mixed effect model.

The study adopted a mixed regression model, where the regression analysis of Equation 1 was carried out using STATA 15.0 software. The regression results are shown in Table 9.

The regression analysis results in Table 9 show that the adjusted R^2 was 0.928, indicating that the model's goodness of fit was good. Most of the indicators were in line with expectations. The regression results could reasonably explain the dependent and independent variables. The specific regression analysis results were as follows.

The indicators of trade facilitation played a positive role in promoting the export of Chinese agricultural products to ASEAN countries. However, the influence degree of each index was not the same. The economic freedom index (EF), as a proxy variable of market access and the business operating environment of ASEAN countries, was significantly positive at the confidence level of 10%, indicating that the economic freedom of ASEAN countries had a positive correlation with the scale of China's agricultural exports. For every 1% increase in the economic freedom of ASEAN countries, China's agricultural exports to ASEAN countries increased by 0.336%. The higher the economic freedom index of the ASEAN countries, the larger the market size of China's agricultural products exported to the ASEAN.

The regression analysis shows that trade across borders (TAB) presented a significant positive correlation with China's agricultural exports to the ASEAN market at the confidence level of 1%. This shows that improving the customs clearance efficiency and reducing the clearance costs helped to increase the export scale of agricultural products. The export scale increased by 2.369% when the trade across borders increased by 1%.

The regression results show that infrastructure quality (Infra) had a positive correlation with the export scale. The improvement of infrastructure helped to enhance the scale of China's agricultural exports to the ASEAN market. For every 1% increase in infrastructure score, the export scale increased by 0.017%. In addition, gross domestic product (GDP) played a positive role in promoting the scale of agricultural exports at the confidence level of 10%. Every 1% increase in the GDP of the ASEAN countries led to a 0.796% increase in China's agricultural exports, indicating that the more developed the economy, the stronger the market demand and purchasing ability for Chinese agricultural products.

The exchange rate (ER) level harmed China's agricultural exports at the confidence level of 1%. Every 1% increase in the exchange rate of ASEAN countries decreased the export of Chinese agricultural products by 0.167%. The appreciation of the RMB increased the international price of China's export products and reduced the international competitiveness of the price; therefore, this was not beneficial for China's agricultural exports to ASEAN countries.

The coefficient of the net barter terms of trade (NBTT) was significantly negative at the confidence level of 5%, If the net barter terms of trade (NBTT) of the ASEAN countries raise by 1%, the export decrease by an average of 0.882%. The NBTT factor was contrary to the expected results. The reason why this indicator was inconsistent with the expected direction may be that the agricultural trade between China and ASEAN countries has certain homogeneity and competitiveness. The improvement of the net barter trade terms of ASEAN countries indicates that their products are becoming more competitive in the international market. Therefore, it may restrict China's export of agricultural products to ASEAN countries.

Landlocked country (Land) is negatively correlated to China's agricultural exports to ASEAN countries, and the influence was more significant. For example, at the confidence level of 1%, the influence coefficient reached 1.531%. This shows that landlocked countries were not conducive to expanding China's agricultural exports because of the inconvenient transportation, lack of ports, and high transportation costs of agricultural products.

On the other hand, borders (Bor) showed a positive effect at the confidence level of 10%. The contingency between China and ASEAN countries could reduce transportation costs, reduce the difficulty of export trade, and expand the export scale of agricultural products.

However, the distance (Dis) between the two countries harmed the export of Chinese agricultural products to the ASEAN market. The distance was still an important factor that restricted the export of agricultural products. Each 1% increase in distance will reduce China's agricultural export scale by 2.120%. The farther the distance is, the higher the corresponding transportation cost is, and greater the damage to the transportation of agricultural products, and obstacles to the export of agricultural products. This is also consistent with the conclusion of the classical gravity model.

4.4. Robustness check

To ensure the reliability of the model and avoid the bias of trade facilitation indicators on the empirical results, we adopted the variable substitution method to test the robustness of the model. The World Economic Forum publishes the Global Enabling Trade Report every two years, in which the Enabling Trade Index (ETI) serves as an alternative indicator of trade facilitation. Based on the above model, we introduced ETI as a comprehensive indicator of trade facilitation, replaced the core variables lnEF, lnTAB and lnInfra, and conducted regression, respectively.

Table 10. Results of robustness check.

lnY1	(1) (lnEF,lnTAB,lnInfra)	(2) Replace Variables (ETI)	(3) Add correction coefficients (SI)
lnGDP	0.797***	0.865***	0.329***
	(16.02)	(9.14)	(1.46)
lnEF	0.336*		1.275*
	(0.40)		(0.27)
lnTAB	2.369***		7.199***
	(4.18)		(5.53)
lnInfra	0.0177*		0.0151*
	(0.03)		(1.91)
lnER	−0.167***	−0.137**	−0.0967***
	(−5.35)	(−2.31)	(−1.05)
lnNBTT	−0.883**	−0.0485**	−1.996**
	(−1.58)	(−0.05)	(−0.93)
lnDis	−2.120***	−2.607***	−1.258***
	(−4.00)	(−2.90)	(−0.35)
Bor	0.586*	0.783**	0.997*
	(1.89)	(1.13)	(0.47)
Land	−1.531***	−1.876***	−4.756***
	(−5.55)	(−3.40)	(−2.90)
ETI		2.430**	
		(1.23)	
_cons	7.080*	16.29**	−46.34
	(1.37)	(2.60)	(−1.12)
R^2	0.935	0.935	0.911
adj. R^2	0.928	0.911	0.908

t statistics in parentheses.
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Source: Authors' calculations.

In addition, COVID-19 outbreak comes with a huge shock and structural damage to the global agricultural supply chain. To test the robustness of the regression results under the impact of COVID-19, we introduced the Stringency Index (SI) of the Oxford University Coronavirus Government Response Tracker (OxCGRT) into the regression equation as a new correction coefficients for the global pandemic shock.The comparative analysis results are shown in Table 10.

By comparing the regression analysis results of the three groups, the significance and direction of the replacement variables and adding correction coefficients have not changed significantly. Thus, the model used in this paper is robust.

5. Discussion

At present, scholars generally use a single index of trade facilitation as a core variable for regression analyses. Therefore, the results can only reflect the overall index representing the influence of trade facilitation. However, trade facilitation is a complicated system. The trade facilitation indicators have different internal factors according to different regions, and will have different influence degrees (Ganbaatar et al., 2021). This study confirmed the research results of previous experts and scholars regarding the promotion effect of trade facilitation indicators on agricultural trade (Chahir and Zaki, 2015, Zhang et al., 2019) and clearly distinguished the impact degrees and directions of different elements in trade facilitation on agricultural trade. according to the characteristics of agricultural products in ASEAN countries, trade facilitation indicators were further broken down into economic freedom, trade across borders, and infrastructure quality, which respectively represent the degree of openness, convenience of customs clearance, and infrastructure level of ASEAN countries. These indicators include non-policy indicators that can be quantified as policy and comprehensive indicators. As such, this study made a valuable effort toward studying the selection of agricultural trade indicators.

Results revealed that the trade across borders(TAB) was the most critical factor that affected China's agricultural exports to ASEAN countries. This was followed by the distance(Dis), whether the importing country was landlocked(Land), the net barter terms of trade(NBTT), GDP, whether the importing country was contiguous to China(Bor), Economic Freedom(EF), exchange rate (ER), and the quality of infrastructure(Infra). Among the trade facilitation indicators, economic freedom, trade across borders, and infrastructure quality all played essential roles in promoting China's agricultural exports to ASEAN countries. The results show that the trade across borders had the most prominent influence on China's agricultural exports to ASEAN countries, indicating that the efficiency and cost of customs clearance significantly impacted China's agricultural exports to ASEAN countries. Therefore, the following actions should be taken to improve the frontier distance between China and ASEAN countries: Unify the customs supervision standards, simplify the customs clearance procedures, and improve the transparency of customs supervision and administrative procedures.

Except for dummy variables that can't be changed, the impact factor of Economic Freedom(EF) ranked second, suggesting that the degree of openness to the outside world, market access conditions, and internal business environment of ASEAN countries had a huge impact on China's agricultural exports for enhancing the economic freedom of ASEAN countries. Therefore, policy cooperation to jointly creating a fair and transparent trade environment, and reducing the impact of non-tariff barriers on agricultural trade based on cooperation in the China–ASEAN free trade area should be continuously promoted.

Among the trade facilitation indicators, the level of infrastructure had a positive effect on China's agricultural exports. However, its influence was relatively weak, indicating that the infrastructure level was not the most critical constraint on China's agricultural exports to ASEAN countries. For agricultural trade, China and the ASEAN should increase their investment in transportation technology for the cold-chain Logistics and establish more logistics parks to promote a comprehensive regional transportation infrastructure through the assistance and support of capital, technology, personnel, and materials.

This study improved the statistical accuracy of research into the trade of agricultural products by removing the sections that did not belong to the scope of agricultural products in the HS code. However, there are still some non-agricultural products at the subitem level of the HS code. Since the agricultural products we considered covered 34 sections, there were a large number of items and subitems included. Accordingly, the workload to delete the non-agricultural products would be enormous. Nevertheless, the scale of the non-agricultural products accounted for a tiny proportion of the whole. Therefore, this study summed the values of each product category to obtain the total amount of agricultural products imported from China by each country. There is still a degree of error in agricultural statistics from a scientific rigor point of view. With more efficient statistical methods and databases, this problem could be solved in the future.

In 2018, the Global Competitiveness Report adjusted its methodology to measure infrastructure quality from 10 to 100 points (Schwab, 2019). The infrastructure in 2018 and 2019 was summarized and averaged according to the railway, highway, waterway, and aviation scores. Although there is a certain connection and continuity in the data, there is still a lack of accuracy. As ASEAN countries are generally small and have topographies that involve various mountains and rivers, this is not conducive to construct railway and road facilities. Hence, the overall level of infrastructure is relatively low. China currently exports agricultural products to ASEAN countries mainly by sea and petty trade in the border areas, with some transport using inland rivers, such as the Mekong River. Therefore, if more refined proxy indicators can be introduced according to the characteristics of agricultural trade varieties and transportation modes of target countries, more accurate infrastructure impact factors could be obtained. This problem will be studied in the future to produce optimized methods.

Due to the possibility of multicollinearity, the population index and agricultural added value index were excluded from our model. Due to the large population of ASEAN countries, agricultural product structure has both homogeneity and difference from China. Hence, the direction and degree of influence of these indicators on China's agricultural exports remain to be further studied.

6. Conclusions

Based on the classical gravity model in international trade research, this study introduced trade facilitation proxy indicators such as economic freedom, trade across borders, and infrastructure quality as the core explanatory variables. Statistics were studied, and a mixed model regression analysis was carried out regarding the scale of China's agricultural exports to ASEAN countries. Trade facilitation was found to play a positive role in promoting the export of Chinese agricultural products to ASEAN countries. The trade across borders was the most important influencing factor, indicating that promoting China's agricultural exports to ASEAN countries requires both sides to strengthen their customs clearance cooperation and simplify the customs clearance process according to the characteristics of agricultural products. Further, non-tariff barriers should be reduced and upgrading the establishment of animal and plant quarantine and food safety cooperation information network is required. The impact of Economic freedom was second only to the trade across borders indicating that both sides need to increase their investment and trade liberalization cooperation continuously. China and ASEAN should speed up the development of FTA 3.0, promote cooperation in the digital economy and green economy, industrial cooperation, and upgradation of the FTA. The quality of the infrastructure positively affected China's agricultural exports to ASEAN countries, but the influence was relatively weak. China and ASEAN countries could strengthen their infrastructural cooperation in terms of the cold chain transportation of agricultural products, cross-border logistics parks, and inland river transportation. Continue to promote the construction of the New International Land-Sea Trade Corridor, give full play to the role of the China-Laos railway in agricultural trade, and further shorten the transport time for China's agricultural exports.

Among the control variables, the landlocked, net barter terms of trade, distance, and exchange rate factors were found to have decreasing impacts on China's agricultural exports to ASEAN countries in decreasing order of importance.

As a very important agricultural trade partner of China, there are still few studies on the impact of trade facilitation of ASEAN countries on agricultural trade, but they are also very valuable. In the background of the pandemic and the Russia-Ukraine conflict, due to the short period and relatively little data, the long-term impact and assessment of trade facilitation need to be further tracked and studied. Together, the variable structure and heterogeneity of China's agricultural exports to ASEAN countries are also issues that are worthy of further research and consideration.

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Data availability statement

The data used to support the findings of this study are included within the article.

Disclosure statement

The authors declare that they have no competing interest.

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