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Study on the Potential of China's Fruit and Vegetable Products Export to the RCEP Partners

XIE Guo-e,WU Jia-meng
East China University of Science and Technology, Shanghai, China

China is one of the world's major exporters of fruit and vegetable products, and the expansion of fruit and vegetable exports is important for increasing agricultural income. Based on time-varying stochastic frontier gravity model and trade inefficiency model, this paper empirically analyzes the influencing factors and trade efficiency of China's fruit and vegetable products export to RCEP partners from 2001 to 2019. The results show that China's GDP per capita, the population of importing countries, and common language conditions have positive effects on China's fruit and vegetable products export to RCEP partners. GDP per capita of importing countries, the population of China, and geographical distance between trading parties hinder trade in fruit and vegetable products. The presence of trade inefficiencies constrains China's fruit and vegetable products export to RCEP partners, with liner shipping connectivity and trade freedom having a positive relationship with export efficiency of fruit and vegetable products. Variable trade costs and fixed trade costs have a negative relationship with export efficiency of fruit and vegetable products, which hinder trade in fruit and vegetable products,while financial freedom and free trade agreements have no significant impact on export efficiency of fruit and vegetable products.

Keywords: RCEP, China's fruit and vegetable products export, trade potential, stochastic frontier gravity model

Introduction

In November 2001, the Doha Round initiated by the World Trade Organization (WTO) reached an impasse due to the huge differences in the agricultural trade negotiations. In order to promote foreign trade and sustain economic growth, many countries changed their mindset and took different approaches. Looking at regional economic cooperation, they accelerated the negotiation of bilateral and regional free trade agreements. On November 15, 2012, Asia-Pacific countries signed the Regional Comprehensive Economic Partnership (RCEP), the world's biggest trade pact. The agreement involves all 10 member countries of the ASEAN and five of its major trading partners—China, Japan, South Korea, Australia, and New Zealand. From China's perspective, it is a new opportunity and platform for close cooperation between China and East Asian countries, which will help the deeper development of China's trade relations with RCEP partners (Zhuang,L. Li, & R. L. Li, 2014). On 15 November 2020, 15 countries, excluding India, finally signed RCEP after 31 rounds of negotiations. The agreement officially came into force on 1 January 2022. So far, the 15 RCEP member

XIE, Guo-e,Ph.D.,AssociateProfessor,Department of Economics, School of Business, East China University of Science and Technology, Shanghai, China.
WU Jia-meng, Graduate Student,Department of Economics, School of Business, East China University of Science and Technology,Shanghai, China.

countries have a total population of 2.278 billion, accounting for 29.38% of the world. The GDP is US $24.05 trillion, accounting for 29.37% of the world. It is a free trade area agreement with the most populous, largest, and most promising in the world. Since this year, member countries will gradually implement all the commitments and obligations of the RCEP agreement, and the immediate zero tariff on a significant proportion of goods will bring greater trade opportunities to member parties.

For the RCEP member countries, agricultural trade has been a significant part of their trade. It's also a challenge and concern throughout the negotiation process. After the signing of RCEP agreement, the tariff reduction of agricultural products made a breakthrough. More than half of the member countries will achieve zero tariff on more than 90% of their agricultural products. For the first time, China and Japan have reached a tariff concession arrangement for agricultural products. Japan will cancel tariffs on more than 60% and China will cancel tariffs on more than 80% of agricultural products. In terms of trade facilitation, to improve customs clearance efficiency, member countries will follow more efficient rules, such as requiring customs to release perishable products within six hours, which will greatly improve the efficiency of customs clearance for fresh produce. The achievements of the RCEP are of great significance to the expansion of fruit and vegetable trade between member countries. China is one of the world's leading exporters of fruit and vegetable products, with total exports of fruit and vegetable maintaining an overall growth trend, rising from US$2.181 billion in 2001 to US$16.557 billion in 2019, an increase of 659%. Among them, other RCEP member countries are the main export destinations of China's fruit and vegetable products. The research of Liu and Zhao (2017) shows that in China's agricultural trade with RCEP partners, only fruits and vegetables and aquatic animal products have a comparative advantage. In recent years, China's total vegetable exports have shown a significant upward trend, gradually taking a place in the international market, and are now one of the key industries in the field of international trade (Ai, 2020). At the same time, China is also a major fruit country in the world based on realistic factors such as the history of cultivation of fruits, the variety, and production of fruits (Yan, 2019). China's export prospects for fruit and vegetable products are good. Many studies analyze the international competitiveness of China's fruit and vegetable exports based on a comprehensive index. The results all indicate that China's foreign trade in fruit and vegetables is growing strongly and has great potential for development (Ren, Li, Zhang, & Kang, 2017; Qiao, 2019; Balerjiang & Buwa, 2019). What factors influence China's fruit and vegetable products export? How about the potential of China's fruit and vegetable products export to RCEP partners? In order to take advantage of the various preferential trade arrangements under the RCEP agreement and expand China's trade in fruit and vegetable products with the RCEP partners, we need to consider these questions. It will help us propose some measures to enhance China's fruit and vegetable products export to the RCEP partners.

While the RCEP has attracted widespread attention, there have been an increasing number of studies on the related area. Chen and Ni(2014) have measured the trade effects of RCEP by constructing a GTAP model. The results show that RCEP has a significant positive impact on member countries. India's imports and exports have increased significantly; China's exports have increased to a certain extent, while Japan, Australia, and South Korea have significant room in imports. Lu and Li(2018) have also used the GTAP model to simulate the impact of the RCEP coming into effect on the economic development of major countries within and outside the region. They found that the RCEP agreement coming into effect can bring different degrees of economic growth to all member countries. Huang (2019) measured the agricultural trade potential between China and

Japan by constructing a traditional trade gravity model in the context of assuming the signing of the RCEP and concluded that the RCEP would be beneficial to the development of China-Japan agricultural trade.

Overall, most of the current studies on the trade of RCEP member countries focus on the potential impact of RCEP on the overall trade of member countries, with very few studies on the impact on a particular type of product. Studies on China's fruit and vegetable products export focus on their international competitiveness. No studies have yet focused on China's fruit and vegetable products export to the RCEP partners. The methods are mostly simple statistical data analysis, lacking sufficient examination of influencing factors and further exploration of export potential. Therefore, this paper will investigate this issue and construct a stochastic frontier gravity model to empirically analyze the influencing factors of China's fruit and vegetable products to the RCEP partners and measure their export efficiency and export potential, so as to provide reference for the government or enterprises to take measures to further expand exports of fruit and vegetable products to the RCEP partners.

Facts About China's Fruit and Vegetable Products Export

RCEP Partners Become the Core Market of China's Fruit and Vegetable Export

China's fruit and vegetable products export to the RCEP partners rose from US$1.434 billion to US$9.992 billion from 2001 to 2019, maintaining a stable growth trend overall. Based on an average annual share perspective, Japan occupies about 33.96% of the market, ranking first, with Vietnam and Malaysia in second and third place respectively, accounting for 15.72% and 11.03%. ASEAN as a whole occupies a larger share of 55.39%, while Brunei holds only 0.06% of the market share. In 2001, China's fruit and vegetable products export to ASEAN amounted to US$274 billion, occupying 19.13% of China's fruit and vegetable products export to the RCEP partners. In 2019, China's fruit and vegetable products export to ASEAN increased to US$7.897 billion and the share grew to 78.97%.

In recent years, the share of China's fruit and vegetable products export to the RCEP partners has remained at a relatively stable level. As shown in Table 1, the share was 65.77% in 2001 and 60.40% in 2019, basically stable at 50%-60%. Most of the RCEP members are developing countries and their industrial and economic development is at a low level overall, so China's fruit and vegetable products have certain relatively comparative advantages. In addition, the short transport distance is conducive to reducing trade costs and transport expenses. It helps increase China's fruit and vegetable products export to the RCEP partners. At present, RCEP partners have become the core region of China's export of fruit and vegetable products. The bilateral trade in fruit and vegetable products has great potential after the signing of the RCEP agreement.

Table 1

China's Exports of Fruit and Vegetable Products to the RCEP Partners and the World

Year	China's fruit and vegetable products export to RCEP partners (USD billion)	China's fruit and vegetable products total export to the world (USD billion)	The former versus the latter (%)
2001	14.34	21.81	65.75%
2003	14.55	24.38	59.68%
2003	16.78	29.31	57.25%
2004	20.31	34.54	58.80%
2005	22.78	41.19	55.29%
2006	26.35	49.99	52.72%

Table 1 to be continued

2007	27.26	56.75	48.03%
2008	29.98	63.26	47.39%
2009	36.54	72.32	50.52%
2010	55.13	101.57	54.27%
2011	67.45	119.11	56.63%
2012	60.04	106.77	56.23%
2013	68.97	120.43	57.27%
2014	72.92	125.45	58.13%
2015	85.19	142.37	59.84%
2016	89.45	160.41	55.76%
2017	91.84	165.05	55.65%
2018	92.97	158.03	58.83%
2019	100.00	165.57	60.40%
Average annual growth rate	12.06%	12.43%	-

Source: UN Comtrade.

Analysis on the Export Competitiveness of China's Fruit and Vegetable Products

In order to analyze the export potential of China's fruit and vegetable products to the RCEP partners, we need to first investigate their international competitiveness. Based on the total exports of fruit and vegetable products over the years, this paper selects the world's major fruit and vegetable exporters—the United States, Spain, Mexico, and the Netherlands, for comparison with China. Here we use RCA index to show the international competitiveness of fruit and vegetable products. The formula is as follows.

$$RCA_{ij} = \frac{X_{ij}/X_{it}}{X_{wj}/X_{wt}} \quad (1)$$

whereRCA_{ij}denotes a country's fruit and vegetable industrythatrevealed comparative advantage index, X_{ij}/X_{it} denotes a country's exports of fruit and vegetable products as a proportion of that country's total exports, and X_{wj}/X_{wt} denotes total world exports of fruit and vegetable products as a proportion of total world exports.

Table 2

Fruits and Vegetables RCA Indices for China and the World's Major Exporters, 2001-2019

Country / Year	China		USA		Spain		Mexico		Netherlands	
	Fruit	Vegetable	Fruit	Vegetable	Fruit	Vegetable	Fruit	Vegetable	Fruit	Vegetable
2001	0.34	1.80	1.17	0.70	6.16	6.49	1.03	4.03	1.06	3.49
2003	0.34	1.33	1.31	0.75	6.52	6.54	1.27	4.23	1.28	4.25
2005	0.29	1.25	1.50	0.84	5.90	6.95	1.45	4.53	1.48	3.78
2007	0.30	1.02	1.42	0.80	5.72	6.12	1.69	4.03	1.58	3.95
2009	0.36	1.01	1.48	0.81	5.52	6.22	1.73	4.03	1.53	3.45
2011	0.35	1.33	1.65	0.77	5.46	5.38	1.60	4.13	1.71	3.79
2013	0.36	1.01	1.75	0.79	5.55	5.88	1.70	4.02	1.77	3.89
2015	0.36	0.98	1.53	0.72	5.22	5.37	1.94	3.66	1.63	3.72
2017	0.35	1.18	1.43	0.74	4.53	5.27	2.40	3.93	1.76	3.39
2019	0.37	1.06	1.35	0.73	4.32	5.62	2.39	4.15	1.79	3.60

Source: TradeMap.

Table 2 shows that in terms of fruits, Spain's RCA indices have always remained above 2.5, which is extremely competitive, but have slightly decreased in recent years. The RCA indices of the United States, Mexico, and the Netherlands are basically stable above 1.25, indicating strong competitiveness. While China's RCA indices of fruits fluctuate in the range of 0.3 to 0.4, which does not have a competitive advantage. Regarding vegetables, the RCA indices of Spain, Mexico, and the Netherlands are all greater than 2.5 in all years, with significant competitive advantages. China's RCA indices of vegetables are basically greater than 1, indicating strong international competitiveness. RCA value of the United States is below 1, which means having no competitive advantage. It shows that, compared with other major fruit and vegetable exporting countries, China's vegetables have a certain competitive advantage, but the international competitiveness of fruits is weaker.

Table 3

RCA Index for Fruits and Vegetables in China and Other Major RCEP Exporters, 2001-2019

Country / Year	China		Thailand		Vietnam		Australia	
	Fruit	Vegetable	Fruit	Vegetable	Fruit	Vegetable	Fruit	Vegetable
2001	0.34	1.80	0.66	1.60	5.41	1.62	1.04	1.75
2003	0.34	1.33	0.59	1.33	3.40	1.27	1.04	0.96
2005	0.29	1.25	0.60	1.46	4.05	1.13	0.94	0.95
2007	0.30	1.02	0.61	1.58	3.50	1.58	0.77	0.84
2009	0.36	1.01	0.66	1.41	3.35	1.73	0.70	0.90
2011	0.35	1.33	0.91	1.61	3.70	1.67	0.43	1.06
2013	0.36	1.01	0.90	1.97	2.93	1.14	0.75	1.12
2015	0.36	0.98	1.01	2.10	3.21	0.88	1.16	1.92
2017	0.35	1.18	1.47	1.41	4.28	0.69	0.95	2.57
2019	0.37	1.06	2.25	0.91	3.17	0.35	1.02	0.86

Source: TradeMap.

Meanwhile, in order to compare the international competitiveness of China's fruit and vegetable products with those of other RCEP countries, Thailand, Vietnam, and Australia were selected based on the total annual exports of fruit and vegetables. Table 3 shows that among the RCEP countries, China has some competitive advantage in vegetables in recent years but the advantage is less stable, while in fruits China has no competitive advantage. Vietnam and Thailand have a clear competitive advantage, and Australia has a more balanced competitiveness in fruits and vegetables.

Theoretical Analysis

Analysis on Influencing Factors Based on the Traditional Gravity Model

Tinbergen (1962) was the first to use gravity model to analyze international trade flows. He intuitively concluded that the trade volume between the two countries is directly proportional to their per capita GDP, but inversely proportional to the geographical distance. After that, scholars continued to revise and add the population to the model. As a result, the core factors affecting international trade flows generally contain GDP, total population, and geographical distance between the two countries (Bergstrand, 1989; Simon & Keller, 2002).

The scale of China's fruit and vegetable products exports to the RCEP partners is also influenced by the above objective factors. According to the existing literature, the impact of population size on international trade is uncertain, which may be positive or negative(Deardorff, 1995). On the one hand, the increase of the total population indicates the expansion of the labor force, which is conducive to the production of more fruit and vegetable products, but on the other hand, it also represents the increase of the domestic demand for fruit and vegetable products, thereby reducing the export volume of fruit and vegetable products. The steady expansion of GDP as a proxy for the size of the economy means that the country's level of economic development is progressing. As an exporter, the increase of China's economy represents an increase in the potential supply of fruit and vegetable products. As importers, the increase of the economies of the RCEP partners represents an increase in the potential demand for fruit and vegetable products. So the increase of both the GDP of China and the importing countries is beneficial to China's fruit and vegetable exports. The greater the transport distance, the higher the cost and longer the time spent on transporting the fruit and vegetable products, which is detrimental to the export of fruit and vegetable products. So the geographical distance between countries has a negative effect on the export of Chinese fruit and vegetable products.

Analysis on Influencing Factors Based on Stochastic Frontier Gravity Model

The efficiency of China's fruit and vegetable products export to the RCEP partners is also affected by other trade inefficiency factors. In addition to the traditional model, this paper specially considers the characteristics of fruit and vegetable products, and adds the influence of liner transportation connectivity, port efficiency, and customs environment, trade freedom, and financial freedom, bilateral free trade agreements, variable trade costs, and fixed trade costs. Fruit and vegetable products need to be kept fresh due to their perishability, so the impact of liner shipping connectivity, port efficiency, and customs environment needs to be considered in particular. According to a report published by UNCTAD 2020, Asian countries are among the global leaders in maritime trade. As most of the RCEP member countries are coastal and located in the Asia Pacific region, improving liner shipping connectivity will help China's fruit and vegetable products reach their destinations quickly, thereby promoting exports to the RCEP partners. The optimization of customs procedures and the improvement of logistics and transport efficiency at ports, as well as the improvement of the business environment at ports, will significantly shorten the time and improve the efficiency of customs clearance. For goods such as fruits and vegetables, which require freshness and are time-sensitive, it will be particularly beneficial and undoubtedly boost their exports. Trade freedom indicates the extent to which a country is constrained in foreign trade by tariff and non-tariff barriers. The higher the value, the more open the trade, and the smoother the trade between countries. With the signing of the RCEP agreement, the elimination or substantial reduction of tariffs between member countries will further increase the freedom of trade, which is very beneficial to the export of fruits and vegetables. Financial freedom indicates the level of financial development and perfection of financial markets in the importing country, with higher values representing smoother financial flows and efficient financial services in the importing country. Therefore, to a certain extent, financial freedom can also promote the export efficiency of fruit and vegetable products. According to the theory of regional economic integration, the signing of free trade agreements between countries is conducive to lowering trade barriers and reducing trade frictions. Most of the RCEP partners, except Japan, have signed bilateral free trade agreements with China, therefore, the signing of the RCEP agreement will significantly promote the export efficiency of Chinese fruit and vegetable products to Japan. Variable trade costs and fixed

trade costs represent the costs in the process of China's export of fruit and vegetable products. The higher the cost, the less conducive to the export of fruit and vegetable products. Therefore, they are factors that hinder trade efficiency (see Figure 1).

In addition, after the signing of the RCEP agreement, Article 13 of Chapter II of the agreement on trade in goods is about the elimination of agricultural export subsidies (Chinese agricultural products are rarely subsidized and this provision will make China's agricultural products more competitive). Article 17, regarding the general elimination of quantitative restrictions and the implementation of rules of origin where the value of origin of goods can be accumulated in the region,is very conducive to the expansion of intra-regional trade and the export of Chinese fruit and vegetable products to the RCEP partners.

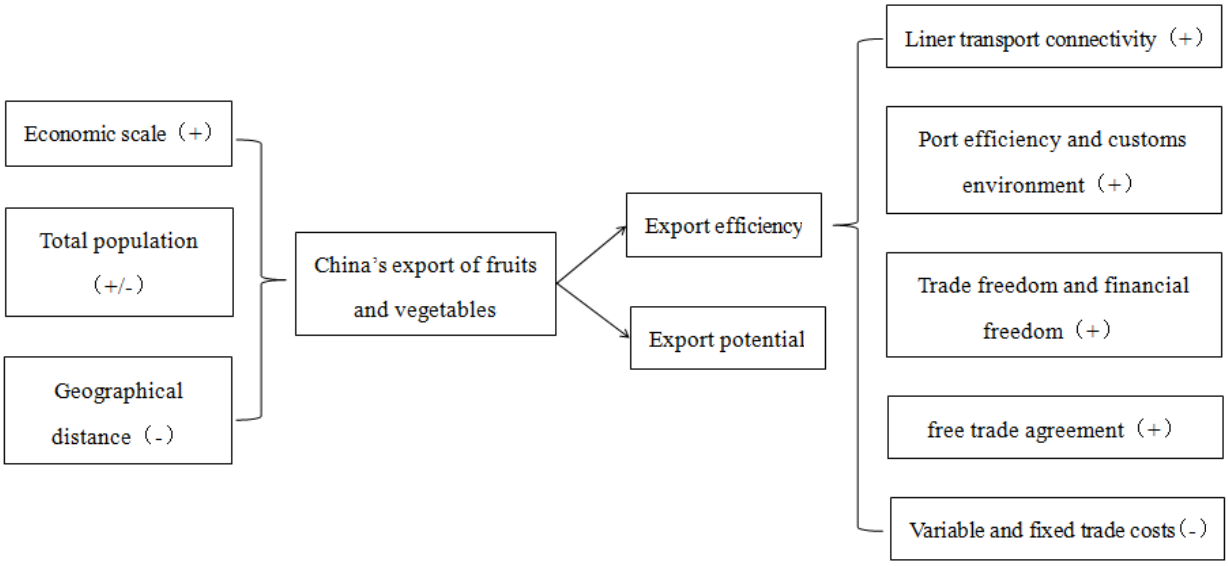

*Figure 1.*Theoretical analysis on China's export of fruit and vegetable products to the RCEP partners, Source: collated by the author.

Empirical Analysis

Model Setting and Selection of Variables

Setting the time-varying stochastic frontier gravity model. The stochastic frontier gravity model proposed by Aigner, Lovell, andSchmidt (1977) and the trade inefficiency model proposed by Battese and Coelli (1995) are commonly used in the field of international trade to measure export potential and export efficiency. So it is the basis for constructing an empirical model of China's fruit and vegetable products export to the RCEP partners.

Armstrong (2007) points out that objective variables are mainly considered in the stochastic frontier gravity model, while artificial variables are considered in the inefficiency model. Therefore, this paper constructs a stochastic frontier gravity model.

$$\ln T_{ijt} = \beta_0 + \beta_1 \ln PGDP_{it} + \beta_2 \ln PGDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln D_{ij} + \beta_6 Z_{ij} + v_{ijt} - u_{ijt} \quad (9)$$

where i is China, j is the RCEP partner, t is the year and T_{ijt} is the actual export value of China's fruit and vegetable products to country j. $PGDP_{it}$, $PGDP_{jt}$ represent the GDP per capita of China and the importing country, respectively, in constant 2010 dollars. POP_{it}, POP_{jt} represent the total population of China and the

importing country, respectively. D_{ij} is the transportation distance; Z_{ij} is other natural factors, such as borders, common language, etc. v_{ijt} is the random error term and $u_{ijt}$is the trade inefficiency term.

Setting the trade inefficiency model. In order to further explore the influencing factors of trade inefficiency, combining the existing research results of scholars at home and abroad, as well as considering the availability of data and the fact that fruit and vegetable products are agricultural products, this paper selects the main factors affecting the export of Chinese fruit and vegetable products to establish a trade inefficiency model for analysis, and the model is expressed as follows:

$$u_{ijt} = \alpha_0 + \alpha_1 \ln\ SHP_{jt} + \alpha_2 \ln\ PC_{jt} + \alpha_3 \ln\ CE_{jt} + \alpha_4 \ln\ TRA_{jt} + \alpha_5 \ln\ FIN_{jt} + \alpha_6 FTA_{jt} + \alpha_7 \ln\ VTC_{jt} + \alpha_8 \ln\ FTC_{jt} + \omega_{jt} \quad (10)$$

Among them, the specific explanations are as follows.

Table 4

Definition of Trade Inefficiency Model Variables

Variables	Definition	Explanation	Expectation
SHP_{jt}	Liner transport connectivity index	It represents the maritime transport capacity of importing countries. Maritime transport is crucial in foreign trade of fruit and vegetable products, based on the fact that most of the RCEP member countries are coastal countries.	Negative correlation with trade inefficiency
PC_{jt}	Port efficiency	It is closely related to transport costs, expressed in terms of the volume of goods transported at seaports and airports.	Negative correlation with trade inefficiency
CE_{jt}	Customs environment	The customs environment affects the efficiency of customs clearance and trade costs, as measured by hidden trade barriers, customs clearance efficiency, and cleanliness.	Negative correlation with trade inefficiency
TRA_{jt}	Trade freedom	It represents a country's exposure to tariff and non-tariff barriers in the area of foreign trade.	Negative correlation with trade inefficiency
FIN_{jt}	Financial freedom	It reflects the level of financial sector development and efficiency of financial markets in the importing country.	Negative correlation with trade inefficiency
FTA_{jt}	Free trade agreement	Dummy variable. The signing of a free trade agreement between the two parties can promote economic integration and thus lay the foundation for the elimination of trade barriers.	Negative correlation with trade inefficiency
VTC_{jt}	Variable trade costs	Fruits and vegetables are fresh agricultural products and heavily influenced by transportation costs (Peng & Zhou, 2021), expressed as the spherical distance between China and the main cities of each of the countries along the route according to latitude and longitude (Kancs, 2007).错误!未找到引用源。	Positively correlated with trade inefficiency
FTC_{jt}	Fixed trade costs	It represents the degree of openness of the importing country's economy, expressed as the ratio of the Index of Economic Freedom of the importing country to the Index of Economic Freedom of China (Qian& Xiong, 2010).	Positively correlated with trade inefficiency

Source: collated by the author.

Sample Selection and Data Source

This paper selects the panel data of China's exports to the 10 ASEAN countries, Japan, South Korea, Australia, and New Zealand from 2001 to 2019 as the research sample. Due to the serious lack of data in Laos, it is excluded. Use FRONTIER4.1 for empirical analysis.

The data of T_{ijt} are from the United Nations trade database, $PGDP_{it}$, $PGDP_{jt}$, POP_{it}, POP_{jt}, SHP_{jt}, $PC_{jt}$are from the world bank database. D_{ij}, VTC_{jt} are from the CEPII database. TRA_{jt}, FIN_{jt}, FTC_{jt} are collated by the index of economic freedom. $FTA_{jt}$is from the China free trade area service network. $CE_{jt}$is from the global competitiveness report and the world bank database.

Empirical Process and Result Analysis

Model applicability test. In order to ensure the applicability and validity of the stochastic frontier gravity model, this paper needs to determine the form of the model through a likelihood ratio test. The results of the likelihood ratio test are shown in Table 5.

Table 5

Likelihood Ratio Test Results

Original hypothesis	Constrained model	Unconstrained model	LR statistic	1% critical value	Conclusion
No trade inefficiency	-285.498	-245.391	80.214	9.210	Rejected
Trade inefficiency is non-time-varying	-321.332	-285.498	71.668	9.210	Rejected
No linguistic variables are introduced	-245.391	-211.734	67.314	18.475	Rejected
No boundary variables are introduced	-245.391	-237.557	15.668	18.475	Not rejected

Based on the results of the hypothesis test, the trade inefficiency term exists and this paper can build a stochastic frontier gravity model to study it. The trade efficiency of China's fruit and vegetable export to the RCEP partners from 2001 to 2019 will change over time. The boundary variables do not have a significant impact on the study of the trade efficiency of fruit and vegetable product exports and therefore should be excluded. Reject "No introduction of language variables", i.e. China's fruit and vegetable export trade should take language into account, which will have some impact on the results.

The revised model is:

$$\ln T_{ijt} = \beta_0 + \beta_1 \ln PGDP_{it} + \beta_2 \ln PGDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln D_{ij} + \beta_6 Lang_{ij} + v_{ijt} - u_{ijt} \quad (11)$$

Regression analysis of the stochastic frontier gravity model. After determining the model based on the results of the likelihood ratio test, the regression estimation was conducted using the stochastic frontier gravity model. The results are shown in Table 6.

Table 6

Regression Results of the Stochastic Frontier Gravity Model

Variables	Time-invariant model		Time-variant model	
	Coefficient	*z*-value	Coefficient	*z*-value
$\ln PGDP_{it}$	2.889*	1.938	3.043**	2.461
$\ln PGDP_{jt}$	0.736***	15.310	-0.336***	2.672
$\ln POP_{it}$	-25.036	-1.035	-2.466*	-1.694
$\ln POP_{jt}$	1.225***	27.357	1.058***	9.338
$\ln D_{ij}$	-0.592***	-4.997	-0.929***	-2.643
$Lang_{ij}$	1.678***	9.181	1.305***	4.318
σ^2	1.919*	1.655	6.449**	1.987
γ	0.78^{0}***	10.488	0.933***	25.225
η	-	-	0.073***	3.445
Log likelihood	-346.233	-265.738		
LR test	145.226		160.991	

Note. *, **, *** denote 10%, 5%, and 1% significance levels respectively.

Comparing the results of the time-varying model and the time-invariant model, the signs of the coefficients of the variables remain largely consistent, indicating the robustness of the time-varying stochastic frontier gravity model.γ denotes the share of trade inefficiencies in the random error term and its value is 0.933. It has passed the 1% significance test, indicating that the gap between China's actual and potential maximum of fruit and vegetable products export to the RCEP partners is basically due to the existence of trade inefficiencies. Therefore, the stochastic frontier model is feasible and necessary. In addition, the parametersη in the time-varying model are significantly positive, indicating that the inefficiency term changes over time, which is consistent with the test results.

China's GDP per capita ($PGDP_{it}$) passed the 1% significance test with a positive coefficient, indicating that the increase in China's economic development is beneficial to the production and supply of fruit and vegetable products. So it has a positive impact on China's fruit and vegetable products export to the RCEP partners. The GDP per capita of the importing country ($PGDP_{jt}$) passed the 1% significance test, but the coefficient was negative. As the level of economic development of the importing country increases, the income of its people has increased to a certain extent. So the demand for fruit and vegetable products has been upgraded, and it is more inclined to import from countries with high quality of fruit and vegetable products. The negative coefficient for China's population (POP_{it}) was mainly due to the increase in China's population, which led to an expansion in domestic demand for fruit and vegetable products, thus negatively affecting exports of fruit and vegetable products. The population coefficient of the importing country (POP_{jt}) was positive. As the population of the importing country increases, the consumption of fruit and vegetable products is also increasing. So the import scale of China's fruit and vegetable products is expanding. Distance (D_{ij}) passed the 5% significance test with a negative coefficient. As most fruit and vegetable products are perishable and vulnerable, the longer the distance, the higher the transport requirements and costs, thus affecting trade in fruit and vegetable products. The positive coefficient for common language ($Lang_{ij}$) passed the 1% significance test, meaning that having a common language between countries has a positive effect on trade in fruit and vegetable products. Countries that share a common language can communicate more easily and thus have an advantage and initiative in trade.

Regression analysis of the trade inefficiency model. The regression results of the trade inefficiency model in Table 7 show that the liner shipping connectivity index (SHP_{jt}) was significantly negative at the 1% level, i.e. it had a positive effect on trade efficiency, indicating that the improvement of maritime transport capacity and efficiency is beneficial to China's fruit and vegetable products export. Improving the maritime transport system is crucial to China's fruit and vegetable products export. Port efficiency (PC_{jt}) was significantly and negatively related to trade inefficiency. The efficiency of ports is related to the most basic transportation issue of exporting fruit and vegetable products. High efficiency of ports will effectively reduce transportation costs, which in turn will contribute to the increase of trade volume of China's fruit and vegetable products export. Customs environment (CE_{jt}) had a negative coefficient and passed the 1% significance test. It has an impact on customs clearance efficiency and trade costs, so a better customs environment is more conducive to China's fruit and vegetable products export. Trade freedom (TRA_{jt}) had a positive impact on trade efficiency and passed the 5% significance test, indicating that a more open trade environment in the RCEP partners is conducive to trade efficiency and has a positive impact on China's fruit and vegetable products export. The coefficient of financial freedom (FIN_{jt}) was significantly negative, indicating that the opening of the financial market and the improvement of the efficiency of the financial system are beneficial to

China's fruit and vegetable products export. However, the *t*-value was too small and didn't pass the significance test, indicating that the promotion effect on the export of Chinese fruit and vegetable products is not significant. The coefficient of free trade agreement (FTA_{jt}) had a positive effect on trade efficiency but didn't pass the significance test, probably among the RCEP partners, excluding Japan, all have signed bilateral free trade agreements with China, so the effect on China's of fruit and vegetable products export is not significant. Variable trade costs (VTC_{jt}) and fixed trade costs (FTC_{jt}) were significantly positively related to trade inefficiency and passed the significance test. As fresh agricultural products, the export of fruits and vegetables is more affected by transport costs and therefore has a dampening effect on the increase in trade volume of China's fruit and vegetable exports.

Table 7

Regression Results of the Trade Inefficiency Model

Time-varying stochastic frontier gravity model			Trade inefficiency model		
Variables	Coefficient	*z*-value	Variables	Coefficient	*z*-value
ln $PGDP_{it}$	1.385***	5.456	SHP_{jt}	-0.138***	-4.285
ln $PGDP_{jt}$	-0.163***	-2.515	$PC_{\cdot jt}$	-1.024***	-6.335
ln POP_{it}	-2.812***	-23.107	CE_{jt}	-0.127***	-3.651
ln POP_{jt}	1.239***	9.687	TRA_{jt}	-0.076**	-2.215
ln D_{ij}	-0.098***	-8.665	FIN_{jt}	-0.113	-0.563
$Lang_{ij}$	4.186***	15.237	FTA_{jt}	-0.248	-0.998
σ^2	0.896***	5.334	VTC_{jt}	0.071***	4.683
γ	0.974***	3.744	FTC_{jt}	0.742**	2.244
Log likelihood	-230.893		LR test	254.137	

*Note.***, *** denote 5%, and 1% significance levels respectively.

Analysis of Export Potential

The efficiency value of China's fruit and vegetable products export to the RCEP partners can be obtained through the empirical results, and then the export potential of China's fruit and vegetable products can be calculated by substituting the existing actual export value of fruit and vegetable products into Equation (4).

Table 8

Efficiency and Potential of China's Fruit and Vegetable Products Export to the RCEP Partners in 2019

	Export efficiency	Actual export value (USD billion)	Export potential (USD billion)
Malaysia	0.887	10.928	12.325
Indonesia	0.125	11.960	95.974
Philippines	0.094	4.555	48.393
Thailand	0.774	14.195	18.332
Vietnam	0.934	32.861	35.171
Myanmar	0.104	2.591	24.913
Cambodia	0.056	0.034	0.620
Singapore	0.925	1.713	1.851
Brunei	0.323	0.056	0.173
Japan	0.871	14.184	16.283
Korea	0.832	5.646	6.784
Australia	0.713	0.982	1.376
New Zealand	0.558	0.219	0.393

Among the 10 ASEAN countries, Thailand and Vietnam have high domestic production of fruit and vegetable products and are moreover the world's leading exporters of fruit and vegetable products. Their export efficiency has reached a high level and therefore their export potential is relatively low (see Table 8). China's fruit and vegetable products export to Indonesia, Cambodia, the Philippines, and Myanmar may be due to factors such as economic size, national development, quality of infrastructure, and institutions, resulting in export inefficiencies and therefore the potential to export on a larger scale relative to itself. Upon closer inspection, it can also be noted that the size of export potential is not only influenced by the level of export efficiency, but also related to the size of demand in the importing country. For example, although China's export efficiency to Japan, Thailand, and Vietnam has reached a high level overall, they still have a large export potential due to the size of their imports.

Robustness Tests

To ensure the reliability of the empirical results, this paper draws on the study of Li and Yang (2019) to introduce a lagged first order of the liner shipping index in the trade inefficiency model to conduct robustness tests on it.

Table 9

Regression Analysis Results of Robustness Test

Time-varying stochastic frontier gravity model			Trade inefficiency model		
Variables	Coefficient	*z*-value	Variables	Coefficient	*z*-value
ln $PGDP_{it}$	2.974***	2.920	$SHP_{jt\_}1$	-0.028***	-2.911
ln $PGDP_{jt}$	-0.046***	-8.004	PC_{jt}	-0.431***	-7.870
ln POP_{it}	-26.579***	-30.470	CE_{jt}	-0.112***	-6.353
ln POP_{jt}	0.890***	3.107	TRA_{jt}	-0.019***	-9.224
ln D_{ij}	-0.960***	-3.401	FIN_{jt}	-0.054	-0.536
$Lang_{ij}$	1.145***	11.686	FTA_{jt}	-0.519	-0.474
σ^2	1.325***	9.290	VTC_{jt}	3.741***	4.741
γ	0.968***	3.591	FTC_{jt}	0.599***	4.940
Log likelihood	-222.546		LR test	247.295	

*Note.**** denote 1% significance levels.

By comparing the regression results in Table 7 with those in Table 9, it can be seen that the signs of the variables in the model remain consistent. Excluding financial freedom and free trade agreements, the regression results for the remaining variables are significant. Therefore, the empirical results of this paper are robust and the research findings are reliable.

Conclusions and Policy Implications

Through the above analysis, this paper draws the following conclusions: China's fruit and vegetable products export to the RCEP partners are affected by economic size, population size, and geographical distance. Their export efficiency is also affected by factors such as liner transportation connectivity, port efficiency, and customs environment, trade freedom and financial freedom, bilateral free trade agreements, and variable trade costs, and fixed trade costs. The RCEP agreement on tariff concessions, elimination of agricultural export subsidies, removal of quantitative restrictions, and implementation of regional accumulation rules of origin value will further promote China's fruit and vegetable products export to the RCEP partners. The empirical

results based on the stochastic frontier gravity model illustrate that China's GDP per capita, the population size of the importing country, and the common language condition have a facilitating effect on China's fruit and vegetable products export to the RCEP partners. The GDP per capita of the importing country, the size of China's population, and the geographical distance between the two trading parties are detrimental to trade in fruit and vegetable products. The empirical results based on the trade inefficiency model show that liner shipping connectivity, trade freedom, and export efficiency of fruit and vegetable products are positively correlated and all promote trade in fruit and vegetable products. Variable trade costs and fixed trade costs are negatively correlated with export efficiency of fruit and vegetable products, which hinder trade in fruit and vegetable products. Financial freedom has no significant effect on export efficiency. According to the results of the trade efficiency and trade potential measurements, China's fruit and vegetable products export to the RCEP partners have greater development prospects, with great potential for exports to Indonesia and the Philippines.

The above findings have the following policy implications. First, strengthen the research and publicity on the RCEP agreement and related policies. Fruit and vegetable producers and trading enterprises can understand the significance of the RCEP agreement for themselves and make better use of the various preferential measures under the agreement to further promote exports to the RCEP partners. Secondly, improve the transport and maritime transport systems. China should further improve its transport network with the RCEP partners on the basis of improving domestic transport conditions. Besides, accelerate the construction of maritime transport networks with member countries to improve the efficiency of maritime transport to ocean-going countries, such as Australia and New Zealand. Thirdly, improve the quality of port support facilities to enhance the efficiency of logistics and transportation. In international trade, ports are the essential link between import and export, and are the collection and storage centers for goods, playing an important supporting role for trade. Based on the reality that the RCEP agreement is constantly advancing, China should join the rest of the RCEP partners to improve the quality of port facilities and improve the efficiency of logistics, which is of great significance for fruit and vegetable products that need to be preserved. Fourthly, strengthen the customs environment. The purpose of building the customs environment is to speed up the efficiency of customs clearance of goods. As fruits and vegetables are perishable and vulnerable products, fast and efficient customs clearance will help reduce the risk of detention and the cost of customs clearance for fruits and vegetables, and speed up the flow of trade. At the same time, it will reduce the burden of trade procedures, reduce customs clearance formalities, and thus eliminate extraneous costs, and improve trade efficiency. Fifthly, it is important to enhance trade freedom and economic freedom. China should strive to create an open and free trade environment, strengthen communication with member countries, understand the differences between different national systems, and be accommodating. And improve economic freedom to reduce transaction costs associated with export trade in fruit and vegetable products, thereby improving trade efficiency.

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