Research on Agricultural Trade Potential between Hebei Province and RCEP Member Countries under the Background of Rural Revitalization——Based on the Time-varying Stochastic Frontier Gravity Model

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Abstract. Based on the data of agricultural trade between Hebei Province and RCEP member states from 2011 to 2021, this paper explores the main influencing factors of agricultural trade between Hebei Province and RCEP member states based on time-varying stochastic frontier gravity model and trade inefficiency model, and further calculates trade efficiency. In view of the above research, the paper makes relevant recommendations.

Keywords: agricultural trade; Hebei Province; RCEP; time-varying stochastic frontier gravity model; rural revitalization

1 Introduction

With the signing of more bilateral or multilateral free trade negotiation agreements around the world, the world economy has once again come to a crossroads, with the eight-year-old Regional Comprehensive Economic Partnership (RCEP) officially signed in November 2020, since the world's largest free trade area was established. In the context of economic globalization and rising trade protectionism, the agreement has protected the stable operation of agricultural trade while dealing with the uncertainty of the international environment. In the process of signing and promoting the RCEP, China itself has frequent agricultural trade exchanges with RCEP member countries, and Hebei province has a special position in China's agricultural trade, and it is also an important content of China's agricultural trade with RCEP.

The "Rural Revitalization Strategic Plan (2018-2022)" proposes to "build a new pattern of agricultural opening to the outside world and establish a sound agricultural trade policy system", which requires us to effectively implement the rural revitalization strategy into practice to promote high-level agricultural products [1]opening to the outside world. At the same time, it also shows that Hebei Province and RCEP member countries have ushered in new opportunities for agricultural trade.

[1] Agricultural products refer to all agricultural products under HS code Chapter 01-24, among which 01-05 refers to animal products, 06-15 refers to fruit and vegetable products, and 16-24 refers to food processing products.

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2 Model setting and data explanation

2.1 Theoretical model

The model used in this paper is the stochastic frontier gravity model. Tinbergen (1962) [1] and Poyhonen (1963) [2] were the first to apply the trade gravity model to the research in the field of international trade. However, the traditional trade gravity model included the unobobserved part in the error term, which caused the estimation of trade efficiency to be biased. Therefore, the stochastic frontier analysis method was introduced into the model. Aigner (1977) [3] and Meeusen (1977) [4] constantly improve the stochastic frontier analysis method in the analysis of technical efficiency in the production function. After introducing this idea, the traditional error term can be decomposed into trade inefficiency term and random error term, which are specifically expressed as follows:

$$T_{ijt} = f(X_{ijt}, \beta)\, exp(v_{ijt})\, exp(-\mu_{ijt}), \mu_{ijt} \geq 0 \tag{1}$$

Taking the logarithm of both sides, we get:

$$ln\, T_{ijt} = ln\, f\,(X_{ijt}, \beta) + v_{ijt} - \mu_{ijt}, \mu_{ijt} \geq 0 \tag{2}$$

Among them, T_{ijt} is the actual trade volume between country i and country j in the period t, which is the main factor affecting the actual trade volume, $\beta$is the parameter to be estimated, v_{ijt} is the random disturbance term, subject to the standard normal distribution with the mean of 0 and the variance of σ^2, μ_{ijt} is the trade non-efficiency term, which is generally considered to be subject to the semi-normal distribution, and is independent of v_{ijt}.When μ_{ijt} is zero, the expression of the stochastic frontier gravity model is as follows:

$$T'_{ijt} = f(X_{ijt}, \beta)\, exp(v_{ijt}) \tag{3}$$

Among them, T'_{ijt} stands for trade potential, which refers to the potential trade volume reached between the two sides in the absence of trade resistance. Thus, the formula for calculating trade efficiency is obtained:

$$TE_{ijt} = {}^{T_{ijt}}\!/_{T'_{ijt}} = exp(-\mu_{ijt}), TE_{ijt} \in (0,1) \tag{4}$$

Among them, TE_{ijt} is the trade efficiency, which can be used to analyze the trade potential of both sides. When the data belongs to intertemporal panel data, the original technical inefficiency term is no longer realistic if it does not change with time. In order to accurately measure the trade inefficiency, time-varying factors are introduced into the stochastic frontier gravity model, and the expression is as follows:

$$\mu_{ijt} = \{exp[-\eta(t - T)]\}\mu_{ij} \tag{5}$$

η represents parameters to be estimated among them. $\eta < 0$ means that the trade non-efficiency item increases with time; μ_{ijt} follows a truncated normal distribution with mean μ and variance σ^2.

In this paper, we choose the one-step method proposed by Battese and Coelli(1992)[5] produced more rigorous analytical results. The basic form of a one-step expression is:

$$\mu_{ijt} = \alpha Z_{ijt} + \varepsilon_{ijt} \tag{6}$$

Among them, α is the parameter to be estimated, Z_{ijt} is the main factor affecting the trade inefficiency, and ε_{ijt} is the random error term, which follows the standard normal distribution with mean 0 and variance σ^2.Then, according to the "one-step method", bring formula (6) into formula (2), and get the following new expression:

$$ln\, T_{ijt} = ln\, f\left(X_{ijt}, \beta\right) + v_{ijt} - \left(\alpha Z_{ijt} + \varepsilon_{ijt}\right) \tag{7}$$

2.2 Model setting and variable selection

The traditional gravity model only includes economic scale and geographical distance. Later, the gravity model was expanded. Linnemann (1966) [6] included population scale in the model to measure the market size of import and export countries. Bergstrand (1985) [7] introduced the dummy variable of whether the two sides have a common language into the model and believed that having a common language could improve trade efficiency. Armstrong (2007) [8] divided the influencing factors into two types: natural factors and human factors. Factors that would not change in the short term, such as economic scale, distance and language, were classified as natural factors and used as core variables to explain the model, while human factors were used as factors affecting trade inefficiencies. The stochastic frontier gravity model is set as follows:

$$\begin{aligned} ln\, T_{ijt} = {} & \beta_0 + \beta_1\, ln\, P\, GDP_{it} + \beta_2\, ln\, P\, GDP_{jt} + \beta_3\, ln\, P\, OP_{it} + \beta_4\, ln\, P\, OP_{jt} \\ & + \beta_5\, ln\, D\, IS_{ijt} + \beta_6 \ln GAP_{ijt} + \beta_7 COMLAN_{ij} + \beta_8 RRS + v_{ijt} - \mu_{ijt} \end{aligned} \tag{8}$$

Among them, T_{ijt} is the explained variable, indicating the actual total trade volume of agricultural products between Hebei Province and RCEP member states during the period t; $ln\, P\, GDP_{it}$ and $ln\, P\, GDP_{jt}$ respectively represent the real GDP per capita of Hebei Province and the 12 RCEP member states during the t period (in 2015 constant US dollars), which is used to measure the economic size of the economy and is generally considered to have a positive impact on trade. The data came from Hebei Statistical Yearbook, Foreign trade database and WDI database; $ln\, P\, OP_{it}$ and $ln\, P\, OP_{jt}$ respectively represent the respective population sizes of Hebei Province and RCEP member states during the t period, which are used to measure market demand and generally promote trade. The data were obtained from Hebei Statistical Yearbook and WDI database; $ln\, D\, IS_{ij}$ indicates the distance between Hebei Province and the respective capitals of RCEP member countries, which measures the transportation cost of agricultural products in trade. The farther the distance, the higher the cost of trade and the more unfavorable to trade. The data from Google Maps; $ln\, G\, AP_{ijt}$ represents the absolute value of the per capita GDP difference between Hebei Province and RCEP member countries during the period t. Linde theory holds that the smaller the economic development gap between the two countries, the greater the possibility of trade; $COMLAN_{ij}$ indicates whether the two sides of the trade have a common language. Having the same language can improve the convenience of trade and promote the development of trade. Data from French CEPII database.

In order to further explore the factors affecting trade inefficiency in agricultural trade between Hebei Province and RCEP member countries, a trade inefficiency model is established through the "one-step method", and the expression is as follows:

$$\mu_{ijt} = \alpha_0 + \alpha_1 ATF_{jt} + \alpha_2 GE_{jt} + \alpha_3 PS_{jt} + \alpha_4 MF_{jt} + \alpha_5 TF_{jt} + \alpha_6 FF_{jt} + \alpha_7 RRS_{ijt} + \alpha_8 FTA_{ijt} + \varepsilon_{ijt} \quad (9)$$

Among them, ATF_{jt} represents the air traffic volume, which is an indicator to measure the level of national transport infrastructure. The better the infrastructure, the more conducive to bilateral trade. The data comes from WDI database. GE_{jt} and PS_{jt} respectively represent the government efficiency and political stability of the trading partner country. The higher the government efficiency and political stability of the trading partner country, the more conducive to the development of bilateral trade. Data are derived from the WGI database. MF_{jt}, TF_{jt}, and FF_{jt} respectively represent the monetary, trade, and financial freedom of trading partners and measure the social and economic system. The index ranges from 0 to 100. The higher the score is, the more complete the social and economic system is. RRS_{ijt} is a dummy variable, indicating whether there is effective support of the rural revitalization strategy in bilateral trade. The implementation of the rural revitalization strategy is conducive to the foreign trade of Hebei Province to a certain extent, and the data are collected by the Rural Revitalization Strategic Plan (2018-2022). FTA_{ijt} is a dummy variable, indicating whether China has signed free trade agreements with its trading partners. Relevant studies show that signing FTAs is conducive to trade between the two sides. Data are collected from the website of the Ministry of Commerce of China.

3 Empirical analysis and results discussion

3.1 Result analysis of stochastic frontier gravity model

In this paper, two tests are set by using the likelihood ratio test method. One is the existence test of trade non-efficiency items; The second is whether the non-efficiency items of trade are time-varying. Table 1 shows the results of the applicability test: at the significance level of 5%, the null hypothesis that there are no trade inefficiencies is rejected.At the same time, the original hypothesis that the trade inefficiency does not change with time is rejected.

Table 1 Results of hypothesis testing of stochastic frontier gravity model.

Null hypothesis	Constraint model	Unconstrained model	LR	5% critical value	conclusion
Trade inefficiencies do not exist	-136.77	-107.24	59.06	7.05	reject
Trade inefficiencies do not change over time	-110.95	-107.24	7.42	5.14	reject

As can be seen from Table 2, the value is 0.84, which passes the significance level test of 1%, indicating that there is a large gap between the actual trade volume and the potential trade volume, and most of the gap between the two is caused by the non-efficiency factors of trade in the random disturbance term. The value is 0.07 and passes the test at the significance level of 1%, indicating that the agricultural trade efficiency of Hebei Province and RCEP member countries increases with the passage of time, which further proves the accuracy of adopting the time-varying trade inefficiency model.

From the regression results of the main explanatory variables of the model(Table 2): (1) $ln\ P\ GDP_{it}$ and $ln\ P\ GDP_{jt}$ are positive and passes the test at the significance level of 1%, indicating that with the expansion of economic scale of both sides, agricultural development has been promoted to a certain extent, agricultural input has increased, and various aspects of production technology, factors and other aspects have been improved, and agricultural output has increased. It is conducive to bilateral trade in agricultural products. (2) $ln\ P\ OP_{it}$ and $ln\ P\ OP_{jt}$ pass the test at the significance level of 1%, but the coefficient of the former is negative, indicating that the larger the population size of Hebei Province, to a certain extent, can provide labor resources for the production of agricultural products, thus greatly reducing foreign exports; The population size coefficient of RCEP member countries is positive, indicating that the larger the population size, the larger the market size, the greater the demand for agricultural products. (3) $\ln DIS_{ij}$ coefficient is negative, but does not pass the significance test, indicating that the increase of distance will increase the transportation cost of trade. However, through the above analysis, it is found that the agricultural products of Hebei Province are mainly exported to Japan and ASEAN, while the export level to Australia and New Zealand, which are far away, is very low. (4) $\ln GAP_{ijt}$ coefficient is 0.05, which passes the test at the significance level of 5%, indicating that it has a small promotion effect on trade exchanges, and does not conform to the Linde demand theory. This paper holds that to some extent, this theory cannot fully explain the demand preferences of agricultural trade between developing countries and developed countries, so it cannot significantly affect the bilateral agricultural trade [9]. (5) $COMLAN_{ij}$passes the test at the significance level of 1%, and the coefficient is positive, indicating that having a common language can promote bilateral trade.

Table 2 Estimation results of time-varying stochastic frontier gravity model.

variable	coefficient	T-value
Constant term	300.26	277.28
$\ln P GDP_{it}$	3.39^{***}	9.42
$\ln P GDP_{jt}$	1.08^{***}	10.10
$\ln P OP_{it}$	-78.33^{***}	-84.09
$\ln P OP_{jt}$	1.40^{***}	9.70
$\ln D IS_{ij}$	-0.03	-0.38
$\ln G AP_{ijt}$	0.05	1.72
$COMLAN_{ij}$	0.84^{***}	3.27
σ^2	1.47	1.55
γ	0.84	7.01
η	0.07	3.20
LogLikehood	-107.97	
LR test	65.02	

Note：***indicates passing the test at 1% significance level

3.2 Analysis of trade inefficiency model results

In this paper, "one-step method" is adopted to estimate the trade inefficiency model and further explore the factors affecting the trade inefficiency. Table 3 shows the estimated results: (1) The coefficient of ATF_{jt} is negative and passes the test at the significance level of 1%,

indicating that the improvement of the transportation infrastructure of RCEP member states will reduce the losses during the transportation of agricultural products, thus promoting bilateral trade and improving trade efficiency. (2)The coefficient of GE_{jt} is negative and passes the test at the significance level of 1%, indicating that when the government efficiency of RCEP member countries is improved, the trade flow between the two sides is more concise, saving trade time and cost, and improving trade efficiency. The coefficient of PS_{jt} passed the significance level test of 1%, but the coefficient is not consistent with expectations. According to the original data released by WGI, the stability score of the government of the Philippines, Thailand and other countries is negative, and the regime is less stable than other countries, which will increase the resistance of bilateral trade to a certain extent, which is not conducive to trade exchanges. (3) MF_{jt} passes the test at the significance level of 5%, and the coefficient is positive, which may be because the increase of monetary freedom will stimulate the economic development of RCEP member countries to a certain extent, expand the internal demand for agricultural products, and thus reduce foreign exports; Neither FF_{jt} nor TF_{jt} passed the significance test, possibly because: according to the index data of financial freedom, the scores of individual countries such as Myanmar are extremely low, which is not conducive to the development of bilateral trade. Meanwhile, with the signing of various free trade agreements, most countries and regions will be less affected by the fluctuations of these index data. (4) The coefficient of RRS_{ijt} is negative and passes the test at the significance level of 10%, indicating that the achievements of rural revitalization have become more and more significant, which has powerfully changed the rural landscape, promoted the agricultural development of Hebei Province, pushed the opening up of agricultural products to a higher level, and improved trade efficiency. (5) The coefficient of FTA_{ijt} is negative and has passed the significance level test of 1%. The signing of trade agreement can minimize the impact of restrictions caused by some trade barriers, reduce trade inefficiency and promote more trade exchanges.

Table 3 Trade inefficiency model estimation results.

Stochastic frontier gravity model			Trade inefficiency model		
variable	coefficient	T-value	variable	coefficient	T-value
Constant term	300.88	309.12	Constant term	-4.95	-2.01
$ln\,P\,GDP_{it}$	3.46***	17.28	ATF_{jt}	-0.04***	-2.84
$ln\,P\,GDP_{jt}$	0.88***	13.36	GE_{jt}	-3.51***	-6.38
$ln\,P\,OP_{it}$	-77.32***	-143.15	PS_{jt}	1.86***	3.85
$ln\,P\,OP_{jt}$	1.19***	23.44	MF_{jt}	0.09**	2.52
$ln\,D\,IS_{ij}$	-0.24***	-7.28	TF_{jt}	0.01	0.29
$ln\,G\,AP_{ij}$	0.03	1.12	FF_{jt}	0.02	1.37
$COMLAN_{ij}$	0.73***	9.42	RRS_{ijt}	-0.37*	-1.79
			FTA_{ijt}	-3.39***	-3.99
			σ^2	1.13***	8.15
			γ	0.97***	108.22
			$LogLikehood$	-65.09	
			$LR\ test$	150.79	

Note：***, ** and *indicate passing the test at a significance level of 1%, 5% and 10% respectively

3.3 Measurement and potential analysis of trade efficiency

Based on the trade inefficiency model established by "one-step method", (Figure 1)it shows the changes of agricultural trade efficiency between Hebei Province and RCEP member states and between Hebei Province and ASEAN, Japan, South Korea, Australia and New Zealand respectively from 2011 to 2021. From 2011 to 2021, the overall bilateral trade efficiency of agricultural products between Hebei Province and RCEP member countries showed a slow upward trend, rising from 0.62 in 2011 to 0.66 in 2021. The low trade efficiency means that there is a large trade potential. It can be seen that there is a large agricultural trade potential between Hebei Province and RCEP member states. The differences of economic development level, geographical location and resource endowment make the efficiency of agricultural products trade between different countries vary. ASEAN is the largest trading partner of Hebei Province, and the change of agricultural trade efficiency is roughly the same as the overall situation of RCEP member countries, while Japan is slightly higher than that of RCEP member countries. The maximum value is no more than 0.8, and Australia's agricultural trade efficiency is the lowest, no more than 0.5, but it reached 0.93 in 2014. New Zealand's agricultural trade efficiency is not stable, but the overall trend is still upward. Meanwhile, the total trade volume of the two countries is also low, due to the distance, agricultural trade structure and other reasons. Making the agricultural products trade with Hebei Province inefficient and unstable; South Korea's agricultural trade efficiency is the highest, the average level is above 0.9, indicating that the bilateral trade volume of agricultural products with Hebei Province is close to the frontier level.

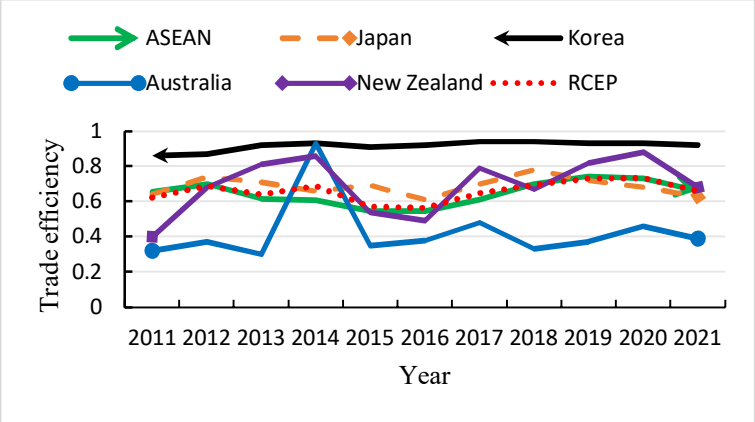

Figure 1 Trade efficiency of agricultural products between Hebei Province and RCEP by country from 2011 to 2021.

4 Conclusions

First, in the time-varying stochastic frontier gravity model, the economic scale of Hebei Province and RCEP member states, the population of RCEP member states, and whether there is a common language have a significant positive impact on agricultural trade, while the population size of Hebei Province has a significant negative impact on agricultural trade. Second, in the trade inefficiency model, air transport (ATF_{jt}), government efficiency (GE_{jt}),

rural revitalization strategy (RRS_{ijt}) and free trade agreement (FTA_{ijt}) can improve the trade efficiency of agricultural products between Hebei Province and RCEP member countries, while government stability (PS_{jt}) and monetary freedom (MF_{jt}) will hinder the improvement of trade efficiency, which is not conducive to bilateral trade.

5 Suggestions

In order to improve the efficiency of agricultural trade between Hebei Province and RCEP member countries, the following suggestions are put forward: First, promote the upgrading of free trade zones and improve the social and economic system for agricultural trade. Second, strengthen the construction of relevant port infrastructure in China and improve the air transport capacity of Hebei Province. Third, we should implement professional management according to local conditions. Fourth, we need to effectively align the rural revitalization strategy with the RCEP.

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