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Does Agricultural Product Trade Promote the Green Development of China's Agriculture?—Based on the Perspective of Agricultural Green Total Factor Productivity

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Abstract: Agricultural green total factor productivity plays an important role in the path of agricultural greening and modernization, it is conducive to the realization of high-quality agricultural development. In order to explore the relationship between agricultural product trade and agricultural green total factor productivity, the SBM-ML index method was chosen to use MaxDEA software to measure the agricultural green total factor productivity of each province from 2006 to 2020. Empirical results show that agricultural product trade can effectively promote agricultural green total factor productivity and promote the process of agricultural greening; it improves agricultural green total factor productivity through agricultural technology progress. Therefore, agricultural product trade can effectively improve agricultural green total factor productivity, and all provinces must promote the sustainable and healthy development of agricultural product trade. The government can formulate relevant agricultural product trade policies based on its trade development status and economic development level according to local conditions.

1. Introduction

China's agricultural trade has grown rapidly, and has rapidly transformed from small-scale exports to earn foreign exchange at the beginning of its accession to "large imports and large exports" (Li Xiaolong et al., 2018)[1]. As imports and exports continue to maintain double growth, China's total agricultural product trade continues to expand. In 2021, China's agricultural product import and export volume was US$304.17 billion, an increase of approximately 10 times compared to 2001. Specifically, the growth rate of imports is faster than the growth rate of exports. From 2001 to 2021, the export volume increased from US$16.07 billion to US$84.354 billion, and the import volume increased from US$11.83 billion to US$219.814 billion. The rapidly increasing import volume is mainly in agricultural products. Labor-intensive products and finished products are the main types of China's agricultural exports. Compared with exports, China imports a larger amount of agricultural products. Most of the imported products are land-, technology- and capital-intensive products and their finished products that are relatively disadvantaged in production. The largest imports are soybeans, cotton, pigs and cattle mutton.

The long-term extensive management of China's agriculture has also created some problems. First of all, there is an imbalance problem in the development process of agriculture, which has not formed sustainable development; secondly, consumers are more interested in green and safe agricultural products, but the current market supply of such products is insufficient. In order to effectively alleviate ecological and economic pressures, changing the production structure is an important measure. On this basis, promoting green agricultural development is one of the main ways to solve the dilemma of agricultural production and consumption (GaoYang,et al. 2018)[2]. China's economy has now shifted to a stage of high-quality development, and improving total factor productivity is in line with the connotation of high-quality development. Agricultural green total factor productivity can objectively reflect the level and sustainability of agricultural green development. Agricultural product trade plays a decisive role in optimizing the supply structure of agricultural products and improving the supply capacity and quality benefits of agricultural products. It can effectively promote agricultural modernization and green agricultural development. Therefore, exploring the relationship between agricultural product trade and agricultural green total factor productivity can promote the development of green agriculture, and continue to promote agricultural and rural modernization.

At present, there are relatively abundant studies on agricultural green total factor productivity. Based on existing research results, this paper first uses MaxDEA software and SBM-ML index method to measure China's agricultural green total factor productivity, and builds a system GMM model and a dynamic panel threshold model for empirical testing. Compared with the existing literature, this article has three innovations. Firstly, in the agricultural green total factor productivity measurement system, most previous scholars chose one of the two indicators of agricultural non-point source pollution and agricultural carbon emissions as undesirable output. This paper combines the current situation of China's agricultural development to calculate both indicators as undesired outputs, which is more in line with the current agricultural production environment and agricultural low-carbon production requirements; secondly, a heterogeneity test is conducted to divide 30 provinces into three parts. Then this paper decomposed agricultural green total factor productivity into two channels to test the heterogeneity of influencing channels; finally, the regional economic development level is used as a threshold variable to explore the threshold effect of agricultural product trade on agricultural green total factor productivity.

2. Theoretical analysis and research hypotheses

Grossman and Kruger proposed the trade environment effect in 1992. According to the trade environment effect, agricultural product trade will affect the quality of the agricultural environment and agricultural green development, and it is an important influencing factor of agricultural green total factor productivity. From the perspective of scale effect, the expansion of agricultural trade volume will have a negative impact on domestic resource consumption and environmental pollution (Kuang Yuanpei et al., 2011)[3], and it will have a negative effect on the green development of agriculture. But on the other hand, agricultural product import trade will bring about scientific and technological progress to increase agricultural green total factor productivity. While China has become a major agricultural product trade country in the world, it has also become a major agricultural product trade deficit country (Liang Jun et al., 2018)[4]. Therefore, from the perspective of scale effects, the deficit in agricultural product trade will promote the green development of agriculture. From the perspective of structural effects, the green barriers encountered by agricultural products in the export process will force agricultural producers to adjust agricultural production methods and improve agricultural green production efficiency. From the perspective of technical effects, trade can play a certain role in promoting the flow of resources, information sharing, technology dissemination, etc., and can promote the sharing of advanced technologies through technological spillovers. The import trade of agricultural products will promote the development of agricultural economy and push agricultural technology.

This article proposes hypothesis 1: Agricultural product trade can effectively promote green agricultural development and have a positive impact on agricultural green total factor productivity.

The improvement of trade liberalization will lead to a reduction in the cost of foreign agricultural products entering the country. The advanced breeding methods and marketing concepts attached to imported agricultural products will have technological spillover effects on developing countries (Shang Jie et al., 2019)[5]. In addition, accelerating the development of agricultural products in various regions the speed of information among countries can also reduce market information costs. It can encourage countries to carry out technological innovation to enhance product competitiveness. Solow proposed the analysis method of Solow residual and total factor productivity in 1957 and applied it to the neoclassical growth model. This theory shows that technological progress is the main factor affecting total factor productivity. Therefore, trade openness can promote Technological progress will enhance total factor productivity.

This article proposes hypothesis 2: Agricultural product trade promotes agricultural green total factor productivity growth through technological progress.

3. Analysis of agricultural green total factor productivity measurement results

3.1 Research methods

The ML index method based on the SBM model can simultaneously incorporate multiple inputs and multiple outputs to measure agricultural green total factor productivity. It can reflect the structural and systematic nature of traditional total factor productivity technology and also well reflect the inclusion of environmental pollution. The SBM model is based on slack variables, which was proposed by Tone in 2001[6]. The specific expression form of the model is as follows:

$$\overset{*}{\rho}=\min\frac{1-\frac{1}{M}\sum_{m=1}^{M}\frac{S_m^x}{x_{m0}}}{1+\frac{1}{S_1+S_2}\left(\sum_{r=1}^{S_1}\frac{s_r^g}{y_{r0}^g}+\sum_{k=1}^{S_2}\frac{S_k^b}{b_{k0}^b}\right)}$$

$$s.t.\sum_{j=1}^{J}\lambda_i^t Y_{rj}^t - S_r^g = y_{rj}^t, r=1,\cdots,S_1;\sum_{j=1}^{J}\lambda_j^t X_{mj}^t + S_k^b = b_{bj}^t, k=1,\cdots,S_2;$$

$$\sum_{j=1}^{J}\lambda_j^t X_{mj}^t + S_m^x = x_{mj}^t, m=1,\cdots,M;\sum_{j=1}^{J}\lambda_j^t=1,\lambda_j^t\ge 0, j=1,\cdots,J$$

$$S_k^b\ge 0, S_r^g\ge 0, S_m^x\ge 0, j=1,\cdots,J \tag{1}$$

4. Model construction and variable selection

4.1 Model construction: dynamic panel model.

Considering that changes in economic conditions will be affected by past behavioral patterns, agricultural green total factor productivity in the current period will also be affected by the previous period, and there will be a certain degree of inertia. Based on this, this paper constructs a dynamic panel model to empirically test the relationship between agricultural product trade and agricultural green total factor productivity. It introduces a lag period of agricultural green total factor productivity and selects the system generalized moment model (GMM model) to analyze agricultural product trade. This paper establishes the following dynamic panel regression model:

$$gtfp_{it} = \beta_0 + \beta_1 gtfp_{it-1} + \beta_2 trade_{it} + \sum \beta x_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

In this model, $gtfp_{it-1}$ is the lagged one-period term of agricultural green total factor productivity and $trade_{it}$ represents the core explanatory variable; i represents each region; t represents the year; x represents control variables; μ_i and λ_t respectively are province and year effects; ε_{it} represent random error terms.

4.2 Variable selection

The explained variable. The agricultural green total factor productivity measured by selecting the corresponding input and output indicators is the explained variable in this article. Drawing on existing research practices (Li Gucheng et al., 2014)[7], the chain index of agricultural green total factor productivity was changed to a year-on-year growth index with 2006 as 1.

Core explanatory variables. As the core explanatory variable of this article, the level of agricultural product trade is measured by the total amount of agricultural product trade and processed logarithmically. The agricultural product trade volume of each province in this article comes from the agricultural product trade volume statistical table released by the Ministry of Commerce.

Control variables. Based on the existing literature and the actual situation of China's agricultural development, this article selects fiscal agricultural expenditure, agricultural technology investment, rural human capital level, and agricultural disaster rate as control variables.

4.3 Data source

This article selects the remaining 30 provinces in the country for research. The relevant indicator data for measuring the agricultural green total factor productivity of each province come from the statistical yearbooks of each province from 2006 to 2020. The data of agricultural product trade volume come from the "Agricultural Products" published by the official website of the Ministry of Commerce. Import and export trade volume statistical table"; the control variables are derived from the statistical yearbooks of each province. The descriptive statistics of all variables are shown in Table 1 below.

Table 1: Descriptive statistical table of each variable

variable	symbol	sample size	mean	standard deviation	minimum	maximum
agricultural green total factor productivity	gtfp	420	1.169	0.211	0.628	2.677
agricultural green technology efficiency	gec	420	1.004	0.188	0.398	2.596
agricultural green technology progress	gtc	420	1.182	0.221	0.756	2.708
agricultural trade	trade	420	4.844	1.715	-0.741	7.872
export trade	exp	420	4.097	1.413	-0.741	7.133
import trade	imp	420	3.719	2.597	-8.791	7.498
fiscal support	gov	420	0.111	0.032	0.028	0.203
technological input	ino	420	9.788	0.759	7.769	10.950
rural human capital	edu	420	7.749	0.604	5.945	9.837
agricultural disaster rate	dis	420	0.190	0.147	0.000	0.706

5. Analysis of empirical results

5.1 GMM regression analysis

This paper uses a dynamic panel model to test the relationship between agricultural trade and agricultural green total factor productivity, and the model regression results are shown in model (1) in Table 2. In addition, export trade and import trade are tested, which are model (2) and model (3) respectively.

Table 2: Regression results of GMM model

variable	(1)	(2)	(3)
trade	0.0431*** (5.07)		
exp		0.0303*** (3.63)	
imp			0.0264*** (5.77)
gov	-1.653*** (-6.56)	-1.898*** (-7.53)	-1.882* (-6.74)
ino	-0.221*** (-8.18)	-0.243*** (-15.17)	-0.240*** (-10.69)
edu	0.0160* (1.96)	0.005 (0.46)	0.0235** (2.94)
dis	-0.0651 (-1.94)	-0.0963** (-3.21)	-0.0780* (-2.50)
L.gtfp	0.209*** (20.73)	0.207*** (16.72)	0.213*** (18.36)
constant term	2.315*** (7.17)	3.486*** (11.67)	1.928*** (7.34)
N	390	390	390
Sargan	0.7915	0.806	0.804
AR(1)	0.008	0.008	0.008
AR(2)	0.491	0.482	0.500

Note: ***, ** and * represent significance levels of 1%, 5% and 10% respectively; The values of the z test are in parentheses, and the values of AR (1), AR (2) and Sargan are p-values. The following table is the same.

From the regression results of GMM model, it can be seen that agricultural green total factor productivity can be improved both from the perspective of agricultural trade as a whole and from the perspective of export and import alone. For every 1% increase in agricultural trade, agricultural green total factor productivity increases by 4.3%. The lag term of agricultural green total factor productivity is significant and the coefficient is positive, indicating that there is a continuous dynamic change. Agricultural production in the current period will be affected by technological innovation and production input in the previous period, and emissions in the earlier period will also have an impact on emissions in the later period. According to the regression results of control variables, the estimated parameters of fiscal support and technological input pass the significance test, which indicates that the government's strengthening of financial support for agriculture will increase the enthusiasm of agricultural production, and large-scale operation will bring certain pressure on the agricultural environment. It is not conducive to the improvement of agricultural green total factor productivity. There is a negative relationship between agricultural technology input and agricultural green total factor productivity, which indicates that technological innovation in agricultural production has received extensive attention. However, most of the technologies used in agriculture at present are aimed at expanding output, which will also increase the use of fertilizers and pesticides in agricultural film to a certain extent. Agricultural producers do not realize that environmental protection should be coordinated with economic growth. Rural human capital has a positive promoting effect on agricultural green total factor productivity, which indicates that consumers' demand for clean and environmentally friendly agricultural products expands with the popularization of rural education, producers will increase the production of agricultural green agricultural products. The agricultural disaster rate (dis) does not pass the significance test.

5.2 Influence channel heterogeneity

Agricultural technical efficiency and agricultural technological progress are the two decomposition channels of agricultural green total factor productivity. Therefore, we can continue to explore which specific channel of agricultural trade has an effect on agricultural green total factor productivity. As can be seen from the regression results in Table 3, agricultural trade promotes the green development of agriculture through the progress of agricultural green technology. The trade of agricultural products has a significant negative effect on the efficiency of agricultural green technology, which indicates that there is still some room to improve the efficiency of agricultural technology in the current process of agricultural green.

Table 3: Regression results of influence channels of agricultural trade

variable	agricultural technical efficiency	agricultural technological progress
	(4)	(5)
trade	-0.0482*** (-7.54)	0.0444*** (6.27)
gov	-1.341*** (-11.53)	2.540*** (16.79)
ino	-0.113*** (-10.26)	-0.0794*** (-6.25)
edu	0.0138 (1.33)	-0.113*** (-8.34)
dis	-0.0032 (-0.15)	-0.272*** (-3.21)
constant term	2.413*** (18.96)	2.067*** (13.55)
N	390	390
Sargan	0.858	0.716
AR(1)	0.008	0.002
AR(2)	0.919	0.306

5.3 Robustness test

Table 4: Robustness test

variable	(6)	(7)	(8)
trade	0.009* (2.41)	0.0219* (2.47)	0.0424*** (5.30)
Control variables	yes	yes	yes
constant term	1.269*** (4.63)	0.911 (1.18)	2.797*** (8.36)
Sargan	0.781		0.865
AR(1)	0.009		0.001
AR(2)	0.529		0.862

This paper will conduct the robustness test from the following three aspects. The first is to replace the agricultural trade with the proportion of agricultural trade to the added value of agriculture. The second is to change the fixed effect model for testing. The third is the outlier processing. On the basis of the original data, all variables are indorned by 5%. The test results of various methods are shown in Table 4, which are respectively models (6), (7) and (8). It can be seen from the results in the table that agricultural product trade can still promote agricultural green total factor productivity, indicating that the original conclusion is relatively robust.

6. Conclusions and policy recommendations

This paper uses the SBM-ML index method to estimate China's agricultural green total factor productivity from 2006 to 2020, and uses the systematic GMM model and the dynamic panel threshold model to test the influence mechanism between agricultural trade and agricultural green total factor productivity. The following conclusions can be drawn. First of all, the development of agricultural trade can improve agricultural green total factor productivity and promote the green process of China's agriculture. In addition, the influence of agricultural trade on agricultural green total factor productivity has regional heterogeneity, which is more obvious in the eastern region. Secondly, agricultural green total factor productivity was decomposed into agricultural green efficiency and agricultural green technology progress, and the improvement of agricultural green total factor productivity mainly came from the channel of agricultural green technology progress.

Based on the above conclusions, in order to give full play to the positive role of agricultural trade in promoting agricultural green total factor productivity, the following suggestions are put forward. Firstly, a good trade environment for agricultural products can promote the sustainable and healthy development of agricultural trade. It is necessary to give agricultural products a good market environment and promote the trade position of domestic agricultural products in the international market. We should improve the agricultural import and export trade system and optimize the structure of agricultural import and export. At present, China's import volume of agricultural products is relatively large and the domestic demand for agricultural products is strong, the continuous import of agricultural products has become an inevitable trend. We should actively adjust the structure of agricultural products, and learn to absorb advanced foreign technologies from the import of agricultural products to carry out innovation and finally promote the process of green agriculture in China. At present, the production and input costs of domestic agricultural products are high, and there is a price gap between domestic and foreign agricultural products. We should promote strategic agricultural international cooperation, expand trade channels, and promote the diversification of import markets. Secondly, we should make good use of foreign green production technology and high-standard access system for agricultural products to encourage domestic agricultural producers to carry out production reform, and ultimately improve the export quality of China's agricultural products. It is necessary to increase the added value of domestic agricultural exports and expand the scale and brand of agricultural exports. At present, the development of digital economy and online services is accelerating, and it is necessary to actively improve the cross-border e-commerce platform to comply with this trend. In addition, while developing trade in agricultural goods, we should also actively expand trade in agricultural services, and promote advantageous agricultural materials, agricultural technology, and agricultural machinery to the world.

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