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The Influence of Trade and Foreign Direct Investment on Green Total Factor Productivity: Evidence from China and Korea*

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Abstract

Purpose – This paper intends to conduct theoretical analysis and empirical test on the action mechanism of South Korea-China trade and South Korea's FDI to China on green total factor productivity, so as to provide a new perspective and ideas for the improvement of China's green total factor productivity and promote the high-quality development of China's economy

Design/methodology – This paper uses the data of 30 provinces, autonomous regions and municipalities in China from 2004 to 2017 as the research sample, adopts the GML index method of SBM Directional Distance Function to measure GTFP, and analyzes the influence of South Korea-China trade and FDI from South Korea on China's GTFP.

Findings – Trade is conducive to promoting technological progress, which has a significant promotion effect on China's green total factor productivity. While FDI has a significant inhibitory effect on China's green total factor productivity, which verifies the "pollution haven" hypothesis. In addition, such influence has certain regional overall heterogeneity. Trade has a more significant promoting effect on GTFP in eastern coastal areas, while FDI has a more significant inhibitory effect on GTFP in central and western inland areas. The interaction between trade and FDI is conducive to the improvement of green total factor productivity, indicating that the benign mechanism of trade and FDI has been formed. Urbanization, industrial structure, human resource level and investment in science and technology are all conducive to the improvement of GTFP.

Originality/value – Through theoretical analysis and empirical test on the action mechanism of South Korea-China trade and South Korea's FDI on green total factor productivity, this paper provides a solid theoretical foundation for the further development of China-South Korea economic and trade cooperation in the future.

Keywords: Foreign Direct Investment (FDI), Green Total Factor Productivity (GTFP), Korea -China Economy and Trade, Trade

JEL Classifications: F18, F40

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1. Introduction

The report of the 19th National Congress of the Communist Party of China pointed out that "China's economy has changed from the stage of high-speed growth to the stage of high-quality development, and is in the crucial period of transforming the mode of development, optimizing the economic structure and transforming the driving force of growth", and reiterated that "we must adhere to the principle of quality first and efficiency first, and take the structural reform of the supply side as the main line, so as to promote the quality change, efficiency change and dynamic change of economic development, and improve the total factor productivity yield", The word "green" has been highlighted four times, emphasizing that "building ecological civilization is the millennium plan for the sustainable development of the Chinese nation". It fully shows that "supply and demand dislocation" and "transformation of growth mode forced by resource and environment constraints" are two major problems under the new normal situation of China's economy. The 13th Five-Year Plan points out that green is a necessary condition for sustainable development, and the concept of green development is the direction that China must adhere to in the future development process. Total Factor Productivity (TFP), as the engine of sustainable economic development, is crucial to China's economic transformation and upgrading.

However, the traditional calculation method of total factor productivity does not consider the factors of resource waste and environmental pollution. With the highlight of environmental protection in China, many scholars add resource and environmental factors to the traditional total factor productivity, and adopt the Green Total Factor Productivity (GTFP) to measure the level of green high-quality economic development. Under the background of economic globalization, China has been deeply integrated into the global value chain division system, and the promotion of Green Total Factor Productivity has been unable to break away from the global division system with trade and foreign direct investment (FDI) as the main carriers. At present, China is in the critical period of economic transformation, and technological progress is the premise of achieving sustainable economic growth, which is conducive to the transformation of China's economic development into an economic growth model supported by total factor productivity. While a country's technological progress depends on R&D investment and talent cultivation of domestic high-tech industries, foreign innovation activities can also play a direct or indirect role through knowledge spillover. Trade and FDI are the main ways of technology transfer and knowledge spillover among countries, which are conducive to the spillover and diffusion of green technology with the expansion of the scale of opening up, thus promoting the green total factor productivity and realizing green economic development.

After the establishment of diplomatic relations between China and South Korea, bilateral economic and trade cooperation has developed steadily, healthily and rapidly. China is South Korea's largest trading partner, largest export market and largest import source country, and South Korea is China's third largest trading partner. On account of data from the Ministry of Commerce of the People's Republic of China in 2019, the import and export volume of bilateral goods between the South Korea and China was US $284.53 billion, among which the South Korea exported US $173.57 billion to China and imported US $110.96 billion from China. South Korea's trade surplus with China was $62.61 billion. By the end of 2019, South Korea was China's second largest source of foreign investment, with a total of US $82.58 billion in actual investment in China. In 2019, South Korea invested 2,108 projects in China, an increase of 12% over the previous year. And the actual adoption of South Korea's investment reached US $5.54 billion, an increast of 18.7% over the previous year.

So, with a comprehensive consideration of economical and environmental benefits, can

open development and green development be both achieved at the same time? Do South Korea's trade with China and FDI have a positive or negative net effect on China's GTFP? What is the path of action? Is the interaction between trade and FDI conducive to the improvement of green total factor productivity? These problems are worthy of our in-depth study. Therefore, this paper intends to conduct theoretical analysis and empirical test on the action mechanism of South Korea-China trade and South Korea's FDI to China on GTFP, so as to provide a new perspective and thinking for the improvement of China's Green Total Factor Productivity (GTFP) and provide a solid theoretical foundation for the development of China-South Korea economy and trade.

2. Literature Review

2.1. Research on the Influence of FDI on GTFP

Viewing a quantity of previous researches, it can be concluded that the foreign direct investment is often treated as a control variable to explore its impact on green total factor productivity in the regression model. Due to different samples and time spans as well as methodologies, no consensus has been reached about this proposition.

In terms of technology transfer, Wang and Blomstrom (1992) hold the view that the foreign direct investment can provide the abundant capital, advanced management experience and efficient chain to the host country. Of course, those three will promote enterprises to invest in R&D and technological innovation more. In other words, the foreign direct investment can improve the total factor productivity in the host country. Furthermore, in cooperating with China's regional environmental efficiency, Wang, Wu and Yan (2010) attempt to discuss the impact of foreign direct investment on environmental total factor productivity. Using the panel data across 30 provinces and employing the Tobit model to perform empirical analyses, they find that the foreign direct investment has a significant effect on promoting both environmental efficiency and environmental total factor productivity. With the same sample, Xu and Deng (2012) agree with findings of Wang, Wu and Yan (2010). they believe that the foreign direct investment has a positive effect on environmental total factor productivity.

On the contrary, some relating scholars propose different kinds opinions. Yang and Wang (2016) set China as an example to debate the impact of foreign direct investment on green total factor productivity. Because of regional difference, they find that the foreign direct investment has a negative effect on green total factor productivity in the west area of China. In the following researches, Zhu and Ren (2017) also find that the foreign direct investment has a negative effect on green total factor productivity growth in China. In addition, Rafindadi, Muye and Kaita (2018) conduct a comparative analysis. They figure out that developing countries often do not pay enough attention to the comprehensive ecological improvement so as to develop their economies. However, They also point out that developed countries transfer the production with high pollution to those developing countries. This has a significant environmental pollution effect on host country, which is not beneficial to the promotion of green total factor productivity. Besides, Ren and Lv (2019) find that due to the monopoly effect, absorbing the foreign direct investment poses a negative effect on green total factor productivity.

Furthermore, a number of scholars believe that the foreign direct investment has a time-varying or neutral effect on total factor productivity. Kukulski and Ryan (2011) conduct a discussion about this topic. Via controlling the institutional quality, financial development level, investment level and innovation heterogeneity, their findings indicate that the influence

of foreign direct investment on host country's green total factor productivity is uncertain and time-varying. With another point of view, Li, QI and Li (2016) find that the foreign direct investment can neither promote the green technology progress nor improve the green technology efficiency. That is to say, the foreign direct investment has no effect on green total factor productivity. Moreover, Wang and Wang (2017) conduct the regression analysis on green total factor productivity with a sample of China's service industry. Their results also show that the foreign direct investment has no significant effect on green total factor productivity.

2.2. Research on the Impact of Foreign Trade on GTFP.

Except for the impact of foreign direct investment on green total factor productivity, a large quantity of scholars point out that the foreign trade is also an important determinant of total factor productivity. To fully understand how the foreign trade affects the total factor productivity, they attempt to study this proposition from different kinds of aspects. Madsen (2007) treats Organization for Economic Cooperation and Development countries as a sample to discuss the relationship between knowledge import and total factor productivity. Taking use of 135 years of data to conduct empirical analyses, His findings suggest that there is a strong relationship between both of them. Generally speaking, in the past century, 93% of total factor productivity growth is entirely due to knowledge imports. Subsequently, Sun (2008) sets China's manufacturing industry as a research object to analyze the impact of trade openness on total factor productivity. He finds that the trade openness can significantly promote the total factor productivity growth. Moreover, he also finds that the only channel for trade openness to promote the total factor productivity growth is the technology spillover. In addition, Wei (2009) proves the reliability of Sun's results in 2008.

Seen from aspect of both competition and knowledge integration, Wan, Baylisk and Mulder (2015) indicate that the foreign trade is conducive to the total factor productivity through both competition and knowledge integration. As for the same proposition, Huang, Han and Ge (2017) regard the Belt and Road countries as an example to perform an empirical analyses. They believe that in these countries, the trade mode of primary products has forced enterprises to reduce product costs by employing cheap labor and ignoring technological innovation. Therefore, the trade openness has a negative effect on green total factor productivity. Conversely, adopting the same sample, Ji and Xu (2018) find that the trade openness has a positive effect on green total factor productivity incorporating with four other controlling variables such as economic development, infrastructure, financial development and institutional quality. But, With a sample of European countries, Wu, Ge and Xu (2018) also find that a better trade openness can significantly improve the green total factor productivity. Using the spatial panel model, Ho, Wang and Yu (2018) certificate that there is a significant innovation spillover effect on foreign trade, which is conducive to the total factor productivity.

In summary, those previous researches mentioned above have analyzed the impact of foreign direct investment and foreign trade on total factor productivity in different aspects. Compare with those achievements they obtained, we propose some innovations in this paper. First, each data of trade and foreign direct investment from South Korea to China is firstly selected to perform a research due to the great contribution of South Korea's trade to China. Second, the Malmquist Luenberger index of SBM directional distance function is employed to access the green total factor productivity. This index have a better reflection on coordinated development relationship environment and economic growth. Third, this paper not only analyzes the influence mechanism of trade and foreign direct investment on green total factor

productivity, but also tests the influence of trade, foreign direct investment and their interaction term on green total factor productivity. Finally, because of the difference in the level of economic development among different regions in China, this paper will further analyze the impact of trade, foreign direct investment and their interaction term on green total factor productivity among different regions, respectively.

3. Methodology

3.1. The Action Path of Trade on GTFP

Trade openness has brought about the expansion of market scale and the deepening of professional division of labor, which has injected strong impetus into China's economic growth (Zhang Tong-Bin & Liu Feng-Qi, 2018). Foreign trade enlarges the market scope of Chinese enterprises, which not only enables China to form economies of scale through large-scale commodity export, but also helps to reduce the cost of intermediate products needed by Chinese enterprises, improve the quality of their products, and enhance their production capacity and competitive advantage. At the same time, China's enterprises are faced with the "reverse force" mechanism formed by external pressure, which is conducive to the optimization, innovation, transformation and upgrading of enterprises. Under the background of deepening specialization and division of labor, Chinese enterprises can fully grasp the opportunity of low cost of resources and labor force, improve the efficiency of factor utilization, continue the comparative advantage, and realize the rapid growth of output. Trade opening accelerates the spread of knowledge and technology, which is conducive for Chinese enterprises to learn green and clean technologies from developed countries, reduce environmental pollution in the production process, reduce environmental governance costs, and promote productivity (Li Xiao-Ping & Zhu Zhong-Di, 2004). In addition, with the continuous expansion of the scale of trade opening, the accumulation level of human resource and the technological innovation and imitation ability of enterprises can be improved, which is conducive to the promotion of China's green total factor productivity. Based on the above facts, hypothesis 1 is proposed in this paper.

H1: Trade is conducive to promoting GTFP.

Since 2012, China's trade structure has undergone a profound transformation; with a huge trade surplus, a substantial increase in the export of industrial manufacturing, and a high proportion of high pollution, high consumption and resource-based products in the export trade. It has brought great pressure to the environment (Ni Sha, 2018). The environmental effect of trade opening is the result of import and export mutually promoting and offsetting each other. Trade opening makes the geographical distribution of industries significantly different, which further affects the direct effect of trade opening on green development (Lu Fei, Liu Ming-hui, Sun Yuan-yuan, 2018). In terms of regional differences, the eastern coastal region of China has a superior geographical location, convenient transportation facilities, and the government has given a lot of policy support. Therefore, the eastern coastal region enjoys frequent trade activities, which have given birth to a large number of manufacturing enterprises and accelerated its economic development, but at the same time, it has also brought about environmental pollution problems that cannot be ignored. With the enhancement of ecological and environmental protection in China, the eastern coastal areas have accelerated the upgrading of trade structure by virtue of their own economic advantages, thus promoting green development. By contrast, the inland areas in the central and western

regions are not well connected, their foreign trade is underdeveloped, and their industries are mostly resource-intensive. As a result, their industrial structure is upgraded slowly, their trade structure is unreasonable, and their resource consumption and environmental pollution are aggravated, which seriously affect the environmental quality. Therefore, although the expansion of trade opening promotes the upgrading of China's industrial structure, it is not conducive to the improvement of the ecological environment. Especially, the export trade of industrial manufacturing with high pollution and consumption increases the consumption of resources and the emission of pollutants in China, thus exacerbating the environmental pollution. Unreasonable foreign trade structure and huge trade surplus make China's environment face great pressure, which is not conducive to the improvement of GTFP. Considering that the impact of trade on the environment may vary among regions, this paper proposes hypothesis 2.

H2: The effect of trade on promoting GTFP has regional heterogeneity.

3.2. The Action Path of FDI on GTFP

With the expansion of opening to the outside world and the deepening of international economic integration, China's FDI has achieved sustained and rapid growth. FDI provides rich capital, advanced management experience and efficient production chain for the development of China's national economy (Ma Lijun, 2013), alleviates the shortage of capital in the early stage of China's reform and opening up, and promotes technological R&D and innovation. At the same time, FDI is beneficial to reduce the cost of introducing advanced technologies in China, promotes the flow and application of advanced technologies in China, and brings about technology spillover effect. Moreover, the transnational flow of productive factors optimizes the efficiency of resource allocation and plays a significant role in promoting the rapid development of China's economy. First of all, the introduction of foreign capital can accelerate the flow of domestic and foreign workers, which is conducive to the domestic enterprises to learn, imitate and apply the advanced technology and management experience of foreign enterprises; secondly, FDI enterprises can establish a forward and backward integration with local enterprises in value chain and industrial chain, which is conducive to the knowledge and technology spillover from developed countries or regions to developing countries and/or less developed regions, thus generating vertical technology spillover effect (Wang Hui & Wang Shu-Qiao, 2016).

The "pollution haven" hypothesis has been prevalent in FDI academia. In view of the high cost of environmental pollution, developed countries will transfer some pollution-intensive enterprises to developing countries with lax environmental regulations to reduce the cost of pollution control. While, in order to enhance their competitiveness in attracting foreign investment, developing countries will reduce the level of environmental regulation and introduce some pollution-intensive industries and low-technology industries, which will aggravate environmental pollution and hinder the improvement of green total factor productivity (Cole M A, Elliot R J R, 2006; Nie Fei & Liu Hai-Yun, 2015). The introduction of FDI will also occupy the market share of enterprises in the importing country, and even form monopolies on some industries, hinder the production of local enterprises, hinder the improvement of independent R&D ability of enterprises in the importing country, form technology dependence, and thus have a negative impact on GTFP. The demonstration effect, technology spillover effect and competition effect of foreign direct investment have a certain lag; the environmental pollution problem brought by foreign direct investment has an inertia, which will gradually accumulate over time; in order to develop the regional economy, some

local governments tend to relax environmental regulations, lower environmental standards and blindly attract foreign investment -- these factors may cause damages to the ecological environment (Sang Bai-Chuan & Zhang Cai-Yun, 2018). Therefore, foreign direct investment may play a long-term role in promoting GTFP, but it cannot significantly promote GTFP in the short term. In view of this, hypothesis 3 is proposed in this paper.

H3: FDI plays a long-term role in promoting green total factor productivity.

4. The Empirical Analysis

4.1. Model Setting

In order to verify the research hypothesis, this paper constructs the following basic model:

$$\begin{aligned}\ln GTFP_{i,t} = a_{i,t} + \ln FDI_{i,t} + \ln TRADE_{i,t} + \ln FDI_{i,t} * \ln TRADE_{i,t} + \ln URB_{i,t} \\ + \ln SEC_{i,t} + \ln HUM_{i,t} + \ln RD_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{1}$$

Where, subscript i represents region, subscript t represents time; The explained variable is GTFP, while the explanatory variable FDI is South Korea's investment in Chinese provinces and cities, and TRADE is the trade volume between South Korea and China. lnFDI *lnTRADE is the interaction term between trade and investment; URB is the urbanization level; SEC is the level of industrial structure; HUM is manpower development level; RD is the R&D level of science and technology; ε are random disturbance terms.

4.2. Variable Selection

4.2.1. Explained Variable: Green Total Factor Productivity (GTFP).

As for the measurement of GTFP, Chung et al. proposed the directional distance function and expanded the Malmquist index into the Malmquist-Luenberger index. In this method, both desirable output increase and undesirable output decrease can be considered. Moreover, SBM directional distance function can solve the problem of input-output insufficiency or non-slack. Therefore, the Malmquist-Luenberger index method based on SBM directional distance function is adopted in this paper to calculate GTFP. Based on the index of GML directional distance function SBM, this index can also be decomposed into technical efficiency change index GEC and technical progress change index GTC, which are as follows:

$$GML_t^{t+1} = \frac{1 + S_V^G(x^t, y^t, b^t; g)}{1 + S_V^G(x^{t+1}, y^{t+1}, b^{t+1}; g)} = GEC_t^{t+1} \cdot GTC_t^{t+1} \tag{2}$$

$$GEC_t^{t+1} = \frac{1 + S_V^t(x^t, y^t, b^t; g)}{1 + S_V^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}; g)} \tag{3}$$

$$GTC_t^{t+1} = \frac{[1 + S_V^G(x^t, y^t, b^t; g)] / [1 + S_V^t(x^t, y^t, b^t; g)]}{[1 + S_V^G(x^{t+1}, y^{t+1}, b^{t+1}; g)] / [1 + S_V^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}; g)]} \tag{4}$$

The index of GML represents the change of t+1phase relative to t phase. If the index is greater than 1, it represents the growth of GTFP. If less than 1, it represents a decrease in

GTFP. If it is equal to 1, it represents that GTFP is in a stable state, and the same rule applies to technological progress and technological efficiency.

Existing literature usually adopts SFA or DEA to measure GTFP. Relatively speaking, DEA has the following advantages: There is no need to set specific production functions and the inclusion of non-expected variables in multiple input variables is allowed. Therefore, under the DEA framework, this paper uses directional distance function (DDF) considering the undesirable output and combines with Global Malmquist-Luenberger productivity index to calculate the GTFP of 30 provinces and cities in China from 2004 to 2017. Here, environmental pollution and energy consumption are incorporated into the total factor productivity accounting framework system, and the Malmquist productivity index method of data envelopment analysis is adopted to measure China's GTFP index.

The selection of input and output indicators is defined as follows: ①Input index, this paper chooses labor, capital and energy as the input index. For labor input, the number of people employed at the end of the year (unit: ten thousand people) in each province is selected as the proxy index to measure labor factors. For capital input, capital stock index is selected to represent it. For the calculation of capital stock, the perpetual inventory method of Shan Haojie (2008) is used for reference to estimate the capital stock (unit: one hundred million yuan) of each province. We take 1978 as the base period, and use the fixed assets price index for the reduction. For energy input, since the energy consumption in the process of economic production includes oil, coal and natural gas, the energy consumption converted by standard coal method (unit: ten thousand tons of standard coal) is used to measure, and energy consumption is regarded as the main source of undesirable output; ②output index mainly includes desirable output and undesirable output. As for the desirable output, the GDP of each province and city (unit: one hundred million yuan) is used to represent the expected output. Taking 1978 as the base period, the GDP reduction index is used to offset the impact of inflation. For the unexpected output, considering that SO2 is a major environmental pollutant and the main object of environmental pollution control in China, the carbon dioxide (unit: ten thousand tons))in each province and urban area is selected as the proxy index of environmental pollution. In addition, the GTFP index is the GTFP change rate relative to the previous year, which cannot be directly used in econometric regression, so it should be transformed accordingly. This paper assumes that the green total factor productivity (GTFP) level in 2004 is 1, and then the GTFP level in 2005 is multiplied by the GTFP index in 2005. By the same process, the GTFP level index of 30 provinces and cities in China from 2004 to 2017 can be obtained.

4.2.2. Core Explanatory Variables

South Korean investment in China (FDI). FDI can influence GTFP in various regions through industrial transfer, technology connection and knowledge spillover. In this paper, the foreign direct investment data expressed in US dollars is converted into the annual average exchange rate, and the foreign direct investment (unit: one hundred million RMB) is obtained. On this basis, the logarithm processing is carried out to measure the level of foreign direct investment.

South Korea-China Trade (TRADE). In this paper, the South Korea-China Trade data expressed in US dollars is converted into the average exchange rate of each year to obtain the trade data expressed in RMB, and logarithmic processing is carried out to measure the level of South Korea-China trade.

4.2.3. Control Variables

Urbanization level (URB). Urbanization level promotes total factor productivity growth but has threshold effect. The ratio of urban to population is usually used as a measure of urbanization and the logarithm is calculated.

Industrial structure (SEC). Industrial structure upgrading can promote green total factor productivity growth more than energy efficiency improvement. Considering that the secondary industry is the main source of energy consumption and pollution emissions, this paper uses the added value of the secondary industry/gross domestic product of each region to measure the industrial structure, and the logarithm is calculated.

Human resource (HUM). Technical reform and innovation require human resource to realize. The professional skills, experience and knowledge quality of human resource have a significant role in promoting green technology innovation. The average years of education in each region are selected as the proxy variable, and the logarithm is calculated.

R&D investment intensity (RD). The intensity of R&D investment is usually expressed by the proportion of R&D expenditure in regional GDP, which is an important indicator to measure the scale of scientific and technological activities, investment level and innovation capacity of a region. The logarithm is calculated.

4.2.4. Data Description

Due to the lack of data, the research sample does not include data from Xizang, Hong Kong, Macao and Taiwan. The sample covers a total of 30 provinces (autonomous regions and municipalities directly under the Central Government), covering a period from 2004 to 2017. The original data are mainly from China Statistical Yearbook, China Business Yearbook, China Labor Statistics Yearbook, the statistical yearbooks of various regions, the website of Ministry of Commerce of China, Korea Trade Association, and The Export- Import Bank of Korea.

Table 1. Variables and Data Sources

Abbreviation	Variable	Data source
GTFP	the Green Total Factor Productivity assumes that the green total factor productivity (GTFP) level in 2004 =1	China Statistical Yearbook, the statistical yearbooks of various regions2004 to 2017
FDI	South Korean investment in China	The Export- Import Bank of Korea https://www.koreaexim.go.kr
TRADE	South Korea's trade with China's provinces and cities	Korea Trade Association www.kita.net
URB	The ratio of urban to population is usually used as a measure of urbanization	China Statistical Yearbook
SEC	added value of the secondary industry/gross domestic product of each region to measure the industrial structure	China Statistical Yearbook, the statistical yearbooks of various regions
HUM	he average years of education in each region are selected as the proxy variable	the statistical yearbooks of various regions
RD	The intensity of R&D investment is usually expressed by the proportion of R&D expenditure in regional GDP	the statistical yearbooks of various regions

4.2.5. Full Sample Regression Results

Table 2. Full Sample Regression Results

Variables	(1)	(2)	(3)	(4)
C	-2.805***	-3.045***	-3.041***	-2.799***
	(-6.972)	(-7.781)	(-7.736)	(-7.161)
lnFDI	-0.001*		-0.001*	
	(-1.854)		(-1.938)	
lnTRADE		0.035**	0.036**	
		(2.376)	(2.402)	
lnFDI*lnTRADE				0.004*
				(1.886)
lnURB	0.658***	0.637***	0.638***	0.668***
	(7.587)	(7.566)	(7.549)	(7.892)
lnSEC	0.009	0.048	0.053	0.014
	(0.147)	(0.745)	(0.808)	(0.228)
lnHUM	1.912***	2.009***	2.007***	1.910***
	(11.981)	(12.955)	(12.889)	(12.295)
lnRD	0.078***	0.079***	0.078***	0.076***
	(5.750)	(5.942)	(5.792)	(5.762)
R2	0.880	0.883	0.882	0.885
aj-R2	0.869	0.872	0.871	0.875

Note: The t value in brackets, *, ** and *** indicate that the statistical value is significant at 10%, 5%and 1%, respectively.

Taking 30 provinces, autonomous regions and municipalities as samples, this paper adopts fixed effects regression model to analyze the impact of South Korea's trade with China and FDI on GTFP. The regression results are shown in Table1. Model (1) is the benchmark regression of FDI to GTFP, Model (2) is the benchmark regression of trade to GTFP, Model (3) introduces trade on the basis of model (1) to test the influence of both trade and FDI on GTFP. Model (4) is the benchmark regression of the interaction terms of trade and FDI to GTFP. As can be seen from the regression results of model (2) and model (3), trade has a positive promotion effect on the improvement of GTFP. The regression coefficient is positive and both of them are significant at 5%. Hypothesis 1 is supported, indicating that the net utility of trade between South Korea and China on China's GTFP is positive, and the technology spillover effect, scale effect, human resource effect and competition effect generated by it are effectively released in China. The opening up of trade between South Korea and China is conducive to the introduction of green technologies and the improvement of pollution control. It is conducive to learning advanced management experience and effective production technology from South Korea, promoting technological progress and innovation in China, and thus promoting the improvement of GTFP. Moreover, with the deepening of China's opening to the outside world, the market scale has been further expanded, the efficiency of resource allocation has been improved, and scale economy has been formed,

which is conducive to the realization of green production and improvement of environmental quality.

From the regression results of model (1) and model (3), FDI has a reverse inhibitory effect on GTFP, and the regression coefficient is negative and both are significant at 10%, indicating that FDI has a negative net effect on GTFP, which verifies the "pollution haven" hypothesis. The reasons may lie in the following aspects: First, South Korea has a high level of environmental regulations. Considering the cost of environmental pollution control, these regulations will promote the transfer of polluting industries to developing countries. However, China is still a large developing country with low level of environmental regulation. In the international division of labor, China mainly introduces some FDI with high pollution intensity. This shows that foreign-funded enterprises have occupied a large number of market shares in China, which leads to the reduction of production and the decline of profits of domestic enterprises, and is not conducive to the technological innovation of enterprises in various regions of China; Second, China's digestion and absorption capacity and introduction and re-innovation capacity of advanced technologies from South Korea are insufficient at present, and the technological spillover effect brought by FDI is not effective, thus hindering the improvement of GTFP. It can be seen that FDI plays a long-term role in promoting green total factors, so hypothesis 3 is supported. From the regression results of model (4), the interaction terms of trade openness and FDI have a positive promotion effect on GTFP, and the regression coefficient is positive and significant at 10%, indicating that the expansion of trade weakens the reverse inhibitory effect of FDI on GTFP. The opening of trade has widened the channels of attracting foreign investment in various regions; the diversified demand for foreign capital has enhanced the competitive strength of each region, and has improved the current situation that each region relies on relaxing the level of environmental regulation to attract foreign investment; the improvement of environmental regulation level can effectively release the technology spillover effect and demonstration effect of FDI, which is conducive to promoting technological innovation and progress of enterprises, realizing green production and improving GTFP.

From the regression results of control variables, the impact of urbanization level on GTFP is positive, the regression coefficient is positive, and both of them are significant at the level of 5%. Thus it can be seen that since the reform and opening up, with the gradual release of the three dividends of reform, population and resources, the marginal effect of urbanization characterized by "labor-intensive" and "institutional reform" on improving the efficiency of resource allocation and TFP gradually increases.

The impact of industrial structure on national TFP is positive, but not significant. However, in the regional analysis, the proportion of the secondary industry in GDP in the East has a positive and significant impact on the GTFP at the level of 1%, while the proportion of the secondary industry in the central and western regions has a negative impact on the GTFP at the level of 1%. This is because the eastern coastal cities are relatively developed areas in China, and the secondary industry has gradually changed from high energy consumption and high pollution to low energy consumption and clean new industry, which has the characteristics of low-carbon and environmental-friendly, and can drive economic growth. However, most enterprises in the central and western regions are still in the middle stage of industrialization led by manufacturing industry. The acceleration of industrialization is often accompanied by resource consumption and environmental pollution, which is not conducive to efficiency improvement and technological progress.

The effect of human resource on GTFP is positive. This is similar to the research results of most scholars. In summary, human resource acts on GTFP mainly through three channels:

First, the increase of human resource intensity can squeeze out energy use, reduce energy intensity and improve energy efficiency by changing technology; Second, the improvement of human resource promotes green technology to act on pollution reduction; The effect of human resource on GTFP is significantly positive. Third, the cultivation of human resource improves the production efficiency and learning ability of workers, which is conducive to the learning of foreign advanced technology and management experience, and helps to enhance people's awareness of energy conservation and emission reduction, thus affecting the conditions of energy and environment.

The impact of science and technology input on GTFP is positive, which indicates that the increase of science and technology expenditure of the government can increase the R&D of enterprises, promote production technology innovation, be conducive to scientific and technological progress, and then promote the efficiency of resource allocation.

4.2.6. Regional Sample Regression Results

Considering that trade and economic development levels are different in different regions, there may be regional differences in the impact of trade and FDI on GTFP, this paper divides the whole sample into eastern coastal areas and central and western inland areas for empirical analysis, and the results are shown in Table 3 and Table 4. From the regression results of model (2) and model (3), trade has a significant role in promoting the GTFP of the eastern coastal area. From the regression results of model (1) and model (3), the influence coefficient of FDI on GTFP in the eastern coastal area is negative, and has not passed the significance

Table 3. The Eastern Coastal Areas Regression Results

Variables	(1)	(2)	(3)	(4)
C	-6.621***	-6.871***	-6.579***	-6.302***
	(-8.149)	(-9.186)	(-8.294)	(-7.296)
lnFDI	-0.005		-0.014	
	(-0.394)		(-1.099)	
lnTRADE		0.115**	0.137**	
		(2.075)	(2.347)	
lnFDI*lnTRADE				0.007*
				(1.912)
lnURB	0.555***	0.541***	0.517***	0.545***
	(3.223)	(3.184)	(3.010)	(3.176)
lnSEC	0.572***	0.667***	0.714***	0.607***
	(3.411)	(3.921)	(4.068)	(3.587)
lnHUM	3.453***	3.496***	3.381***	3.334***
	(11.002)	(12.033)	(10.945)	(10.010)
lnRD	0.111***	0.106***	0.087***	0.103***
	(6.189)	(5.790)	(4.925)	(5.929)
R2	0.849	0.855	0.856	0.850
aj-R2	0.833	0.839	0.839	0.834

Note: The t value in brackets, *, ** and *** indicate that the statistical value is significant at 10%, 5%and 1%, respectively.

test; FDI has an inhibitory effect on GTFP in the central and western inland regions, while the impact coefficient of trade on GTFP in the central and western inland regions is positive, but it fails the significance test. The reasons may lie in the following aspects: at present, the eastern coastal areas have a relatively high level of economic development and have gathered a large amount of high-quality human resource. Moreover, the trade opening areas are mostly located in the eastern coastal areas, which is conducive to technology spillover effect and thereby promoting the GTFP in the eastern coastal areas. In addition, with the improvement of the level of environmental regulation and the increase of labor costs in the eastern coastal areas, environmental pollution intensive industries begin to transfer to the central and western inland areas, which will increase the environmental pollution pressure in the central and western regions.

Moreover, the level of foreign trade, economic development and science and technology investment in the central and western inland regions are relatively low, which cannot absorb the effects of trade opening and FDI technology spillover. Therefore, FDI is not conducive to the improvement of green total factor productivity in the central and western regions, and hypothesis 2 is verified. It can be seen from the regression results of model (6) and model (8) that the interaction terms of trade opening and FDI have a promoting effect on GTFP in the two regions, indicating that the benign mechanism of trade opening and FDI has been formed.

Table 4. The Central and Western Inland Areas Regression Results

Variables	(5)	(6)	(7)	(8)
C	-0.044 (-0.094)	-0.170 (-0.362)	-0.089 (-0.188)	-0.031 (-0.066)
lnFDI	-0.007* (-1.677)		-0.007* (-1.694)	
lnTRADE		0.001 (0.070)	0.001 (0.117)	
lnFDI*lnTRADE				0.002* (1.885)
lnURB	0.969*** (9.480)	0.970*** (9.456)	0.963*** (9.408)	0.970*** (9.413)
lnSEC	-0.909*** (-7.244)	-0.924*** (-7.297)	-0.827*** (-6.001)	-0.896*** (-6.949)
lnHUM	0.822*** (4.390)	0.866*** (4.601)	0.839*** (4.430)	0.810*** (4.281)
lnRD	0.055*** (7.103)	0.058*** (7.054)	0.56*** (6.978)	0.049*** (7.019)
R2	0.907	0.911	0.907	0.908
AD-R2	0.898	0.902	0.898	0.900

Note: The t value in brackets, *, ** and *** indicate that the statistical value is significant at 10%, 5%and 1%, respectively.

5. Conclusion

This paper theoretically analyzes the mechanism of the trade between South Korea and China and South Korea's FDI to China on GTFP. Based on the data of 30 provinces, autonomous regions and municipalities in China from 2004 to 2017, this paper uses the Malmquist -Luenberger index method of SBM directional distance function to measure GTFP, and selects the fixed effect model to empirically analyze the influence of South Korea-China trade and FDI from South Korea on China's GTFP. The result shows that: At the national level, trade between Korea and China has a significant promoting effect on GTFP, while FDI has a significant inhibitory effect on GTFP, and this effect has certain regional heterogeneity. Trade opening has a more significant promoting effect on GTFP in eastern coastal areas, while FDI has a more significant inhibiting effect on GTFP in central and western inland areas. The interaction between trade opening and FDI is conducive to the improvement of GTFP, indicating that a benign mechanism of trade opening and FDI has been formed. Urbanization, industrial structure, human resource and science and technology investment are all conducive to the improvement of GTFP.

Based on the conclusions, this paper proposes the following policy recommendations. In terms of government, First, different regions should formulate different policies of trade opening and foreign investment introduction according to the actual situation. The eastern coastal areas should further expand the trade opening on the original basis. With the increase of labor costs in the eastern coastal areas, the introduction of foreign direct investment should gradually transfer from labor intensive industries to technology intensive industries, so as to give full play to the advantages of FDI. The central and western inland areas should improve the level of environmental regulation, make use of their own advantages to introduce more labor-intensive foreign enterprises, and increase the absorption capacity of green technology.

Second, we should further promote the speed of urbanization process, optimize the industrial structure, material capital and human resource accumulation, improve the ability of independent innovation, promote the digestion and absorption of foreign advanced technology, speed up the research and development of environmental protection technology, and improve the ability to control environmental pollution, so as to realize green development, and accelerate the formation of regional transportation network to promote the flow of production factors among regions.

Taking the firms into account, First, further expanding bilateral trade between South Korea and China and optimizing the import and export structure. We will accelerate the transformation of export trade from a quantitative to a qualitative one, reduce reliance on industries with low added value, high consumption and high pollution, and adopt strict environmental protection and energy consumption standards to force the upgrading of the industrial structure of export trade. In addition, we should expand the import trade of high and new technology, especially increase the import of green and clean technology, actively guide the effective cooperation between China's scientific and technological research and development and green and clean technology, and improve the ability of enterprises to digest, absorb and utilize green and clean technologies, so as to give full play to the positive net effect of trade liberalization on promoting green total factor productivity.

Second, improving the level of environmental regulation and optimizing the FDI introduction mechanism. At present, the introduction of foreign-funded enterprises should pay more attention to quality control. At the same time, we should strengthen the supervision of foreign-funded enterprises. We can also attract high-quality foreign-funded enterprises through preferential tax policies, industrial support funds, government subsidies and other preferential policies, optimize the structure of foreign direct investment, enhance the

absorptive capacity of various regions, and effectively release the technology spillover effect, demonstration effect and competition effect of FDI, so as to realize the positive promotion of FDI to GTFP.

To this end, there some limitations in this paper. For instance, these influences of foreign direct investment and trade in different industries on GTFP are much more different. Due to the data unavailability, no concrete contents about those differences are mentioned in the main body of this paper. Of course, these shortages can provide a good direction for future scholars to re-study this proposition.

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