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An Empirical Study on the Impact of Foreign Direct Investment on Green Total Factor Productivity

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Abstract: In order to study the impact between Foreign Direct Investment (FDI) and Green Total Factor Productivity (GTFP), this work first introduces the concepts of FDI and GTFP and the impact mechanism between them. Then, the calculation method of GTFP is explored. According to the influencing factors, the impact model of FDI on GTFP is constructed. Finally, the influence degree coefficients of each influencing factor are calculated through experiments, and the influencing factors and influence degree of FDI on GTFP are obtained. The results show that the parameter of domestic research and development (R&D) capital investment is the largest, reaching 11.47, which is significant at 1%. It indicates that the growth of GTFP is most affected by domestic R&D capital investment, and the two are positively correlated. The research on the influencing factors of FDI on GTFP is of practical significance to the growth of GTFP under the influence of FDI.

Keywords: Foreign Direct Investment; Green Total Factor Productivity; influence degree Coefficient; action mechanism.

1. Introduction

With the gradual progress of the socialist market economy, China's economic society has achieved leapfrog development, followed by various pollution and the lack of resources. In order to overcome this difficulty, China has clearly put forward the concept of green development to promote green transformation and sustainable development of the economic society [1]. Therefore, relevant experts and scholars proposed using Green Total Factor Productivity (GTFP) to measure the performance of green economic growth [2]. As an important part of economic development, Foreign Direct Investment (FDI) affects the green transformation of China's economy. Studying the relationship between FDI and GTFP is a key step for using FDI to drive green economic development [3]. The basic model of international research and development (R&D) spillover named Coe-Helpman (C-H model) only briefly shows some influencing factors of total factor productivity, which is not very suitable for GTFP. Thereby, it is essential to explore the factors affecting GTFP.

In this context, in order to better analyze the relationship between FDI and GTFP, this work analyzes the mechanism of FDI on GTFP based on the concepts of the two. Then, according to the directional distance function and Global Malmquist-Luenberger (GML) index, the calculation method of GTFP is studied. Then, based on the C-H model, the control variables are introduced to build the impact model of FDI on GTFP. Finally, Province A is taken as the research object to discuss the influence degree of each factor through empirical calculation of each parameter value in the model. This analysis of the factors that influence GTFP under the influence of FDI can provide a theoretical basis for promoting GTFP under the FDI influence.

2. Method

2.1. Analysis of the mechanism of FDI on GTFP

In a narrow sense, FDI refers to the investment of foreign investors in domestic enterprises. In essence, FDI is a cross-border transfer of capital to obtain lasting benefits, and investors have the right to operate and manage enterprises [4]. GTFP refers to TFP after full consideration of resources and environment. Total Factor Productivity (TFP) refers to the economic growth of a country or region through scientific and technological progress and quality improvement. It reflects the scientific and technological development and quality improvement of the country or region. The higher the TFP is, the more its economic growth depends on technological progress and quality improvement [5]. However, GTFP is reflected in the improvement of the utilization rate of green products and the growth of economic benefits generated by the progress of green science and technology. It is specifically shown in the results calculated after considering the investment of capital, labor and energy at the investment end and the expected output and unexpected output at the output end [6]. Therefore, the analysis of the impact mechanism should examine the impact of FDI on the traditional TFP part and the impact of FDI on the environmental part. Figure 1 displays the specific impact mechanism.

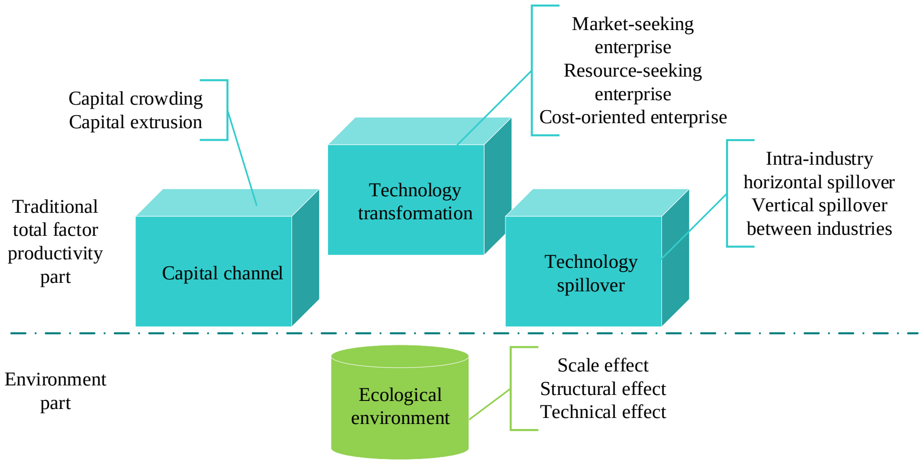

Figure 1. Impact mechanism of FDI on GTFP

Figure 1 shows that the impact mechanism of FDI on GTFP can be researched from four aspects. First, capital channels. FDI will affect a country's capital operation environment after it flows into the country. It is manifested as capital crowding in or capital crowding out effect. From the perspective of investment formation, the comprehensive benefit of FDI to TFP depends on the relative degree of crowding in effect and crowding out effect. Second, technology transformation. Foreign-funded enterprises act on the technological progress of local countries through technology transformation, thus improving TFP. The effect of the technology transformation of foreign-funded enterprises is related to industries in which foreign capital flows. Relatively speaking, the technology transformation effect of market-seeking enterprises is higher than that of resource-seeking and cost-oriented enterprises. Third, technology spillovers. Technology spillovers can be divided into intra-industry horizontal spillovers and inter-industry vertical spillovers. The horizontal spillover effect of an industry is caused by the interaction among enterprises in the same industry, which is embodied in the demonstration-simulation effect, competition effect and labor spillover effect. Among them, the demonstration-simulation effect positively impacts TFP, while the competition and labor spillover effects have positive and negative effects. Inter-industry vertical spillovers refer to the technology spillovers generated by the vertical relationship between foreign-funded enterprises and other industrial enterprises in the same value chain. According to the relative position of large transnational corporations and domestic enterprises in the same value chain, the relationship between industries can be divided into forward association and backward association. The inter-industry technology spillovers brought by foreign-funded enterprises will also have forward correlation and backward correlation effects. Industrial spillovers in both directions will enhance TFP. Fourth, the ecological environment. The impact of the ecological environment is the key to distinguishing GTFP from traditional TFP. After the foreign capital flows into the local country, it will lead to significant changes in the local economic scale, industrial structure (IS) and environmental technology, thus causing positive or negative impacts on China's ecological environment, which is finally directly reflected in GTFP. However, these three information transmission modes can be attributed to the scale effect of the national economy, the internal structure effect and the environmental technology effect. The combined effect of the three effects is the final effect of FDI on the environment [7].

2.2. Calculation method of GTFP

The first step is to establish a set of production processes, including expected and unexpected outputs. It is set that there are $t(t = 1,2,\cdots,T)$ periods and $k(k = 1,2,\cdots,K)$ provinces. Each province is a Decision Making Unit (DMU). Each DMU uses h inputs $a = (a_1, a_2, \cdots, a_h) \in Q_h^+$ to produce u expected outputs $b = (b_1, b_2, \cdots, b_u) \in Q_u^+$ and v unexpected outputs $c = (c_1, c_2, \cdots, c_v) \in Q_v^+$. Then, the input-output value of k province in t period is (a^{kt}, b^{kt}, c^{kt}). Equation (1) is the set of production possibilities at this time.

$$P^t(a^t) = \{(b^t, c^t): \sum_{k=1}^K \theta_k^t b_{ku}^t \ge b_{ku}^t, \forall u; \sum_{k=1}^K \theta_k^t c_{kv}^t = c_{kv}^t, \forall v; \sum_{k=1}^K \theta_k^t a_{kh}^t \le a_{kh}^t, \forall h; \sum_{k=1}^K \theta_k^t = 1, \theta_k^t > 0, \forall k \quad (1)$$

In (1), θ_k^t is the weight of the observation value of each cross-section, and the constraint $\sum_{k=1}^K \theta_k^t = 1, \theta_k^t > 0, \forall k$ indicates that the returns to scale of the production technology are variable. If this condition is removed, it indicates that the returns to scale are unchanged.

The second step is to define the directional distance function, as shown in equations (2) - (6) [8].

$$S_O^G(a^{k,t'}, b^{k,t'}, c^{k,t'}, f^a, f^b, f^c) = \max(S^a, S^b, S^c)\left[\frac{1}{H}\sum_{h=1}^H \frac{S_h^a}{f_h^a} + \frac{1}{U+1}\left(\sum_{u=1}^U \frac{S_u^b}{f_u^b} + \sum_{v=1}^V \frac{S_v^c}{f_v^c}\right)\right]/2 \quad (2)$$

$$s.t. \sum_{t=1}^T \sum_{k=1}^K \theta_k^t a_{kh}^t + s_h^a = a_{k'h'}^t, \forall h \quad (3)$$

$$\sum_{t=1}^T \sum_{k=1}^K \theta_k^t b_{ku}^t + s_u^b = b_{k'u'}^t, \forall u \quad (4)$$

$$\sum_{t=1}^T \sum_{k=1}^K \theta_k^t c_{kv}^t + s_v^c = c_{k'v'}^t, \forall v \quad (5)$$

$$\sum_{k=1}^K \theta_k^t = 1, \theta_k^t \ge 0, \forall k; s_h^a \ge 0, \forall h; s_u^b \ge 0, \forall u; s_v^c \ge 0, \forall v \quad (6)$$

S_O^G is the directional distance function with variable returns to scale. $(a^{k,t'}, b^{k,t'}, c^{k,t'})$ is the input-output quantity of the input, expected output and unexpected output in the t period of k province. (f^a, f^b, f^c) is the direction vector of input decrease, expected output increase and unexpected output decrease. (S^a, S^b, S^c) is the relaxation vector, which represents the amount of overuse of input, insufficient expected output, and excessive unexpected output.

The third step is to combine the GML index. Based on the directional distance function, equation (7) is the GML index expression [9].

$$GML_t^{t+1} = \frac{1+S_O^G(a^t,b^t,c^t;f)}{1+S_O^G(a^{t+1},b^{t+1},c^{t+1};f)} \tag{7}$$

In (7), the indexes less than 1, equal to 1, and greater than 1 represent the decline, unchanged, and increase of GTFP from t period to t+1 period, respectively. The index can be decomposed into Green Efficiency Change (GEC) and Green Technical Change (GTC). Equations (8) - (10) are specific expressions [10].

$$GML_t^{t+1} = GEC_t^{t+1} \times GTC_t^{t+1} \tag{8}$$

$$GEC_t^{t+1} = \frac{1+S_O^t(a^t,b^t,c^t;f)}{1+S_O^t(a^{t+1},b^{t+1},c^{t+1};f)} \tag{9}$$

$$GTC_t^{t+1} = \frac{[1+S_O^G(a^t,b^t,c^t;f)]/[1+S_O^t(a^t,b^t,c^t;f)]}{[1+S_O^G(a^{t+1},b^{t+1},c^{t+1};f)]/[1+S_O^t(a^{t+1},b^{t+1},c^{t+1};f)]} \tag{10}$$

$GEC_t^{t+1} < 1$ means the efficiency of green science and technology decreases, and $GEC_t^{t+1} > 1$ means the efficiency of green science and technology increases; $GTC_t^{t+1} > 1$ indicates the improvement of green technology, and $GTC_t^{t+1} < 1$ indicates the decline of green technology.

2.3. Establishment of the impact model of FDI on GTFP

Equation (11) is the basic model of international R&D spillover (C-H model) [11].

$$lnTFP_k = \delta_k^0 + \delta_k^y lnC_k^y + \delta_k^j lnC_k^j \tag{11}$$

Cy is the stock of domestic research capital spillovers, and Cj is the stock of foreign research capital spillovers obtained through import trade. Combined with the C-H model, factors such as ecological regulation, IS, regional economic situation, human resource level, and domestic development capital investment are introduced. Together with the first-order lag term of the predicted variable, a dynamic panel model is obtained, as shown in equation (12).

$$GTFP_{kt} = \delta_0 + \delta_1 GTFP_{k,t-1} + \delta_2 EDL_{kt} + \delta_3 HCL_{kt} + \delta_4 DCI_{kt} + \delta_5 IS_{kt} + \delta_6 ETI_{kt} + \delta_7 FDI_{kt} + \rho_k + \gamma_{kt} \tag{12}$$

$GTFP_{k,t-1}$ is the first-order lag term of GTFP. FDI_{kt}, EDL_{kt}, HCL_{kt}, DCI_{kt}, IS_{kt}, and ETI_{kt} represent FDI, Economic Development Level (EDL), Human Capital level (HCL), Domestic R&D Capital Investment (DCI), IS and Environmental Treatment Intensity (ETI), respectively. ρ_k is the unobservable regional response effect. It is caused by individual behavior differences and does not change with time. γ_{kt} is a random disturbance term, which gathers the influence of countless non-significant factors on the predicted variable. Based on this, an indicator model of influencing factors of FDI on GTFP is constructed. Figure 2 presents its structure.

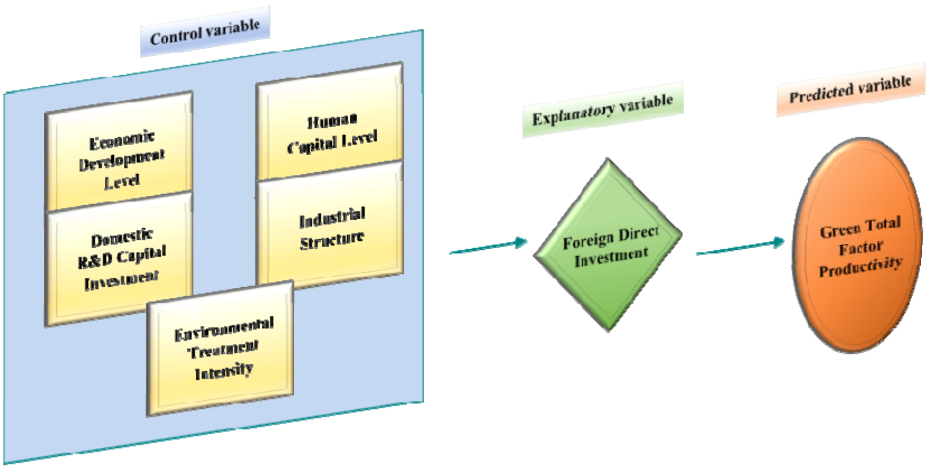

Figure 2. Indicator model of influencing factors of FDI on GTFP

Figure 2 reveals that the predicted variable is GTFP and the explanatory variable is FDI level. The controlled variables are EDL, HCL, DCI, IS and ETI.

3. Result

3.1. Descriptive statistics

With Province A as an example, descriptive statistics are made on the controlled variables ETI, IS, EDL, HCL, DCI, explanatory variable FDI and predicted variable GTFP of each subordinate city from 2008 to 2020. Figure 3 shows the result.

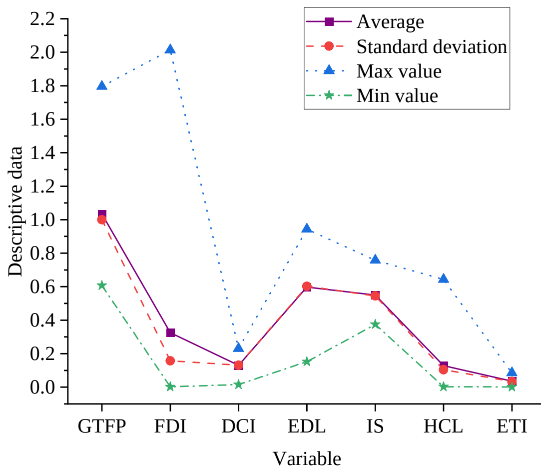

Figure 3. Descriptive statistics of each variable

Figure 3 suggests that the average value of GTFP is 1.0343, which is greater than 1, indicating that the overall green economy level of Province A is good. The comparison between the maximum and minimum values shows a large regional difference in Province A, not only in the FDI level, but also in EDL, HCL and IS.

3.2. Parameter estimation using system Generalized method of moments (GMM) estimation

The experiment uses the system GMM to estimate the parameters in equation (12). Figure 4 shows the system GMM results.

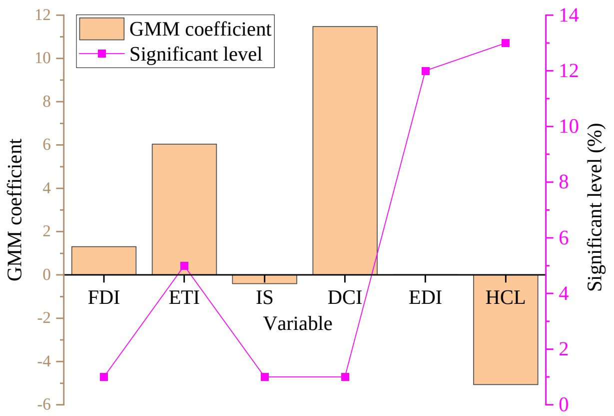

Figure 4. Empirical results of the impact of FDI on GTFP in Province A

Figure 4 shows that the coefficient of FDI is 1.304, which is significant at 1%. The coefficient of ETI is 6.041%, which is significant at 5%, and the coefficient of DCI is significant at 1%, which is 11.47, indicating that FDI, ETI and DCI can promote the growth of GTFP. The IS coefficient is significant at the level of 1%, which is -0.408, indicating that the industrialization degree will inhibit the growth of GTFP. However, EDL and HCL do not pass the significance test, indicating that they have little impact on GTFP.

4. Conclusion

In order to explore the influencing factors of FDI on GTFP, this work first introduces the concepts of FDI and GTFP and the influencing mechanism between them. By studying the calculation methods and influencing factors of GTFP, the impact model of FDI on GTFP is constructed. With Province A as the research object, the following conclusions are obtained through experimental calculation of model parameters. (1) The FDI, ETI and DCI coefficients are all positive and significant at 5%, indicating that these three variables can significantly promote GTFP growth. (2) The parameter of DCI is the largest, 11.47, and significant at 1%, indicating that the growth of GTFP is most affected by DCI, and the two are positively correlated. There are still some research deficiencies. Only Province A is studied this time, and the results can be consistent in provinces with similar development to Province A. However, the impact of GTFP nationwide is uncertain. The sample size can be further expanded to study more representative provinces, or directly study the impact of FDI on GTFP at the national level.

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