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Comparative Study on Reverse Technological Spillover of China's OFDI among Different Worldwide Economic Groups and Regions

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

This paper adopts the principle of Malmquist productivity growth index calculation to analyze the Chinese outward foreign direct investment (OFDI) for recent 10 years and its reverse technological spillover to the home country. To this end, the paper uses the two-stage (parametric and nonparametric) optimization approach to estimate the elasticity of China's OFDI that contributes to the development of domestic reverse technological spillover and economic efficiency. Besides, in order to appropriately evaluate the effect of reverse technological spillover, this paper also utilizes the component of technological progress in the Malmquist productivity growth index to measure total factor productivity (TFP). Finally, this paper provides the comparative analysis of reverse technological spillover across worldwide economic groups and regions that China has the outward foreign direct investments (OFDI) with.

As a result, China's direct investment overseas in recent 10 years exhibits an obvious positive effect on the reverse technological spillover domestically. Such effect is the largest from the African continent where China has direct investment, and is the weakest from the Asian continent. But according to the classification of per capita GDP criteria, the elasticity effect of reverse technological spillover on the Chinese OFDI hardly differs among groups of countries with different income classes. Besides, research results reflect that China, as the largest developing country, the

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outward foreign direct investment (OFDI) of an extensively large scale is just about to start, and the Chinese OFDI till now still shows an obvious motivation for seeking resources, while the proportion of technology-seeking type of OFDI is not enough.

Keywords: Non-parametric analysis; theory of FDI and MNEs; reverse technological spillover; China and comparative studies; total factor productivity (TFP); economic growth.

1. INTRODUCTION

For over 30 years of reform and opening-up, China's foreign direct investment (FDI) has experienced from scratch to full-fledged development. Since the beginning of the 21st century, China has implemented the "going out" strategy, the scale of foreign direct investment has ever enlarged, and the speed and quality of foreign direct investment have significantly escalated, which play an increasingly important role in the global investment field. In 2014 China's non-financial outward foreign direct investment (OFDI) reached $107.2 billion, rose 15.6% around the year, the total foreign direct investment amounted to $123.1 billion, very close to the actual utilization of inward foreign direct investment (IFDI) of $128.5 billion. It implies that the Chinese foreign direct investment has reached the upper limit of hundreds of billions of dollars, so it becomes one of the three world's largest economies investing directly overseas. In addition, China's two-way (inward and outward) foreign direct investment (FDI) levels have gradually approached the balance [1].

According to the neoclassical economic growth theory, if technological progress is the source of economic growth, the transnational foreign direct investment (FDI) provides a threshold opportunity in realizing technological progress and economic growth. An ever-enlarged scale of China's foreign direct investment (FDI) is beneficial to promote the domestic economic growth in China. In particular, its main factors influential to the economic growth are reflected in the effects of economic growth, technological progress, industrial structural upgrading and international trade promotion. Yet, the effect of economic growth is represented by rationalization of resource allocation, accumulation of investment capitals, and improvement of science and technology. In addition, the effect of technological spillover can promote the improvement of total factor productivity (TFP), and thus increase economic outputs of the whole economy.

There are two types of reverse effects of technological spillover for the foreign direct investment of Chinese experiences. One is to study advanced technologies and experiences of management overseas, so-called strategic capital or technology-seeking type of reverse effect of technological spillover, which is beneficial to improve the technology of investing countries. Second, foreign direct investment (FDI) extends the industrial life cycle by transferring excess production capacities from home to the outside, making domestic enterprises of investing countries to reap more profits. Besides, FDI may also be advantageous for the investing countries in sparing more room to promote the development of high-tech and tertiary industries domestically, which on the other hand, is called the resource-seeking type of reverse effect of technological spillover [2]. The combination of these two types of reverse effects of technological spillover plays an important role in promoting technological progress measured theoretically by the total factor productivity (TFP).

Normally, the effect of strategic asset-seeking type of reverse technological spillover occurs in countries with the foreign direct investment (FDI) in high technology, for the reason that the technological level of developed countries is usually higher than that of developing countries. In fact, the strategic asset-seeking type of FDI from developing countries to developed countries does play a positive role in escalating technologies of investing countries domestically. Particularly to say, the reverse effect of technological spillover of FDI for the developing countries can be divided into two stages: in the first stage, the subsidiary branches of oversea companies of investing countries obtain a technological spillover effect through cooperative research and development (R&D) with counter-partners from host countries, and also through purchasing middle products, enjoying after-sale-services, hiring technical workers and management personnel in markets of the host countries. In the second stage, the subsidiary branches of oversea firms from investing countries thus transform newly acquired advanced technologies and products to the domestic headquarters through an internal conducive mechanism in lawful ways. Afterwards, the home companies of investing countries can then spread the obtained new knowledge all over around the other relevant enterprises and industries domestically, thereby offering an impetus for developing countries to promote its scientific and technological progress to a higher level through investing overseas.

This paper intends to adopt the Malmquist productivity growth index approach to analyze the impact of China's outward foreign direct investment (OFDI) to host countries with different income levels, as well as in different geographical regions and economic unions, particularly in perspectives of the effects of economic growth, technological progress, and their decomposition factors as well.

2. LITERATURE REVIEWS

2.1 Traditional Theories of Multinational Investment Research

Since the 1960s, the academia has appeared a number of different points of views on the multinational direct investment activities, such as the theory of comparative superiority by Kiyoshi Kojima [3], a Japanese scholar, theory of monopolistic superiority by Stephen Hymer [4] and C. P. Kindlebrerger, theory of market internalization by British scholar Peter J. Barkley, Mark Casson [5], A. Rugman (2005) [6] and Stephen Yong, theory of product cycling by R. Vernon [7], and etc. In the late 70s of last century, John H. Dunning [8], a British economist, put forward to a compromised theory of combination of the "three advantages" of international direct investment based on summarizing prior theories, thought that the international multinational investment mainly depended on the comprehensive levels of three advantages including ownership advantage, internalization advantage and location advantage. In the 1980s, Dunning [8] further put forward to the theory of development stages of international direct investment. In particular, with the development of the world economy, the net foreign direct investment, namely the inward foreign direct investment (IFDI) minus the outward foreign direct investment (OFDI), is thought to exhibit a cyclical trend of change. Generally it experiences five different stages stated as follows: the first stage refers to under-developed countries, who accept little foreign direct investment, and make little direct investment overseas either, thereby their net FDI approaches zero, or negative sometimes; the second stage includes most of developing countries, who absorb foreign capitals as their main objective, while invest a few direct capitals abroad, thus the net foreign direct investment (NFDI) would mostly be a negative number; the third stage is involved in most emerging industrialized countries, such as China, whose outflow of direct capital investment becomes increasingly faster than the inflow of direct investment. During this stage, although the net foreign direct investment (NFDI) remains negative, the gap of differences is diminishing. And finally, the fourth and fifth stages are typically referred to those developed countries, in which the net amount of FDI is usually positive, namely, the outflow of direct investment exceeds that of the inflow. On the one hand, countries in the fourth stage show strong ownership capabilities and internalized advantages, plus the positive NFDI is further increased. On the other hand, the net foreign direct investment (NFDI) of developed countries in the fifth stage has reached the maximum limit, thus its absolute value begins to drop, mainly due to the reason that the dollar amount of cross-investments among these developed countries is gradually increased. However, studies of the above literatures are mainly based on activities of foreign direct investment (FDI) with regarding to developed countries as research targets, so that they may over-emphasize different sorts of advantages of FDI presumably possessed by developed countries, thus have some limitations in explaining growing phenomena of FDI activities with developing countries [8].

2.2 Researches of International Investment Theory in Developing Countries

With the development of global economic integration continuously, the amount of foreign direct investment in developing countries grows rapidly, and the proportion of total amount of foreign direct investment over the world gradually increases every year. Accordingly, academic studies of FDI of developing countries have also increased in recent years, which provide a beneficial supplement to traditional investment theories. Research works of these new studies mainly include the double gap theory by H.B. Chenery [9], A.M. Strout and Bruno, the small-scale technological theory by Louis T. Wells [10], the technological localization theory by S. Lall [11], the industrial upgrading theory of technological innovation by John A. Cantwell and Paz Estrella E. Tolentino [12], and etc. According to the double gap theory, restrictions of economic growth of developing countries are mainly due to two constraint conditions, one is saving gap and the other is foreign exchange gap. However, introducing FDI is of great importance in making up the above two gaps. Yet, the small-scale technological theory assumes that, compared to developed countries, developing countries possess a comparative advantage of low production costs, which is suitable to explain the early stages' FDI activities for developing countries moving forward to the internationalization. On the other hand, both of the theory of technological localization and the theory of technological innovation for industrial upgrading focus on the competitive advantage of developing countries devoted to the transnational business world that can make full use of their capabilities characterized with "learning experiences" and "imitation skills" to absorb and grasp existing high technologies from the developed countries.

3. DESIGN AND MEASUREMENT OF ECONOMETRIC MODEL

3.1 Theoretical Basis of the Malmquist Productivity Growth Index

Since the 70s of last century, the Malmquist productivity growth index is widely used to measure the economic efficiency. The academia defines the basic element of Malmquist productivity growth index using the distance function. It is in fact a functional expression of production technology with multiple outputs and multiple inputs. This means that, for any period t, the output-based distance function, such as D(t, 0), is looking for the proportion that makes certain x(t) as large as possible. Only when the production is on the border or frontier, the distance of output-based equation is equal to 1, namely, D[x(t), y(t)]=1. We must specify two distance equations between two different periods of time to define the Malmquist productivity growth index, and the specific expression is shown as follows (Fare et.al, 1994; Grosskopf et.al, 2003; Pastor et.al, 2007) [13-15]:

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}}. \quad (1)$$

By the above expression, the Malmquist productivity growth index can be decomposed into two elements: Scale efficiency change (EFFCH) and technological progress (TECHCH). The fractional component outside the bracket represents for efficiency change, describing the relative efficiency increase due to scale change between two periods, t and t+1, or sometimes called the "catching-up" effect. The geometric average of two factions within the bracket reflects the cutting-edge efficiency change due to technological transformation between two periods, or sometimes called the "technological or innovative" effect.

It is important to note that, according to the neoclassical economic growth theory, the Solow residual identity measures the total factor productivity (TFP) that represents for technological progress. Under the assumptions of Hicks neutrality and constant return to scale, the component of technological effect that measures technological progress in the Malmquist productivity growth index, theoretically equals the total factor productivity (TFP) that is measured using the Solow residual. However, because of the existence of unavoidable errors when using Solow identity to measure the total factor productivity (TFP), the resulted measurement of TFP or technological progress by the Solow identity thereby contains a lot of estimation bias and mostly inconsistency with real-world experiences in many occasions. So this study uses the component of technological progress underlying in the Malmquist productivity growth index to calculate the total factor productivity (TFP).

3.2 Measurement of the Malmquist Productivity Growth Index

To measure the Malmquist productivity growth index, this paper firstly uses the input and output data of China's provinces to construct a benchmark frontier of production technology, then make each respective production technology compared to the technological benchmark frontier to calculate the distance equation for each province, and finally calculate the Malmquist productivity growth index according to Equation (1) for each province, as well as a nationwide Malmquist productivity growth index. To this end, four distance equations must be estimated based on any two adjacent time periods, t and t+1. For example, to calculate the distance equation Dt(xt, yt), the linear non-parametric optimization problem that solves the distance can be formulated as follows:

$$(D_o^t(x^{k,t}, y^{k,t}))^{-1} = \max \theta^k$$

s.t.

$$\sum_{k=1}^{K} z^{k,t} y_m^{k,t} \geq \theta^k y_m^{k,t} \qquad m = 1,\ldots,M$$
$$\sum_{k=1}^{K} z^{k,t} x_n^{k,t} \leq x_n^{k,t} \qquad n = 1,\ldots,N$$
$$z^{k,t} \geq 0 \qquad k = 1,\ldots,K. \tag{2}$$

where the letter z is the intensity variable; Theta (θ) is the reciprocal of distance equation; x and y are input and output variables, respectively.

The advantage of the above first stage estimation that uses the non-linear optimization programming technique in the production efficiency analysis is that it fits the actual reality of observations the best, thus is the most consistent to the real world. However, the problem of it is that the constructed technological frontier is segmented and unsmooth. But such defect can be compensated by using a parametric functional equation to reform and estimate the distance function once again in the second stage. Therefore, in addition to the above nonparametric optimization estimation, this paper also uses the parametric logarithmic functional form to revalue the distance function in the second stage [16].

By using the above stated two-stage optimization method to estimate the distance equation and thus the Malmquist productivity growth index, no matter what the production function is parametric or non-parametric, both of the estimated distance functions can be further used to calculate the decomposition effects of scale efficiency and technological progress, the second component of technological effect is further used to measure the total factor productivity (TFP) as in the section that follows.

3.3 Calculation of TFP and Contribution of FDI to the Technological Progress

To measure the contribution of FDI to the technological progress and economic growth, we first assume that the relationship of a country's output (Y), capital stock (K), labor input (L), and foreign direct investment (FDI) can be expressed with the Cobb-Douglas (C-D) production function, thus the following functional form of production can be obtained:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} FDI_t^{\gamma} \tag{3}$$

where, the upper-case letter A represents for the technological level of a country in time period t. We usually assume constant return to scale in production function, that is, α+β=1. Also note that TFP is the total factor productivity, representing for the technological progress in time period t. Thus, according to the Solow residual identity equation, TFP can be defined as follows:

$$TFP_t = \frac{Y_t}{K_t^{\alpha} L_t^{\beta}} \tag{4}$$

Substituting the above Equation (4) into Equation (3), and replacing the outward foreign direct investment (OFDI) for the FDI under an outward open economy, and then take the natural logarithm on both sides of the equation, thus the basic measurement equation that examines the effect of OFDI on the technological progress can be expressed as follows:

$$\ln TFP_{it} = \alpha_{0i} + \alpha_{1i} \ln OFDI_{it} + \varepsilon_{it} \tag{5}$$

where, TFP_{it} represents for the total factor productivity for Country i in time period t, measuring the home country's reverse technological spillover from OFDI in this paper; $OFDI_{it}$ is the outward foreign direct investment in host country i at time period t; and ε_{it} is the random effect [17,18].

4. EMPIRICAL ANALYSIS AND DISCUSSION

4.1 Data Sources and Processing

This paper focuses on examining China's Malmquist productivity growth index and its scale efficiency and technological progress under the open economy, and analyzes the effect of China's outward foreign direct investment (OFDI) to different countries and economic alliances, particularly on the effect of reverse technological spillover to the home investing country of China. Considering the availability and comparability of data, included in the research scope is 150 countries to whom China has foreign direct investment, and the number of years of study is set from 2004 to 2015. Besides, sample countries covered relevantly in the study are partitioned into two alliances, Association of Southeast Asian Nations (ASEAN) and European Union (EU), and are also regrouped according to different level of GDP per capita and different geographical continents. This paper thereby gives comparative analysis of the reverse technological spillover to the home investing countries across different classified groups.

The basic economic data used to calculate the Malmquist productivity growth index, such as the annual average GDP, the fixed capital stock, labor inputs, and the capital investment both domestically and overseas, price indexes and currency exchange rates, such as the price index of investment in fixed assets and GDP deflators, are all sourced from the National Statistical Yearbook of China (2004-2015 editions) issued by the National Bureau of Statistics. The flow and stock data of foreign direct investment (FDI) are sourced from the Statistical Bulletin of the Chinese foreign investment issued by the Ministry of Commerce of China (former Ministry of Foreign Economic Trade), and dollar values are converted into RMB values according to the mid-value of exchange parity. All the stock values are converted into the constant 2004 basic price using the fixed asset price index, while the flow values are converted into the constant 2004 basic price using provincial GDP price deflators. Finally, the GDP and population data of the sample hosting countries to whom China has the OFDI are drawn from the annual world development indicators (WDI) released by the World Bank on a yearly basis [19].

4.2 Empirical Analysis and Discussion

First of all, according to the principle of Malmquist productivity growth index calculation, this paper adopts the two-stage optimization programming technique to estimate the Chinese provincial productivity growth index for the recent 10 years from 2004 to 2014, and its two decomposition factors of technological progress and scale efficiency, as described above. Table 1 summarizes yearly average values of estimated calculation. The overall annual average of China's productivity growth rate is positive, grows at 1.21% per year, which reflects that, compared with about 10% of an average annual GDP growth rate for a recent decade, the average annual growth rate of productivity that represents for the level of economic efficiency is relatively low, although it is still positive. Besides, the two decomposition effects of technological progress and scale efficiency play almost balanced roles in promoting the productivity growth, increasing at 3.0% and 3.3% respectively, slightly higher in terms of scale efficiency.

Second, the effect of technological progress is reflected in a certain period of time by an increased value of total outputs to the whole economy holding constant of all inputs of factor resources, including labor, capital, land, and a series of other tangible resources, which can be measured equivalently to the growth of total factor productivity (TFP). In this regard, the effect of foreign direct investment (FDI) on the technological progress can be estimated under the open economy using Equation (5).

According to the first-order difference stationary test equation, it first examines the sequential variables of productivity growth, technological progress and scale efficiency estimated for stability. Table 2 summarizes the testing result, showing that the time variables of growth rates of productivity, scale efficiency and technological progress are all stationary with the first-order integration at the 1% significance level.

Finally, the paper estimates impacts of China's outward foreign direct investment (OFDI) on the total factor productivity (TFP) or technological progress, the effect of scale efficiency and the overall productivity growth as well. The result of technological effect is summarized in Table 3, and the other two estimation results of responsive factors are provided in Table 4 and Table 5 as follows.

From the viewpoint of statistical significance, the estimated parameters are significant at the 1% level, and the econometric models are in overall best fit the raw observations. Because the econometric models are double logarithmic equation, the coefficients of estimated parameters measure the sensitivity or elasticity rate of the outward foreign direct investment (OFDI) corresponding to the dependent responsive variables. Thus, in the economic point of view, China's foreign direct investment overseas has an obvious positive effect of reverse technological spillover to the home investing country in recent 10 years. On average, 1% increase in China's outward foreign direct investment (OFDI) causes 7.42% increase of reverse technological spillover to the home country (see Table 3). From the perspective of investing in different continents, the reverse technological spillover of foreign direct investment (FDI) in South Africa (or Africa) to the home country has the largest effect with a 21.1% (or 14.4%) elasticity rate. The second is Europe, followed by Oceania and North America, producing the reverse technological spillover effect of 13.34%, 12.07% and 11.7%, respectively at home. On the other hand, the weakest reverse technological spillover effect is made in Asia, followed by Latin America, taking the effecting rate of 7.88% and 9.43%, respectively. The reverse technological spillover of China's OFDI to the two economic alliances, European Union (EU) and Association of Southeast Asian Nations (ASEAN), ranks in between the two extremes, slightly higher than the average level of 7.42%. In addition, according to the divisional groups of countries by GDP per capita, the difference of reverse technological spillover effect across groups is not very obvious due to different income categories, only ranged from 4% to 6% in terms of elasticity effects, accounting for less than 2% of the overall difference. Generally, the reverse effect of technological spillover of economies with income per capita less than $20,000 is a little bit higher than those above that same income level of $20,000.

Table 1. Productivity growth index and decomposition effects of China (2005-2013)

Year	Malm	EffCh	TechCh
2005	1.0130	1.0470	0.9710
2006	0.8999	0.8161	1.1066
2007	0.9836	0.9612	1.0267
2008	0.9172	0.8552	1.0767
2009	0.9618	0.9158	1.0516
2010	1.3878	1.6640	0.8428
2011	1.0245	0.9235	1.1098
2012	0.9375	0.8828	1.0640
2013	0.9832	0.9642	1.0200
Overall	**1.01206**	**1.00331**	**1.02992**

** Figures in the table are calculated by the author with GAMS*

Table 2. Results of stationary test for time-series sequences Model for China

Depend	Independ	Coef.	Std. Err.	t	P>t
Model1:	L_ln_N_TECHCh	-1.6360	0.1022	-16.01	0.0000
D_ln_N_TECHCH	L_D_ln_N_TECHCh	0.2859	0.0621	4.60	0.0000
	_cons	1.1565	0.0725	15.96	0.0000
Model 2:	L_ln_N_Malm	-1.3291	0.0907	-14.66	0.0000
D_ln_N_Malm	L_D_ln_N_Malm	0.3139	0.0638	4.92	0.0000
	_cons	0.9357	0.0637	14.68	0.0000
Model 3:	L_ln_N_EFFCH	-1.4407	0.0971	-14.84	0.0000
D_ln_N_EFFCH	L_D_ln_N_EFFCH	0.2837	0.0643	4.41	0.0000
	_cons	1.0021	0.0676	14.82	0.0000

**Reslts of the table are estimated by the author with Stata*

Table 3. Estimated results of reverse technological spillover of China's OFDI

ln_TechCh	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	Adj R^2	ln_TechCh
ln_Area_all	0.0742	0.0023	32.0700	0.0000	0.0688	0.0795	0.9913
ln_Asia	0.0788	0.0058	13.4900	0.0000	0.0653	0.0923	0.9526
ln_Africa	0.1448	0.0190	7.6400	0.0000	0.1011	0.1886	0.8643
ln_SA	0.2110	0.0462	4.5700	0.0030	0.1018	0.3202	0.7129
ln_Europe	0.1334	0.0189	7.0700	0.0000	0.0899	0.1769	0.8449
ln_LA	0.0943	0.0075	12.5300	0.0000	0.0770	0.1117	0.9455
ln_NA	0.1178	0.0143	8.2300	0.0000	0.0848	0.1508	0.8812
ln_Oceania	0.1207	0.0165	7.2900	0.0000	0.0825	0.1588	0.8530
ln_EU	0.1140	0.0151	7.5400	0.0000	0.0791	0.1488	0.8613
ln_EAU	0.1117	0.0133	8.3900	0.0000	0.0810	0.1424	0.8852
ln_GDP5ThB	0.0520	0.0017	31.0900	0.0000	0.0481	0.0559	0.9908
ln_GDP10ThB	0.0533	0.0016	34.2300	0.0000	0.0497	0.0569	0.9924
ln_GDP20ThB	0.0556	0.0018	30.8100	0.0000	0.0515	0.0598	0.9906
ln_GDP40ThB	0.0492	0.0014	34.8000	0.0000	0.0460	0.0525	0.9926
ln_GDP60ThB	0.0459	0.0013	35.0700	0.0000	0.0429	0.0490	0.9927
ln_GDP60ThA	0.0485	0.0010	48.5800	0.0000	0.0462	0.0508	0.9962

**Results are estimated by the author with Stata*

Table 4. Estimated effects of China's OFDI on productivity growth by groups

ln_Malm	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	Adj R^2	ln_Malm
ln_Area_all	0.0732	0.0026	27.7100	0.0000	0.0671	0.0793	0.9884
ln_Asia	0.0779	0.0058	13.5000	0.0000	0.0646	0.0912	0.9527
ln_Africa	0.1432	0.0187	7.6600	0.0000	0.1001	0.1863	0.8651
ln_SA	0.2116	0.0454	4.6600	0.0020	0.1042	0.3189	0.7215
ln_Europe	0.1332	0.0173	7.6900	0.0000	0.0932	0.1732	0.8658
ln_LA	0.0931	0.0076	12.2800	0.0000	0.0756	0.1106	0.9433
ln_NA	0.1165	0.0140	8.2900	0.0000	0.0841	0.1489	0.8828
ln_Oceania	0.1197	0.0160	7.5000	0.0000	0.0829	0.1564	0.8600
ln_EU	0.1131	0.0145	7.7900	0.0000	0.0796	0.1465	0.8690
ln_EAU	0.1106	0.0129	8.6000	0.0000	0.0810	0.1403	0.8902
ln_GDP5ThB	0.0513	0.0018	28.0600	0.0000	0.0471	0.0556	0.9887
ln_GDP10ThB	0.0526	0.0019	28.1200	0.0000	0.0483	0.0569	0.9887
ln_GDP20ThB	0.0549	0.0022	25.2300	0.0000	0.0499	0.0599	0.9860
ln_GDP40ThB	0.0486	0.0017	28.5800	0.0000	0.0447	0.0525	0.9891
ln_GDP60ThB	0.0453	0.0015	29.9200	0.0000	0.0418	0.0488	0.9900
ln_GDP60ThA	0.0478	0.0017	28.5300	0.0000	0.0439	0.0516	0.9891

**Results are estimated with Stata*

Table 5. Estimated effects of China's OFDI on scale efficiency by economic groups

ln_EffCh	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	Adj R^2	ln_EffCh
ln_Area_all	0.0723	0.0041	17.4700	0.0000	0.0628	0.0818	0.9713
ln_Asia	0.0770	0.0066	11.6000	0.0000	0.0617	0.0923	0.9369
ln_Africa	0.1416	0.0195	7.2500	0.0000	0.0965	0.1866	0.8513
ln_SA	0.2111	0.0457	4.6200	0.0020	0.1031	0.3191	0.7178
ln_Europe	0.1321	0.0177	7.4600	0.0000	0.0913	0.1730	0.8585
ln_LA	0.0920	0.0086	10.7300	0.0000	0.0722	0.1118	0.9269
ln_NA	0.1151	0.0149	7.7400	0.0000	0.0808	0.1494	0.8675
ln_Oceania	0.1183	0.0166	7.1200	0.0000	0.0800	0.1567	0.8467
ln_EU	0.1118	0.0152	7.3700	0.0000	0.0768	0.1468	0.8556
ln_EAU	0.1094	0.0136	8.0300	0.0000	0.0780	0.1408	0.8760
ln_GDP5ThB	0.0507	0.0029	17.6900	0.0000	0.0441	0.0573	0.9719
ln_GDP10ThB	0.0520	0.0030	17.6100	0.0000	0.0452	0.0588	0.9717
ln_GDP20ThB	0.0542	0.0033	16.5800	0.0000	0.0467	0.0617	0.9682
ln_GDP40ThB	0.0480	0.0027	17.5800	0.0000	0.0417	0.0543	0.9716
ln_GDP60ThB	0.0448	0.0025	18.2600	0.0000	0.0392	0.0505	0.9736
ln_GDP60ThA	0.0472	0.0027	17.3100	0.0000	0.0409	0.0535	0.9707

**Results are estimated with Stata*

In a nutshell, the above analyses show that, as the largest developing country, China's large-scaled foreign direct investment (FDI) overseas is just about to start: foreign direct investment in other developing countries focuses mainly on domestic obsolete industries, so called a resource-seeking type of foreign direct investment; for the foreign direct investment in developed countries, the Chinese enterprises pay more attention on accessing host countries' high and advanced technologies, considered to be a strategic asset-seeking type of foreign direct investment. The reverse technological spillover of both types of foreign direct investment (FDI) to the home country is difficult to take effect in a short period of time. But, in contrast, the reverse technological spillover effect of China's resource-seeking type FDI in other developing countries exhibits a higher level than that of the strategic asset-seeking type FDI concentrated in hi-tech-intensive developed countries by now. In fact, it shows that China's current FDI has an obvious motivation in seeking resources overseas, yet the proportion of technology-intensive foreign direct investment (FDI) outside the mainland is quite small. However, the existing advanced and high technologies mostly possessed in developed countries should become important sources from which developing countries can attract reverse technological spillovers.

Similarly, this research also finds that 1% of outward foreign direct investment (OFDI) contributes 7.32% and 7.23% of productivity growth and scale efficiency improvement to the home investing country (China), respectively (See Table 4 and Table 5), very close to that of the contribution to the technological progress of the home country. That is to say, China's current OFDI has a balanced effect on both the economic efficiency and scale efficiency to the domestic economy, as well as on the technological progress, all increasing at nearly the same growth rate, intended to promote the development of the economy.

5. CONCLUSIONS

This paper adopts the principle of Malmquist productivity growth index calculation to analyze the Chinese outward foreign direct investment (OFDI) for recent 10 years and its reverse effect of technological spillover to the home country. To this end, the paper uses the two-stage (parametric and nonparametric) optimization approach to estimate the elasticity of China's OFDI that contributes to the development of domestic reverse technological spillover and economic efficiency. Besides, in order to appropriately evaluate the effect of reverse technological spillover, the paper also utilizes the component of technological progress in the Malmquist productivity growth index to measure the total factor productivity (TFP) instead of Solow residual. It is found that China's direct investment overseas in recent 10 years exhibits an obvious positive effect on the reverse technological spillover at home. Such effect is the largest from South Africa or Africa where China has direct investment, and is the weakest from the Asian continent. But according to the classification of per capita GDP, the elasticity effect of reverse technological spillover on the Chinese OFDI hardly differs among groups of countries with different income classes.

In summary, above facts reflect that China, as the largest developing country, the outward foreign direct investment (OFDI) of an extensively large scale is just about to start, and the Chinese OFDI till now still shows an obvious motivation for seeking resources, while the proportion of technology-seeking type of OFDI is not enough. However, the most high and advanced technologies existing in the developed countries should be an important source from which developing countries can absorb the reverse technological spillovers.

The methodology used in the paper extends the Malmquist productivity growth index calculation, which is appropriate in studying the aggregate level of input-output based efficiency and technological improvement, however, neglects some detailed factors that may also be important in affecting the above results. Besides, the timeframe and targeted observations under this study may not be complete or comprehensive enough to provide the most valid conclusions, which can only be regarded as references for relevant studies. Further researches for the purposed of both methodological and empirical improvement are eminently required for future studies.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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