Regional Differences of OFDI Reverse Technology Spillover Effect: An Empirical Analysis based on China's Provincial Panel Data

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Abstract

As a technology spillover path, outward foreign direct investment plays an important role in promoting domestic technological progress. In this paper, we select China's provincial data from 2003 to 2014 and study on the basis of international R&D spillover model. The study shows that technology transmitted by OFDI exerts no significantly positive impact on TFP. Meanwhile, the sub-regional regression result shows that there are obvious regional differences in the reverse technology spillover of OFDI. It contributes to the growth of TFP in the east while has no effect in the central and west.

Keywords

Outward foreign direct investment, Reverse technology spillover, Total factor productivity, Regional differences.

1. Introuduction

With the acceleration of the economic globalization and economic integration, capital, technology and other factors flow faster and faster in the worldwide. A country's technological improvement can be realized not only through independent R&D but also external access, such as foreign direct investment (FDI), trade and other methods. With the increasing outward foreign direct investment (OFDI) in developing countries, technology spillover under this channel has attracted many scholars' attention. For a long time, China only got the low-end technology. In order to get rid of the plight, China's enterprises begin to seek technology. The focus shifts from absorbing foreign capital to paying equal attention to attract foreign investment and invest abroad. The 2014 Statistics Bulletin of China's Outward Foreign Direct Investment shows that during 2003 and 2014 China's foreign investment stock increased from $33.2 billion to $745.02 billion. And it is the first time that China squeezes into the global top 10. Whether the rapid growth of OFDI promotes China's technological progress or our country has acquired the reverse technology spillover from host country or the reverse spillover effect has regional differences. Therefore, discussing the regional differences of reverse technology spillover has important significance. This has important implications in using technology spillover to promote China's economic growth.

2. Literature Review

2.1 Current foreign research

The research on reverse technology spillover of Outward Foreign Direct Investment carried out by foreign scholars started in the 1990s. It can be divided into two aspects: the theoretical study and the empirical study. Siotios (1999) [1] examined the outward foreign direct investment behavior of enterprises that without technical advantages. He believes that enterprises choose outward foreign direct investment due to the existence of technology spillover. Braconier (2001) [2] tried to find out the relationship between R&D capital stock owned by host country and technology spillover obtained by home country. Through the panel data of Swedish multinationals, he found that there is a positive relationship between the two. The more a country invests in countries with abundant R&D factor, the more reverse technology spillover can be obtained. And it has a positive effect on promoting domestic technical progress. Nigel Driffield and James Love (2003) [3] used Britain manufacturing industry data and concluded that reverse technology spillover effect exists but is limited in the industry with high R&D intensity. Bitzer and Kerekes (2008) [4] used data from 17 OECD countries to test whether OFDI is a potential channel for knowledge and technology diffusion. The research shows that home country cannot obtain reverse technology spillover effect and the effect of OFDI on TFP is negative. Herzer (2011) [5] studied the impact of OFDI reverse technology spillover on home country technical level by using the data from developing countries. The conclusions supported that reverse technology spillover contribute to home country technological progress.

2.2 Current domestic research

Domestic scholars do research on OFDI reverse technology spillover start late, but the research achievements are abundant. Wang Ying (2008) [6], Zou Ming (2008) [7] and Fu Haiyan (2014) [8] found that China's outward foreign direct investment exists reverse technology spillover effect and it significantly improved the technical level. However, its impact is less than foreign direct investment and domestic R&D. Bai Jie (2009) [9] and Liu Weiquan (2010) [10] found that the contributing effect of OFDI on China's technological level is not obvious. Liu Mingxia (2010) [11] and Sha Wenbing (2012) [12] considered that the reverse technology spillover of China's OFDI exists regional differences. The reverse technology spillover obviously enhanced technical level in the eastern region, while in the central and western regions it's not significant. Ouyang Yanyan (2012) [13] and Han Yujun (2015) [14] discussed the influence of host country location factors on reverse technology spillover effect. They found that human capital, intellectual property protection and R&D expenditure in the host country in favor of reverse technology spillover and promote the technical innovation in the investing countries.

Most of the current researches only focus on the effect of reverse technology spillover under OFDI channel on a country's technical level. And ignore the technology spillover through FDI channel and import trade channel. Therefore, in this paper we also include the foreign direct investment and import trade into analysis model. So that we can compare FDI and import trade technology spillover with OFDI reverse technology spillover. Whether there exists difference in their effects on technology level or not. Furthermore, we also consider the regional differences of reverse technology spillover effect. In order to enrich the existing research and provide advice for regional foreign investment policy.

3. Empirical Model and Data Sources

3.1 Construction of empirical model

Coe and Helpman (1995) thought that in an open economy a country's technological progress depends not only on its own R&D investment but also on the knowledge spillover from foreign countries. And the basic econometric model of international R&D spillover is given.

$$\log F_i = \alpha_i^0 + \alpha_i^d \log S_i^d + \alpha_i^f m_i \log S_i^f$$

In the above formula, i represents the country, F is total factor productivity, S_i^d represents domestic R&D capital stock, S_i^f represents foreign R&D capital stock obtained through trade channel and m_i is the proportion of imported goods in GDP in country i. Since the C-H model has been put forward, it has become the basis for scholars to study international technology spillover. Van Pottelsberghe and Lichtenberg (2001) extended the C-H model and used G7 countries as dummy variable. They also added the cross-terms into the model and got the following model:

$$\log F_{it} = \alpha_i + \alpha^d \log SD_{it} + \alpha^{d7} G7 \log SD_{it} + \alpha^f \log SF_{it} + \alpha^{f7} G7 \log SF_{it} + \varepsilon_{it}$$

Here F_{it} is the TFP of country i at period t, SD_{it} and SF_{it} are domestic and foreign R&D capital, G7 is the dummy variable of G7 countries and ε_{it} is residuals.

In this paper, we introduce import trade, foreign direct investment and OFDI as spillover channels into the empirical model, which is based on the C-H and L-P models. In order to examine the impact of reverse technology spillover on domestic technological progress, we use the panel data of 30 provinces in China from 2003 to 2014.The empirical model is as follows:

$$\ln TFP_{it} = \alpha_0 + \alpha_1 \ln S_{it}^{domestic} + \alpha_2 \ln S_{it}^{import} + \alpha_3 \ln S_{it}^{FDI} + \alpha_4 \ln S_{it}^{OFDI} + \varepsilon_{it}$$

Here i stands for the province, t represents the year, TFP is total factor productivity, $S_{it}^{domestic}$ represents R&D capital stock, S_{it}^{import} and S_{it}^{FDI} are foreign R&D capital stock obtained through import trade and FDI, S_{it}^{OFDI} is foreign R&D capital spillover cause by OFDI and ε_{it} is residuals.

3.2 Data sources and processing

(a). Estimation of total factor productivity

Total factor productivity refers to the ratio of output to total factor input and it reflects the effect of technological progress on economic development. As a comprehensive index, it can be used to measure the impact of reverse technology spillover of OFDI on technological progress. We use the Malmquist productivity index based on DEA method to calculate total factor productivity, which is based on Caves (1982) and Fare (1994) research findings. And we use the DEAP2.1 Software to estimate the TFP of 30 provinces from 2003 to 2014. According to Caves, the Malmquist productivity index can be expressed as:

$$M_i^t = \frac{D_i^t(x^t, y^t)}{D_i^t(x^{t+1}, y^{t+1})}$$

The above formula measures the rate of change in TFP from period t to t+1. Where D_i is the distance function, x is input vector and y is output vector. In order to avoid the randomness of the choice of technical reference system, Fare uses the geometric mean of the Malmquist productivity index in two periods to calculate the changes in TFP.

$$M_i(x^{t+1}, y^{t+1}; x^t, y^t) = \left[\frac{D_i^t(x^t, y^t)}{D_i^t(x^{t+1}, y^{t+1})} \times \frac{D_i^{t+1}(x^t, y^t)}{D_i^{t+1}(x^{t+1}, y^{t+1})}\right]^{\frac{1}{2}} = \frac{D_i^t(x^t, y^t)}{D_i^{t+1}(x^{t+1}, y^{t+1})}\left[\frac{D_i^{t+1}(x^{t+1}, y^{t+1})}{D_i^t(x^{t+1}, y^{t+1})} \times \frac{D_i^{t+1}(x^t, y^t)}{D_i^t(x^t, y^t)}\right]^{\frac{1}{2}}$$

The above equation only measures the growth rate of provincial TFP relative to the previous period. The TFP of each province should multiply the Malmquist index of the year.

Calculating the TFP involves setting input variable and output variable. In this paper, we use the real GDP of each province as output variable and set the year 2003 as base period. We deflate the data to express at 2003 constant price so as to eliminate price changes. As to input variables, we use each province's fixed capital stock and labor input. The fixed capital stock is calculated by using the perpetual inventory method and the formula is: $K_{it} = I_{it} / P_{it} + (1-\delta)K_{i,t-1}$. Here i stands for province, t stands for year, K is the fixed capital stock, I is gross fixed capital formation, P is the price index of fixed asset investment and δ is the capital depreciation rate (set to 9.6%). The labor input is expressed by the number of employed persons at the end of the year. The above data comes from China Statistical Yearbook and Statistical Yearbook of each province.

(b). Estimation of domestic R&D capital stock

With respect to the estimation of domestic R&D capital stock in each province, we use the method proposed by Griliches (1980). The formula is $S_{it}^{domestic} = RD_{it} + (1-\delta)S_{i,t-1}^{domestic}$. Here $S_{it}^{domestic}$ and $S_{i,t-1}^{domestic}$ represent R&D capital stock of province i at period t and t-1. RD_{it} is the real R&D expenditure deflated according to the base price. δ is the capital depreciation rate and we set it to 5%. We use the following formula to calculate the base period R&D capital stock: $S_{i,2003}^{domestic} = \frac{RD_{i,2003}}{g+\delta}$ (g is the average value of regional R&D expenditure's logarithmic growth rate. The data comes from China Statistical Yearbook of Science and Technology.

(c). Estimation of foreign R&D capital spillover through import trade

First, we calculate the R&D capital spillover obtained through import trade from the national level. The formula is as follows: $S_t^{import} = \sum \frac{IM_{jt}}{GDP_{jt}} S_{jt}$. IM_{jt} is the total imports that China import from j country during period t. GDP_{jt} and S_{jt} are gross domestic product and R&D capital stock in country j. We choose America, Britain, France, Canada, Germany, Italy, Japan, Australia, Singapore, Russia and Hongkong as sample countries, which have trade with China. Then, we calculate the foreign R&D capital spillover obtained by each province through import trade. The formula is: $S_{it}^{import} = \frac{IM_{it}}{IM_t} S_t^{import}$. IM_{it} represents the import volume of province i at period t. While IM_t is China's total imports at period t. The above data comes from China Statistical Yearbook and the OECD database.

(d). Estimation of foreign R&D capital spillover through FDI

In order to calculate the foreign R&D capital spillover obtained by each province through FDI channel, we follow the above research approach. The calculation formulas are: $S_t^{FDI} = \sum \frac{FDI_{jt}}{Y_{jt}} S_{jt}$, $S_{it}^{FDI} = \frac{FDI_{it}}{FDI_t} S_t^{FDI}$. FDI_{jt} is the amount of investment country j in China at period t. Y_{jt} is the gross fixed capital formation of country j. FDI_{it} is the amount of FDI attracted by each province. FDI_t is the national's FDI. The data comes from China Statistical Yearbook.

(e).Estimation of foreign R&D capital spillover through OFDI

We follow the above research approach and use the following calculation formulas: $S_t^{OFDI} = \sum \frac{OFDI_{jt}}{Y_{jt}} S_{jt}$, $S_{it}^{OFDI} = \frac{OFDI_{it}}{OFDI_t} S_t^{OFDI}$. Here, $OFDI_{jt}$ is China's OFDI in country j, $OFDI_{it}$ is the OFDI amount of each province and $OFDI_t$ is the total OFDI amount of China. The remaining variables have the same meaning as above. The data comes from the Statistical Bulletin of China's Outward Foreign Direct Investment and OECD database.

4. Empirical Results and Analysis

In order to accurately examine the regional differences of reverse technology spillover of OFDI, we divide the 30 provinces into the eastern, central and western. The eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. The central region includes Shanxi, Jilin, Hei Longjiang, Anhui, Jiangxi, Henan, Hubei and Hunan. The western region includes Nei Menggu, Guangxi, Chongqing, Sichuan, Guizhou, Yunan, Shanxi, Gansu, Qinghai, Ningxia and Xinjiang. We use the Stata12.0 Software to carry out the analysis. First, we test the robustness and co-integration relationship of panel data. Then, we carry out regression analysis and the results are as follows:

4.1 The unit root test of panel data

In order to avoid spurious regression, we use LLC Test and Fisher-ADF Test to the robustness of panel data. The final results are shown in Table 1.

Table 1. Unit root test of variables

Variables	Horizontal sequence		Results	First order difference		Results
	LLC Test	Fisher-ADF Test		LLC Test	Fisher-ADF Test	
ln*TFP*	-6.1340	57.7468	Unstable	-9.3646	78.3237	Stable
	(0.0012)	(0.2285)		(0.0000)	(0.0000)	
$LnS^{domestic}$	44.6149	54.1188	Unstable	29.9555	83.7079	Stable

	(0.0326)	(0.5634)		(0.0000)	(0.0000)	
$\ln S^{import}$	15.3446	43.9946	Unstable	13.0366	170.023	Stable
	(0.0000)	(0.1024)		(0.0000)	(0.0000)	
$\ln S^{FDI}$	26.3683	38.7972	Unstable	12.7949	141.98	Stable
	(0.0007)	(0.1434)		(0.0000)	(0.0000)	
$\ln S^{OFDI}$	-13.8026	-7.8254	Unstable	-17.8735	-11.6322	Stable
	(0.0195)	(0.4753)		(0.0000)	(0.0000)	

Note: The corresponding P values are in the parentheses

It can be seen from the above table that the horizontal sequence of each variable is not stable, but after first difference the P value of each variable passes inspection. On this basis, we use co-integration test to examine the long-term relationship between variables.

4.2 Co-integration test of panel data

Table 2. Co-integration test of variables

Test Method	Statistics	Statistic Value	P Value
Kao Test	ADF	-3.9126	0.0000
Pedroni Test	Panel v-Statistic	0.3614	0.3589
	Panel rho-Statistic	2.8935	0.9981
	Panel PP-Statistic	-7.0478	0.0000
	Panel ADF-Statistic	-6.220	0.0000
	Group rho-Statistic	6.0955	1.0000
	Group PP-Statistic	-8.9116	0.0000
	Group ADF-Statistic	-7.3544	0.0000

The above table shows that Kao test, PP-Statistic and ADF-Statistic in Pedroni Test all rejected the null hypothesis. It indicates that there is a long-term stable co-integration relationship between TFP and R&D capital stock spillover under different channels.

4.3 Sample regression results

Before the regression analysis, we should choose which model we will use, the mixed estimation model or fixed effect model or random effect model. Table 3 shows that F test and LM test all reject the mixed estimation model. However, Hausman test shows that we should choose fixed effect model. The regression results are shown in Table 4.

Table 3. Model selection

Test Method	Statistic Value	P Value
F Test	F(29,326)=54.61	0.000
LM Test	Chi2(4)=281.20	0.000
Hausman Test	Chi2(5)=203.42	0.000

Tabel 4. Sample regression results

Variables	Nationalwide	Eastern region	Central region	Western region
α_0	1.0423	1.0548	1.0384	1.1127
	(0.000)	(0.000)	(0.000)	(0.000)
$\ln S_{it}^{domestic}$	0.0010	0.0017	-0.0005	0.0004
	(0.000)	(0.000)	(0.286)	(0.262)

$\ln S_{it}^{import}$	0.0018 (0.000)	0.0005 (0.102)	0.0133 (0.000)	0.0190 (0.007)
$\ln S_{it}^{FDI}$	0.0003 (0.051)	0.0006 (0.052)	-0.0145 (0.000)	-0.0034 (0.172)
$\ln S_{it}^{OFDI}$	-0.0010 (0.055)	0.0019 (0.016)	-0.0035 (0.293)	-0.0104 (0.119)
Adj-R^2	0.579	0.605	0.538	0.562
Sample size	360	132	96	132
Section number	30	11	8	11

According to the above results, the following conclusions can be drawn:

First, China can obtain foreign R&D capital spillover through the import trade and foreign direct investment channels. Every 1% increase in import trade and foreign direct investment, it can promote China's total factor productivity grow 0.0018% and 0.0003%. At the same time, the regression coefficient of domestic R&D capital is 0.001. It shows that there is technology spillover in domestic independent R&D and it promotes China's technical progress. However, China's OFDI can't make foreign R&D capital overflow to home country. It hinders the growth of China's total factor productivity and fail to promote our technological progress.

Second, there are obvious regional differences in the reverse technology spillover of outward foreign direct investment. In the eastern region, the reverse technology spillover of OFDI fosters the growth of TFP. For every 1% increase in foreign investment, the total factor productivity can be increased by 0.0019%. And there also exists technology spillover phenomenon in domestic R&D, foreign direct investment and import trade. They all have a positive effect on the eastern region technology. Among them, the impact of domestic R&D is the largest. While in the central and western regions, the regression coefficient of S_{it}^{OFDI} is negative. This indicates that the reverse technology spillover of OFDI hasn't appeared yet. Foreign R&D capital cannot influence China's technology level through OFDI. Moreover, technology spillover didn't occur under OFDI channel in the central and western regions. Only the regression coefficient of import trade is positive and can make the TFP grow 0.0133% and 0.019% in the central and western regions. The reason for the regional differences is that the economic development level and education level in eastern region is significantly higher than that in central and western regions. In the process of reverse technology spillover, the central and western regions may lack absorptive capacity. This causes foreign R&D resource can't combined effectively with local economic productive activities and fail to facilitate regional technical progress.

5. Conclusions and Suggestions

In this paper, the empirical study on China's provincial panel data shows that there are obvious regional differences in the reverse technology spillover of OFDI. With the superior geographical position, the eastern region gained reverse technology spillover and local technical level has been improved. But this kind of reverse technology spillover effect does not exist in the central and western. Outward foreign direct investment and foreign direct investment have failed to bring advanced science and technology to China. The phenomenon of technology spillover only exists in import trade.

In order to further expand the reverse technology spillover effect of OFDI and enhance the level of domestic technology, we put forward the following recommendations.

Firstly, the government should encourage local enterprises to develop outward investment so as to optimize the pattern of opening to the world. The eastern region should fully exert its own advantages and steadily improve the quality of foreign investment. Under the guidance of national strategy, central and western regions should formulate foreign investment policy that in accordance with regional development.

Secondly, enterprises should improve their own absorptive capacity. Whether the advanced technology acquired through OFDI can be digested and absorbed by enterprises is the key to promoting domestic technological progress. Therefore, higher education should be strengthened in the east. It also need to cultivate compound talents to enhance regional science and technology innovation. While the central and western regions should focus on basic education and quality education. Improving per capita education level and encouraging independent learning.

Thirdly, increasing R&D investment to enhance the ability of independent innovation. This is the basic way to develop a country's science and technology power. The government should increase R&D investment and improve R&D efficiency. It also need to guide the interaction among enterprises, universities and research institutes to achieve knowledge sharing and cooperation in R&D. And gradually establish a dynamic innovation system.

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