

The Improvement and Application of Econometric Model for Reverse Spillover Effect of Technology Sourcing FDI

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Abstract

Domestic enterprises expect to obtain foreign advanced technology through foreign direct investment, but its reverse spillover effect has been the lack of effective measurement. This paper use foreign research results for reference, and tries to improve and apply the econometric model for reverse spillover effect of technology sourcing FDI.

Key words: Technology sourcing FDI; Econometric model; Test

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INTRODUCTION

Under the unsatisfactory circumstances of technology spillover effect of FDI, more and more competitive China's enterprises began to conduct foreign direct investment to acquire foreign advanced technology, and the research proves that the reverse spillover effect of technology sourcing FDI could improve total factor productivity of the national industries or enterprises of home country. However, the actual effect of this kind

of FDI has been the lack of corresponding metrological analysis, so it has important practical significance to analyze the reverse spillover effect of technology sourcing FDI of China's enterprises at the national level.

1. THE IMPROVEMENT OF REVERSE SPILLOVER EFFECT MODEL

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 Coe and Helpman (1995) proposed international R&D spillover effect model:

$$\text{Log}F_{it} = \alpha_i + \alpha^d \log SD_{it} + \alpha^f \log SF_{it} + \varepsilon_{it} \quad (1)$$

Wherein, i means different countries; t indicates time; $\text{Log}F$ shows the natural logarithm form of total factor productivity; SD stands for domestic R&D capital stock; SF expresses foreign R&D capital stock; α_i is cross-sectional data items of country i ; α^d signifies the output elasticity of domestic R&D capital stock; α^f represents the output elasticity of foreign R&D capital stock; ε is error items. This model reflects that the growth rate of a country's total factor productivity is not only influenced by domestic R&D capital stock, but also affected by foreign R&D capital stock.

Van Pottelsberghe de la Potterie (2001) took FDI outflows as spillover channel and introduced it into this model for the first time to test the spillover effect of technology sourcing FDI. S_i^{ft} can be shown as:

$$S_i^{ft} = \sum_{j \neq i} \frac{t_{ij}}{k_j} S_j^d, \text{ of which, } t_{ij} \text{ means the foreign direct}$$

investment flows of investor i to j country; k_j shows the gross fixed capital formation of investee country j ; S_j^d expresses domestic R&D capital stock of investee

country. $\frac{t_{ij}}{k_j}$ stands for adjusting weight of the investee

country's R&D capital stock, which reflects the contrast relation between FDI from investor country and domestic investment of investee country.

Jürgen Bitzer (2005) believes that the above model ignored the third-country effect of R&D spillovers. So he improved foreign R&D stock based on FDI S_{ct}^{ft}

$$:S_{ct}^{ft} = \frac{f_{ct}^{out}}{k_{ct}} \sum_{l \neq c} S_{it}^D, \text{ of which, } f_{ct}^{out} \text{ indicates the FDI}$$

stock of the investor country in period t, and k_{ct} signifies the physical capital stock of the investor country in period t. $\sum_{l \neq c} S_{it}^D$ represents the sum of R&D capital stock within countries except for investor country, including the third-country effect.

Considering the advantages and disadvantages of these two models, and combined with the actual situation of China's statistical data, the author improved the model as follows:

$$LnTFP_t = \alpha_0 + \alpha_1 LnSD_t + \alpha_2 LnSF_t + \varepsilon_t \quad (2)$$

Of which, TFP_t is total factor productivity of China in period t; SD_t means the domestic R&D capital stock in China in period t; SF_t refers to the reverse spillover of foreign R&D capital stock through FDI in China in period t. $SF_t = \frac{OFDI_t}{K_t} \sum_m SD_{mt}$, of which, $OFDI_t$ indicates China's FDI stock in period t; K_t stands for China's physical capital stock in period t. $\sum_m SD_{mt}$ represents the sum of R&D capital stock of foreign countries in period t. The meaning of this model is that the growth rate of China's total factor productivity is not only influenced by domestic R&D capital stock but also affected by foreign R&D capital stock through the way of China's FDI.

2. THE APPLICATION OF IMPROVED ECONOMETRIC MODEL

Select the 23 years' data from 1988 to 2010 to conduct analysis.

2.1 The Calculation of Total Factor Productivity TFP_t

Take Solow Residual Method to estimate the $LnTFP_t$. Assuming that the Cobb-Douglas production function $Y_t = A_t K_t^\alpha L_t^\beta$ to satisfy the Hicks neutral, which means technical progress does not affect the marginal rate of substitution between K and L ; additionally, the returns to scale of K and L are invariable, which means $\alpha + \beta = 1$, and the total factor productivity:

$$LnTFP_t = LnY_t - \alpha LnK_t - \beta LnL_t \quad (3)$$

In order to obtain $LnTFP_t$, it needs to estimate α and β firstly. Y_t selects 23 the value of real GDP; K_t means physical capital stock of each year; L_t stands for the quantity of employment at each end of year. Taking use of regression equation $Ln(\frac{Y_t}{L_t}) = LnA + \alpha Ln(\frac{K_t}{L_t}) + \varepsilon$ with the constraints of $\alpha + \beta = 1$ to conduct OLS estimation for α , and adds variables of AR(1) and AR(2) to eliminate the autocorrelation, so it is: $Ln(\frac{Y_t}{L_t}) = -0.856018 + 0.762697 Ln(\frac{K_t}{L_t}) + [AR(1) = 1.200582, AR(2) = -0.480634]$, so $\alpha = 0.763, \beta = 0.237$, takes them into equation(3) to calculate the value of $LnTFP_t$.

2.2 The Calculation of Domestic R&D Capital

Stock SD_t

$SD_t = (1 - \delta)SD_{t-1} + R_t$, of which, δ is depreciation rate of R&D capital stock, as 5%; R_t means R&D expenditure in period t; the R&D stock in period 0 refers to the R&D stock in 1987 $SD_0 = \frac{R_0}{\delta + g}$, g stands for the average growth rate in form of logarithm of R&D expenditure in each period.

2.3 The Calculation of Foreign R&D Capital Stock

Spillover SF_t

Using the calculation method of Jürgen Bitzer (2005) for reference, $SF_t = \frac{OFDI_t}{K_t} \sum_m SD_{mt}$, calculates the reverse spillover to China of foreign R&D capital stock through FDI channels of China's enterprises. The calculation method of SD_{mt} is the same as that of domestic R&D capital stock, and δ is also 5%. For the selection of foreign country m , combined with the mainly destinations of technology sourcing FDI of China's enterprises, the author chooses 14 countries, such as the United States, to represent the R&D overall stock of the rest countries in the world except for China, and the ever year R&D expenditure of different countries is obtained by the proportion of yearly R&D expenditure to GDP multiplies by the yearly real GDP.

2.4 The Stability ADF Test

Because the macroeconomic variables are usually non-stationary, therefore, it is necessary to conduct the stability ADF test for time series before analysis. Take the ADF unit root test method to conduct the stability test for $LnTFP_t, LnSD_t$ and $LnSF_t$. Shown as Table 1:

Table 1
Adf Unit Root Test Results

Variable	Test form	ADF test Statistic	Critical value	Stability	Order of integration
LnTFP	(1,c)	-2.355613	-3.012363	unstable	I(1)
D(LnTFP)	(0,n)	-2.973797	-1.958088	stable	
LnSD	(1,n)	2.056422	-3.012363	unstable	I(2)
D(LnSD)	(0,n)	3.889785	-1.958088	unstable	
D(LnSD,2)	(0,t)	-3.935869	-3.658446	stable	I(1)
LnSF	(0,c)	-2.795166	-3.004861	unstable	
D(LnSF)	(0,c)	-4.426329	-3.012363	stable	

It is clear that $LnTFP_t$, $LnSD_t$ and $LnSF_t$ are all unstable time series, so it needs further co-integration analysis to $LnTFP_t$ and $LnSF_t$.

2.5 Johanson Co-Integration Test

According to the Akaike Information Criterion (AIC) and Schwarz Criterion (SC) minimum standards, it confirms the lag order is 3 orders. The test form is to choose a sequence of a linear trend and the co-integration equation only with cross-sectional data items. The test results are shown as Table 2:

Table 2
Johansen Co-Integration Test

Null Hypothesis	Eigenvalue	Trace statistic	Trace statistic 5% critical value	P value
No Co-integration Relationship At Least Existence of a Co-integration Vector	0.866004	38.19548	15.49471	0.0000
	0.000340	0.006466	3.841466	0.9354

It is clear that: the trace statistic of the first null hypothesis is larger than its critical value (38.08230 >15.49471), so the first null hypothesis is rejected; however, the trace statistic of the second null hypothesis is smaller than its critical value (0.006108 <3.841466), which means the second null hypothesis is accepted. Therefore, it shows that there is a long-term co-integration relationship between $LnTFP$ and $LnSF$. Additionally, Eviews5.0 provides co-integration regression equation between $LnTFP_t$ and $LnSF_t$ as follows:

$$ECM = LnTFP_t + 0.037927 LnSF_t \tag{4}$$

Of which, ECM indicates non-equilibrium error, and it reflects that there is a negative correlation relationship between the growth rate of China’s total factor productivity and foreign R&D stock, which means the growth of China’s FDI not only failed to bring positive reverse spillover effect to promote China’s total factor productivity; on the contrary, it produced negative effect, which hinders the improvement of China’s total factor productivity.

2.6 The Error Correct Model

Granger theory points that if several non-stationary variables exist co-integration relationship, these variables must have error correction model expression. Established error correction model of $LnTFP_t$ and $LnSF_t$ as follows:

$$\Delta LnTFP_t = \alpha_0 + \alpha_1 ECM_{t-1} + \sum_i^n \alpha_{2i} \Delta LnTFP_{t-i} + \sum_i^n \alpha_{3i} \Delta LnSF_{t-i} + \varepsilon_t$$

Of which, ECM_{t-1} is a lag of non-equilibrium error, and it means the control and correction of long-term co-integration relationship of $LnTFP$ and $LnTFP$ for short waves of $LnTFP$ ($\Delta LnTFP_t$), and its coefficient α_1 is a correction factor, which means the correction speed of non-equilibrium error for the short-term fluctuations of $LnTFP$, and $\alpha_1 ECM_{t-1}$ is called error correction item. n is the optimal lag order number which takes the residual ε_t as white noise, and selects the lag order 3.

The short waves of $LnTFP$ are influenced not only by error correction term but also by the short waves of hysteretic $LnSF$. Take advantage of Eviews5.0 to estimate error correct model as follows:

$$\begin{aligned} \Delta LnTFP = & -0.429779(LnTFP(-1) \\ & + .037927 LnSF(-1) \\ & + 0.673961) + 0.701634 \Delta LnTFP(-1) \\ & -0.323169 \Delta LnTFP(-2) + 0.274358 \Delta LnTFP(-3) \\ & -0.023356 \Delta LnSF(-1) - 0.036205 \Delta LnSF(-2) \\ & -0.033089 \Delta LnSF(-3) + 0.02101 \end{aligned}$$

It can be perceived that the correction factor is -0.429779, and its absolute value is smaller than 1, which means it is not very obvious for long-term equilibrium system of $LnTFP$ and $LnSF$ to the short waves of $LnTFP$. The coefficient of $LnTFP$ is significantly negative, which illustrates the negative correlation between short-term total factor productivity in China and foreign R&D spillover, and the growth or decline of the short-term foreign R&D spillover would lead to reverse change of China’s total factor productivity.

CONCLUSION

Based on above analysis, it is clear that, no matter long-term or short-term, the technology sourcing FDI of China’s enterprises not only failed to form positive reserves spillover effect, but it hinders the improvement

of China's total factor productivity. Although it may be derived from the model and data problems, from the model point of view, it is mainly caused by the scale limitation of the technology sourcing FDI of China's

enterprises. In the model, $\frac{OFDI_t}{K_t}$ as the adjustment

coefficient of foreign R&D stock, which means the larger the scale of FDI, the more foreign R&D stock would spill, and it would contribute to the improvement of total factor productivity in the home country. According to the survey made by Roland Berger Company, only 16% China's leading enterprises operate overseas business in order to obtain advanced technology and brand assets; in the selection of overseas operational aspects, R&D only accounts for 16%. Compared with the large scale economic capacity, such small scale foreign investment is not enough to become the effective carrier and channel of reverse spillover to transfer foreign R&D resources. In addition, many reasons, for example, the insufficiency of absorptive and embedded ability of China's enterprises in subsidiaries or R&D institutions in host countries, the dislocation between obtained technology and the development demand of domestic enterprise and market,

the potential crowding-out effect for domestic R&D investment and the insufficiency of spillover mechanism at the industry and country level, lead to the weak spillover effect, which should be taken actions based on above reasons.

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