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Xiao, Minqi
Graduate School of Economics, Kyushu University

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Research of Technology Spillover Effects of FDI in China—Based on Meta-analysis*

Minqi Xiao†

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1. Introduction

For the coming decades, attention to FDI technology spillover is increasing among economists. Especially for developing countries, how to use FDI technology spillover to improve technological level of their national enterprises has been practically significant. Here I take china as the basement to make some analysis of FDI technology spillover, for China has become the world's largest FDI recipient countries in the coming years. This paper examines the extent to the effect of FDI technology spillover to China.

There is now numerous and influential literature on FDI technology spillover (see, among others, Caves (1971&1974), Blomstrom (1983)), the key issues to this analysis are the factors which influence FDI technology spillover and how to measure the effects of it. At the beginning of the research, scholars just used theoretical models to analysis such issues, but by Caves (1974) as a pioneer, scholars began to analysis FDI technology spillover problem on the empirical research, quantitative economics from the perspective of the current study is the foreign scholars launched FDI technology spillover in the main research method, the basic approach from the research above is divided into two parts: positive FDI technology spillover and negative FDI technology

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† Graduate School of Economics, Kyushu University, Japan
E-mail: syou@en.kyushu-u.ac.jp

spillover.

Caves (1974) tested the spillover effects of FDI in Canada and Australia through the use of manufacturing industry in 1966 using cross-sectional data, Caves found that the Canadian manufacturing profitability of local enterprises and foreign investment within the industry was positively correlated, and labor productivity in Australian manufacturing and the industry was also positively related to foreign capital, in his opinion, the manufacturing sector in Canada and Australia, the effect of FDI technology spillover was positive. And then Blomstrom and Perssion (1983) get the same conclusion as Caves by using the industry section data of the Mexican. Liu (2000) also found that in the UK manufacturing sector there existed positive FDI technology spillover effect by between using industry panel data from 1991 to 1995.

But Aitken and Harrison (1999) found that there existed negative FDI technology spillover effects through analyzing the enterprises of Venezuelan by using the manufacturing sector panel data from 1976 to 1989 and then Damijan (2001) adopted manufacturing enterprises panel data of eight transitional countries which include: Bulgaria, Czech Republic, Estonia, Hungary, Poland, Romania, Slovakia and Slovenia between 1994 and 1998. The result showed that the manufacturing sector in these countries, the effect of FDI technology spillover was not significant. Through applying manufacturing industry panel data of UK from 1989 to 1992, Driffield (2001) concluded that: there did not find any investment, output and R & D spillover effects caused by FDI.

Review from the literatures above we can see that FDI technology spillover on the empirical results are inconsistent, in different countries there may come to different conclusions, and even for the same country, such as the UK, different scholars have come to exactly opposite conclusions. In order to resolve these conflicts, scholars begin to focus on introducing new testing methods: because FDI technology spillover occurs through the way of non-market transactions, and so it is difficult to measure it. For the continuous advancement of statistical techniques which creates good conditions for our research for measuring, some new testing methods, research in recent years has been a preliminary application, this paper attempts to apply some new data analysis methods Meta-analysis into measuring whether FDI technology spillover happens and how to get a more general conclusion.

In this paper, according to former researchers, first I try to use the model created by Caves (1974) and Blomstrom (1983) to make a simple analysis of FDI technology spillover based on China's industrial sector from 1990 to 2008 and then try to propose a new data integration analysis method- Meta-analysis which is a statistical method that being used to compare and synthesize research results of the same technological problem, and if this comparison and synthesis have meaning or not depends on whether this comparison and synthesis are satisfied specific conditions (such definition is based on the definition of Fleiss and Gross (1991)). Meta-analysis is based on the statistical analysis and it is used to explain the reasons for such differences and to identify

the relevant factors. It is to compare and synthesize a number of research results of the same kind and meanwhile explains that Meta-analysis is as the same as other statistical methods, which has requests to data and clarifies the vague concept that any result could be used in Meta-analysis.

Particularly, using Meta-analysis is to solve problems as follows: (1) to increase the statistical efficiency, save the research cost and strengthen the proof credibility; (2) to reveal the existence of uncertainty in a single research, examine the causes of heterogeneity among researches through tests of heterogeneity, estimate the possible and variable bias, and analyze the difference of research results to make scopes of effective estimations more accurate; (3) to resolve the problems that single researches could not to solve and introduce new topics; (4) to deal with large quantities of similar documents without the researching number limitation. In summary, by quantitatively assessing effect sizes and sampling error across studies, Meta-analysis offers multiple benefits compared with traditional narrative literature reviews. Although it is not widely applied to economics by now, I hope this paper would be a good attempt.

Our paper develops as follows. First I introduce the model to analyses the effects of FDI to China's technological progress in "Section 2" and present the conclusion. Then in "Section 3" I try to judge related factors influencing on FDI technology spillover from the empirical results using Meta-analysis and in "Section 4" I analyze the effect of FDI and present my main results of this paper. Finally in "Section 5", I discuss how our results relate to the existing literature and concluding the signification of our paper, furthermore I point out the inadequacies of this paper and some possible extensions of thes models.

In this paper, the greatest difficulty lies in the use of Meta-analysis to integrate the analysis-how to determine the effect value of the structure and how to select the appropriate effects model. At present, this method has not been applied in the economic field; this is my effort direction for my future research.

2. Economic growth and FDI technology spillover based on China's industrial sector

In this section, I consider applying empirical analysis into analysis FDI technology spillover for China's industrial sector. To using theoretical model to describe the phenomenon of FDI technology spillover describe first that how to measuring FDI technology spillover effect, in this section, in order to distinguish different sources of FDI from foreign investment and from Hong Kong, Taiwan and Macao regions, I make to parameters to judge the influence of FDI technology spillover.

According to Caves (1974) and Blomstrom (1983) and other scholars of the classical test model, here I build the following empirical model:

$$\ln(p)=\alpha_0+\alpha_1\ln(conc)+\alpha_2\ln(q)+\alpha_3\ln(scale)+\alpha_4 fp\_hmt+\alpha_5 fp\_fori+\varepsilon \quad (2.1)$$

Where

1) p represents the overall labor productivity of enterprises, with the added value of enterprises and employees of the ratio of measurement.

2) *conc* represents capital intensity, measured by per capita net value of fixed capital capital-intensive enterprises, with an average balance of net fixed assets and the total number of employees in the ratio of the average measurement.

3) *fp* represents the extent of foreign investment in industry, *fp_fori* represents foreign investment, *fp_hmt* represents investment from Hong Kong and Macao and Taiwan. Here *fp* is to measure the impact of foreign capital, if its coefficient is positive, then the spillover effect is positive; the other hand if the coefficient is negative, then the spillover effect is negative; if the coefficient is not significant, then the spillover effect is not obvious.

4) q represents human capital, it is used to measure the impact on labor productivity, with the average number of employees in all industries and enterprises the ratio of the number of measurement.

5) *scale* represents company size, it is to measure the impact on labor productivity, with a total sales value and business enterprises the ratio of the number of measurement.

6) ε is the random error.

2.1. FDI to China from 1990 to 2008

The data used in this paper is taken from: "China Statistical Yearbook 2008" which provides all of the data of industrial sector in China from 1998 to 2007, "China Statistical Yearbook" of year 1996 to year 2000; the National Economic and Social Development Statistics from 1990 to 2008. Industry sector should be divided into many sub-sectors, but for simplistic in this section it does not take systematic differences between industries into account, here I use the average data of the entire industrial sector to analysis.

2.2. Empirical finding

2.2.1 Inspection of the correlation between dependent variables and independent variables

In order to ensure the reasonableness of the linear model, here first take the test of the correlation between dependent variables and independent variables, from the results given by Table 2-1, the explanatory variables and the Explained variable is highly linear correlated which shows that the construction of the linear model is appropriate.

Table 2-1 Correlation analysis between variables

	LOG(P)	LOG(CONC)	LOG(Q)	LOG(SCALE)	FP_HMT	FP_FORI
LOG(P)	1.000000	0.989489	-0.962343	0.997059	0.890021	0.970760
LOG(CONC)	0.989489	1.000000	-0.951944	0.985354	0.874062	0.932967
LOG(Q)	-0.962343	-0.951944	1.000000	-0.940216	-0.858897	-0.934090
LOG(SCALE)	0.997059	0.985354	-0.940216	1.000000	0.886304	0.967539
FP_HMT	0.890021	0.874062	-0.858897	0.886304	1.000000	0.867607
FP_FORI	0.970760	0.932967	-0.934090	0.967539	0.867607	1.000000

2.2.2 Regression Analysis

Equation (2.1) is estimated using the ordinary least squares (OLS) by the time-series data. The result is shown in the Table 2-2

Table 2-2 Different sources of FDI on China's industrial sector, technology spillover effect analysis

Explanatory variables	Explained variable
Constant	-5.553(0.972)**
ln(q)	-0.472(0.089)*
ln($scale$)	0.841(0.112)*
ln($conc$)	0.335(0.137)*
fp_hmt	0.448(1.213)
fp_fori	1.968(0.972)*
R-squared	0.99
Adjusted R-squared	0.99

Figures in parentheses are t statistics,*,**, Represent 1% and 5% significant level.

2.2.3 Analysis of the results and conclusion

The R-squared value shows that the test has a high fitting of the equation, the model's explanatory power of labor productivity is more than 90%. Foreign investments take a significant positive spillover effects for domestic enterprises while Hong Kong, Macao and Taiwan's investment has not generated expectations of technology spillover effect for domestic enterprises.

From Table 2-3, we can find that per capita sales and per capita income on the asset levels of foreign investment enterprises in per capita sales and average total assets level of foreign enterprises which indicates a higher level of technology is much larger than Hong Kong, Macao and Taiwan-invested enterprises and domestic enterprises.

Now we can say that whether FDI could take positive spillover depends on the source of FDI, and this result once again shows that the generation of FDI technology spillover is not an

"auto-place" process, the capital will also affect the occurrence of technology spillover, according to the actual situation of China, there are some positive technology gap between foreign and domestic enterprises so that positive technology spillover is likely to occur.

Table 2-3 Nature of enterprise ownership by the 2007 Enterprise Statistics

Company Property	Amount of enterprises (unit)	Sales Revenue (million)	Total assets (million)	Amount of workers (million)	Per capita sales (million)	Average total assets (million)
HongKong, Macao, Taiwan	31949	41456	34071	1108.7	37.4	30.7
Foreign	35507	84042	62296	1244.3	67.5	50.1
Domestic	269312	274219	256670	5522.2	49.7	46.5
Totol	336768	399717	353037	7875.2	50.8	44.8

Data Source: "China Statistical Yearbook 2008."

3 . Meta-analysis based on factors of FDI technology spillover

3.1. The main factors of FDI technology spillover and Meta-analysis model

Till now in theory, the factors of FDI technology spillover do not have a uniform definition, through the consolidation of relevant literature I found that most of the researches are beginning analysis from the host country and foreign invested enterprises, from such two ways to discussing the factors of FDI technology spillover. Sorting from the literatures we get following factors:

1) Openness of the host country's economic

2) Technology gap between domestic enterprises and foreign invested enterprises

3) Technology intensity of domestic enterprises and R & D investment level

4) FDI source

In this chapter, Meta-analysis is used to get the relationship between the main factors of FDI technology spillover and FDI technology spillover between the factors each others. The key of Meta-analysis is the selection of effect size, here according the purpose of this chapter; I choose the correlation coefficient of the factors of FDI technology spillover as the effect sizes.

3.2. Data collection and analysis

3.2.1 Literature collection and coding

In this section first I search literatures through the "Articles Database", "China Academic Journal (CNKI)" and other databases to find published FDI technology spillover on China from

January 2000 to January 2009 and finally I choose 89 literature for this research. This paper let ES, SE and ω represent the effect of value, effect size and the standard deviation of effect of ES, the subscript Z_i denote correlation coefficient, in accordance with Meta-analysis, we must first convert the various correlation coefficients according to some formula. Here I use Fisher formula to convert the correlation coefficient value of the desired effect ES_{Z_i}, the Conversion formula is as following:

$$ES_{Z_i}=0.5\ln\left[\frac{1+r}{1-r}\right] \tag{3.1}$$

$$SE_{Z_i}=\frac{1}{\sqrt{n-3}} \tag{3.2}$$

$$\omega_{Z_i}=\frac{1}{SE_{Z_i}}=n-3 \tag{3.3}$$

where r is the correlation coefficient between factor variables, n is the number of samples of this research, ES_{Z_i} is the effect size, SE_{Z_i} Is the standard deviation, ω_{Z_i} is weights.

3.2.2 Meta-analysis

1) The relevant statistics of effect size:

(1) weighted average effect size:

$$\overline{ES_{Z_i}}=\frac{\sum_{i=1}^{i=16}\omega_{Z_i}\cdot ES_{Z_i}}{\sum_{i=1}^{i=16}\omega_{Z_i}} \tag{3.4}$$

(2) weighted average standard deviation of effect size:

$$SE_{\overline{ES_{Zi}}}=\sqrt{\frac{1}{\sum_{i=1}^{i=16}\omega_{Z_i}}} \tag{3.5}$$

(3) confidence intervals for weighted average effect size:

$$\overline{ES_{L_i}}=\overline{ES_{Z_i}}-z_{1-\alpha}(SE_{\overline{ES_{Zi}}}) \tag{3.6}$$

$$\overline{ES_{U_i}}=\overline{ES_{Z_i}}-z_{1-\alpha}(SE_{\overline{ES_{Zi}}}) \tag{3.7}$$

(4) z statistics (test for significant average effect size)

$$z=\frac{|\overline{ES_{Z_i}}|}{SE_{\overline{ES_{Zi}}}} \tag{3.8}$$

(5) Q Statistics (homogeneity test):

$$Q=\sum_{i=1}^{i=16}\omega_{Z_i}(ES_{Z_i}-\overline{ES_{Z_i}})^2 \tag{3.9}$$

2) Statistical test results

Homogeneity test is based on statistical test level, through STATA we can get that:

$Q=2.148, 2.054, 1.425, 3.124<\chi^2_{15,0.05}$, therefore, each factors is homogeneous in nature and so here will use a fixed effects model which named General-Variance-Based statistical method for

analysis.

Let $\alpha=0.05$, throuth STATA, we get the results shown in Table 3-1, where: η_1 denotes the openness of the economy, η_2 denotes the technology gap, η_3 denotes R & D, η_4 denotes FDI sources, ξ denotes FDI technology spillover.

The results can be obtained as following: the first and second groups z is larger than 1.96,so for $p\leq0.005$ is statistically significant; but for the third group z is smaller than 1.96, showing the statistically insignificant; and for the fourth group z is larger than 2.58, so for $p\leq0.01$ is statistically significant.

Table 3-1 the results of Meta-analysis

Factors	Q	z	$\overline{ES_{Z_i}}$ (95% Confidence interval)
η_1	2.148	2.145	0.167 (0.025, 0.284)
η_2	2.054	2.049	0.148 (0.021, 0.265)
η_3	1.425	1.871	0.127 (0.015, 0.194)
η_4	3.124	3.214	0.201 (0.033, 0.317)

3）Synthesis matrix of correlation coefficient

To further study the relationship between factors, next let we analyze the coefficient between factors through matrix through synthesis matrix of correlation coefficient the conversion formula is:

$$r=\frac{e^{2\overline{ES_{Zi}}}-1}{e^{2\overline{ES_{Zi}}}+1} \tag{3.10}$$

Table 3-2 Summary of the correlation coefficient matrix

Variable	ξ	η_1	η_2	η_3	η_4
ξ	1				
η_1	0.25	1			
η_2	−0.34	0.21	1		
η_3	−0.02	0.18	−0.25	1	
η_4	0.15	0.41	0.28	0.32	1

3.2.3 Conclusion and discussion

As can be seen from the results of Meta-analysis, the openness of the economy, the technology gap, R & D investment, FDI source and FDI technology spillover are significant correlated, and

further more that the interaction of the factors can impact FDI technology spillover and so the economic growth. From the results we can see that the greatest impact is from the technology gap, followed by economic openness and FDI sources. The impact of R & D investment is negative and the smallest, which is not very consistent with most research, the causes of this result may be that the lack of the data, according to Meta-analysis, it requires data as many as possible, the deficiency of the corresponding values may lead to inaccurate results.

4 . Policy recommendation

As China is gradually increasing the size to attract foreign investment, foreign capital through the improvement of the supporting policies, improve the investment environment, seize the opportunity to improve the scale and level of foreign investment to help our economy has made rapid development of long-term issue is extremely important. The results from this study, we see that, FDI technology spillover is significant here, so China should continue to use foreign investment and encourage foreign multinationals to invest in China as an important policy maintained. In this chapter the conclusions based on the results of the analysis to make recommendations for the following areas:

4.1. Positive and open economic policies in order to introduce higher-quality FDI

First, strengthen the publicity in Western countries, so companies in these countries would have a deeper understanding about china's invest environment; Second, carrying out the investment promotion activities to improve the existing investment promotion methods, by encouraging multinational corporations to establish R & D center of the country, thus substantially improving the proportion of funds from developed countries, and that the level of foreign investment in China would quality to a new level in future.

4.2. Enhance the level of human capital

Regardless of controlling the technology gap or enhancing the absorption of FDI technology spillover level, we need good human capital as a support. Create a good environment for the development of incentive mechanisms and to cultivate more talents to strengthen our overall research capacity.

4.3. Improve the absorptive capacity of enterprises

China's accession to WTO which taking in the challenging of high-tech multinational companies, China's enterprises is now at a disadvantage to obtain the production and development of space, in imitation, based on the need for comprehensive improvements. In another hand, China's

enterprises must establish appropriate mechanisms for absorption and innovation to adapt to changes in the external environment. As competition further intensifies, the level of decline in the profitability of local enterprises, faced with a crisis of survival, local enterprises must be through the transformation of corporate structures so as to enhance the efficiency of business management, and establishing its own brand to gain core competitive advantage is also a key point.

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