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Empirical Research on Different Sources of FDI's Technology Spillovers in Chinese Industrial Sector

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Abstract
Based on the extension of Cobb-Douglas production function model,we used the 1995-2012 time series data of Chinese industrial sector to research the different sources of FDI's technology spillovers,and found that the FDI from Hong Kong, Macao and Taiwan regions (HMT) has a positive and significant technology spillovers in Chinese industrial sector; Elsewhere, the FDI from Asia (except HMT), Africa and North America has a positive technology spillovers but not significant, and from Europe, Latin America, Oceania and affiliated islands of Oceania has a negative technology spillovers .Finally, this paper puts forward some policy and suggestions that how to get more FDI's technology spillovers in Chinese industrial sector.

Key words: Investment sources; FDI; Technology Spillovers; Cobb-Douglas Model

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INTRODUCTION

After the reform and opening up, especially since the 1990s, lots of foreign direct investment (FDI) inflows in China and got rapid growth (Figure 1). According to the world investment report 2014 released by U's trade development organization, the amount of FDI inflows in China reached at $124 billion and accumulated total of $1.45 trillion which made a high record and been second only to the United States in the world. FDI could not only increase the host country's capital stock, expand the scale of production, and provide employment opportunities for the host country, but also generate technology spillover effects to the host country.

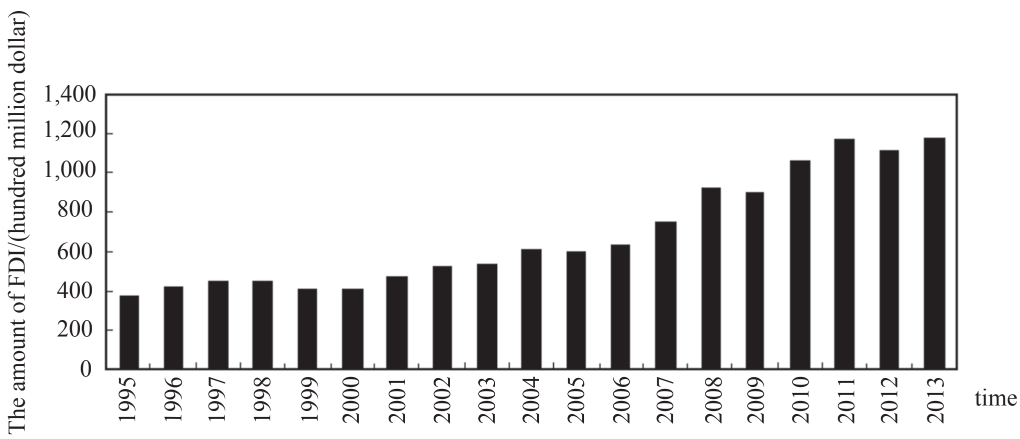

Figure 1.
The Amount of China Actually Using FDI During 1995-2013
Note. Source: Sorted by the annual data of the state data.

Many scholars did research on FDI technology spillovers extensively for many years, but did not get consistent conclusions. There were many domestic scholars did similar research on FDI technology spillovers and revealed that FDI could generate positive spillover effects to our country. But the researches about the technology spillover effects distinguished the source of FDI were few, especially subdivided the source into Hong Kong, Macao and Taiwan regions (HMT) and other parts of Asia (except HMT), Africa, Europe, Latin America, North America and Oceania and affiliated islands of Oceania seven areas had not been seen. There were two reasons of selecting the above seven areas. One was that China made use of the actual FDI of the seven areas accounting for over 99% of the world (Figure 2), almost covering all sources of FDI. The other was that the different source of FDI had obvious difference in technology level, investment field, management mode, etc.. So, it was necessary to divide them carefully when examining the FDI technology spillover effects to Chinese industrial sector and to verify whether or not the different sources of FDI in the Chinese industrial sector had different technology spillover effects. We used the 1995-2012 time series data of China's industrial sector, based on the extension Cobb-Douglas production function model, and discussed the different sources of FDI's technology spillover effects in the Chinese industrial sector.

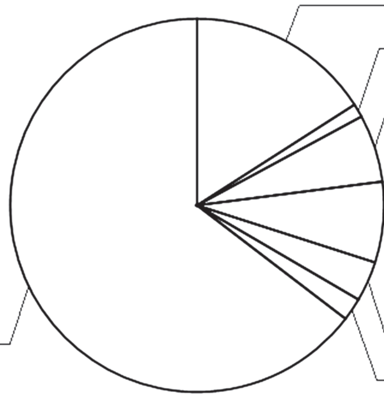

Figure 2.
The Ratio of China Using the Actual Seven Areas' FDI Accounting for the World's
Note. Source: Sorted by the annual data of the state data.

1. LITERATURE REVIEW

Most of the scholars researched on FDI's technology spillovers believed that there were a positive effect to the host country, but there were also a few scholars took empirical studies on individual country and region, found that FDI's technology spillover effect was not significant, even negative.

There were many foreign scholars supported positive spillover effect. Caves (1974) selected the Canadian and Australian manufacturing industry cross section data in 1966,and confirmed the existence of FDI's technology spillover effect between the two countries (Caves, 1974); Kokko (1994) found that when the technology gap between multinational companies and local enterprises was small, the FDI's technology spillover effect was significant (Kokko, 1994); then, Kokko et al. (2007) used the Mexico industry cross section data for empirical research, and built a simultaneous equation model to test the interaction effect between local and foreign enterprises, confirmed the significant spillover effect could produce by competition effect besides study and demonstration effects (Kokko & Zejan, 2007); Liu et al. (2000) used the Britain manufacturing industry's panel data of 1991-1995 and found that the FDI's spillover effects were also significant. It was similar to Kokko's view, at the same time, they also found that when the technology gap was small, the technology spillover effect was more significant.They believed that it leaded by the local enterprises with high absorption capacity (Liu & Wei, 2000); Wooster and Diebel (2006) pointed out that technology spillover effect of FDI in Asian countries and regions was significant and positive (Wooster & Diebel, 2010). When Lin et al. (2009) examined the effect of FDI on China's manufacturing enterprises, they found that FDI had a positive vertical linkage effect at the regional level and national level and still existed horizontal spillover effect at the regional level Lin, P. (Liu & Zhang, 2009); Suyanto and Salim (2011) revealed that there was a positive backward spillover effect in Indonesia (Salim, 2011).

There were some foreign researches did not support the positive spillover effect. Aitken and Harrison (1999) selected Venezuela manufacturing enterprises panel data during 1976-1989, and found negative spillover effect across the country. Driffield (2001) used the UK manufacturing industry panel data during 1989-1992, and did not find any positive effect; Damijan et al. (2003) did a research on the eight transformation economies

(Bulgaria, the Czech republic, Estonia, Hungary, Poland, Romania, Slovakia and Slovenia) and used the manufacturing enterprises panel data during 1994-1998, found that the spillover effect was not significant; Thangavelu and Pattnayak (2011) pointed out that there was a large technology gap between India's local and foreign enterprises and the spillover effect between the industry was negative.

The representative domestic research were mainly taken from the macro level of the whole nation and industrial or manufacturing level of individual provinces across the country, most researches revealed positive technology spillover effect of FDI, rare a negative effect. Qin and Hu (1998) used the 1995 industrial census data to take a cross-section regression analysis on extractive industries, manufacturing, electricity, gas and other industrial and found that the FDI technology spillover effect was remarkable; He and Xu (1999) used the industrial sector of time-series data during 1985-1999, took empirical research of FDI spillover effect in Chinese industrial sector, and shown that there was a positive spillover effect in the industry, and with the introduction of FDI's scale enlargement, the tendency of positive effect was strengthen; Chen (2003) used cross-section data and confirmed that FDI spillover effect of China's manufacturing industry was significant. Xian and Yan (2005) used chinese provincial level data to analysis the FDI's spillovers on China's innovation ability, and shown that FDI had a significant and positive spillover effect on the amount of the patent application; Xie (2006) used panel data of 29 provinces during 1994-2003 and found that FDI had significant spillover effect to raise the technical efficiency of provinces; Zhong (2010) used the regional level data, thought that FDI can not only stimulate and promote the regions productivity performance, but also indirectly lead to other parts' productivity improvement; Yu (2011) argued that FDI's technology spillovers could significantly promote the technological progress in China, it was a important way to promote the technical level in our country.

2. MODEL SETTING AND DATA SOURCES

2.1 Model Setting

There were three kinds of model to estimate the FDI's technology spillover: (a) Based on the extension Cobb-Douglas production function model, taking the FDI into the variable setting, examining whether the FDI's spillover effect of the host country was significant and positive; (b) Sabirianova-Svejnar-Terrell model (SST), the total factor productivity of foreign and local enterprises was introduced to estimate the FDI's spillover effect in the modle and distinguished the share of FDI productivity spillover effect on local enterprises and foreign enterprises; (c) The econometric analysis model based on the FDI technology spillover effect interacting with the host country's R&D, the model was thought that the R&D could generate positive effect to the enterprise productivity and the R&D had absorption effect on FDI. When making regression analysis, the R&D spending accounted for the proportion of the added value (R&D/Y) and the R&D/Y interaction item with FDI was introduced into the regression model to research whether the R&D and technology innovation absorbed the FDI's technology spillovers (Ping, Guan, & Deng, 2007).

We use the extension Cobb-Douglas production function model in this paper.

Assuming that the Chinese industrial sector's industrial added value satisfies

$$Y=AL^{\alpha}K^{\beta}. \tag{1}$$

Among them, A, L, and K represent technological progress Chinese industrial sector labor input, Chinese industrial sector capital input respectively; alpha in labor output elasticity and beta for the output elasticity of capital.

In order to distinguish the different source of FDI's technology spillover effect to the Chinese industrial sector, we assume that A can be decomposed into

$$A = B\left(\frac{F_{HMT}}{K}\right)^{\gamma}\left(\frac{F_{\text{Asia}}}{K}\right)^{\kappa}\left(\frac{F_{\text{Africa}}}{K}\right)^{\sigma}\left(\frac{F_{E}}{K}\right)^{\lambda}\left(\frac{F_{LD}}{K}\right)^{\nu}\left(\frac{F_{NA}}{K}\right)^{\varepsilon}\left(\frac{F_{\text{Oceania}}}{K}\right)^{\theta} \tag{2}$$

B represents the exogenous technological change. $\frac{F_{HMT}}{K}$, $\frac{F_{\text{Asia}}}{K}$, $\frac{F_{\text{Africa}}}{K}$, $\frac{F_{E}}{K}$, $\frac{F_{D}}{K}$, $\frac{F_{LD}}{K}$, $\frac{F_{NA}}{K}$ and $\frac{F_{\text{Oceania}}}{K}$ represent the FDI technological change of HMT and other parts of Asia (except HMT), Africa, Europe, Latin America, North America, Oceania and affiliated islands of Oceania respectively.

Taking the Equation (2) into Equation (1), we can get a production function with FDI technology spillover effect. And taking the two sides of the production function into logarithmic, and put the random disturbance μ into the right hand equation,we can get the regression model (including C=LnB),

$$\begin{aligned}\text{Ln}Y &= C + \alpha\text{Ln}L + \beta\text{Ln}K + \gamma\text{Ln}\left(\frac{F_{HMT}}{K}\right) + \kappa\text{Ln}\left(\frac{F_{\text{Asia}}}{K}\right) \\ &+ \sigma\text{Ln}\left(\frac{F_{\text{Africa}}}{K}\right) + \lambda\text{Ln}\left(\frac{F_{E}}{K}\right) + \nu\text{Ln}\left(\frac{F_{LD}}{K}\right) + \varepsilon\text{Ln}\left(\frac{F_{NA}}{K}\right) \\ &+ \theta\text{Ln}\left(\frac{F_{\text{Oceania}}}{K}\right) + \mu.\end{aligned} \tag{3}$$

2.2 Source of Data and Instruction

Because the data of year 2013 can't get complete, we selected Chinese industrial sector's time series data during 1995-2012. The data comes from the China statistical yearbook, the statistics bulletin of the national economy and social development of the year 2012 and the national data. All variables and data sources are shown in Table 1.

Table 1
Each Variable Induction and Data Sources

Variable	Induction	Sources
Y	Representing the industrial added value of all state-owned and non-state-owned above designated size industrial enterprises. In order to eliminate the price influence, the value divided by the corresponding index of industrial production (1995 for the base period).	The China statistical yearbook of 1996-2011 and the statistics bulletin of the national economy and social development of year 2012
K	Representing the annual average net value of fixed assets of all state-owned and non-state-owned above designated size industrial enterprises. In order to eliminate the price influence, the value divided by the corresponding index of investment in fixed assets (1995 for the base period). Because the data of 2011 and 2012 can not be found in the statistical yearbook,we adopt the difference between the original fixed assets and depreciation to replace.	The China statistical yearbook of 1996-2011
L	Representing the number of annual workers of all state-owned and non-state-owned above designated size industrial enterprises	The China statistical yearbook of 1996-2012
$\frac{F_{HMT}}{K}$, $\frac{F_{\text{Asia}}}{K}$, $\frac{F_{\text{Africa}}}{K}$, $\frac{F_E}{K}$, $\frac{F_D}{K}$, $\frac{F_{LD}}{K}$, $\frac{F_{NA}}{K}$, $\frac{F_{\text{Oceania}}}{K}$	Representing the HMT, and other parts of Asia (except HMT), Africa, Europe, Latin America, North America, Oceania and affiliated islands of Oceania's capital.In order to eliminate the price influence, the value divided by the corresponding index of CPI (1995 for the base period).Because of data of 2012 missing, we adopt the nearly three years increase rate to estimate the value.	The annual data of the state data of 1995-2011

In the existing literatures, most took the net value of fixed assets of foreign department or the proportion of the employment of foreign company accounted for the whole department in the industrial sector to measure the FDI's technology spillover effect. We use the ratio of the different sources of actual foreign capital and average net value of fixed asset to proxy. In the process of data collection, we find that only HMT capital and the other foreign capital we can get, but there are not the separate statistics data of the seven areas capital. We use the proportion of the seven areas of actual capital accounting for the whole world capital and multiply the foreign capital to represent the different sources of the FDI capital.

3. DATA ANALYSIS AND RESULT DISCUSSION

We make a regression with the above data and equation, and the results are shown in Table 2.

Table 2
The Results of Different Sources of FDI's Technology Spillover EffectiIn Chinese Industrial Sector

Explanatory variable	Coefficient	*T*-statistic
C	2.483647	2.224796*
Lnk	0.385028	1.670567
LnL	0.605829	1.885834*
Ln $\frac{F_{HMT}}{K}$	0.796096	3.063622**
Ln $\frac{F_{\text{Asia}}}{K}$	0.007376	0.068103

To be continued

Continued

Explanatory variable	Coefficient	*T*-statistic
Ln $\frac{F_{\text{Africa}}}{K}$	0.258076	1.660171
Ln $\frac{F_E}{K}$	-0.11428	-0.690003
Ln $\frac{F_{LD}}{K}$	-0.079565	-1.067828
Ln $\frac{F_{NA}}{K}$	0.008452	0.121558
Ln $\frac{F_{\text{Oceania}}}{K}$	-0.191412	-1.307265
R^2	0.989973	
Adj-R^2	0.978694	
D.W.	1.861115	
F-statistic	87.76444	

Note. * and * * represent the 10% and 5% significant level, respectively.

The value of the determination coefficient and the adjustment determination coefficient are over 0.97, it means that the model is better to fit the data. The *F*-statistic value is 87.76 which is bigger than the critical value of 3.39 under 5% significance level, showing that the mutual influence between explanatory variable and explained variable is significant. In order to test whether the model exists heteroscedasticity and autocorrelation, we conduct the ARCH inspection and D.W. testing respectively and the results show that the model overcomes the heteroscedasticity and autocorrelation.

When setting the model, we use the ratio of FDI to the average net value of fixed assets of *K* to eliminate multicollinearity. At the same time, in order to prevent the occurrence of spurious regression, we make a unit root test for the residual error of the regression equation and test whether residual is smooth. If the residual sequence is smooth, the regression equation setting is reasonable, showing that there is a stable equilibrium relationship between variables, otherwise existing unequilibrium relationship (Table 3).

Table 3
The Result of ADF Test on the Level of Residual Sequence

ADF value	Significance level	ADF threshold
-3.685996	1%	-3.959148
	5%	-3.081002
	10%	-2.681330

From the ADF test results, there is no unit root under the confidence level of 5%, namely the residual error sequence is smooth, and the regression is not spurious regression. Therefore, we may say that there is a stable equilibrium relationship between variables.

From Table 2, capital and labor inputs can promote the development of Chinese industrial sector, but the role of labor input is more significant. Each additional unit of capital input can improve 0.39 unit of industrial added value, and each additional unit of labor input can improve 0.61 unit of industrial added value. The reason may be that labor-intensive industries account for a significant share of China's industrial sector, and the proportion of capital and technology intensive industry is relatively small. What's more, the FDI from HMT has a positive and significant technology spillovers on China's industrial sector; Elsewhere, the FDI from Asia (except HMT), Africa and North America has a positive technology spillovers but not significant, and from Europe, Latin America, Oceania and affiliated islands of Oceania has a negative technology spillovers.

We know that the channel of the FDI's technology spillover effect includes imitation, competition, contaction and the human capital flow. FDI's technology spillover effect is closely related to the local enterprises technical level, and the technology gap between the local and foreign firms exists the nonlinear relationship. When the technology gap is small, the spillover effect is more noticeable, this is because that in the industry of smaller technology gap, competition is more fully and effectively, it is benefit to conduct spillovers, when the gap is bigger, the foreign capital enterprises can put the local enterprises out of the market with its advanced management and technology, which is not conducive to spillovers, even leading to negative effect. Therefore, the relationship between the significance FDI's technology spillover effect and technology gap are shown in Figure 3 (Zhang, 2013).

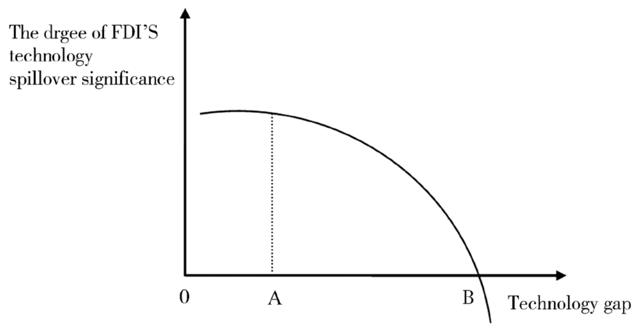

Figure 3
The Curve Relationship Between the Degree of FDI's Technology Spillover Effect Significant and Technology Gap

Combined Table 2 and Figure 3, we can get three reasons of leading the different sources FDI's technology spillover effect in Chinese industrial sector inconsistently.

Firstly, the reason that the FDI from HMT can generate positive and significant technology spillover effect is that the FDI is small and most of them are flow into the china's labor-intensive industries. The technical level is low, but higher than domestic enterprises overall. And there is a certain technology gap between foreign and local enterprises, but the gap is not big (near the point A in Figure 3). It is benefit to develop a competitive market, and domestic and foreign enterprises can promote and influence each other, generating technology spillover effect effectively. On the other hand, HMT and mainland have a common history and culture origin, so, it is easy for two sides enterprises communications and promote the development of linkage effect greatly. Local enterprises can imitate and learn the advanced technology and management mode easily, and improve their own technical level and management efficiency. In addition, from Figure 2, we can see that the FDI share from HMT flows into Chinese industrial sector accounting for 64.6% of the entire FDI flow of 2013, the positive and significant technology spillover effect affect the overall Chinese industry sector in a large degree.

Secondly, the FDI from the other parts of Asia (except HMT), Africa and North America region generates unsignificant technology spillover effect on the Chinese industrial sector. The reason is that the FDI from the other parts of Asia is not only including developed countries' like Japan, but also developing countries' such as Vietnam, Thailand, Malaysia in the Chinese industrial sector. Japanese enterprises possess advanced technology and its technical level is higher than local enterprises. A large amount of human capital can flow between the foreign enterprises and local enterprises freely which can make local enterprises to imitate advanced technology quickly. It can generate positive spillover effect on chinese industrial sector to some degree. In addition, the FDI from Vietnam, Thailand, Malaysia and other developing countries,their technical level is most close to the local enterprises', so the technology spillover effect is not significant, but some FDI's technical level is fall behind the local enterprises', their purpose of coming into Chinese industrial sector is imitating and learning from local enterprises' relative advanced technology which can produce negative spillovers in some degree. So, from the whole part of the other Asia (except HMT), the FDI's technology spillover effect is not significant. The overall technical level of foreign capital enterprises from Africa which falls behind the local enterprises and forms a big technology gap(near the point B in Figure 3). In most cases, they enter into the Chinese industrial sector for China relatively advanced technology. Therefore, it can not produce technology spillover effect on local enterprises. The FDI from North America mainly entre the high-tech industry. Its technical level is much higher than local enterprises'. It even can crowd the local enterprises out of the market and their technology gap is big (near the point B in Figure 3) which is difficult to local enterprises for learning. What's more, these multinational companies also have a strong sense of technology protection which is difficult for imitation. Therefore, there is no significant technology spillover effect in the Chinese industrial sector.

Thirdly, the FDI from Europe, Latin America, Oceania and affiliated islands of Oceania regions generates the negative technology spillover effect to Chinese industrial sector, the reason is that on the one hand, compared with the local enterprises, FDI has advantages in technology and management,especially over the domestic enterprises on the technical level. When these foreign companies entering the local market will put the local enterprises out of the market through competition and establish a monopoly market, obtain excess profit.In this case, that may produce negative technology spillover effect (near the point B in Figure 3). On the other hand, the technology level of FDI from Latin America and Oceania and affiliated islands of Oceania regions is falling behind the local enterprises which can cause a big technology gap and generate a negative spillover effect in some degree.

CONCLUSION AND SUGGESTION

Although, the empirical researches at home and abroad show that FDI's technology spillover effect does exist in the host country, but because of the difference of the research ideas, models, methods, and the limitation of data acquisition, etc., the results are often not same. We use the 1995-2012 time series data of Chinese industrial sector, based on the extension Cobb-Douglas production function model to research the different sources of FDI's technology spillover effect in Chinese industrial sector and we can draw the conclusion that: One, the unit input of labor make a higher contribution of increasing industrial added value to the unit input of capital. Two, the FDI from HMT has a positive and significant technology spillovers in Chinese industrial sector; Elsewhere, the FDI from Asia (except HMT), Africa and North America has a positive technology spillovers but not significant, and from Europe, Latin America, Oceania and affiliated islands of Oceania has a negative technology spillovers.

In order to make Chinese industrial sector gaining more positive and significant technology spillovers, we should do as the following three aspects:

First of all, we should actively introduce FDI, but in the process of introducing FDI, we should not only pay attention to the amount of FDI, but also the quality of FDI. When the foreign enterprises' technical level is higher than the local enterprises' appropriatly, it can generate positive and significant technology spillover effect, so as to enhance the technology level and management of Chinese industrial sector,such as the FDI from HMT. What's more, we should also introduce the FDI with advanced technology (such as the FDI from Europe and America regions) actively. Although it may cause extrusion effect, but in the long run, the local enterprises will get a better method to imitate or study and obtain the spillover effect. We should be careful to introduce the FDI with the same technical level of local enterprises or even lower than the local enterprises' (such as FDI from Africa and other parts of Asia), because it can produce negative spillover effect.

Then, the labor-intensive industries account for a high proportion in Chinese industrial sector, but the proportion of capital and technology intensive industry is low at the present stage. In order to carry out industrial structure adjustment and transformation, we should raise our innovation level, make a heavy effort to the domestic enterprises' technical innovation and upgrading, and apply high and new technology and advanced applicable technology to upgrade traditional industries, improving the overall technical level of local enterprises, narrow the technology gap and gain significant technical spillover effect.

Finally, when we strongly improve the technology level of local enterprises and shrink the technology gap with the developed countries. We should also take other measures, like giving better welfare and higher salary rewards, to attract foreign senior managers and technicists to work in the local enterprises and showing their management and technical talents to improve local enterprises' imitation and learning effect. Then, it can generate positive and significant technology spillover effect and improve the technology level of local enterprises and their management efficiency.

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