

Study on Regional Differences of Spillover Effect of Foreign R&D in China

based on Provincial panel data of large and medium sized industrial enterprises

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Abstract—China's land area is vast and the regional differences are significant. The study on regional differences of spillover effect of foreign R&D in China is of great significance to the implementation of the regional policy formulation and innovation driven strategy. However, there are few studies on the regional differences of spillover effect. This paper makes a study on the regional differences of foreign R&D spillover effect in China based on panel data of Large and Medium-sized Industrial Enterprises. The results show that there are obvious differences between China eastern, central and western region of the influence of innovation output by foreign R&D investment. It turns out to be promoted eastern region's innovation output and inhibited central region's innovation output, in the western this inhibition become more prominent. Research results also indicate that foreign R&D will inhibit the innovation investment of three regions.

Keywords- foreign R&D; spillover effect; innovation output; innovation investment; regional differences

I. INTRODUCTION

Since 1990s, China has gradually become a hot country for overseas research and development activities of transnational corporations, and the research and development purpose of foreign capital in China also gradually transitions from initially supporting local production and making use of local resources to strategic height of global research and development network's layout. Whether research and development activities of foreign capital can promote the improvement of local enterprise independent innovation ability of host country or not has become an unavoidable significance issue of our country in the process of promoting independent innovation strategy and innovation-driven development strategy, so the research about spillover effect of research and development of foreign capital also becomes a hot field.

In China, a country with vast territory and significant regional difference, research and development activities of foreign capital have already had obvious differentiation in the aspect of intensive degree in various regions. In addition, economic development degree of various regions, technological development level and conditions of resource endowment in China vary in thousands of ways, thus

researching the relationship between research and development of foreign capital can't solve practical problems from national level. Therefore, the research problem of this paper is: in terms of such a big country like China, whether there exists difference in the spillover effect of research and development of foreign capital in different regions under the premise that there exist regional differences? What's the influence of intervention of research and development of foreign capital on innovation input and innovation output in those enterprises in east-central-west regions of our country? Based on the consideration of spatial correlation, this paper adopts province-level panel data of large and medium-sized industrial enterprises and direct indexes of research and development innovation and attempts to carry out research about regional difference from spillover effect of research and development of foreign capital in the eastern, western and medium regions.

II. RESEARCH OVERVIEW AND PROBLEM POSING

A. Research Overview

The research about spillover effect of foreign R&D in China deepens and refines the research about FDI knowledge spillover which has obtained many considerable achievements. As the degree of economic globalization increasingly deepens, the research about spillover effect on research and development of foreign capital still doesn't have any final conclusions, but it basically forms three opinions: "Theory of Promotion", "Theory of Repression" and "Theory of Double-edged Sword" (Sheng Lei, 2010)[1].

"Theory of Promotion" contends that there not only exists spillover effort of research and development of foreign capital, but it is also very remarkable. Empirical analyses of Mohnen(1990)[2], Hsiao-Lan Liu, Hsin-Yi Lin, and Shin-Kun Peng.(2010)[3], Zhang Zhen-gang(2012)[4] indicated: technology spillover of research and development of foreign capital generates a prominent effect on local enterprise innovation ability, but whether there exists technology spillover of research and development of foreign capital or not depends on absorbing ability of local enterprises.

"Theory of Repression" thinks research and development of foreign capital doesn't generate any spillover effect on host countries, and it will generate negative effect on their

technological innovation. For example, researches about enterprise in Venezuela and India carried out by Aitken and Harrison(1999)[5],Feinberg, S.E. and Majumdar.S (2001)[6] showed that the entry of transitional corporations generates obvious negative effects on research and development of corporate in this country.

Reddy's(1997)[7]"Theory of Double-edged Sword" thought in terms of host countries, there are advantages and disadvantages about the entry of transnational countries. Du Debing (2006)[8]thought that there exist "three advantages and disadvantage" in research and development of foreign capital, that is, foreign capital enlarges the whole research and development scale of our country, but foreign tradesmen further strengthen technical control; Research and development of foreign capital in China benefits talents aggregation, but it aggravates the struggle for human resource market; Technology of foreign capital spills over to some extent, but there also exists the risk of "counter diffusion" of technology.

In recent years, researches about heterogeneity of spillover effect on research and development of foreign capital have gradually attracted more attention. Coe(2008)[9],Alistair Dieppe and Jan Mutl(2013)[10]studied and found that in the same department, the effect of research and development on total factor productivity is positive, but as a whole, it has negative effect on other departments and countries, and at the same time, these effects show high degree of heterogeneity in different departments and countries.

B. Problem posing

At present, researches mostly concentrate on the measure of spillover effect on research and development of foreign capital and don't bring the relationship between research and development of foreign capital in different spatial scale and independent innovation into systematic analytical framework. Tang Lizhi's (2009)[11]empirical results showed that the spillover effects of foreign R & D activities have obvious regional differences in Fujian. Previous researches mostly focus on the study about essential of spillover effect on research and development of foreign capital and measure of quantity. Based on the aforementioned researches, this paper will adopt provincial panel data of large and medium-sized industrial enterprises in our country to investigate the current situation of influence of research and development of foreign capital on independent innovation in east-central-east regions and three provinces in northeast of our country with the purpose of cleaning up regional difference of spillover effect on research and development of foreign capital in China.

III. MODEL, VARIABLE AND DATA

A. Selection of model

This paper adopts the panel data analysis method of individual model. Taking use of panel data model contributes to scientifically analyze the relationship between the intervention of research and development of foreign capital and variables of independent innovation, which can estimate

the effect of certain elements which are difficult to measure on explained variables.

The analyses about individual analysis model and the model of time series analysis contain Fixed-effect Model (FEM) and Random-effect Model (REM). Both of them take regional difference into account and their difference lies in that random model supposes the differences among provinces obey certain random distribution. According to Hausman Test method which proposed by William H. Greene (1997)[12], if the value of statistics W is larger than critical value, choose fixed effect model, and if not, choose random effect model.

Set basic model as:

$$Y = X\beta + \mu \quad (1)$$

and i cross-section data shows as:

$$Y_i = \begin{pmatrix} y_{i1} \\ y_{i2} \\ \dots \\ y_{i30} \end{pmatrix} \quad (2), \quad \mu_i = \begin{pmatrix} \mu_{i1} \\ \mu_{i2} \\ \dots \\ \mu_{i30} \end{pmatrix} \quad (3),$$

$$X_i = \begin{pmatrix} PFR \& D_{i1} & Ln(csiz e)_{i1} & Ln(scale)_{i1} \\ PFR \& D_{i2} & Ln(csiz e)_{i2} & Ln(scale)_{i2} \\ \dots & \dots & \dots \\ PFR \& D_{i30} & Ln(csiz e)_{i30} & Ln(scale)_{i30} \end{pmatrix} \quad (4).$$

Y is dependent variable and represents capacity of independent innovation. y_{it} represents the index of independent innovation in the t province in the i year. This paper carries out Log processing towards all Y_i values.

μ represents random error term. Among, $\mu_{it} = \alpha_i + \zeta_{it}$ is residual term, and α_i represents individual factors of each province. Fixed effect model supposes α_i is a fixed constant; random effect model supposes α_i is a random variable.

X is independent variable and includes three indexes: $PFR \& D$, $CSIZE$ and $SCALE$. Among the three indexes, $CSIZE$ and $SCALE$ are control variables. We carry out Log processing towards enterprise scale and investment scale just like the capacity of independent innovation.

The model after Log processing is:

$$\ln(Y_{it}) = \alpha_0 + \alpha_1 PFR \& D + \alpha_2 \ln(CSIZE_{it}) + \alpha_3 \ln(CSCALE_{it}) + \mu \quad (4)$$

In this formula, α_1 is the parameter which measures the impact of intensity of research and development's intervention of foreign capital on innovation ability of domestic enterprises. If α_1 is obviously positive, which indicates research and development of foreign capital promotes the improvement of capacity of independent innovation and also supports the opinion of "Theory of

Promotion”; conversely, if is obviously negative, it supports “Theory of Repression”.

B. Variable and data selection

This paper chooses three indexes: funds for research and development input (Y_1), the quantity of research and development personnel (Y_2) and patent application quantity (Y_3). Among the three terms, the first two terms are indexes of innovation input and the last one is index of innovation output. In order to avoid the situation where relative indexes are same, but absolute indexes are very different, thus this paper adopts absolute indexes.

The degree of intervention of research and development of foreign capital is measured by the proportion of funds for research and development of foreign capital in total funds for research and development of whole industry. $PFR\&D$ = volume of expenditure of research and development of foreign capital in industries / total volume of expenditure of research and development of whole industry. In addition, taking the stronger relationship between enterprise scale and innovative and research and development capability of enterprises, choose domestic enterprise scale ($CSIZE$) and industries investment scale ($SCALE$) as control variables.

TABLE I. INDEX AND DEFINITION

Index	Definition of Index
Y_1 (Funds for research and department input)	Total volume of internal expenditure of scientific and technological activity in whole industry — total volume of internal expenditure of scientific and technological activity in foreign-owned enterprise
Y_2 (Quantity of research and development personnel)	Quantity of scientific and technological activity personnel in whole industry — quantity of scientific and technological activity personnel in foreign-owned enterprise
Y_3 (Patent application quantity)	Patent application quantity in whole industry — Patent application quantity in foreign-owned enterprises
$PFR\&D$	Volume of expenditure of research and development of foreign capital in industries / Total volume of expenditure of research and development in whole industry
$CSIZE$	(Sales of products in whole industry-sales of products in foreign-owned enterprise) / (Quantity of enterprise in whole industry-quantity of foreign-owned enterprise)
$SCALE$	Renovation and reformation investment + Investment in capital construction

This paper focus on the study of the spillover effect’s regional differences of foreign capital R & D in China, which requires the selection of empirical data, must meet two basic conditions: First, the data must be sub regional (provincial) statistics of the data; two is that the data must distinguish between domestic and foreign investment. Considering the availability of data, and ensure the stability and reliability of the empirical results, we selected the 1998-2008 data of large and medium-sized industrial enterprises in the sub region of the internal and external as the empirical data of this study.

IV. ANALYSIS ABOUT EMPIRICAL RESULTS

From the result which is gotten by respectively analyzing panel data of large and medium-sized industrial enterprises in the three regions of east, middle and west. It can be seen that the result of data fitting is better. Variables of other regions mostly pass 10% T test, except there is a higher significance level in the variables of western region. All the inspection results of Hausman support fixed effect model (seen in TABLE II). According to results of empirical analysis, intervention of research and development of foreign capital brings different regional effects to east-central-west regions. In the aspect of innovation output, intervention of research and development of foreign capital promotes independent innovation of domestic enterprises in eastern region, but it has inhibition effect on independent innovation of foreign-owned enterprise in central and western regions; in the aspect of innovation input, in terms of central and western regions with relative backward economic development, intervention of research and development of foreign capital will suppress the capacity of domestic enterprise innovation input.

TABLE II. INDEX AND DEFINITION

		Domestic enterprises patent application		Domestic enterprises Science and technology funds		Domestic enterprises Scientific and technical personnel	
East	Constant	-4.9285	-4.8691	2.2463	2.2763	9.0081	9.0662
		4.5126** *	- 4.5344***	4.8027** *	4.8197***	21.9187** *	21.9766 ***
	Pfr&d	2.0780	1.3609	0.2472	0.0151	-0.1613	-0.5578
		3.4694** *	2.7908***	0.9637	0.0657	-0.7158	2.8031***
	csize	0.9279	1.2976	0.9017	1.0842	0.5198	0.8736
		3.9950** *	8.2430***	9.0654** *	13.5195** *	5.9467***	12.7784** *
	scale	0.3461	0.0867	0.3379	0.2065	-0.2337	-0.4901
		1.5844	0.5160	3.6125** *	2.5669 **	2.8429***	7.0744***
	W	7.2411 [#]		17.9402 ^{##}		81.5397 ^{###}	
Middle	Constant	-6.5960	-5.5555	1.9401	2.0996	10.9031	10.8672
		6.7255** *	- 6.1825***	3.8357** *	4.1670***	27.5254** *	27.2766** *
	Pfr&d	-1.0979	-0.9886	-1.0520	-1.0543	-0.9090	-0.9624
		-2.1979** *	2.0531***	4.0837** *	4.1425***	4.5056***	4.8200***
	csize	0.5048	0.7121	0.6120	0.6464	0.4879	0.4930
		3.1421** *	4.9746***	7.3862** *	8.1110***	7.5194***	7.8555***
	scale	0.8367	0.5896	0.5902	0.5507	-0.3674	-0.3670
		4.3301** *	3.4597***	5.9230** *	5.7651***	4.7078***	4.8760***
	W	9.1936 [#]		3.3275		9.4666 [#]	
West	Constant	-5.0542	-4.7601	3.6211	3.8481	11.6879	12.0717
		3.5315** *	- 4.1475***	7.0103** *	7.7281***	20.6364** *	21.2081** *
	Pfr&d	-0.4290	0.2840	-1.2928	-1.3155	-1.0899	-1.2749
		-0.2855	0.1991	-2.3839**	-2.4591**	-1.8330*	-2.1645**
	csize	1.3179	1.3213	0.9496	1.0054	0.4390	0.5475
		4.4811** *	7.3167***	8.9461** *	10.9585** *	3.7715***	5.2077**
	scale	0.1305	0.0976	0.1736	0.1163	-0.4558	-0.5612
		0.4325	0.5004	1.5944	1.2221	3.8187***	5.1646***
	W	3.6309		1.9317		6.1088 [#]	
model		FEM	REM	FEM	REM	FEM	REM

Note: *, **, *** represent the 10%, 5% and 1% significance level; #, ##, ### represent the 10%, 5% and 1% significance level of Hausman test.

A. Effects on independent innovation of domestic enterprises in eastern region

Eastern region is the most developed region in Chinese economy and is also a region where intervention of research and development of Chinese foreign capital is higher. The intervention level of research and development of foreign capital in 11 provinces of eastern region averagely is 28.9%

from 1998 to 2008. Among these cities, Shanghai reaches up to 63% and Fujian is 54% and Beijing is 41%. In terms of eastern region, under fixed effect model, Pfr&d coefficient value (elasticity) of patent application of domestic enterprises is 2.0780 and it passes 1% T test of significant level with very high confidence level (seen in TABLE II), which means that the entry of research and development of foreign capital plays a very prominent role in promoting innovation output of domestic enterprises in eastern region and improves the ability of independent innovation output of domestic enterprises. However, under fixed effect model, Pfr&d coefficient of expenditure of scientific and technological activity in domestic enterprises and scientific and technological personnel in eastern region respectively are 0.2472 and -0.1613, which indicates research and development of foreign capital promotes expenditure of scientific and technological activity in domestic enterprises, but it suppresses the input of scientific and technological activity personnel.

Research and development has a negative effect on quantity of personnel of scientific and technological activity of domestic enterprises in eastern region and its main reason is that carrying out research and development activities of foreign capital occupies human resource of science and technology of China. However, research and development plays certain role in promoting research and development funds input of domestic enterprise in eastern region, which is due to the need of competition between domestic enterprise and those of foreign-owned, so domestic enterprises will pay more attention to research and development input. The reasons why research and development input of foreign capital has a motivating effect on innovation output can be summarized as: advanced science and technology of eastern region, good regional absorbing ability and increase in pressure of competition. Fierce competitions which are brought by foreign-owned enterprises also compel domestic enterprises in eastern region to constantly adopt new techniques and research and develop new products; corporate strength is strong. With larger scale, domestic enterprises in eastern region have the strength of capital and technical level to carry out new research and development activities.

B. Effects on independent innovation of domestic enterprises in central region

The proportion of intervention of research and development of foreign capital in central region is lower than that in eastern region. In central region, the proportion of intervention of average research and development funds of foreign capital in Hei Longjiang, Hunan, Jilin and Shanxi during the 11 years from 1998 to 2008 is about 10%. In terms of central region, under fixed effect model, Pfr&d coefficient value (elasticity) of patent application of domestic enterprises is -1.0979 and passes 5% T test of significant level (seen in TABLE II), which indicates the entry of research and development of foreign capital has an very obvious inhibiting effect on innovation output of domestic enterprises in central region from 1998 to 2008; under fixed effect model, coefficient values of expenditure

for scientific and technological activity of domestic enterprises and personnel of scientific and technological activity of domestic enterprises respectively are -1.0520 and -0.9090 and both of them pass 1% T test of significant level, which states the entry of research and development of foreign capital suppresses innovation input of central region.

There are some reasons why research and development of foreign capital suppresses innovation input and output of central region as follow: ① there is a large technological gap between domestic enterprises and foreign-owned ones in central region and domestic enterprises benefit from smaller knowledge spillover of foreign-owned enterprises. ② income of domestic enterprises with low technological level through imitating foreign-owned enterprises is more than that of self-development new technique, which reduces the enthusiasm of innovation input of domestic enterprises. ③ under severer environment of market competition, these enterprises with extremely small scale don't have motivation to pursue innovation, thus intervention of foreign-owned enterprises will reduce innovation input.

C. *Effects on independent innovation of domestic enterprises in western region*

Western region is the most backward region in the aspect of Chinese economic development and is also a region with lowest proportion of intervention of foreign capital. The average proportion of intervention in the nine provinces of western region doesn't reach 3.6% except Tibet. Among the nine provinces, Sinkiang is only 0.028%. The analyses about western region show under fixed effect model, Pfr&d coefficient value (elasticity) of patent application of domestic enterprises is -0.4290. the confidence level is low (seen in TABLE II), but to a certain degree, it also can reflect intervention of research and development activity of foreign capital from 1998 to 2008 presents inhibiting effect on innovation output of domestic enterprises in western region; under fixed effect model, Pfr&d coefficient values of expenditure for scientific and technological activity of domestic enterprises and personnel of scientific and technological activity of domestic enterprises respectively are -1.2928 and -1.0899 and both of them pass 5% and 10% T test of significant level, which states the entry of research and development of foreign capital suppresses innovation input of western region.

Research and development presents obvious inhibiting effect on independent innovation of western region and the main reasons are that technological absorbing ability of western region is weak with the serious loss of enterprise and innovation resources and constraint of resource and environment conditions of the region itself. Factors of modern service industry like innate climate, resources, relative inconvenient traffic, weak economic strength and finance restrict economic development. In the research and development link, enterprises in western region not only are short of motivation, but also short of strength. And intervention of foreign-owned enterprises increases market

competition and overwhelming technological gap also aggravates this tendency of enterprises.

V. CONCLUSIONS

Since the reform and open policy, Chinese economy has gained great-leap-forward development, but our country as a whole still in the catch-up stage and there is still a larger gap compared to developed countries. As the main part of independent innovation of our country, how domestic enterprises to deal with and grasp spillover effect which is brought by research and development of foreign capital and how to draw on advantages and avoid disadvantages and improve independent innovation capacity appear particularly important. In economic area of east-central-west regions in China, intervention degree of research and development of foreign capital and the abilities of domestic enterprises are different, so making overflowing regional difference of research and development of foreign capital clear has a directional significance on formulation of regional difference policies.

Through the research of this paper, the main conclusions are as follows:

- The influence of research and development of foreign capital on independent innovation output of China is related to regional development level, and regional development level directly decides regional adsorbing ability.
- The influence of research and development of foreign capital on independent innovation input of China presents inhibiting effect, but there exists very strong technology spillover.
- Past Research and development of foreign capital investment in China can stimulate domestic enterprises with strength increase the input of research and development funds to some degree, but domestic enterprises can't do anything when facing that research and development institutes occupies human resources of science and technology, causing scientific and technological talents drain, but at the same time, it also plays a part in training scientific and technical personnel, and the return of these talents will bring more spillover.

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