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Empirical Study of FDI Spillover Effect and the Relationship with Environment

Yanping Bai and Yu Zhang
School of Management, Capital Normal University, Beijing, China
School of Computer Science, Beijing University of Civil Engineering and Architecture, Beijing, 100044, China

Abstract: This study used Generalized Method of Moments (GMM) estimation method to test the horizontal, forward and backward spillover effects of the Foreign Direct Investment (FDI) and the impact of environmental regulation on industrial technological progress, the effect of environmental regulation on the effect of FDI on industrial technological progress, by using the correlated data of 39 industries during 2001-2010 in Beijing. Empirical results showed several important conclusions: First, FDI horizontal spillover has promotion effects on industrial technological progress; second, FDI forward spillover had uneven promotion effects on industrial technological progress and the enhancing of environmental regulation intensity also had significant promotion effects on industrial technological progress; third, the studies suggested that the enhancements of environmental regulation also facilitated FDI horizontal spillovers in the long run.

Key words: Empirical study, FDI spillover effect, GMM estimation

INTRODUCTION

The open policy of China's economic reform since the 1980s has attracted heavy Foreign Direct Investment (FDI) flows into China and especially to Beijing and induced significant economic growth during the past two decades. FDI of Beijing increases every year from 1980-2010. In Table 1, in 2010, the FDI of Beijing has reached 636.358 million and FDI of year 2010 was 1.59 times more than the FDI of year 2001. The FDI ratio of Beijing to China in year 2001 was 25.67%, in year 2010 is 20.74% and the mean of ten years was 25.34%.

Table 1 showed that in the early stage of China's opening up, FDI inflow increased at a modest rate until the early 1990s. The realized value of inward FDI to China was $3.49 billion in 1990 but soared to $27.5 billion in 1993. The figure reached $37.5 billion in 1995, peaked at $45.3 billion in 1997 before declining to $40.3 billion in 1999, largely due to the negative effects of the East Asia financial crisis. The volume of FDI inflow in 2000 was $40.7 billion. The surge in FDI after 1993 was driven by several factors. Following Deng Xiaoping's support of further economic liberalization in 1993, the Chinese government resumed a policy of far reaching economic reforms and launched a new round of measures to attract FDI.

Table 1: Amount of FDI in Beijing from 2001-2010

Year	FDI (million $)
2001	401
2002	422
2003	450
2004	501
2005	532
2006	550
2007	580
2008	608
2009	612
2010	636

*Statistical yearbook of Beijing from 2002-2011

FDI to China is characterized by a very uneven geographic distribution. Regional breakdown of FDI shows a dividing line between coastal provinces and inland provinces in attracting foreign capital. As Table 1 shows, in 1996 nearly 90% of FDI (in realized value) was concentrated in coastal provinces and more precisely in five of them: Guangdong, Jiangsu, Fujian, Shanghai municipality and Shandong received more than 65% of total FDI. The Central region received only 9% and the West region only 2.45% of the total FDI inflow in that year. The geographic distributions of inward FDI in 1998 and 2000 (and in fact throughout the second half of the 1990s) were almost the same as it was in 1996. This uneven distribution is primarily due to the fact that the Coastal region is the most developed area in China and was the first region to allow FDI when China opened up in the 1980s.

Corresponding Author: Yanping Bai, School of Management, Faculty of Normal University, Beijing, 100048, China
Tel: 0086-13466373257 Fax: 0086-10-68902339

Given the concern regarding the accuracy of government statistics on GDP and FDI made know by the academic community (Rawski, 2001; Young, 1995), most of the empirical studies have supported the positive contributions of inward FDI to China's economic performance in general and rapid growth in particular. Some recent studies have reconfirmed the critical importance of inward FDI upon future sustainable growth in China using a two-stage growth accounting decomposition approach (Whalley and Xin, 2010; Yao, 2006) while a regional growth perspective in other countries such as Russia (Brock, 2005) is also emphasized (Mullen and Williams, 2005).

Empirical studies of FDI spillover effects on innovation in China are rare. The only work is a recent study by Hu and Jefferson (2001). The authors used data for large-and medium-size enterprises to examine the spillover effects of FDI in manufacturing industries in China. They found that inward FDI has a positive effect on introduction of new products in China.

The study using provincial data is motivated by the fact that spatial proximity is of crucial importance for technology and knowledge spillovers, as documented in the literature on R and D spillovers. It is well recognized that geographic proximity facilitates flow of knowledge. The probability that knowledge is transmitted from one agent to other decreases as geographic distance increases. The closer a local firm is located to an FDI firm, the more likely and more frequently their employees will interact with each other and more frequent labor moves between these two firms. Moreover, the spatial aspect is also important for vertical spillovers between FDI firms and their local suppliers which often are located close to one another.

To investigate the determinants of FDI shows and its regional agglomeration behavior, factors commonly cited by studies included costs of production factors, market size, agglomeration effects, financial incentives and investment environment (Lim, 2001; Ng and Tuan, 2002; Taube and Ogutcu, 2002; Tuan and Ng, 1995). A series of studies examining factors affecting FDI regional agglomerations and its impacts on regional economic development suggested two key approaches in understanding the issue of the economic development of Pearl River Delta PRD) region: (1) The impacts of regional agglomerations following Krugman (1990) concept of Core-Periphery System (CPS) or the city link and (2) An institutional approach emphasized on economic reform in terms of timing of opening and the role of institutional reform. Selected major studies included Tuan and Ng (2004) and Ng and Tuan (2006). Following the steps of institutional reform in China, it is likely that the remarkable economic performance in GDP growth and FDI inflows in Yangtze River Delta (YRD) recorded since 1990s may well be explained by the same approach as in the early opened PRD.

Some scholars aboard has studied the relationship between FDI and environmental pollution, the analysis results showed it was undetermined. Some thought the two had a certain casual relationship, others thought they had nothing effect. List and Catherine (2000) studied the effect of environmental regulation to the FDI of American states; they showed the stricter of environmental regulation the less of the FDI in this state. For example, they found that the expenditure on environmental regulation rising 1% in Arizona, the FDI decreased 0.262%. Does the stricter environmental policy in China do adverse effect to the FDI in China? This study wants to do empirical study to judge it.

Literatures usually think the spillover channel of FDI can be divided into two types: horizontal spillover and vertical spillover. With the increasing degree of economic globalization, the trade barrier, investment barrier of each country and each area decrease greatly. So, other policy and rules affecting FDI spillover effect become more and more important, among these rules, the intensity of environmental regulation has more and more effect on one country's competitive power. Especially at present, the amount that Beijing induces foreign investment raises every year. But the industry pollution goes seriously, worsen environmental quality induce the focus on whether China has become "pollution heaven" (development country want to seek profit- maximizing and evade host country's strict environmental standard, choosing to enter low environmental standard developing country) of multinational pollution enterprise.

The empirical research of overseas for environmental regulation performance is more early than domestic. The research is focused on the effect of environmental regulation to pollutant discharge. Today, aiming at the argue on environmental regulation and FDI spillover effect, some research support "pollution heaven" hypothesis, thinking that FDI has relationship with environmental pollution of host country and restrict environmental regulation would decrease FDI enter. But other researches support that restrict environmental regulation could benefit from the improvement of environment quality.

Domestic scholars have deeply discussed on this problem. Cole and Elliott (2005) did empirical study on the

relationship of FDI and pollution concentrated industry and found foreign merchants transfer pollution concentrated industry through FDI. Other research also found that the inflow of FDI really has negative effect on domestic environment and it can result in China become "pollution heaven" (Jeppesen *et al*., 2002).

The study on that after FDI enter one country, whether strengthening environmental regulation would affect FDI spillover effect or not, especially on differentiating the technology spillover effect of horizontal FDI, forward FDI and backward FDI is relative minor. In order to make up the study deficiency, the study use the correlated data of 39 industries during 2002-2011 in Beijing to examine the horizontal technological progress and the effect of environmental regulation on the marginal effect of FDI on industrial technological progress.

MODEL AND DATA

Model: The following estimated model shows the relationship of industry productivity, FDI spillover effect and environmental regulation:

$$TFP_{it} = u_i+\delta_1 HF_{it-1}+\delta_2 FW_{it-1}+\delta_3 BW_{it-1}+\beta_4 EP_{it}+\varepsilon_{it} \quad (1)$$

Here, i and t represent industry and time, respectively; TFP_{it} represent i industry's productivity; HF_{it-1}, FW_{it-1}, BW_{it-1} stand for each industry's horizontal, forward and backward spillover effect. EP_{it} is the evaluation index for each industry environmental regulation intensity.

The following dynamic relationship equations test whether EP_{it} has effect on the horizontal, forward and backward FDI of each industry:

$$\delta_1 = \beta_1+\beta_5 EP_{it-1}+\beta_7 EP_{it-2} \quad (2)$$

$$\delta_2 = \beta_2+\beta_7 EP_{it-1}+\beta_8 EP_{it-2} \quad (3)$$

$$\delta_3 = \beta_3+\beta_9 EP_{it-1}+\beta_{10} EP_{it-2} \quad (4)$$

Here, β_5, β_7 and β_9, respectively represent the effect on the horizontal, forward and backward FDI of each industry in the same term, put Eq. 2-4 into 1, then can get Eq. 5:

$$TFP_{it} = u_i+\beta_1 HF_{it-1}+\beta_2 FW_{it-1}+\beta_3 BW_{it-1}+\beta_4 EP_{it}+ \beta_5 EPHFi_{t-1}+\beta_6 EPHF_{it-2}+\beta_7 EPFW_{it-1}+ \beta_8 EPFW_{it-2}+\beta_9 EPBW_{it-1}+\beta_{10} EPBW_{it-2}+\varepsilon_{it} \quad (5)$$

In Eq. 1 and 5, add dependents' lagging variables and then can get Eq. 6 and 7:

$$TFP_{it} = u_i+\alpha_1 TFP_{it-1}+...+\alpha_p TFP_{it-p}+\beta_1 HF_{it-1}+\beta_2 FW_{it-1}+ \beta_3 BW_{it-1}+\beta_4 EP_{it}+\varepsilon_{it} \quad (6)$$

$$TFP_{it} = u_i+\alpha_1 TFP_{it-1}+...+\alpha_p TFP_{it-p}+\beta_1 HF_{it-1}+\beta_2 FW_{it-1}+ \beta_3 BW_{it-1}+\beta_4 EP_{it}+\beta_5 EPHF_{it-1}+\beta_0 EPHF_{it-2}+ \beta_7 EPFW_{it-1}+\beta_8 EPFW_{it-2}+\beta_9 EPBW_{it-1}+\beta_{10} EPBWi_{t-2}+\varepsilon_{it} \quad (7)$$

If used OLS estimation, the results would be biased and inconsistence. So this study uses GMM to estimate coefficients of the dependents.

Data: The sample data to calculate industry productivity and FDI spillover effect come from "statistical yearbook of Beijing" (2002-2011). The study uses correlated data of 39 industries from year 2002-2011. In order to calculate FDI forward and backward spillover effect, using the input-output data of "statistical yearbook of Beijing". To calculate the index for environmental regulation intensity, using the discharge of industry waste water, discharge of industry waste gas, discharge of SO_2. All the data are alternated to the price of year 2001.

The FDI data of each province in China comes from China Statistical Yearbook, calculate the mean of FDI of each provinces in year 2008-2012. Using X_{regu} presents environmental regulation. X_{regu} presents Industrial pollution control value, the data also come from China Statistical Yearbook. X_f is the "three waste". X_{GDP} expresses the GDP of each provinces. It indicates the economic scale and developing level. X_{wage} is the average wage of year 2008-2012. Descriptive statistics of independents can be showed in Table 2. Time series data can be showed in Table 3.

EMPIRICAL TEST RESULTS

- Use data in Table 1, building the following regression equation:

$$Y_{FDI} = \beta_0+\beta_1 X_{regu}+\beta_2 X_{regu}+\beta_2 X_{GDP}+\beta_5 X_{wage} \quad (8)$$

The regression results as follows:

$$Y_{FDI} = -337336-1.95956X_{regu}+102.6839X_{GDP}+ 30.50302X_{wage}=(-3.86557)-(-1.92556)+(4.861637)+(3.123159)$$
$$R_2 = 0.722725, F = 22.58993$$

β_0, β_1, β_2, β_3, all passed the significant test based on $\alpha = 0.1$. The sign of coefficient X_{regu} is negative as estimated, it means stricter the environmental regulation, less FDI of local government

Table 2: Descriptive statistics of independents

Province	FDI (million dollar)	X_{regu} (million yuan)	X_{GDP} (billion yuan)	X_{wage} (billion yuan)
Beijing	189877.75	69804.925	2377.54500	15502.50
Tianjin	179427.25	40768.050	1566.47500	11947.50
Hebei	95495.50	61807.925	4872.98500	7458.75
Shanxi	27361.25	59392.800	1632.91750	6686.50
Neimenggu	9202.25	30420.500	1351.82250	6840.75
Liaoning	195319.00	89650.375	4438.89000	8503.00
Jilin	34626.00	49345.250	1770.25250	7601.00
Heilongjiang	37166.75	80754.000	3136.06250	7519.25
Shanghai	347247.00	64352.925	4306.28750	17633.25
Jiangsu	651241.75	146193.900	8248.10000	9892.00
Zhejiang	159373.00	134469.275	5784.22000	12605.25
Anhui	29830.75	41937.025	3010.60000	6882.50
Fujian	389652.25	44084.025	3763.54250	10154.50
Jiangxi	35218.75	15244.950	1998.42775	6793.25
Shandong	273841.00	234174.275	8201.26250	8322.50
Henan	53980.25	62777.325	4927.61750	6705.25
Hubei	100502.50	52384.575	4125.20000	7402.75
Hunan	74008.50	41223.750	3553.25750	7894.50
Guangdong	1172259.50	127140.075	9173.34000	13195.50
Guangxi	60751.75	38186.925	2034.41000	7427.50
Hainan	52483.75	3157.650	493.64750	7210.50
Chongqing	29271.25	20115.425	1562.02000	7789.50
Sichuan	43307.75	45582.675	3930.97000	8020.75
Guizhou	3488.75	18534.950	958.04250	7207.25
Yunnan	12305.50	37471.050	1919.86000	8927.75
Shanxi	29555.75	31852.625	1593.58250	7471.00
Gansu	5410.50	38011.275	964.40000	8186.25
Qinghai	1027.00	3167.375	255.77250	10012.00
Ningxia	2602.75	16111.125	258.22500	8311.50
Xinjiang	2129.25	23393.450	1283.76500	8431.75

Table 3: FDI time series date from year 1996-2011

Year	Real FDI (billion dalar)	Real FDI (billion yuan)	Three waste mission (nillion yuan)	GDP per capital (yuan)
1996	16.61	48.7700	76310	855
1997	18.74	64.7100	95076	956
1998	23.14	86.1300	114709	1103
1999	31.94	118.8800	133601	1355
2000	33.92	127.7100	132634	1512
2001	34.87	166.7900	147624	1634
2002	43.66	232.4100	152056	1879
2003	110.07	606.9900	196225	2287
2004	275.15	1585.4143	212830	2939
2005	337.67	2910.2700	239292	3923
2006	375.21	3133.3800	345812	4854
2007	417.25	3469.1100	396085	5576
2008	452.57	3751.7100	458200	6054
2009	454.63	3763.9200	486142	6307
2010	403.19	3337.7300	545870	6546
2011	407.15	3370.5500	613630	7083

- Building another regression equation:

$$Y_{FDI} = \beta_0+\beta_1 X_f+\beta_2 X_{averageGSP} \quad (9)$$

Then, using the data from Table 2 to do regression; having the following regression equation:

Y_{FDI} = -533.329-0.01202X_t +1.595942$X_{averageGDP}$ = (-6.37223)-(-8.26404)+(14.22896) R^2 = 0.989523, F = 613.8802

Based on significant level $\alpha = 0.05$, all the coefficients passed t-test and F-test. The degree of fitting is very high. The environmental regulation and FDI has negative relationship.

The column 3 and 4 in Table 4 consider the horizontal, forward and backward FDI spillover effect as endogenous variable. From the regression results, the coefficient of discharge of waste water is negative; it means the environmental regulation of waste water is the reason for decreasing horizontal FDI spillover effect.

Table 4: OLS Result of the effect on the horizontal, forward and backward FDI

Item	(1)	(2)	(3)	(4)
Total factor production (TFP) (-1)	0.37***	0.43***	0.37***	0.38***
TFP (-2)	-0.13***	-0.16***	-0.16***	-0.07***
FDI spillover effect				
Horizontal factor (HF) (-1)	-0.18	-0.34***	-0.22	-0.25**
Forward (FW)(-1)	0.46***	0.33***	0.28***	-0.16
Backword (BW)(-1)	0.91***	1.17***	0.85***	1.34***
Environmental regulation intensity	WA	SO_2	WA	SO_2
EP	0.015	0.071***	-0.29***	0.065
EP(-1)	-	-	0.94***	0.027
Constant	-0.19***	-0.16***	-0.66***	-0.14***
Independent	TFP	TFP	TFP	TFP
No. of sample	199	198	197	196
Statistics m_1	-4.45	-4.28	-4.37	-4.21
p-value	0.00	0.00	0.00	0.00
Statistics m_2	-0.75	-0.66	-0.46	-0.07
p-value	0.41	0.55	0.61	0.93
Statistics Sargan	36.78	35.46	36.53	34.75
p-value	1.00	1.00	1.00	1.00

*,**,***mean 1, 5 and 10% significant level

Table 5: GMM Result of the effect on the horizontal, forward and backward FDI

Item	(1)	(2)	(3)	(4)	(5)
Total factor production (TPF) (-1)	0.37***	0.44***	0.36***	0.49***	0.39***
Total factor production (TPF) (-2)	-0.17***	-0.65***	-0.31***	-0.09***	-0.27***
FDI spillover effect					
Horizontal factor (HF)(-1)	2.16**	0.17	1.91**	-0.19	2.36
Forward (FW)(-1)	-1.03	-0.769***	1.82	-0.81	-2.13
Backword (BW)(-1)	1.08	-0.19	-8.54***	0.82***	-2.16
Environmental regulation intensity	WA -2.49**	SO_2 -1.26***	WA	SO_2	WA -1.16
Horizontal factor EPHF(-1)					
EPHF(-2)	-	-	-2.17***	0.36	-1.54
Environmental regulation forward EPFW (-1)	1.83	3.44***	-	-	5.18*
EPFW(-2)			-1.31	2.19	-2.57
Environmental regulation backword EPBW (-1)	-0.87	2.91***	-	-	-7.08
EPBW (-2)	-	-	9.63***	-1.14	9.69***
Environmental regulation intensity (EP)	-0.026	0.048	0.17	-0.018	0.16
EP(-1)	1.32*	-0.96***	0.53***	0.12**	1.14*
Constant	-1.31*	0.17**	-0.781***	-0.034	-1.23*
Independent	TPF	TPF	TPF	TPF	TPF
Number of sample	199	198	196	195	196
Statistics m_1	-4.39	-4.38	-3.29	-3.16	-3.08
p-value	0.00	0.00	0.0013	0.0015	0.0020
Statistic m_2	-0.45	0.26	-0.53	0.13	-0.69
p-value	0.66	0.76	0.57	0.9098	0.58
Statistic					
Sargan	35.91	33.55	35.12	34.02	34.38
p-value	1.00	1.00	1.00	1.00	1.00

*,**,***mean 1, 5 and 10% significant level

The column 3 and 4 in Table 5 consider the horizontal, forward and backward FDI spillover effect as endogenous variable. From the GMM regression results, the coefficient of discharge of waste water and SO_2 is negative; it means the environmental regulation of waste water and SO_2 is the reason for decreasing horizontal FDI spillover effect.

CONCLUSION

From above analysis, industry environmental regulation intensity has substitute effect for FDI horizontal spillover effect. The important finding of this study is that enforcing the environmental regulation intensity can promote FDI spillover effect. The study examined the horizontal, forward and backward spillover effects of the FDI, the impact of environmental regulation on industrial technological progress and the effect of environmental regulation on the marginal effect of FDI on industrial technological progress. The empirical results showed that FDI horizontal spillover has no promotion effects on industrial technological progress; FDI forward spillover had uneven promotion effects on industrial technological progress and the enhancing of environmental regulation intensity also had significant promotion effects on industrial technological progress.

Further studies suggested that the enhancements of environmental regulation also facilitated FDI vertical spillovers in the long run.

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