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An empirical model of the environmental effect of FDI in host countries: analysis based on Chinese panel data

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Abstract： From the 1970’s, Foreign Direct Investment (FDI) flowed into host countries. With the development of economy in host countries the environment deteriorated. The overall goal of this paper is to estimate whether the impacts of FDI positive or negative on environment in host countries. To meet this overall goal, it is constructed a simultaneous system with data of 28 provinces in China (1992-2008). This system supposes the pollution indicators to be determined by economic scale, industrial composition and pollution density of a province, in which pollution density is created to estimate the environmental effect of FDI more exactly than traditional technological character. Also the domestic and foreign capital is tried to distinguish to make the pollution source clear. Based on a panel data of 28 provinces (1992-2008) with the three-stage least squares (3sls) estimator, the results of the system show that with the domestic investment, the environmental effect is positive, which means that FDI increases pollution emission. The direct environmental effect of FDI, which does not include domestic investment, is different decided by various pollution indicators.

Key words: FDI, pollution emission, host countries

Jel code: F23, F18, O13

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1. Introduction

According to the Year Development Report 2008 of United Nations Conference on Trade and Development (UNCTAD), the total flow of FDI in the whole world was 1833 billion dollars in 2007. The multinational enterprises (MNEs), as the new method to production, affected the economy, employment, technology and so on in host countries. All of these attracted researchers to take study on FDI. However, the one which was neglected but very important was the environmental effect of FDI in host countries.

China is the one of countries with the most amounts of FDI inflows. According to the China Statistical Yearbook of 2009, the actually utilized foreign capital amount was 92.39 billion dollars in China and the accumulation of actual FDI from 1979 to 2008 was 852.61 billion dollars. Until the end of 2006, there were more than 400 MNEs which among the 500 top multinational enterprises investing in China. With the development of economy brought by FDI, the environment deteriorated in China. So would FDI make environment worse in China?

The main pollution indicators and FDI had some relationships. To take a quick look at the relationship between FDI and main pollution indicators(industrial sulfur dioxide (SO_2), industrial dust, industrial polluted gas emission, industrial chemical oxygen demand emission, industrial solid wastes and industrial polluted water emission) the figure was drawn. The accumulation of FDI was regressed with the main pollution indicators in time series. Because only pollution in the industrial factories could be affected by FDI, all of the pollution emission data chosen were from industrial sector. To reduce the effects of scale, variable was taken by logarithm. The relationship can be seen from Figure 1.:

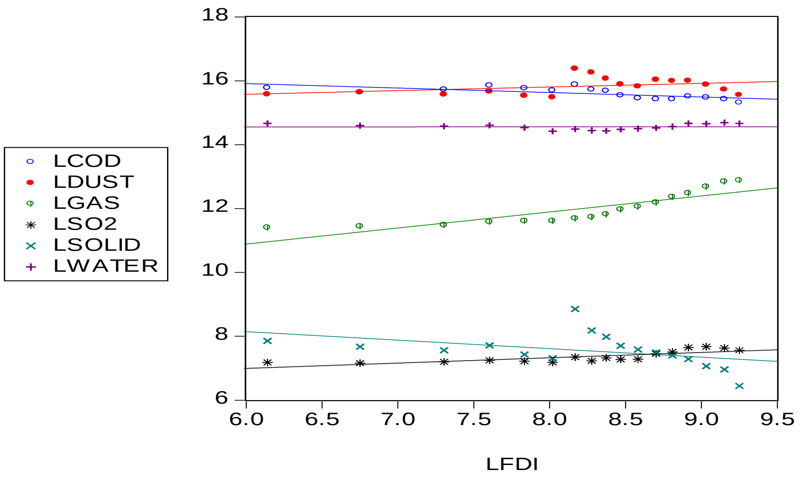

Figure 1. Industrial pollution indicators VS FDI

Source: Chinese environmental statistical yearbooks (1993-2009) and Chinese statistical yearbooks （1993-2009）

It was shown from the Figure 1 that FDI may increase the emission of pollution regard to the industrial sulfur dioxide (SO_2), industrial dust and the industrial polluted gas emission . Nevertheless, for the industrial chemical oxygen demand emission and the solid wastes, FDI may decrease the emission of pollution. And for the industrial polluted water emission, they are indifferent from above. From the simple regression, it may be concluded that the relationship between pollution emissions and FDI was ambiguous. So it needed to go back to the literatures first.

2. Literature Review

2.1 Environmental effect based on trade theory

Although there are not many researchers that studied on the topic of environmental effect of FDI, studying on the relationship between trade and environment is necessary.

Series papers of Copeland and Taylor are the most important papers in this area. They studied the relationship between trade and pollution from 1994. Their paper of 1994 was about the pollution industry transferring from developed countries to developing countries. The paper of 1995 analyzed the environmental effect of trade by two-industry model including the pollution tax. Especially, the paper of 2001 established a general analysis model including economic scale, industrial structure, the technology and the extraneous regulation of government. They concluded that trade could decrease the pollution emission by the data of 108 cities in the whole world. In 2003, they published a book called “Trade and the Environment” which included most of their research on the relationship between trade and environment. According to their theory, it can conclude that trade can affect environment through economic scale, industrial structure and the technology regulated by the government.

On our topic like trade, FDI can also affect environment in host countries by economic scale, industrial structure and the technology. But according to the traditional theory on the effects on host countries of FDI, FDI could affect the technology and the local capital.

Through technology spill over, Javorcik (2004) concluded that FDI could develop the technology in host courtiers through upstream and downstream industry. Glass and Saggi(1998) and many other researchers got the similar results. But most of the study was about the productive technology, or at least they did not distinguish it with environmental technology. And the results from Yang (2010)were totally opposite. The productive technology could make the industrial structure more intensive to increase the amount of pollution emission, while the environmental technology could decrease it definitely. So in the model, the pollution density was used to instead technology to make it more exactly.

About domestic capital accumulation, there were two kinds of opinions. Markusen and Venables(1999) indicated that FDI could crow out the enterprises through competition, and attract the investment in upstream and downstream industries. Holger and Eric(2000)used the Irish data to test the hypothesis, and found that FDI could attract local investment. Laura and Andrés (2004) also drew the similar results. No matter what the results were, it is known that the FDI did affect the capital accumulation.

2.2 Empirical model

In the past researchers focused on the study about the relationship between economic development and environment and gradually established the Environmental Kuznets Curve (EKC). Originated in the EKC, besides GDP and GDP square, FDI model added FDI in it to estimate the effects of FDI on environment, for example, Caterina (2003), Cole et al. (2009). Some papers concluded that FDI could decrease the pollution emission but the others insisted not. It is said in many papers that FDI would increase GDP. The same equation with FDI and GDP could cause the multicollinearity problem. But without GDP, it could not calculate the pollution contributed by local enterprises.

And also, there were many other methods to study it, like unit root test of time series, trend analysis, ganger causality and multicollinearity test, like Samina and Zeeshan (2006), Wheeler (2001). Besides the different results according to the different models, it is considered that these kinds of method might explain it by statistics but could not exposure the reason.

However, just like the analysis through economic model, FDI affected the environment in a host country through not only the economy but also the industrial structure, technology spill and the relegation. To deal with the endogenous variable, more accurate way to make calculation of the environmental effect was the simultaneous equations, for example, He(2008),He(2006) and Bao et al. (2008).

He(2006) used the data of the 29 provinces in China from 1978 to 2003, and took the industrial sulphur dioxide (SO_2) as the pollution indicator. The simultaneous equations models included the economic scale, industry structure, technology effect, effect of FDI on economy and technology according to the Grossman and Krueger(1995). The result indicated that when FDI increased 1%, the pollution emission increased 0.099% at the same time. FDI developed the technology, but FDI enlarged the economic scale, made industrial structure pollution more intensive. The negative effect brought by two effects is more than the positive one with technology. So FDI increased the pollution emission slightly.

Like this paper He (2008) used the data of 80 cities in China from 1993 to 2001, and took the SO_2 and the Total factor productivity (TFP) as the environmental indicators. The result indicated that FDI increased TFP but decreased SO_2. So this paper considered different indicators leading to the different results.

Bao et al.(2008) used the data from 29 provinces from 1992 to 2004 in China, and considered three effects and capital accumulation creatively. And also, he considered the FDI square to conclude that the relationship of FDI and pollution emission was the inverse "U" shape.

Consequently, FDI can effect environment through technology spill over, capital accumulation, economical scale, industrial structure and pollution density. So the simultaneous equations were established to value the environmental effect of FDI.

3. Model

It is established the system on the environmental effect of FDI in host counties by simultaneous equations to examine economic scale, industrial structure and pollution density effect at the same time. To simplify the system we regarded the regulation as exogenous variable decided by the government, and both technology and regulation could be represented by pollution density. So the regulation and the technology were not included in the system. The only thing that needed to do was to examine the effect of FDI on capital accumulation and indirect effect on the three effects. And by adding all of the three effects, it could calculate the pollution effect of FDI.

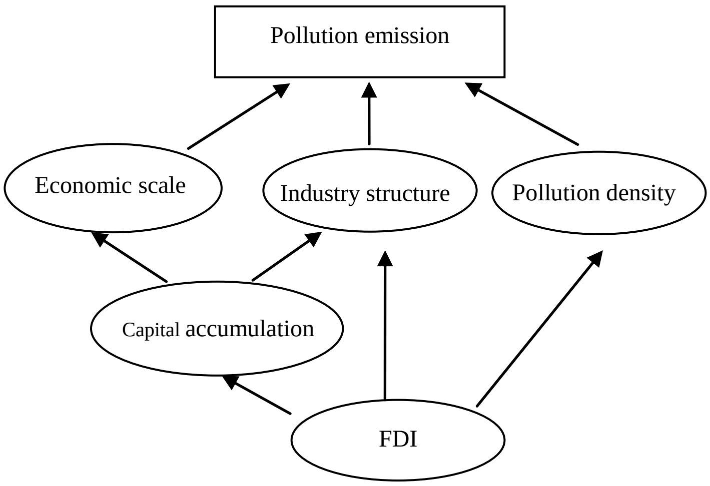

Figure 2 Simple Mechanism from FDI to environment

According to the analysis above, FDI could affect the environment in host country through economic scale, industrial structure and the technology. So the definition equation can be seen as below.

$$z_{it} = s_{it} * \varphi_{xit} * tech_{it} \tag{1}$$

Where “z” is the total amount of pollution emission; “s” is the economic scale; “φ“ is the industrial structure ,the “tech” is the pollution density; and “i” is the location in the year “t”.

In the empirical model the pollution definition equation is shown as below.

$$\log polu_{it} = \log gdp_{it} + \log comp_{it} + \log tech_{it} \quad (2)$$

In this model the GDP was used to estimate the economic scale. Where “comp” is the proportion of the industry output on the total GDP to measure the industrial structure, because that the pollution problem is the most serious problem in industry. At last, it is used the proportion of industry pollution emission on the industry output to calculate the pollution density, which is “tech”.

To examine the effects of FDI, six pollution indicators including industrial sulfur dioxide (SO_2), industrial dust, industrial polluted gas emission, industrial chemical oxygen demand emission (COD), industrial solid wastes and industrial polluted water emission were used to measure the “polu”, which was the total amount of pollution emission.

3.1 Economic Scale

Lots of papers had proved that the inflow of FDI could increase the economic scale for a country or an area. Johnson(2006) used the data from 90 countries from 1980 to 2002 to prove that FDI could develop the GDP. And many other papers did prove that as well. So according to the C-D function and the Wei (2002), the economic scale equation is shown as below.

$$gdp = Ak^{\alpha} fdi^{\beta} l^{\gamma}$$

Where “fdi” is the foreign direct investment; “k” is the domestic capital; “l” is the number of labor and “A”is the technology.

It was taken by logarithm to get the equation 3.

$$\log gdp_t = a_0 + a_1 \log fdi_t + a_2 k_t + a_3 \log l_t + a_4 \log A + \varepsilon \quad (3)$$

Because the regulation could also affect the economic development, so it was added to the model.

$$\log gdp_{it} = a_0 + a_1 \log sfdi_{it} + a_2 sk_{it} + a_3 \log l_{it} + a_4 \log polu_{it} + a_5 \log h_{it} + \varepsilon_{it} \quad (4)$$

In the empirical model, “i” is the location of the province; “t” is the year. So “gdp” is the gross domestic product in province “i” during the year “t”. Other variables are the same. “sfdi” is the accumulation of the actual utilized foreign direct investment. And in this paper all the FDI mentioned is actual utilized foreign direct investment which is more accurate. It is the same to accumulate the domestic capital, which is "sk". "l" is the number of the labors in the end of the year. It will estimate the model by six different pollution indicators. "h" is the human resource which can be calculated by the average years of education. "ε" has expected values (means) of zero and is uncorrelated with the exogenous variables.

3.2 Pollution Density

According to the analysis before, both regulation and technology could affect pollution density. And the pollution emission per unit of output was used to measure it. Because all of the pollution emission data chosen were from industrial sectors, in the pollution density function, it was used the industrial output to measure it. Considering the factors influencing the pollution density, there were regulation and technology as mentioned before. It may use the investment from government on environmental and productive technology to measure the technology. And more staffs in environmental agency means more attention the government paid on, so it used the number of environmental agency staffs. Also the population density in an area could also be the pressure of the government to make stricter regulation, so it was used to measure the pressure and the future of the regulation. The last but the most important factor was human resource which was also included to calculate the environmental sense in daily life.

$$\log tech_{it} = b_0 + b_1 \log sfdi_{it} + b_2 \log sk_{it} + b_3 \log trd_{it} + b_4 \log prd_{it} + b_5 \log \mathrm{dens}_{it} + b_6 \log regu_{it} + b_7 h_{it} + \upsilon_{it} \quad (5)$$

Where "tech" is pollution emission per unit of industrial output, "prd" is the investment in environmental technology, and "trd" is calculated by the investment on the education, science culture and the medicine. Because of the area of every province is constant, the resident population of provinces are used to instead the population density, which is "dens". And "regu" is the number of staffs in environmental agency to measure the regulation.

3.3 Industrial Structure

From the aspect of the pollution density, industry is more intensive than the others. So the proportion of the industry output on the total GDP was taken to measure the industrial structure.

The inflow of FDI changed the industrial structure through capital accumulation and the technology spill over, like Ozyurt (2009).So it was still used "trd" and "prd" in this function. Meanwhile, according to the Copeland and Taylor, higher capital-labor ratio could lead to more intensive structure, so it was added to the model. Wang & Wheeler (2002) concluded that the per capita income could influence the industrial structure. With the development of income, the pillar industry transferred from agriculture to industry and at last to the service. So the model included the per capita GDP square.

$$\log comp_{it} = c_0 + c_1 \log sfdi_{it} + c_2 \log sk_{it} + c_3 \log trd_{it} + c_4 \log prd_{it} + c_5 \log(k/l)_{it} + c_6 \log h + c_7 (\log agdp_{it})^2 + v_{it} \quad (6)$$

Where "comp" is the proportion of the industry output on the total GDP, "k/l" is the ratio of capital on the labors, and "agdp" is the per capita GDP.

3.4 Domestic Capital Accumulation

The inflow of FDI in host countries could crow in or out the domestic capital, like Backer (2002), which used the data of Belgium to examine fluctuation of the number of local enterprises affected by the FDI. And the GDP of the last year could also affect it, so the equation can be seen as below.

$$\log sk_t = q_0 + q_1 \log sfdi_t + q_2 \log gdp_{t-1} + \mu_t \quad (7)$$

3.5 FDI Location

Navaretti & Vnables(2004) concluded that there were two kinds of FDI, vertical FDI or horizontal FDI. The former one was oriented with the lower wage or price of material, while the latter one was to get closer with the customers.

Bigger market could bring more profit to counteract the cost of plants, so one period lag of GDP was taken to calculate the market share. Vertical FDI would consider the product cost like number of labors, wage, and infrastructure. Infrastructure could be calculated by the income of the government, which would be better with the more income.

$$\log sfdi_{it} = d_0 + d_1 \log gdp_{i(t-1)} + d_2 \log sk_{i(t-1)} + d_3 \log gover_{it} + d_5 \log wage_{it} + d_6 \log regu_{it} + d_7 \log l_{it} + v_{it} \quad (8)$$

3.6 Simultaneous Equations and the Expected Signs

So the final simultaneous equations are as below:

$$\log polu_{it} = \log gdp_{it} + \log comp_{it} + \log tech_{it}$$

$$\begin{cases} \log gdp_{it} = a_0 + a_1 \log sfdi_{it} + a_2 sk_{it} + a_3 \log l_{it} + a_4 \log polu_{it} + a_5 \log h_{it} + \varepsilon_{it} \\ \log tech_{it} = b_0 + b_1 \log sfdi_{it} + b_2 \log sk_{it} + b_3 \log trd_{it} + b_4 \log prd_{it} + b_5 \log \mathrm{dens}_{it} + b_6 \log regu_{it} + b_7 h_{it} + \upsilon_{it} \\ \log comp_{it} = c_0 + c_1 \log sfdi_{it} + c_2 \log sk_{it} + c_3 \log trd_{it} + c_4 \log prd_{it} + c_5 \log(k/l)_{it} + c_6 \log h + c_7 (\log agdp_{it})^2 + v_{it} \\ \log sfdi_{it} = d_0 + d_1 \log gdp_{i(t-1)} + d_2 \log sk_{i(t-1)} + d_3 \log gover_{it} + d_5 \log wage_{it} + d_6 \log regu_{it} + d_7 \log l_{it} + v_{it} \\ \log sk_t = q_0 + q_1 \log sfdi_t + q_2 \log gdp_{t-1} + \mu_t \end{cases} \quad (9)$$

The first equation is the definition equation, while the others are the behavioral equations. So the 6 pollution indicators were needed to estimate by the system with 5 equations.

Table 1 The Expected Signs in Models

Dependent Variable	Independent Variable						
Pollution emission "polu"	Scale effect "GDP"	Industrial structure effect "comp"	Pollution density effect "tech"				
Sign	+	+	+				
Scale effect "GDP"	Stock of FDI "sfdi"	Accumulation of domestic capital "sk"	Pollution emission "polu"	Number of labor "l"		Human resource "h"	
Sign	+	+	-	+		+	
Industrial structure effect "comp"	Stock of FDI "sfdi"	Accumulation of domestic capital "sk"	Investment form government on R&D "trd"	Investment from government on environmental technology "prd"	capital-labor ratio "kl"	Human resource "h"	capita GDP square
Sign	?	?	-	-	+	-	+
Pollution density effect "tech"	Stock of FDI "sfdi"	Accumulation of domestic capital "sk"	Investment form government on R&D "trd"	Investment from government on environmental technology "prd"	Population density "dens"	Human resource "h"	Regulation "regu"
Sign	-	?	-	-	-	-	-
Accumulation of domestic capital "sk"	Stock of FDI "sfdi"	one period lag of GDP					
Sign	?	+					
Stock of FDI "sfdi"	One period lag of GDP	Accumulation of domestic capital "sk"	Wage "wage"	Regulation "regu"	Income of government "gover"	Human resource "h"	Number of labor "l"
Sign	+	?	-	-	+	+	+

Source: concluded by author based on literature

The system included 5 endogenous variables. According to the order and rank condition, every equation was over identified. Because of the endogenous problem, considering the limited sample the method of OLS could lead to bias estimator. So there were both two-stage least squares (2SLS) and three-stage least squares (3SLS) that could solve this problem. And 3SLS can calculate the system as a whole, so we use 3SLS[1].

To test the stability of the system, this paper established 4 models. Model 1 included all of the variables, while model 2 was without province variable. Model 3 only included FDI and domestic capital, and model 4 was with the first three equations.

4. Dada

There were two kinds of data, economic data and the environmental data. Although

[1] William H. Greene(2007)，Econometric Analysis，Fifth Edition. 430-449,China Renmin University Press

the environmental data statistic started in 1989 in China, the data of every province was collected in 1992. This paper used the panel data of Chinese provinces from 1992 to 2008.

Six pollution indicators including industrial sulfur dioxide (SO_2), industrial dust, the industrial polluted gas emission, industrial chemical oxygen demand emission, industrial solid wastes and industrial polluted water emission were chosen. The total emission calculated the pollution scale, and the COD, SO_2 and the dust emission estimated the serious pollution problem[2].

Economic data was from "New China statistical yearbook of 55 years (1949-2004)". Because this statistical yearbook included the data until 2004, the data from 2005 to 2008 was from Chinese Statistical Yearbooks of each year. And the FDI flow of every province was collected from 28 Chinese-Province-Statistical Yearbooks. Environmental data was from Chinese Environmental Statistical Yearbooks from 1992 to 2008.

4.1 GDP

To get the real GDP with getting rid of the inflation, it was discounted the nominal GDP by the retail prices of commodities.

4.2 FDI and Domestic Capital

The accumulation of the total capital was needed to calculate. There were many papers about capital accumulation. The popular method is the perpetual inventory. It was chosen in this paper according to Zhang et al(2004).
The function is as below:

$$K_{it} = K_{i,t-1}(1-\delta_{it}) + I_{it} \qquad (10)$$

Where "I" is the total capital, which includes the foreign and domestic capital and "K" is the stock of it. So the accumulation of the capital is the total amount of the present value of the capital accumulation in the last year and the flow capital in this year.

Because the beginning statistic of the capital was not perfect recorded, some

2 Chemical oxygen demand (COD): It is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. Higher the level of COD, higher is the level of impurity in water.
Source: http://www.tutorvista.com/biology/causes-of-water-pollution
High concentrations of sulfur dioxide (SO_2) can result in breathing problems with asthmatic children and adults who are active outdoors. Short-term exposure has been linked to wheezing, chest tightness and shortness of breath. Other effects associated with longer-term exposure to sulfur dioxide, in conjunction with high levels of particulate soot, include respiratory illness, alterations in the lungs' defenses and aggravation of existing cardiovascular disease. Source: http://www.cleanairtrust.org/sulfurdioxide.htmlIndustrial dust when inhaled can increase breathing problems, damage lung tissue, and aggravate existing health problems.
Source: http://knol.google.com/k/industrial-dust-air-pollution-and-related-occupational-diseases#

provinces started the work from 1952. It chose 1952 as the started year. And according to Zhang et al(2004) the 10% of the capital of 1952 was taken as the start capital stork. The permanent assets price index in China has been published from 1991. To discount the total capital, according to Huang et al(2002), it was chosen the retail prices of commodities and the price of 1950 as 100 to be the start year. Also according to Zhang et al(2004) the allowance for depreciation was 9.6%. And what was worthy to say was that because there was lacking of some data of Fujian, Neimenggu and Qinghai province. It was estimated by the time series model.

The method of calculation of FDI accumulation was the same as domestic capital. According to the function as below, it was concluded that the accumulation of the total capital was composed by accumulation of FDI and domestic capital.

$$
\begin{aligned}
K_{it} &= K_{i,t-1}(1-\delta_{it}) + I_{it} \\
&= (Kd_{i,t-1} + Kf_{i,t-1})(1-\delta_{it}) + Id_{it} + If_{it} \\
&= Kd_{i,t-1}(1-\delta_{it}) + Id_{it} + Kf_{i,t-1}(1-\delta_{it}) + If_{it} \\
&= Kd_{it} + Kf_{it}
\end{aligned} \tag{11}
$$

So the stock of FDI were calculated first, and then subtracted it from the accumulation of total capital to get the domestic capital accumulation.

And the FDI in Chinese Statistical Yearbooks was collected in US dollar, so it changed to RMB by average exchange rate of that year. Also, both FDI and domestic capital were treated by the retail prices of commodities at first.

4.3 Human Resource

Human resource was calculated by the average education years of all the population. Educational attainment was widely used to measure the level of human capital (Barro and Lee, 2001), which was the ratio of the sum of all employees' education years to the total population. Specifically, it was set the education attainment of elementary schooling as 6 years, and that of junior middle school, senior middle school and university graduates as 9, 12 and 16 years respectively.

Finally, by taking the logarithm, the homoscedasticity was ensured. So the coefficients in the empirical model were the elastic ones.

Because Hainan province and the municipalities Chongqing were founded in 1997, data of them was not perfect. Besides, the data of Hong Kong, Macao, Taiwan, was collected in different ways. So the samples exclude them. The total data base was from 28 provinces in China from 1992 to 2008.

5. Result

According to the analysis, based on the function (9), the system was established examined by Stata Vision 11.0, and the results were shown in the appendixes from A1 to C2. Appendix A showed the economic scale effect. Industrial structure effect was in appendix B. And last pollution density effect was in the appendix C. It was concluded that the whole system was steady from the results.

And firstly three effects were analyzed of FDI in every equation, and then it was calculated the environmental effect of FDI.

5.1 Effect Analysis

In the economic scale equation, FDI and domestic capital developed the economy, which was the same as anticipation. In the industrial structure equation, FDI made the industrial structure more intensive. Meanwhile, FDI could decrease the pollution density. The last two equations proved that foreign and domestic capital could affect each other, which meant FDI attracted domestic capital, and so did the domestic one. Fortunately, the regulation of the government was not statistic significant for FDI, which meant the strict regulation did not drive FDI out. So the hypothesis “pollution heaven” was not the truth in China.

Consequently, FDI increased the pollution emission through scale and structure effect, while decreased it by pollution density. So the environmental effect of FDI was needed to calculate in the next part.

5.2 Calculation of Environmental Effect

According to the function (9), it is deduced that the result of three effects is as below:

$$
\begin{cases}
\text{Total effect:} \quad \dfrac{\partial \log polu_{it}}{\partial \log sfdi_{it}} = \dfrac{a_1 + b_1 + c_1 + c_5 + (a_2 + b_2 + c_2 + c_5)q_1}{1 - a_4} \\
\text{Economy Scale effect:} \quad \dfrac{\partial \log gdp_{it}}{\partial \log sfdi_{it}} = a_1 + a_2 q_1 + a_4 \left(\dfrac{a_1 + b_1 + c_1 + c_5 + (a_2 + b_2 + c_2 + c_5)q_1}{1 - a_4}\right) \\
\text{Industrial Structure effect:} \quad \dfrac{\partial \log comp_{it}}{\partial \log sfdi_{it}} = c_1 + (c_2 + c_5)q_1 + c_5 \\
\text{Pollution Density effect:} \quad \dfrac{\partial \log tech_{it}}{\partial \log sfdi_{it}} = b_1 + b_2 q_1
\end{cases}
$$

According to these functions, it got the results. Because variables in model 1 were more significantly, it was calculated the total effect of FDI based on the results of it.

Table 2 The results of Scale, Industrial structural and Pollution Density Effects

	model1					
Pollution indicators	water	cod	gas	dust	So_2	solid
Total effect	0.08	0.99	1.34	2.68	1.21	0.38
Economy Scale effect	0.58	0.58	0.61	0.19	0.56	0.61
Industrial Structure effect	0.34	0.98	0.69	0.51	0.78	0.57
Pollution Density effect	-0.85	-0.57	0.04	1.98	-0.14	-0.80

Source: Author's own estimations based on Chinese environmental statistical yearbooks (1993-2009) and Chinese statistical yearbooks （1993-2009）

The results in the table indicated the positive effect of FDI on economy scale and the industrial structure, and the negative pollution density effect. The total effects showed that FDI increased the pollution emission. It was obviously because of the scale and structure effect, which meant FDI increased GDP and made the proportion of industrial output higher. Although the pollution density effect was negative, which meant that FDI decreased the pollution emission, it did not counteract the positive effect of the scale and industrial structure effect. All in all, the pollution effect of FDI was positive.

But what people must notice was that the results only indicated that more FDI led to more pollution emission. It did not mean that only FDI should be responsible for the pollution, because the result included the pollution emission from local enterprises. So the indirect effect of domestic capital was needed to get rid of to get the direct pollution effect of FDI.

To get the direct and indirect effects of FDI, firstly, in the economic scale equation, the scale effect was estimated by coefficient a_1, which indicated the amount pollution emission charged by FDI through economic scale. The indirect effect of domestic capital was calculated by $a_2 q_1$, and also the reflection of pollution on GDP was $a_4(\frac{a_1+b_1+c_1+c_5+(a_2+b_2+c_2+c_5)q_1}{1-a_4})$.

Secondly, in the pollution density equation, the direct effect of FDI was b_1. It was the environmental direct effect through pollution density. The indirect effect was $b_2 q_1$, which measure the pollution from local enterprises influenced by the FDI through technology spill over.

Finally, in the industrial structure equation, when FDI stock increased 1%，proportion of the industry output on the total GDP would increase c_1 percent. The indirect effect was $(c_2 + c_5)q_1 + c_5$, which meant that FDI could “crowed in” or “crowed out” local capital through the “up” or “down” industrial chain.

All of the direct effects were added together to get the total direct environmental effects of FDI. The indirect effect of local capital meant the pollution emission from local enterprises affected by FDI. So the total effect was composed by direct and indirect effects. So the mechanism figure from FDI to pollution emission was shown as below:

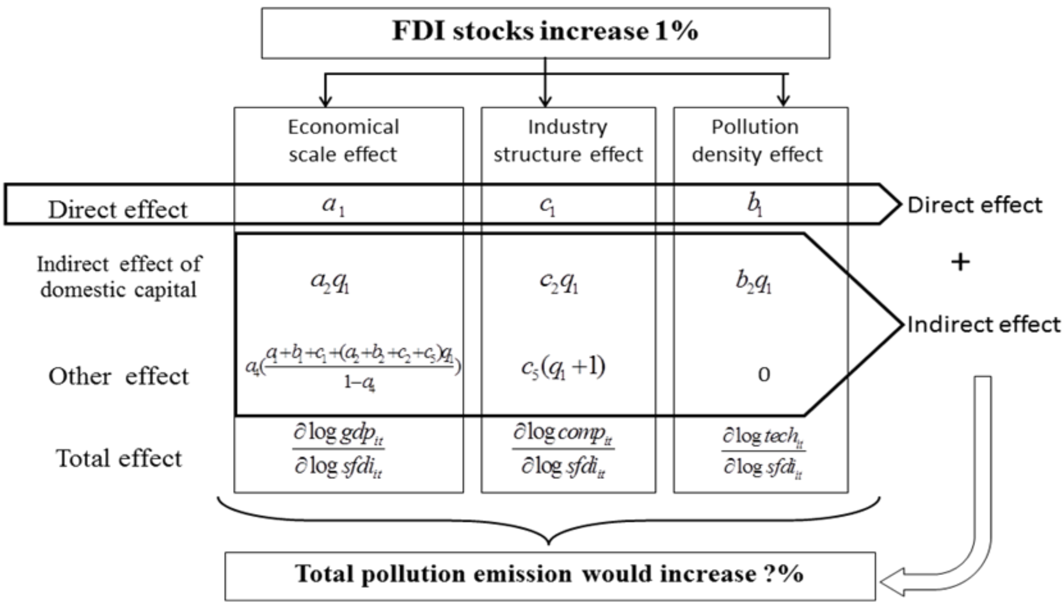

Figure 3 Analyses on the environmental effect

According to the analysis, the calculation of direct and indirect effect is as below in the table 3.

Table 3 Direct and indirect effect of FDI

Pollution indicators	water	cod	gas	dust	SO_2	solid
Direct effect	-0.62	0.04	-0.01	1.82	-0.12	-0.33
Indirect effect	0.70	0.95	1.35	0.86	1.33	0.71

Source: Author's own estimations based on Chinese environmental statistical yearbooks (1993-2009) and Chinese statistical yearbooks （1993-2009）

As can be seen from the Table 3, some direct effects of FDI are positive, while the others are negative. The results were different from the different pollution indicators. But all of the indictors of FDI were positive, which meant that the indirect effects of local enterprises, technology, or other factors were influenced by the FDI increased the pollution emission.

6. Conclusion

This paper established the simultaneous equations including 5 functions with 6 pollution indicators. And the system was based on the data of Chinese provinces from 1992 to 2008 and estimated by 3SLS. Meanwhile in order to test the stability of the system, four models were set up, whose results were similar.

From the definition of amount of pollution emission, economic scale, industrial structure and the pollution density decided it. The results indicated that FDI could develop the economy, make the industry structure more intensive and decrease the pollution density. Considering all of the factors, the total effect was positive, which meant that FDI increased the pollution emission.

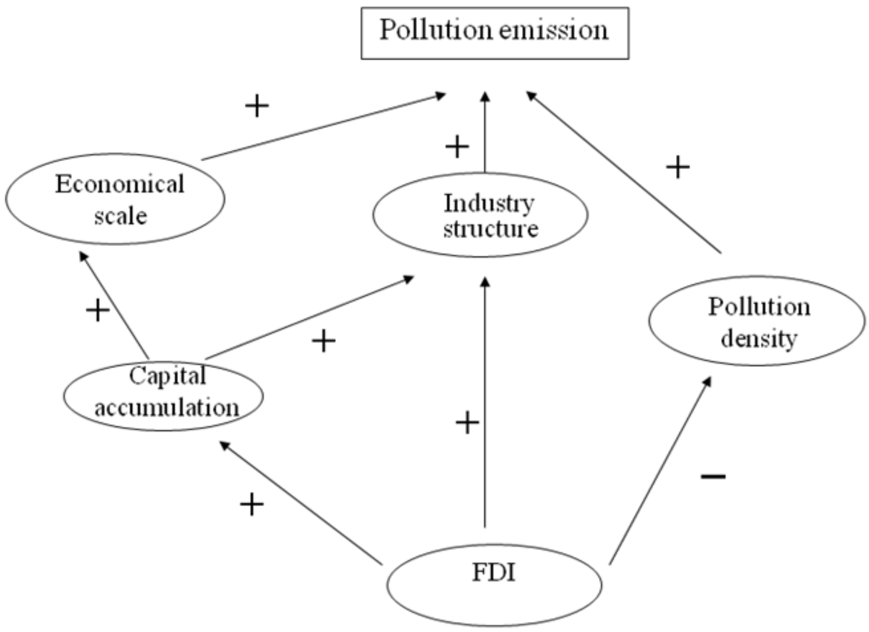

Figure 4 Three Effects of FDI

But what people must notice was that the total effect of FDI included the indirect effects of local enterprises. So the direct effect was separated from it. It was conclude the results were different with different pollution indicators. And it was found that all the indirect effects were positive, which meant that the local enterprises charged more pollution influenced by FDI. FDI attracted more domestic capital, especially into the pollution intensive industry. With the development of GDP, industrial structure became more intensive. So for China, the pollution problem of the local enterprises was more serious.

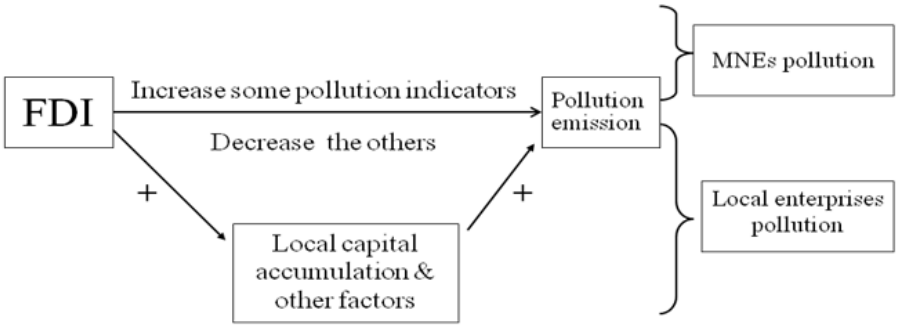

Figure 5 Direct and Indirect Effects of FDI

For China and other developing countries, the pollution density might be the only way to decrease the pollution emission. So the most efficient way to make environment better was to develop the environmental technology and put forward strict laws to regulate enterprises. Especially until now, the regulation on environment did not drive FDI out in China, so stricter law could lead to less pollution without loss of GDP.

References

[1]. Johnson Andreas (2006). The Effects of FDI Inflows on Host Country Economic Growth，CESIS Electronic Working Paper Series，Paper No. 58
< http://www.infra.kth.se/cesis/documents/WP58.pdf >

[2]. Bao Qun, Yuanyuan Chen and Ligang Song(2008). The environmental consequences of foreign direct investment in China, *China's dilemma: economic growth, the environment and climate change*, ANU E press, Asia Pacific Press, Booking Institution Press and Social Academic Press(China) Press.pp.243-264

[3]. Barro. R, and Lee, Jong-Wha(2001). International Data on Educational Attainment: Updates and Implications, *Oxford Economic Papers*, 53(3): 541-63.

[4]. Brian R. Copeland，M. Scott Taylor(1994). North-South Trade and the Environment. *The Quarterly Journal of Economics*,Vol.109: 755～787

[5]. Brian R. Copeland，M. Scott Taylor(1995). Trade and Transboundary Pollution. *The American Economic Review*. 85(4):716−737

[6]. Brian R. Copeland，M. Scott Taylor(2001). International trade and the environment: a framework for analysis. NBER Working Paper No.8540.
< http://www.nber.org/papers/w8540 >

[7]. Brian R. Copeland，M. Scott Taylor(2004). Trade, Growth, and the Environment. Journal of

Economic Literature.Vol. XLII: 7−71

[8]. Brian R. Copeland，M. Scott Taylor(2003). Trade and the Environment. Princeton University Press

[9]. Caterina De Lucia, Trade. Economic growth and Environment Evidence from Cross-country comparisons, < http://ressources.ciheam.org/om/pdf/a57/04001959.pdf >, 2003

[10]. Cole Matthew A., Robert J.R. Elliott, Jing Zhang. Growth, Foreign Direct Investment and the Environment: Evidence from Chinese Cities，Department of Economics, University of Birmingham in its series Discussion Papers with number 09-15 < ftp://ftp.bham.ac.uk/pub/RePEc/pdf/09-15.pdf > ,2009

[11]. He Jie (2008). Foreign Direct investment and air Pollution in China: evidence from Chinese Cities， .*Région et Développement n°*.Vol. 28:132−150

[12]. He Jie (2006). Pollution haven hypothesis and Environmental impacts of foreign direct investment: The Case of Industrial Emission of Sulfur Dioxide (SO_2) in Chinese provinces, *Ecological Economics*，60(1):228-245

[13]. Holger Görg and Eric Strobl.(2000).Multinational companies and indigenous development An empirical analysis. Centre for research on globalization and labor markets, Research Paper,

[14]. Laura Alfaro and Andrés Rodríguez-Clare. Multinationals and Linkages: An Empirical Investigation, 2004, Vol.4 (2):157～163

[15]. Navaretti G.B., Vnables A.J. (2004). Multinational firms in the world economy

[16]. Markusen James R., Anthony J. Venables,1999, Foreign direct investment as a catalyst for industrial development, *European Economic Review*.Vol.43: 335-356

[17]. Ozyurt S.(2009), Total Factor Productivity Growth in Chinese Industry: 1952-2005. Oxford Development Studies, , Vol. 37:1-17

[18]. Wang Hua and David Wheeler (2002). Confronting the Environmental Kuznets Curve. Journal of Economic Perspectives.16(1):147-168

[19]. Backer K. De, L. Sleuwaegen (2002). Does foreign direct investment crowd out domestic entrepreneurship, Departement Toegepaste Economische Wetenschappen in Katholieke Universiteit Leuven, Research Report. No.0120 <https://lirias.kuleuven.be/bitstream/123456789/85777/1/OR_0120.pdf>

[20]. Javorcik B. (2004), Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages, American Economic Review, 94 (3): 605-627

[21]. Glassa Amy Jocelyn, Saggi Kamal(1998), International technology transfer and the technology gap, Journal of Development Economics.Vol.55:369-398

[22]. Samina Khalil and Zeeshan Inam, 2006, Is Trade Good for Environment? A Unit Root Cointegration Analysis. *The Pakistan Development Review*, 45 (4):1187-1196

[23]. Wheeler David, 2001,Racing to the Bottom? Foreign Investment and Air Pollution in Developing Countries, Journal of Environment & Development, 10(3): 225-245
[24]. Huang Yongfeng, Ren Ruoen, Liu Xiaosheng,2002, Capital Stock Estimates in Chinese Manufacturing by Perpetual Inventory Approach, *China Economic Quarterly*.Vol.1:377-396, (in Chinese)
[25]. Wei Houkai(2002), Effects of Foreign Direct Investment on Regional Economic Growth in China，Economic Research Journal, vol.4, (in Chinese)
[26]. Zhang Jun, Wu Guiying, Zhang Jipeng, The Calculation on Physical Capital Accumulation, *Economic Research Journal* 2004, Vol.10:35-44(in Chinese)
[27]. Yang Boqiong(2010), The Influence of FDI on Environment Pollution of Host Countries: Positive Study from China, PhD. (in Chinese)

Appendix A1 Economic Scale Effect

	cod				dust				gas			
	model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4
sfdi	0.38***	0.221743***	0.4395**	0.2225***	0.48***	0.2316***	0.4394***	0.2344***	0.45***	0.22842***	0.4217***	0.2249***
sfdi - std	-0.01	-0.008411	0.0179	0.0105	-0.01	-0.008466	0.0179	0.0104	-0.01	-0.00855	0.0182	0.0104
sk	0.38***	0.616355***	0.4363**	0.5408***	0.33***	0.590689***	0.4365***	0.5685***	0.32***	0.585891***	0.4598***	0.6189***
sk-std	-0.03	-0.023171	0.0243	0.0277	-0.03	-0.023728	0.0243	0.0265	-0.04	-0.028889	0.0248	0.0346
l	0.48***	0.221012***		0.4964***	0.34***	0.193695***		0.4587***	0.47***	0.229009***		0.4595***
l-std	-0.08	-0.019622		0.0767	-0.07	-0.020158		0.0741	-0.08	-0.018758		0.0761
polu	0.02*	0.019552*		0.0478***	-0.17***	0.063772***		-0.0514***	-0.04	0.039158*		-0.0792***
Polu-std	-0.01	-0.010098		0.0126	-0.01	-0.012036		0.0130	-0.03	-0.02035		0.0278
h	0.84***	0.383894**		1.4441***	0.32*	0.542586***		1.0076***	0.88***	0.325046*		1.1422***
h-std	-0.19	-0.168354		0.1990	-0.18	-0.16957		0.1866	-0.18	-0.16473		0.1858
cons	(dropped)	0.058382	(dropped)	-4.2982	(dropped)	-0.48968*	3.7672***	-2.0909	-1.70*	0.209243	(dropped)	(dropped)
cons-std	(dropped)	-0.384944	(dropped)	0.7498	(dropped)	-0.390137	0.1394	0.7101	-0.74	-0.367054	(dropped)	(dropped)
R-sq	0.9945	0.9749	0.9806	0.9899	0.9874	0.973	0.9806	0.9909	0.9833	0.9741	0.9820	0.9905
Chi2	2200000	20346.33	1.74e+06	46363.86	2120000	20166.82	31865.88	49788.96	36827.36	20094.72	1.74e+06	2.64e+06

*** statistically significant at 1% level

** statistically significant at 5 % level

* statistically significant at 10 % level

Notes: Variable-std is the standard deviation.

Source: Authors’ own estimations based on Chinese environmental statistical yearbooks (1993-2009) , Chinese statistical yearbooks （1993-2009）

Appendix A2 Economic Scale Effect (continued)

	SO_2				solid				water			
	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4
sfdi	0.46***	0.219211***	0.4217***	0.2272***	0.44***	0.26006***	0.4161***	0.2228***	0.48***	0.273488***	0.4222***	0.2310***
sfdi -std	-0.01	-0.008497	0.0182	0.0106	-0.01	-0.009965	0.0180	0.0110	-0.01	-0.009295	0.0182	0.0106
sk	0.21***	0.639284***	0.4598***	0.5380***	0.33***	0.598009***	0.4578***	0.6069***	0.18***	0.598576***	0.4590***	0.5315***
sk-std	-0.04	-0.025314	0.0248	0.0305	-0.04	-0.025807	0.0249	0.0318	-0.03	-0.02289	0.0248	0.0285
l	0.53***	0.23583***		0.4835***	0.52***	0.205445***		0.5105***	0.51***	0.343903***		0.4730***
l-std	-0.08	-0.018622		0.0761	-0.1	-0.019835		0.0877	-0.08	-0.021741		0.0753
polu	0.00***	-0.00038		0.0006***	0.02**	0.052775***		0.0146**	0.15***	-0.15367***		0.0608***
Polu-std	0	-0.000276		0.0004	-0.01	-0.005752		0.0074	-0.02	-0.016133		0.0210
h	1.13***	0.253479		1.2591***	0.63***	0.434858**		0.7882***	1.43***	0.043991		1.3779***
h-std	-0.19	-0.167091		0.1928	-0.21	-0.191117		0.2262	-0.19	-0.162966		0.1966
cons	-2.47***	0.338448	(dropped)	(dropped)	(dropped)	0.102627	3.6596***	-3.0667	-4.46***	1.701371***	(dropped)	-3.7968***
cons-std	-0.75	-0.357833	(dropped)	(dropped)	(dropped)	-0.40927	0.1430	0.8177	-0.73	-0.378127	(dropped)	0.7065
R-sq	0.9854	0.9753	0.9820	0.9902	0.9856	0.9686	0.9811	0.9897	0.9867	0.9713	0.9820	0.9898
Chi2	36451.47	20534.72	1.74e+06	2580000.00	1740000	16590.17	27443.00	39220.28	36097.33	20205.07	1.74e+06	47109.70

*** statistically significant at 1% level

** statistically significant at 5 % level

* statistically significant at 10% level

Notes: Variable-std is the standard deviation.

Source: Authors' own estimations based on Chinese environmental statistical yearbooks (1993-2009)， Chinese statistical yearbooks （1993-2009）

Appendix B1 Industrial Structure Effect

	cod				dust				gas			
	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4
fdic	-0.20***	0.177952***	-0.3524***	-0.2089***	-0.38***	0.282136***	-0.3522***	-0.1244***	-0.45 ***	0.195763***	-0.3344***	-0.2465***
fdic-std	-0.06	-0.058615	0.0589	0.0466	-0.08	-0.054661	0.0589	0.0456	-0.09	-0.070777	0.0590	0.0513
kc	0.39**	-0.6432***	0.5933***	0.1576	0.42*	-0.78106***	0.5931***	0.2581	0.05	-0.66854***	0.5697***	0.1390
kc-std	-0.22	-0.157543	0.0805	0.2102	-0.23	-0.155244	0.0805	0.2008	-0.28	-0.165023	0.0806	0.2451
trd	-0.32***	0.273578*		-0.2448*	-0.33*	0.398039**		0.0308	-0.46***	0.280064**		-0.4138***
trd-std	-0.12	-0.140494		0.1470	-0.18	-0.138311		0.1444	-0.18	-0.147916		0.1575
prd	-0.03	0.05403		-0.0312	-0.03	0.064154*		-0.0350*	-0.03	0.054319		-0.0297
prd-std	-0.02	-0.033285		0.0202	-0.02	-0.033267		0.0201	-0.02	-0.033332		0.0202
kl	0.67***	0.667705***		0.6572***	0.45***	0.906361***		0.6456***	0.76***	0.692073***		0.6632***
kl-std	-0.21	-0.156414		0.1856	-0.18	-0.132652		0.1688	-0.27	-0.221821		0.2424
h	-1.94*	-1.30924		-2.7669***	-2.47***	0.383864		-2.4339**	-3.11***	-1.27937		-2.8723***
h-std	-0.77	-0.850483		0.7092	-0.82	-0.82663		0.7064	-0.85	-0.896871		0.7213
agdp2		-0.02166*		0.0155**	0.03**	-0.05601***		-0.0178*	0.05***	-0.02388		-0.2465***
agdp2-std		-0.012932		0.0083	-0.01	-0.010862		0.0075	-0.02	-0.018587		0.0513
cons	3.40**	5.965189***	(dropped)	3.1497	0.53	5.126408**	(dropped)	2.5637	(dropped)	6.165434***	(dropped)	(dropped)
cons-std	-1.98	-1.767233	(dropped)	2.0019	-2.1	-1.698219	(dropped)	1.8892	(dropped)	-1.944005	(dropped)	(dropped)
R-sq	0.7526	0.0863	0.7261	0.7493	0.7484	0.0528	0.7261	0.7427	0.748	0.0811	0.7287	0.7493
Chi2	1304.66	66.2	5402.38	1366.77	1301.72	81.58	5402.35	1367.31	5596.11	62.46	5398.42	5864.31

*** statistically significant at 1% level

** statistically significant at 5% level

* statistically significant at 10% level

Notes: Variable-std is the standard deviation.

Source: Authors' own estimations based on Chinese environmental statistical yearbooks (1993-2009), Chinese statistical yearbooks （1993-2009）

Appendix B2 Industrial Structure Effect (continued)

	SO_2				solid				water			
	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4
fdic	-0.53***	0.174002***	-0.3344***	-0.2562***	-0.38***	0.115543*	-0.2070***	-0.2225***	-0.50***	0.09768*	-0.3349***	-0.2078***
fdic-std	-0.08	-0.05239	0.0590	0.0443	-0.07	-0.068457	0.0445	0.0399	-0.08	-0.059278	0.0590	0.0446
kc	-0.17	-0.66926***	0.5697***	0.0421	-0.40*	-0.62252***	0.3165***	-0.2388	0.16	-0.43764***	0.5704***	0.4204*
kc-std	-0.22	-0.154488	0.0806	0.1893	-0.24	-0.170922	0.0618	0.2022	-0.22	-0.156181	0.0806	0.1921
trd	-0.50***	0.219918		-0.3654*	-0.1	0.241339		-0.0954	-0.40**	0.008818		-0.3066*
trd-std	-0.17	-0.137754		0.1419	-0.15	-0.151005		0.1300	-0.18	-0.141009		0.1426
prd	-0.03	0.052722		-0.0293	-0.05***	0.039314		-0.0502**	-0.03	0.055913*		-0.0313*
prd-std	-0.02	-0.033338		0.0201	-0.02	-0.03523		0.0163	-0.02	-0.033439		0.0202
kl	0.88***	0.330531**		0.7268***	0.77***	0.448324*		0.6452**	0.56***	0.02293		0.3118*
kl-std	-0.17	-0.118567		0.1463	-0.23	-0.215427		0.1987	-0.18	-0.151888		0.1518
h	-3.50***	-1.12142		-3.0022***	-1.68**	-1.90687*		-1.7896**	-3.18***	-0.79986		-2.5942***
h-std	-0.8	-0.810414		0.7032	-0.71	-0.952673		0.6162	0.81 ()	-0.51478		0.7039
agdp2	0.07***	-0.00023***		0.0321***	0.03***	0.001408		0.0208*	0.06***	0.059566**		0.0222***
agdp2-std	-0.01	-0.009626		0.0064	-0.01	-0.018051		0.0089	-0.01	-0.026217		0.0066
cons	(dropped)	4.072793*	(dropped)	6.3427	3.28	5.601511**	-2.9524***	(dropped)	5.34***	4.304847***	(dropped)	0.2421
cons-std	(dropped)	-1.654796	(dropped)	1.6533***	-2.26	-2.105976	0.3545	(dropped)	-1.98	-1.673296	(dropped)	1.7818
R-sq	0.74	0.0679	0.7287	0.7489	0.8518	0.0763	0.8483	0.8574	0.7416	0.0665	0.7287	0.7481
Chi2	5640.21	64.5	5398.41	1405.65	2312.79	53.68	2274.86	9745.24	1324.47	56.69	5398.54	1366.74

*** statistically significant at 1% level

** statistically significant at 5% level

* statistically significant at 10% level

Notes: Variable-std is the standard deviation.

Source: Authors' own estimations based on Chinese environmental statistical yearbooks (1993-2009) , Chinese statistical yearbooks （1993-2009）

Appendix C1 Pollution Density Effect

	cod				dust				gas			
	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4
fdic	-0.14**	-0.20813***	-0.3529***	-0.0316	1.72***	-0.44494***	-0.1616**	0.1565**	-0.01**	-0.00959***	-0.0074***	0.0008
fdic-std	-0.08	-0.053575	0.0836	0.0597	-0.14	-0.054109	0.0847	0.0574	0	-0.002175	0.0032	0.0024***
kc	-0.89***	0.500483**	-0.8447***	-0.9546***	0.50**	0.069586	-0.8432***	-0.4848*	0.09***	0.07071***	0.0905***	0.0825
kc-std	-0.18	-0.21918	0.1142	0.2249	-0.25	-0.216831	0.1158	0.2158	-0.01	-0.009333	0.0044	0.0092
prd	0.03	-0.04236		0.0367	0.03	-0.15896***		0.0291***	0	-0.0005		-0.0013
prd-std	-0.03	-0.042804		0.0292	-0.03	-0.042593		0.0282	0	-0.001784		0.0012
trd		-1.25182***		-0.0598	-0.25	-0.16495		-0.8921**	0.01	0.008537		0.0037
trd-std		-0.169493		0.2007	-0.23	-0.169759		0.1931	-0.01	-0.006947		0.0082
dens	-0.84	0.791299***		-0.7967	-2.72***	0.398168**		-1.5097**	0.01	-0.01615**		0.0151
dens-std	-0.52	-0.136446		0.4937	-0.44	-0.128631		0.4371	-0.03	-0.006435		0.0258
regu	0.30***	0.294779***		0.3010*	0.61***	0.456564***		0.8366***	0.01	0.057854		0.0098
regu-std	-0.13	-0.101582		0.1315	-0.11	-0.084991		0.1157	-0.01	-0.006008		0.0071
h	-3.08***	-1.58434		-3.4242***	1.82*	-3.53567***		-0.0956	-0.09**	-0.06061***		-0.0933*
h-std	-1.03	-1.0175		1.0025	-1.12	-1.002466		0.9663	-0.04	-0.042775		0.0396
cons	(dropped)	2.927582*	(dropped)	23.2219	(dropped)	9.10275***	11.4504***	18.2391***	1.52***	1.443336***	(dropped)	1.5162
cons-std	(dropped)	-2.376301	(dropped)	4.5055	(dropped)	-2.335549	0.6613	4.0372	-0.25	-0.100024	(dropped)	0.2290
R-sq	0.789	0.5642	0.8264	0.8548	0.7653	0.0964	0.8403	0.8769	0.9476	0.8398	0.9490	0.9487
Chi2	44261.96	661.75	2252.79	2687.48	2005.09	89.74	2398.99	3278.38	8014.44	2299.49	4.26e+06	8420.63

*** statistically significant at 1% level

** statistically significant at 5% level

* statistically significant at 10% level

Notes: Variable-std is the standard deviation.

Source: Authors' own estimations based on Chinese environmental statistical yearbooks (1993-2009), Chinese statistical yearbooks （1993-2009）

Appendix C2 Pollution Density Effect (continued)

	SO_2				solid				water			
	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4	Model1	Model2	Model3	Model4
fdic	-0.05*	-0.06235***	0.0231	-0.0173	-0.39***	-1.27367***	-0.5625***	-0.0942	-0.60***	0.385195***	-0.4150***	-0.1432**
fdic-std	-0.03	-0.014472	0.0194	0.0137	-0.12	-0.084028	0.1162	0.0846	-0.11	-0.062812	0.0643	0.0459
kc	-0.18***	0.201588***	-0.1275***	-0.2369***	-0.84**	-0.85731**	-1.0107***	-1.0645**	-0.49**	1.484833***	-0.6253***	-0.5694***
kc-std	-0.06	-0.057564	0.0265	0.0512	-0.39	-0.364515	0.1613	0.3475	-0.2	-0.173121	0.0879	0.1713
prd	0	-0.01901*		0.0052	0.08*	0.107409		0.0731*	0.04	-0.04156***		0.0443*
prd-std	-0.01	-0.011463		0.0067	-0.04	-0.068131		0.0428	-0.02	-0.031625		0.0225
trd	0.15**	-0.15038***		0.0924*	-0.81**	1.046934**		-0.9407**	0.04	-0.99159**		-0.2885*
trd-std	-0.06	-0.045685		0.0458	-0.36	-0.260737		0.2927	-0.2	-0.138229		0.1531
dens	0.18*	0.04798		0.1323	1.89	0.326278		1.8687*	-0.15	-0.37874***		-0.3115
dens-std	-0.1	-0.032964		0.0890	-1.22	-0.241342		1.0933	-0.32	-0.179708		0.3073
regu	0.04*	0.053364**		0.0186	1.12***	0.409818**		1.0270***	0.19**	-0.23791***		0.0631
regu-std	-0.02	-0.020286		0.0234	-0.26	-0.207867		0.2488	-0.08	-0.065644		0.0805
h	0.31	-0.11062		0.3743	-1.44	-3.87192**		-1.4131	-1.87**	-1.90284		-1.2050
h-std	-0.26	-0.264676		0.2316	-1.75	-1.802317		1.5798	-0.87	-0.229278		0.7755
cons	(dropped)	-0.81356**	(dropped)	-0.8398	(dropped)	4.702881**	5.7559***	-10.7595	14.93***	19.15799***	(dropped)	(dropped)
cons-std	(dropped)	-0.615765	(dropped)	0.8459	(dropped)	-4.073825	0.9255	9.5867	-3.63	-2.337732	(dropped)	(dropped)
R-sq	0.8794	0.5194	0.7694	0.7661	0.8232	0.5859	0.8573	0.8886	0.8457	0.5624	0.8383	0.8609
Chi2	9675.38	633.14	2072.75	1500.26	2406.1	693.14	2538.71	3249.29	42509.01	590.38	45879.03	48171.86

*** statistically significant at 1% level

** statistically significant at 5% level

* statistically significant at 10% level

Notes: Variable-std is the standard deviation.

Source: Authors’ own estimations based on Chinese environmental statistical yearbooks (1993-2009), Chinese statistical yearbooks （1993-2009）