University of Oxford

Department of International Development

SLPTMD Working Paper Series

No. 013

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Abstract

This paper uses provincial socioeconomic and environmental data and investigates whether there exists an intra-county pollution haven effect for China. We examine whether differences in the stringency of environmental regulations affect the choice of location for FDI in China. We use a five year-panel dataset for 30 provinces in China that includes three measures of environmental regulations that vary across time and province, and a significant number of control variables including measures of agglomeration and factor abundance. We control for unobserved heterogeneity by using feasible generalised least square estimator. Our results suggest that environmental stringency has a significant and negative effect on FDI, leading us to conclude that, *ceteris paribus*, FDI prefers to locate into regions with relatively weak environmental regulations. This provides some support for the existence of a pollution haven within China.

JEL Classification: F21, O13, Q58

Key words: FDI; environmental regulations; pollution haven hypothesis.

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1. Introduction

Traditional international trade theory tells us that trade is governed by comparative advantage, which postulates that the efficient exchange of goods leads to optimal outcomes. Multinational firms, as agents of free trade, seek cost reductions and respond to market imperfections. Higher domestic costs therefore provide the motivation for multinational corporations to expand their geographical range into other areas. Such a strategy could trigger competition for lax environmental policies in order to gain competitive advantage in "dirty" goods production. A corollary is that developing countries may join a "race to the bottom" by undervaluing environmental damage in order to attract more FDI. Either way, the result is excessive levels of pollution and environmental degradation (Dean *et al.* 2005). This is the so called *pollution haven* hypothesis.

To date, one of the most contentious debates in the FDI and the environment literature focuses on whether inter-country differences in environmental regulations are turning poor countries into "pollution havens". This argument centres on the cost effectiveness of environmental regulations and presumes that there are environmental regulation induced production cost differentials that encourage a firm to relocate its production facility. Theoretical models of pollution havens, including Pearson (1987) and Baumol and Oates (1988), illustrate that developed countries control pollution emissions whilst developing countries do not, and hence become pollution havens. However, the empirical evidence from testing the pollution haven hypothesis (PHH) is mixed.

Dean *et al.* (2005) and Javorcik and Wei (2005) divide the existing PHH literature into three strands: 1) *intra-country*, *inter-region plant location choice*; 2) *inter-industry FDI flows within a country* and; 3) *inter-country FDI location choice*. Using the first approach, Levinson (1996) employs a conditional logit model and finds little evidence that inter-state differences in environmental regulations affect the US plant location choice. A similar approach is adopted by List and Co (2000) who estimate the effect of state environmental regulations on foreign multinational corporations' new plant location decisions from 1986 to 1993, and find that environmental stringency and attractiveness of a location are inversely related. Keller and Levinson (2002) test whether FDI to US states has responded significantly to relative changes in state's environmental compliance costs. They robustly document moderate effects of pollution abatement costs on capital and employees at foreign-owned manufacturing affiliates, particularly in pollution-intensive industries, and on the number of planned new foreign-owned manufacturing facilities. Similarly, Fredriksson *et al.* (2003) use US state-level panel data from four industrial sectors over the period 1977-1987, and find that environmental policy plays a significant role in determining the spatial allocation of inbound US FDI and such effect depends critically on the exogeneity assumption of environmental policy.

A recent study that provides empirical evidence for intra-country pollution havens in China is Dean *et al.* (2005). They estimate whether weak environmental regulations attract foreign investment in China. They construct a location choice model containing firm's production and abatement decisions, agglomeration and factor abundance, and estimate a conditional logit model. Their results show that FDI flows to provinces with high concentrations of foreign investment, relative abundance of skilled labour, concentration of potential local suppliers, special tax incentives, and less state ownership. Environmental stringency only affects certain types of projects in highly polluting industries, with investment originating from Hong Kong, Macau and Taiwan seemingly being attracted to provinces with relatively weak environmental controls. This finding is consistent with the pollution haven hypothesis but contradicts the notion that pollution havens are generated by industrial country investors. This is opposite to the pollution haven hypothesis. In sum, the results suggest little evidence for the pollution haven hypothesis.

There is a scarcity of research that assesses the relationship between the distribution of foreign investment and pollution intensity. One exception is the recent work by Eskeland and Harrison (2003) who adopt the inter-industry analysis approach to examine the pattern of FDI across industries in Mexico, Venezuela, Morocco and Cote d'Ivoire. Their results suggest that it is difficult to find a robust relationship between pollution abatement and the volume of US outbound investment. They find a positive relationship between FDI share and air pollution-intensity of an industry but negative relationship between FDI share and both water pollution and toxic release-intensity. It is suggested that these results are because pollution abatement costs are only a small fraction of overall costs.

A paper employing the inter-country analysis approach is Xing and Kolstad (2002) which presents a statistical test on how US FDI is influenced by the environmental regulations of foreign host countries. The results show that the laxity of environmental regulations in a host country is a significant determinant of FDI from the US for heavily polluting industries and is an insignificant determinant of FDI from the US for less polluting industries. Their findings provide indirect support to the pollution haven hypothesis. However, small size of the data and imperfect coverage of sulphur emissions data mean that care must be taken with the reliability of their results. A more recent paper by Javorcik and Wei (2005) examines the relationship between cross country FDI flows and environmental stringency for 143 multinational firms in 25 countries in Eastern Europe and the former Soviet Union. They find some evidence for the PHH in regressions employing treaties as a proxy for environmental standards in a host country, but the overall evidence is relatively weak and does not survive numerous robustness checks using other proxies of pollution intensity or regulatory stringency.

On balance, the previous empirical studies find little evidence to support the pollution haven hypothesis and the general lack of such results can be summarised as follows. First, as Pearson (1987, pp.124) pointed out, "environmental control costs are a small fraction of production costs in virtually every industry, and the effect on trade will be correspondingly small". Second, FDI may be combined with new techniques, including the latest pollution abatement technologies, rendering the relative stringency of the host country's environmental regulations unimportant. If firms are producing for export, then they may have to meet the environmental product standards of developed countries to be able to gain the access to these markets. And finally, firms may predict that there will be future increases in environmental regulations, and hence choose a production process today that will meet the higher standards of the future (Dean *et al.*, 2002).

There are also a number of issues arise with regards to the econometric estimation of models for the PHH. First, in some studies, the absence of some important variables, such as relative factor abundance and agglomeration, will lead to omitted variable bias. Markusen and Zhang (1999), Head and Ries (1996), Cheng and Kwan (2000) have demonstrated the importance of these variables in explaining FDI incidence (Dean *et al.* 2005). Second, it is difficult to quantify international differences in environmental regulations (Keller and Levinson, 2002 & Javorcik and Wei, 2005). Third, Keller and Levinson (2002) & Levinson and Taylor (2008) both demonstrate that cross-section analyses cannot control for unobserved heterogeneity among countries. The unobserved characteristics, such as unobserved resources and unobserved protection of polluting industries, may be correlated with both regulatory compliance costs and investment. Therefore, use of a continuous, time-varying (panel) dataset becomes important. Finally, most literature uses cost-based measures of environmental standard stringency. Copeland and Taylor (2003) develop a model linking the firm's production and abatement cost. The model suggests a particular specification for testing firm's responsiveness to changes in environmental regulations, which raises the possibility of specification error.

China has, in recent years, become one of the largest recipients of worldwide foreign direct investment (FDI) with inflows of $72 billion in 2005. However, there remains a significant disparity in the geographical distribution of FDI inflows into China. In the mean time, environmental deterioration has become a serious problem associated with rapid economic growth in China, and industrial pollutant emissions are a major cause of the environmental problem. Pollution emissions vary across the Chinese regions, and the strength of the enforcement of the environmental regulations varies across regions. There have been considerable studies investigating the determinants of FDI location choice in China. Labour costs, potential market size, market access, supplier access, infrastructure, productivity, education levels, preferential policies, and spatial dependence are found to have affected the regional distribution of FDI in China (e.g. Coughlin and Segev, 2000; Cheng and Kwan, 2000; and Amiti and Javorcik, 2008). However, these studies all omitted certain structural determinants of FDI, for example, environmental regulation stringency.

In this paper, we address a number of those limitations and investigate whether there exists an intra-county pollution haven effect for China. We adopt a five year-panel dataset for 30 provinces in China that includes three measures of environmental regulations that vary across time and province, and a significant number of control variables including measures of agglomeration and factor abundance. We control for unobserved heterogeneity by using feasible generalised least square estimator. Our results suggest that environmental stringency has a significant negative effect on FDI, leading us to conclude that, *ceteris paribus*, FDI prefers to locate into regions with relatively weak environmental regulations and provides some support for the existence of a pollution haven within China.

The paper is organised as follows. Section 2 describes FDI inflows into China and China's environment problems and environmental regulation system. Section 3 presents our methodology and data, and section 4 reports and discusses the empirical results. The final section concludes.

2. FDI, the Environment and Environmental Regulations in China

Since it launched economic reforms in 1978, China has received enormous FDI flows. General trends and the characteristics of FDI in China have been reviewed by many studies, e.g. Wu (1999), OECD (2000). At the beginning of China's economic reforms, FDI inflows were not significant. FDI increased in the mid-1980s and reached a peak level in the early 1990s. From 1994, the growth rate of FDI slowed down and became negative in 1999. From 2000 onwards, inflows of FDI into China recovered quickly. In 2003, it overtook the US as the biggest recipient of FDI in the world with actually used value of $53.51 billion.

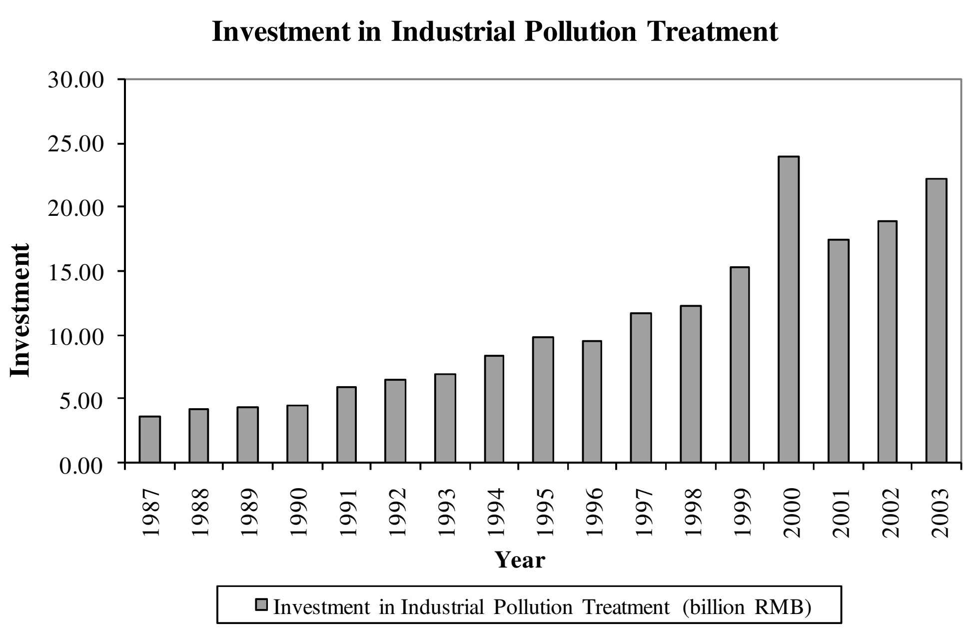
Although the total amount of FDI inflows into China are extremely high, there are significant imbalances in FDI stocks across China in terms of their source, form, geographical and sectoral distribution. According to the report from China's Ministry of Commerce, Asian countries contributed most of the FDI inflows into China, constituting more than 70% of total actually used FDI in China between 1979 and 2003. They are followed by North America and the EU, with 9.57% and 7.55% respectively. With regards to the forms of investment, the establishment of new enterprises like joint ventures and foreign invested companies seem to be the main forms of FDI into China at the current time. Thirdly, the geographical distribution of FDI in China is very imbalanced. Eastern regions have received most of the FDI inflows. 86.27% of cumulative FDI was located in the eastern region, 8.93% in the central region and only 4.80% in the western region between the years 1979 and 2003. And finally, the majority of FDI has flowed into the secondary industry.[1] Among secondary industries, manufacturing attracted 63.66% of the total cumulative contracted FDI by 2003.

[1] Chinese industry is split into the following three main categories. Primary industry refers to extraction of natural resources, i.e. agriculture (including farming, forestry, animal husbandry and fishery). Secondary industry involves processing of primary products, i.e. industry (including mining and quarrying,

China is a large polluting country with rapidly increasing industrial production, domestic and foreign trade and investment. Manufacturing is the primary source of the environmental problems. State Environmental Protection Administration (SEPA) reported that in 2004 industrial air pollution accounted for over 80% of the national total. Although industrial water pollution has decreased year by year, it still accounts for about 45.8% of national total.

Faced with such serious environmental problems, China's central and local governments, as well as some enterprises, have invested a great amount of money for environmental pollution treatment every year. Figure 1 shows the rising trend of investments in industrial pollution treatment from 1987 to 2004. Figure 2 shows provincial share of pollution treatment investment relative to GDP varies across province, an imbalance that is not consistent with GDP levels.

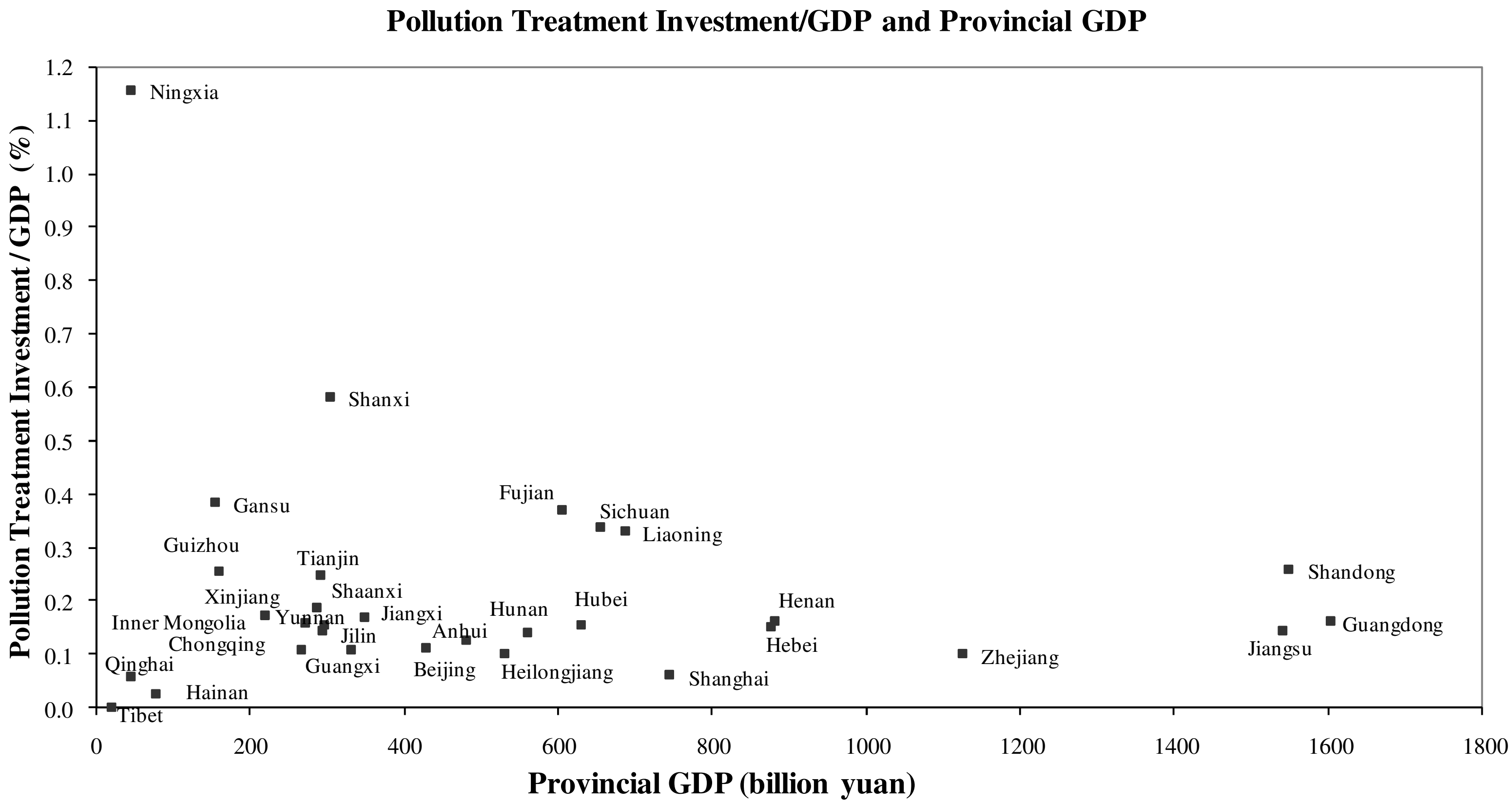
Figure 1 Investment in Industrial Pollution Treatment 1987-2004



Source: China Statistical Yearbook, various years.

manufacturing, production and supply of electricity power, gas and water) and construction. Tertiary industry refers to all other economic activities not included in primary and secondary industry.

Figure 2 Provincial Difference in Pollution Treatment Investment per unit of GDP and GDP in Levels 2004



Source: China Statistical Yearbook, 2005.

Environmental protection in China became the responsibility of the country in 1978 based on the *Constitution of the People's Republic of China*. China established the *Environment Protection Law* (EPL) in 1979 (provisional), and officially enacted it in September 1989. The EPL provides the basic principles governing the prevention of pollution and environmental pollution and imposes criminal responsibility for serious environmental pollution. The effort of the government on environmental protection is ongoing. In 2006, Chinese Premier Wen Jiabao pointed out the importance of green development in his government work report (Reuters, 16/08/2006). Generally, there are no separate environmental standards for foreign investment, but foreign investors' environmental behaviour must abide by Chinese environmental laws and regulations and meet the environmental standards.

Although the regulatory framework seems comprehensive, the enforcement is weak. Ma (2007) points out that the limited power of environmental authorities is one reason for the failure to implement environmental law. Environmental policy is set by the government, overseen by the environmental authorities and implemented by various government departments. The coordination between the environmental authorities and other departments is poor. Excessive pollution happens in some regions due to the failure of local government. As a result, regulatory strength varies significantly across regions. The weak environmental regulatory stringency in China provides an opportunity for some multinational firms to take advantage of weak environmental standards to transfer their out-of-date technologies and pollution-intensive production to China.

3. Methodology

We follow the methodology of previous studies on intra-country, inter-region FDI location choice and investigate the interaction between FDI flows and environmental regulations in China.

3.1 Estimating Model and Data

Multinational corporations (MNCs) are assumed to seek to maximise profit, i.e. to minimise costs. A MNC will view and compare different locations to assess differences in, for example, production costs, government regulations, infrastructure, agglomeration effects and so on. When considering the impact of environmental regulations on foreign plant location choice, the empirical model that is adopted in this paper is given by

$$FDI_{it} = \alpha + \beta_1 ER_{it} + \beta_2 X_{it} + \eta_i + \gamma_t + \varepsilon_{it} \quad (1)$$

where,

FDI is the amount of FDI inflow into region *i* in time period *t*;
ER is the vector of measures to capture environmental stringency;
X is the set of other regional characteristics that may affect FDI;
η is time-invariant regional effects;
γ is location-invariant time effects; and
ε is the idiosyncratic error term.

We employ two variables to capture FDI inflows, one of which is the value of FDI divided by regional GDP (*FDI/GDP*) and the other is FDI divided by regional population (*FDI/POP*). Scaling FDI by GDP or population allows FDI to be comparable across regions and time (see Appendix 1 for variable definitions and sources).

Factors that may influence provincial level FDI include environmental stringency, factor prices, infrastructure, and agglomeration effects.

The level of environmental stringency in different provinces is proxied by three variables:

- *EI1* – the share of investment in industrial pollution treatment projects in total innovation investment. Industrial pollution treatment investment is the total investment of enterprises in construction and installation projects, and purchase of equipment and instruments required in the pollution harnessing projects for the treatments of wastewater, waste gas, solid wastes, noise pollution and other pollution. We use the share of industrial pollution treatment investment in innovation investment to reflect the local government effort in environmental protection. We also normalise the industrial pollution treatment investment using other two methods (see details in Appendix 2).
- *Punish* – the total number of administrative punishment cases filed by the environmental authorities in each region normalised by the number of enterprises

in each region.[2] Administrative punishment cases are those cases that breach environmental protection laws and regulations. *Punish* proxies the strength of enforcement of regional environmental legislation.

- *Charge* – a pollution emission charge normalised by the number of organisations that paid this charge. Pollution emission charge refers to the total amount of 1) pollutant emission charge exceeding the discharge standards; 2) sewage discharge levy; and 3) other four kinds of charges, including increasing levy standards, double charges, overdue charges and compensation fines. The pollution charge is implemented by regional governments and reflects the provincial differences in implementation of the pollution levy system.

These three measures are time varying, which improves upon the 0-3 type of measure of environmental stringency used in Javorcik and Wei (2005). Since more stringent environmental regulations will generate higher pollution taxes or higher pollution abatement costs for the firm, the environmental regulation stringency variables should have a similar impact to factor prices on foreign investment location choice. It is expected that FDI is attracted to provinces with weaker regulations, i.e. with a lower share of investment in industrial pollution treatment investment, with a lower number of normalised administrative punishment cases related to environmental issues, and/or with a lower normalised pollution emission charge. Since pollution emission charge is more visible to enterprises than administrative punishment cases and environmental investment, we expect *Charge* has the strongest impact on FDI location choice, followed by *Punish* and *EI1*, respectively.

Our control variables are as follows:

Manufacturing wage is included as a proxy for factor price differences across each region. The quality of labour force in a region is captured by two measures, labour productivity and the illiteracy rate. Population density is employed as a proxy for land prices and potential market size (assuming that labour mobility between provinces is low). The availability and quality of infrastructure also impacts the overall cost of doing business and hence is an attractive factor to FDI location. We include both railway density and road density to measure the quality of regional transportation network and thus to proxy

[2] The enterprises are all state-owned and non-state-owned enterprises above designated size, which refers to enterprises with an annual sales income of over 5 million RMB yuan (about 0.60 million USD).

the cost and availability of material inputs. Gross regional product (*GRP*) per capita is included to capture the average quality of the government, general infrastructure and the effect of market size differences across regions. The regional gross industrial product value (*GIP*) attempts to capture an agglomeration effect whereby firms locate where hubs of economic activity already exist (Bartik, 1988). *GIP* may also be an indicator of availability of intermediate inputs.

Following the literature, foreign investors are seeking a location with comparative advantages such as cheaper factors that they use in higher proportions. Since unskilled labour is associated with lower labour costs, FDI is also expected to be attracted to provinces with relatively lower manufacturing wages. Some recent empirical studies on intra-country FDI flows find significantly negative effects of wage on aggregate FDI flows in China (eg., Coughlin and Segev (2000) and Cheng and Kwan (2000)). Conversely, wage is also found to be positively related with FDI flows (Gao, 2002). To specify the real impact of wage on FDI inflows, we add wage squared in our estimations and expect an inverted-U relationship between FDI and wage. When wage is below some benchmark, foreign investments are attracted to provinces with high wage level because labour cost is not the most important determinants compared with other factors, such as high regional income and good infrastructure. But when wage is higher than the benchmark, FDI is deterred because wage becomes more important in the standard profit function.

According to the previous work of Head and Ries (1996) and Dean *et al.* (2005), it expected that FDI would like to flow into provinces with better industrial agglomeration and infrastructure. In addition, for foreign investors seeking a large local market they may be expected to invest in areas that have large consumption capability and potential which can be proxied by population density and per capita income. However, population density also proxies land price. In more densely populated areas, land price is usually higher than that in less densely populated areas. The sign of population density is expected to be ambiguous.

Our five-year time period panel data helps to control for unobserved heterogeneity. Since the independent variables do not have immediate influence on the investment location choice, we employ a one-year lag for all independent variables. The lagged independent variables also help to control for the possible endogeneity of these variables.

Therefore, the estimating equation is:

$$\begin{aligned}\ln(FDI_{it}) = \alpha + \beta_1 \ln(ER_{it-1}) + \beta_2 \ln(GRP\ \ per\ Capita_{it-1}) + \beta_3 \ln(Wage_{it-1}) \\ + \beta_4 (\ln(Wage_{it-1}))^2 + \beta_5 \ln(GIP_{it-1}) + \beta_6 \ln(Pop.\ Density_{it-1}) \\ + \beta_7 \ln(Rail\ Density_{it-1}) + \beta_8 \ln(Road\ Density_{it-1}) + \beta_9 \ln(Illiterate\ Rate_{it-1}) \\ + \beta_{10} \ln(Productivity_{it-1}) + \eta_i + \gamma_t + \varepsilon_{it}\end{aligned} \quad (5)$$

where *i* refers to province, and *t* refers to year. We use the log transformation models which could help to correct the positive skewness of variables and make the error term close to homoskedestic.[3]

If there is no effect of the stringency of environmental regulations on FDI across regions, we would expect β_1=0. If $\beta_1 < 0$, we cannot reject the hypothesis that FDI is attracted to provinces with lower regulatory stringency.

The expected signs of the coefficients are as follows:

Coefficients	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}
Expected Signs	-	+	+	-	+	-/+	+	+	+	-

Data used for this study are collected from the China Statistical Yearbook, China Industrial Economy Statistical Yearbooks and China Environment Yearbook. The values of all the data are deflated by the GDP deflator, which is set to 100 for year 1990. All the FDI data, which are measured by US dollars, are transferred to RBM yuan at the middle exchange rate of the year. A complete description of definitions of all variables and sources is provided in Appendix 1. Because one year lags are used for all independent variables in the estimation, all the socioeconomic independent variables of 30 regions are from 1998 to 2002. FDI data used for estimations are therefore from 1999 to 2003.[4]

To gauge the consistency of the sample with what is known about the provincial distribution of foreign investment, we compare the provincial shares of total actually used FDI value in the sample. It is seen that the largest FDI inflows went to eastern

[3] After taking logs, the skewnesses of all the variables are significantly reduced. Results for the levels models are available from the authors on request.

[4] The table for descriptive statistics is available from the authors on request.

regions/provinces. The values of our three environmental stringency variables vary widely across provinces, and a province could appear to be stringent using one measure of environmental regulations but not using the others. The correlation matrix (see Table 1) shows that these three environmental stringency variables do not have a strong correlation. The correlation matrix also shows that our FDI variables seem to have a negative correlation with *EI1* and *Punish*, but a positive correlation with *Charge*. The correlations between the two FDI variables and other independent variables implies that FDI prefers to flow into provinces with better infrastructure, higher population density, higher income level, better agglomeration, higher quality of labour and higher labour costs.

Table 1 Correlations of the Variables

	FDI/ GDP	FDI/ POP	EI1_1	Punish _1	Charge _1	GRP per capita_1	Wage_1	(Wage _1)^2	GIP_1	Pop. Density _1	Rail Density _1	Road Density _1	Illiterate Rate_1	Produc-tivity_1
FDI/GDP	1.000													
FDI/POP	0.859	1.000												
EI1_1	-0.095	-0.120	1.000											
Punish_1	-0.108	-0.113	0.154	1.000										
Charge_1	0.294	0.601	0.060	-0.014	1.000									
GRP per capita_1	0.617	0.904	-0.084	-0.029	0.700	1.000								
Wage_1	0.511	0.781	-0.108	-0.062	0.568	0.862	1.000							
(Wage_1)^2	0.475	0.791	-0.134	-0.108	-0.162	-0.083	0.654	1.000						
GIP_1	0.544	0.553	0.019	-0.027	0.409	0.488	0.433	0.409	1.000					
Pop. Density_1	0.502	0.807	-0.143	-0.157	0.801	0.865	0.674	0.742	0.429	1.000				
Rail Density_1	0.393	0.616	-0.010	0.007	0.465	0.723	0.555	0.571	0.120	0.606	1.000			
Road Density_1	0.697	0.798	-0.098	-0.173	0.538	0.771	0.695	0.701	0.456	0.729	0.723	1.000		
Illiterate Rate_1	-0.321	-0.353	0.004	-0.229	-0.150	-0.421	-0.345	-0.322	-0.266	-0.279	-0.451	-0.430	1.000	
Productivity_1	0.007	0.148	-0.114	0.054	0.114	0.253	0.359	0.334	-0.002	0.181	0.251	0.159	-0.147	1.000

3.2 Selection of Estimators

A problem faced when estimating the model is whether the unobserved individual-specific effects and time effects (η_i and γ_t) should be treated as random variables or as parameters to be estimated for each cross region observation *i* and time *t*. In this paper we estimate both two-way fixed effects and random effects error component models. For our fixed effects models we initially use the within regression estimator which is a pooled OLS estimator based on time-demeaned variables, or uses the time variation in both dependent and independent variables within each cross-sectional observation (Wooldridge, 2000). For our random effects models we choose the generalised least square (GLS) estimator, which produces a matrix-weighted average of the between and within estimator results.[5]

Few assumptions are required to justify the fixed effects estimator. In the estimation, however, η_i and γ_t are not assumed to have a distribution, but are treated as fixed and estimatable. The random effects estimator requires no correlation assumptions, that is η_i ~IID $(0,\sigma_\eta^2)$, γ_t ~IID $(0,\sigma_\gamma^2)$, and ε_{it} ~IID $(0,\sigma_\varepsilon^2)$ are independent of each other. In addition, all the independent variables are independent of η_i, γ_t, and ε_{it} for all *i* and *t*.

In order to calculate whether ε_{it} are uncorrelated with the independent variables, we use the Hausman specification test under the null hypothesis H_0: $E(\varepsilon_{it}|X_{it})=0$. The results of Hausman specification tests suggest that, in most cases, the individual-level effects could be adequately modelled by random effects models.[6]

We presume that all the one-year lagged control variables are exogenous. However, environmental regulation stringency may be endogenous partly because the regions with relatively low FDI inflows may lower their environmental regulation standards in order to attract more FDI, and partly because FDI is an important engine of growth and hence helps to improve regional environment and environmental standards. We employ a Davidson-MacKinnon test of the exogeneity using two-year lagged environmental

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[5] The between estimator is obtained by using OLS to estimate the models which use the time-averages for both dependent and independent variables and then runs a cross sectional regression (Wooldridge, 2000, Chapter 14, pp.442). GLS estimators produce more efficient results than between estimators because they use both the within and between information.

[6] Available from the authors on request.

regulation variables as the instrumental variable. The results suggest that simultaneity bias is not present in our model for all the three environmental regulation variables.

When using data on different provinces that have variation of scale, the variance for each of the panels will differ. Both the fixed effects and random effects estimators can solve the problem of heteroskedasticity across panels. However, neither controls for possible autocorrelation within the panels. In order to test whether the errors suffer from autocorrelation or not, we apply the following dynamic regression model:

$$\varepsilon_{it} = \rho\varepsilon_{it-1} + \nu_{it}, t = 2, \ldots, T \,.. \tag{6}$$

where $|\rho| < 1$ and ν_{it} ~ IID(0, σ_ν^2).

The null hypothesis is H_0: ρ = 0. Thus, ρ should be estimated from the regression of ε_{it} on ε_{it-1}, for all t = 2,…,T. The t statistics for $\hat{\rho}$ show that we can reject the null hypothesis for all log models. That is, there is AR (1) autocorrelation within panels in our log specifications.

One solution is to use the feasible generalised least square (FGLS) estimator. FGLS models allow cross-sectional correlation and heteroskedasticity. It also allows models with heteroskedasticity and no cross-sectional correlation. In addition, it is possible to relax the assumption of non-autocorrelation within panels. FGLS is therefore more efficient than the other two estimators mentioned above.[7]

Since the GLS estimator is less efficient than the FGLS estimator, the random effects results are relatively weak even though GLS estimator is not rejected in most specifications by Hausman specification tests.[8] We therefore concentrate on the FGLS estimation results in the main text. Estimations are run using STATA 9.[9]

[7] We also estimate the models using an alternative method, i.e. OLS models with panel-corrected standard errors (PCSEs), to control for both heteroskedasticity and autocorrelation. The results are broadly similar to those using FGLS. Results are available from the authors on request.

[8] The results of regressions with random effects are available from the authors on request.

[9] The major syntaxes include *xtreg* with *fe* and *re*, *xtgls*, and *xtpcse*.

4. Empirical Results

In this section we only report the FGLS log results because of its advantages mentioned above. We also include a series of sensitivity checks.[10]

Tables 2-4 respectively present the FGLS regression results for the impact of different levels of environmental stringency on two measures of provincial level FDI inflows using data in logs for thirty provinces in China. Table 2 presents the results for *EI1*, Table 3 for *Punish* and Table 4 for *Charge*. Each table includes two parts, depending on the two measures of FDI inflows, *FDI/GDP* for columns 1-4 and *FDI/POP* for columns 5-8.

The results in Table 2 show that the share of industrial pollution treatment investment has a negative and significant effect on FDI inflows into a province. The coefficients are relatively stable across regressions. The coefficients in columns (4) and (8) indicate that for both measures of FDI, a 10 per cent increase in the share of environmental investment of a province would lead to a 0.62 per cent decrease in the amount of FDI inflows into the province. Thus, the more stringent are the environmental regulations the lower is the amount of FDI. Per capita income generally has a positive and statistically significant coefficient, which means that the richer the province, the more foreign investment it attracts. Among all the independent variables, per capita income level has the strongest effect on FDI inflows. The coefficient could be treated as the income elasticity of FDI inflows. A 10 per cent increase in provincial income level could lead to 30-40 per cent increase in FDI.

The coefficients on manufacturing wage and wage square are consistent with our prior expectation in signs, which provide an inverted-U relationship between FDI and wage. When we use *FDI/GDP* as dependent variable, they are not significantly different from zero in most regressions and only achieve marginal significance in column (4); however, become more significant when we estimate on *FDI/POP*.[11]

GIP is intended to capture the degree of agglomeration in a province. The coefficient on *GIP* is not consistent in sign and a statistically significant negative coefficient is found in

[10] The results for sensitivity analysis and levels estimations are available from the authors on request.

[11] The turning point is around 3000-4000 RMB, which is lower than the current income level in China, indicating that labour costs deter FDI inflows at the current income level in China.

regressions (2).[12] The coefficient on population density is negative and only significant at 10% in column (4). FDI locates in less densely populated areas possibly due to the higher land prices.

We now consider our infrastructure variables. The railway density coefficient has significant negative effects on FDI inflows and is also found in all the other regression results in Tables 3 and 4. A possible explanation is the relatively lower railway density in some coastal provinces with higher incomes and higher shares of FDI inflows. In contrast, another measure of a region infrastructure, road density, has a positive and significant coefficient in all regressions in all the three tables. The value of the coefficient remains relatively stable.[13]

The rate of illiteracy in a province has a positively significant coefficient indicating that FDI prefers to locate into regions with a high proportion of unskilled labour. Similarly, our measure of productivity has the consistent sign but it is not significant indicating that productivity does not appear to play an important role in the decision to locate the investment.

[12] We also estimate our regressions using the numbers of enterprises as a proxy of agglomeration. These enterprises include all state-owned and non-state-owned industrial enterprises with an annual sales income of over 5 million RMB yuan. Our main results are unaffected.

[13] We also estimate our regressions including railway density and road density separately but the results were very similar. We also estimated the regressions respectively including numbers of ports in each province and dummy variable for coastal provinces. Both coefficients are positive but not significant.

Table 2 FGLS Regression Results for Log Data with EI1

	FDI/GDP				FDI/POP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EI1_1	-0.087 (-2.69)***	-0.11 (-3.16)***	-0.063 (-2.00)**	-0.062 (-2.03)**	-0.094 (-2.75)***	-0.10 (-2.93)***	-0.062 (-1.93)*	-0.062 (-1.96)**
GRP per capita_1	2.82 (4.03)***	3.48 (4.66)***	3.41 (4.98)***	3.44 (4.86)***	3.43 (4.93)***	3.99 (5.42)***	4.04 (6.04)***	3.98 (5.74)***
Wage_1	5.76 (1.56)	3.22 (0.81)	5.34 (1.45)	6.49 (1.68)*	7.95 (2.24)**	5.53 (1.41)	7.48 (2.03)**	8.54 (2.22)**
$Wage\_1^2$	-0.33 (-1.48)	-0.19 (-0.78)	-0.32 (-1.44)	-0.40 (-1.71)*	-0.46 (-2.11)**	-0.32 (-1.36)	-0.45 (-2.01)**	-0.52 (-2.24)**
GIP_1		-0.60 (-2.00)**	-0.25 (-0.80)	-0.16 (-0.50)		-0.42 (-1.31)	-0.057 (-0.18)	0.045 (0.13)
Pop. Density_1		-1.14 (-1.50)	-1.01 (-1.49)	-1.13 (-1.68)*		-0.96 (-1.25)	-0.88 (-1.21)	-0.92 (-1.28)
Rail Density_1			-0.21 (-1.98)**	-0.25 (-2.32)**			-0.16 (-1.43)	-0.20 (-1.78)*
Road Density_1			0.42 (4.14)***	0.45 (5.30)***			0.45 (4.47)***	0.47 (5.47)***
Illiterate Rate_1				0.27 (2.34)**				0.27 (2.23)**
Productivity_1				-0.18 (-1.47)				-0.17 (-1.34)
Constant	-44.122 (-2.45)**	-27.27 (-1.28)	-40.74 (-2.11)**	-43.51 (-2.20)**	-59.51 (-3.43)***	-44.54 (-2.10)**	-58.28 (-2.96)***	-60.91 (-3.05)***
Wald χ^2	5384.91	5717.34	7051.28	7071.95	8913.67	9316.90	12471.36	13239.35
Observations	149	149	149	149	149	149	149	149

z-statistics in parentheses; time dummies are included; *, **, and *** indicate significant at 10% , 5% and 1% level, respectively.

Table 3 FGLS Regression Results for Log Data with Punish

	FDI/GDP				FDI/POP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Punish_1	-0.051 (-2.13)**	-0.078 (-3.01)***	-0.082 (-3.16)***	-0.076 (-2.85)***	-0.054 (-2.26)**	-0.074 (-2.57)**	-0.078 (-2.62)***	-0.070 (-2.38)**
GRP per capita_1	3.13 (4.51)***	3.79 (5.13)***	3.84 (5.94)***	3.85 (5.75)***	3.63 (5.34)***	4.28 (5.79)***	4.46 (6.99)***	4.36 (6.58)***
Wage_1	5.42 (1.35)	3.41 (-0.81)	4.78 (-1.24)	5.73 (-1.42)	7.63 (1.98)**	5.54 (1.33)	6.64 (1.72)*	7.67 (1.91)*
$Wage\_1^2$	-0.33 (-1.36)	-0.21 (-0.84)	-0.30 (-1.28)	-0.36 (-1.48)	-0.45 (-1.92)*	-0.34 (-1.33)	-0.41 (-1.73)*	-0.47 (-1.94)*
GIP_1		-0.62 (-1.98)**	-0.41 (-1.36)	-0.36 (-1.17)		-0.48 (-1.40)	-0.20 (-0.63)	-0.13 (-0.39)
Pop. Density_1		-0.94 (-1.26)	-0.98 (-1.57)	-1.02 (-1.63)		-0.69 (-0.90)	-0.82 (-1.18)	-0.77 (-1.13)
Rail Density_1			-0.30 (-2.87)***	-0.31 (-2.90)***			-0.26 (-2.25)**	-0.26 (-2.28)**
Road Density_1			0.44 (4.44)***	0.46 (5.28)***			0.46 (4.72)***	0.48 (5.43)***
Illiterate Rate_1				0.21 (1.83)*				0.20 (1.68)*
Productivity_1				-0.16 (-1.32)				-0.14 (-1.14)
Constant	-44.12 (-2.30)**	-31.19 (-1.40)	-39.87 (-2.00)**	-42.58 (-2.10)**	-58.88 (-3.19)***	-47.77 (-2.16)**	-56.75 (-2.80)***	-59.97 (-2.92)***
Wald χ^2	4945.25	6263.02	8235.71	8466.13	8280.40	8852.64	13005.62	13589.33
Observations	147	147	147	147	147	147	147	147

z-statistics in parentheses; time dummies are included; *, **, and *** indicate significant at 10% , 5% and 1% level, respectively.

Table 4 FGLS Regression Results for Log Data with Charge

	FDI/GDP				FDI/POP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Charge_1	-0.12 (-1.01)	-0.14 (-1.16)	-0.22 (-2.00)**	-0.18 (-1.54)	-0.098 (-0.84)	-0.13 (-1.10)	-0.21 (-1.92)*	-0.17 (-1.50)
GRP per capita_1	2.89 (3.95)***	3.47 (4.42)***	3.50 (5.02)***	3.47 (4.80)***	3.57 (4.95)***	3.99 (5.25)***	4.15 (6.27)***	4.02 (5.77)***
Wage_1	3.87 (0.94)	0.49 (0.11)	1.99 (0.49)	3.26 (0.77)	6.69 (1.67)*	3.02 (0.67)	4.18 (1.02)	5.47 (1.29)
$Wage\_1^2$	-0.23 (-0.90)	-0.039 (-0.14)	-0.12 (-0.48)	-0.20 (-0.78)	-0.39 (-1.59)	-0.19 (-0.68)	-0.25 (-0.99)	-0.33 (-1.28)
GIP_1		-0.31 (-0.94)	0.13 (0.39)	0.14 (0.42)		-0.15 (-0.45)	0.30 (0.89)	0.34 (0.97)
Pop. Density_1		-1.39 (-1.67)*	-1.54 (-2.27)**	-1.61 (-2.34)**		-1.22 (-1.45)	-1.42 (-1.92)*	-1.41 (-1.92)*
Rail Density_1			-0.37 (-3.45)***	-0.37 (-3.34)***			-0.31 (-2.69)***	-0.31 (-2.68)***
Road Density_1			0.42 (3.92)***	0.44 (4.46)***			0.45 (4.20)***	0.46 (4.57)***
Illiterate Rate_1				0.22 (1.68)*				0.21 (1.58)
Productivity_1				-0.16 (-1.32)				-0.16 (-1.25)
Constant	-35.64 (-1.81)*	-14.44 (-0.60)	-24.28 (-1.15)	-27.59 (-1.29)	-54.22 (-2.81)***	-32.42 (-1.36)	-42.16 (-1.96)**	-45.52 (-2.09)**
Wald χ^2	4558.54	4891.34	7336.94	6817.20	7749.89	8301.63	12585.14	12082.78
Observations	149	149	149	149	149	149	149	149

z-statistics in parentheses; time dummies are included; *, **, and *** indicate significant at 10% , 5% and 1% level, respectively.

Next, we use *Punish* to measure the strictness of environmental regulations with the same specifications of Table 3 as those in Table 2. The coefficient on the number of punishment cases is negative and statistically significant in all regressions, and the absolute values are relatively stable. In column (4) of Table 3, the coefficient is -0.076, which means that a 10 per cent increase in environment litigiousness of the province leads to a 0.76 per cent decreases in the amount of FDI inflows. As a result, the provinces with stricter environmental standards attract less FDI inflows.

The effect of per capita income is still significantly positive. Similar to the results including *EI1*, the coefficients on manufacturing wage does not have significant effect on *FDI/GDP* but have significant effect on *FDI/POP*. *GIP* and population density remain negatively insignificant. Railway and highway density are similar to previous results. Their coefficients are robust for both signs and magnitudes. The performance of rate of illiteracy and productivity are also similar to those in the previous tables.

In terms of the results using normalised pollution emission charge, Table 4 indicates that foreign investors would like to locate in provinces with lower pollution emission charge standards, i.e. provinces with weaker implementation of environmental standards. However, the results are not as significant as *EI1* and *Punish*. And a 10 percent increase in pollution charge standard may lead to an approximately 2.0 per cent decrease in FDI inflows. Compared to the industrial pollution treatment investment and administrative punishment cases, foreign investors are more sensitive to the pollution emission charge, possibly because it is more visible to the investors and has a more direct impact. The magnitudes of the coefficients on our three measures of environmental regulations are consistent with our expectation that *Charge* has the strongest elasticity, while *EI1* has the weakest.

The results for per capita income and infrastructure variables are very similar to those in the previous four tables. However, wage and squared wage are now insignificant in the regressions on both measures of FDI. *GIP* coefficient is not consistent in sign although it is still not significantly different from zero. Population density becomes negatively significant, indicating that foreign investment prefers less populated provinces where land price is lower. The coefficient on illiteracy rate is less significant but remains stable in magnitude. The results for productivity do not change across the regressions.

We also apply some additional sensitivity checks to labour quality and manufacturing wage. We substitute the rate of illiteracy by the percentage of enrolment in different levels of education. We find positive but insignificant results for primary school enrolment; positive and significant results for junior high school enrolment; and negative but insignificant results for both senior high school and higher education enrolments. These results support our results that FDI is attracted to relatively low education level regions. We also include the interaction term of certain variables, for example, wage × income, wage × rate of illiteracy, and wage × productivity but the results remain broadly the same.

To check the robustness of our results, we drop the three municipalities (Beijing, Tianjin and Shanghai) from our sample. The results of *EI1* and *Charge* show a robust significant and negative effect on the FDI location choice within China; while the coefficient on *Punish* remains negative but less significant in some regressions.

5. Conclusions

This paper uses provincial data from China to examine whether the foreign investment is more or less likely to be attracted to provinces with stringent environmental regulations. Three proxies for the stringency of environmental regulations across provinces are employed for the analysis. It has also addressed a number of limitations in pervious PHH empirical studies by using a panel dataset in a single country context. Evidences from this study support the existence of pollution havens within China, indicating that foreign investors are attracted by the relatively weaker environmental regulations.

Findings from this study have important policy implications. Three decades' of fast economic growth under the present growth mode has made China one of the largest pollution producers in the world, with, probably, the dirtiest air and more and more polluted water resources. "The [annual] economic cost of environmental degradation and pollution … are the equivalent of 8-12 percent of China's annual gross domestic product" (Economy, 2004). "Unless ecological balance is restored within the medium-term, environmental limits could choke off further economic growth" (Woo, 2007).

In this growth process, FDI has played an important role. It is regarded as an engine or catalyst for economic growth, a carrier of advanced technological and managerial knowledge that can drive the technological upgrading of the economy. Evidences from this study suggest that FDI is not an always annoyed blessing. Certain type of FDI from certain sources in certain sectors may seek institutional voids in the developing countries and attempt to locate in 'pollution heavens' where environmental regulation is not stringent.

If a fast economic development is endurable, a sustainable development policy is needed that requires a rethinking about the location of population centers and types of investment including the type and sector of foreign direct investment. Putting an emphasis on the "quality" of FDI rather than the "quantity" of FDI; encourage more environmental friendly knowledge and human capital intensive FDI and control FDI in high energy consumption and high pollution sectors. The negative effect of environmental stringency on FDI can be offset by the improvement of some factors that are attractive to FDI, for example the quality of infrastructure.

Appendix 1 Variables Definitions and Data Sources

Variable	Definition/Source
FDI/GDP	FDI divided by regional GDP (yuan per 10000 yuan). Source: China Statistical Yearbook.
FDI/POP	FDI divided by regional population (yuan per capita at 1990 price). Source: as above; GDP deflator data from Econ Stats, http://www.econstats.com
EI1	Investment in industrial pollution treatment project divided by total innovation investment (yuan per 10000 yuan). Source: as above.
Punish	Total number of administrative punishment cases filed by the regional environmental authorities divided by the number of enterprises (cases per 1000 enterprises). Source: China Environment Yearbook.
Charge	Pollution emission charge divided by the number of organisations paid the charge (yuan per enterprise, at 1990 price). Source: as above.
GRP per capita	Gross regional product per capita (yuan at 1990 price). Source: as FDI.
Wage	Average wage of staff and workers in manufacturing (yuan at 1990). Source: as above.
GIP	Regional gross industrial output value (100 million yuan at 1990 price). Source: as above.
Pop. Density	Regional population density (persons per km^2). Source: as above; area data from http://www.usacn.com
Road Density	Regional highway density (km per 10000 km^2). Source: as above.
Rail Density	Regional railway density (km per 10000 km^2). Source: as above.
Illiterate Rate	Regional illiterate rate and semi-illiterate rate aged at 15 and above; values for 2000 are calculated as the average of the values in 1999 and 2001. Source: as FDI.
Productivity	Overall labour productivity for all foreign funded industrial enterprises (yuan per person per year, at 1990 price); values for 1998 are the average of those for 1997 and 1999. Source: China Industrial Economy Statistical Yearbooks.

Appendix 2 Normalisation of the Share of the Environmental Investment

The investment monies are spent on construction and installation projects, and purchase of equipment and instruments required in pollution harnessing projects for the treatment of wastewater, waste gas, solid waste, noise pollution and other pollution.

All of these investment monies should be counted within investment in innovation, which refers in general to the technological innovation of the original facilities (including renewal of fixed assets) by the enterprises and institutions as well as corresponding supplementary projects for production or welfare facilities and related activities.

Therefore, we normalise the industrial pollution treatment investment by the investment in innovation, i.e. the variable we used in main text, *EI1*. We also construct two alternative variables for the share of environmental investment. *EI2* is normalised by the sum of investment in innovation and capital construction; and *EI3* is normalised by the total investment in fixed assets. Total investment in fixed assets is classified into four parts: investment in capital construction, investment in innovation, investment in real estates development and other investments in fixed assets.

Although the coefficients of *EI2* and *EI3* are less significant than that of *EI1*, the results are roughly consistent with our main results.

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