Determinants of Effective Environmental Regulations: Evidence from China

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EXECUTIVE SUMMARY

Using a unique data set collected from three municipal environmental protection bureaus in China, we investigated the determinants of effective environmental regulations. The effective (actual) environmental regulations were measured by the actual pollution standard imposed on firms, the frequency of inspections done, and the actual pollution levy rates imposed on them.

The study show that plants located in higher GDP per capita areas and whose emissions are more likely to induce pollution damage face stricter effective environmental regulations, including more frequent inspections. Similarly, plants located in urban areas are subject to higher levy rates.

Our results offer important insights on the regulators' behavior: environmental agencies do consider the public’s interests when they determine their monitoring and enforcement strategy. Effective environmental regulations on plants are strongly influenced by the local costs of and benefits from the plants' pollution. This observation is consistent with the principle of environmental economics, wherein environmental regulation is the outcome of balancing economic activity and environmental degradation due to the pollution by taking all benefits and costs into account.

1.0 INTRODUCTION

Environmental regulations in China can be traced back to 1979 when the national Environmental Protection Law (EPL) was first adopted (on a trial basis). Following the EPL, a series of environmental regulations designed to reduce industrial pollution and improve environmental quality have been put in place. Although the pollution control regulation has been amended several times, it always mainly involves a tax on pollution discharges, generally referred to as the pollution levy system.

Environmental management in China is generally decentralized. Article 16 of Chapter 3 of the EPL states that "the local people’s governments at various levels shall be responsible for the environmental quality of areas under their jurisdiction and shall take measures to improve the quality of the environment". Therefore, local governments have extensive flexibility in both formulating and enforcing environmental regulations. For instance, local governments are involved in decisions concerning the pollution concentration standards for firms that discharge to local waterways. Furthermore, the enforcement of environmental regulations (e.g., issuing discharging license, making field inspections, and collecting pollution levies) is the responsibility of local environmental protection bureaus (EPBs). Indeed, pollution levies on firms can be reduced or even eliminated at the discretion of local regulators after appropriate inspections.

China’s fast economic growth has been accompanied by a highly unbalanced regional development. A large disparity exists between the urban and rural areas and between the coastal and inland regions. Differences in per capita income and other socioeconomic parameters such as population density, firm’s ownership, etc. may give rise to heterogeneous preferences concerning environmental quality. For example, higher income areas, which have higher marginal willingness to pay for environmental quality, would typically impose stricter pollution regulations than those in a low income area. As explained by a Chinese state Environmental Protection Agency (EPA) representative, some counties have very poor economic bases and are thus more concerned about improving their economies than about protecting the environment (pers. comm.).

Different local incentives in environmental regulations may also arise due to financial incentives and even conflicting interests: if the local governments hold stakes in firms (as it often happens in poor areas), they may not want those firms under strict environmental regulations. Moreover, environmental authorities may have less incentives to enforce regulations on firms that are important employers of local labor. Finally, the firms' local conditions also matter. For example, firms located in high population density areas may be imposed more strict pollution standards and subjected to more rigorous enforcement. The different local incentives in environmental regulations, combined with local flexibility in formulating and enforcing environmental regulations, inevitably lead to regional diversity in the firms' environmental performance.

Although the regional diversity in the firms' environmental performance has been criticized, recent research (see Wang and Wheeler 2003) suggests that its pattern is consistent with one of the principles of environmental economics: in general, regulation is stricter in areas where income and education are higher.

The variations in effective environmental regulations in China have been pointed out by several papers. At the provincial level, Wang and Wheeler (2003) show that effective water levy rates are responsive to measures of ambient quality and development. Relatively affluent, heavily industrialized coastal provinces have the highest effective levy rates, while many poorer interior provinces have the minimum rates. A few years ago, Wang and Wheeler (2005) analyzed financial incentives and endogenous enforcement of the Chinese pollution levy system using data from 3,000 Chinese factories. They found that, despite central pressure for uniformity in enforcement, firms' compliance with environmental regulations greatly differ .

Unlike Wang and Wheeler (2003, 2005), in this report we focus on analyzing the process that motivates regulators to undertake monitoring activities and how effective environmental regulations are influenced by local conditions. Monitoring activities refer to the number of inspections conducted on firms. Effective environmental regulations refer to the pollutant emission standards and the effective levy rates.

Dasgupta et al. (2001) reckon that, at the plant level, variation in frequency of inspections is a better determinant of the Chinese polluters' environmental performance than variation in pollution levies because inspections make firms perform better environmentally. The impact of increasing firms' pollution concentration standards on their environmental performance is unambiguous: more permissive standards lead to more pollution, and higher effective levy rates lead to firms’ better environmental performance.

Besides focusing on how the local conditions matter when environmental regulatory agencies determine their pollutant concentration standards/effective levy rates and the number of firm inspections, we also studied how firms’ characteristics matter when environmental regulatory agencies set their effective environmental regulations and enforce them. For instance, we examined if firms with foreign direct investments are subjected to higher levy rates and stricter pollution standards and if they are inspected more frequently than state-owned firms, as well as if these have a bearing on pollution standards. Some studies (e.g., Wang and Jin 2007) point out that state-owned firms in China have a large bargaining power on effective levy rates.

We empirically studied the effect of local conditions on the number of inspections conducted on firms, their pollution concentration standards, and the effective levy rates imposed on them. Results indicate that firms located in areas with higher gross domestic product (GDP) per capita are more likely to be imposed stricter pollution concentration standards and higher levy rates and subjected to more inspections. Similar observations were obtained for plants located in urban areas and more populated counties. Moreover, firms with foreign direct investments are more likely to be regulated by stricter standards.

A number of papers have analyzed how firms' local conditions influence enforcement activities in North America. For instance, Deily and Gray (1991) analyzed the effect of local labor market conditions on enforcement of pollution standards. In particular, they analyzed whether the US EPA's enforcement actions depend on the probability of plant closure as a result of these actions. Deily and Gray (1996) in an earlier study introduced the economic theory of regulation to model the regulator's decision. Dion et al. (1998) studied the issue using data from Canadian pulp and paper industrial firms: they show that, *ceteris paribus*, greater inspection effort is allocated to plants whose emissions are likely to cause more damage. Also, variables pertaining to local labor market conditions have a significant impact on the monitoring strategy adopted by regulators.

The rest of the report is organized as follows: section 2 discusses China’s pollution control policy, sections 3 and 4 present the empirical analysis, and section 5 gives the conclusion and implication.

2.0 POLLUTION CONTROL POLICY IN CHINA

Before 2003, the pollution levy system formally required that any plant should pay a fee only based on the quantity of effluent discharge that exceeded the legal standard. Moreover, the pollution levy was actually paid only on the pollutant that exceeded its standard by the greatest amount, but not on all the pollutants that exceeded their standards. If all pollutants do not exceed their standards, lower levy rates were imposed on air and water discharges. Since 2003, plants have been required to pay levies on the pollutants with the three largest estimated fees,[1] and the levy rates have substantially increased. The new regulation aims to give plants stronger incentives for pollution control.

Given that our data set is based on plants' pollution from wastewater for the year 2002, we mainly discuss the pollution levy system in 2002 for wastewater. China's pollution levy system is a two-tier charge system: uniform rates for within-standard pollution and higher and escalating rates for above-standard pollution. If every pollutant emitted by a plant is below the corresponding standard, the plant pays the within-standard levy for wastewater discharges;[2] otherwise, plants pay the above-standard levy.

The above-standard levy is calculated with respect to pollutants emitted by plants above their corresponding standards. Consider plant j emitting M water pollutants that are above the corresponding standards. Namely, for each pollutant i (i=1,...M), the concentration of pollutant i discharged by plant j (noted C_{ji}) is greater than the corresponding legal standard (C_{i*}). The total above-standard levy paid by plant j (L_j) is calculated as follows:

$$L_j=\max\{L_{j1}, L_{j2},\ldots L_{jM}\}$$

where:

$$L_{ji}=R_{1i}P_{ji} \quad \text{if } P_{ji} < T_i \text{ (or equal to } T_i\text{);}$$

$$\quad =L_{0i} + R_{2i}P_{ji} \quad \text{if } P_{ji} > T_i$$

where $L_{0i}=[R_{1i} - R_{2i}]\, T_i$

where L_{ji} is the estimated levy to be paid by plant j on pollutant i; P_{ji} is the discharge factor of pollutant i calculated as $W_j((C_{ji}-C_{i*})/C_{i*})$, where W_j is the total amount of wastewater discharged by plant j; T_i is the threshold factor that determines the levy rate adopted; R_{2i} is the levy rate applied when the discharge factor P_{ji} is below the threshold while the levy rate R_{1i}, with $R_{1i}<R_{2i}$, is applied for above-threshold pollution; and $L_{0i}=[R_{2i}-R_{1i}]T_i$ is a fixed payment. The formula is calculated on a monthly basis (the calculation is illustrated in Annex 1).

The levy function takes into account both the concentration of the hazardous pollutant and the volume of discharged wastewater, since it calculates the discharge factor (Pji) based on both total wastewater discharge and the degree to which pollutant concentration (Cji) exceeds the standard (Ci*). The standard (Ci*) is jointly set by the central and local governments, and it is different by industry sector and waterway where the wastewater is discharged. In particular, the central government sets three levels (high, middle, low) of pollutant concentration standard, and then the local environmental

[1] Suppose that a firm discharges five pollutants above the standards. Then, the firm would estimate the fee to be paid for each of the five pollutants, as if it were to pay the fee for each of these. Before 1993, the firm would pay only the highest of the estimated pollutant fees (and not the sum of all the fees). Since 2003, the total levy paid by the firm is the sum of the highest five pollutant fees.

[2] Since 1993, the standard fee for within-standard wastewater discharges has been RMB 0.05 per ton. Within-standard charges have also been assessed on SO_2 emissions since 1996. USD 1≈RMB 7

authority picks a pollutant concentration standard level for a specific firm. Both levy rates (R1i, R2i) and threshold factor (Ti) are set by the central government and vary by pollutant, but not by industry or region. The levy formula for air pollution is simpler. The within-standard levy is exactly the same as the wastewater levy. As for the above-standard air pollution levy, unlike the water levy, the air levy is assessed on the absolute, rather than percentage, deviation from the concentration standard. For firm j and pollutant i, the potencial levy is Lji=RiVj(Cji-Ci*), where Ri is the levy rate; Vj is the total volume of air emission; Cji is the pollutant concentration, and Ci* is the concentration standard. Again, a firm is assessed only on the highest of its potential levies.

This is the levy calculation formula in theory; in practice the local environmental authority can decide whether or not to decrease the levies to be paid by firms. For instance, state-owned firms may have a bigger bargaining power and therefore could pay lesser levies. Firms belonging to sectors that are not in the priority of the local economic development plan may have less bargaining power in the payment of pollution levies. Moreover, because of the bureaucracy, local governments in developing counties could protect local firms from enforcement policy. For instance, local authorities in China are given considerable flexibility in adopting specific procedures when implementing national environmental policy mandates. City-level environmental protection bureaus are legally responsible for implementing nationally mandated policies, but they are primarily a department of the city government. Heads of the city bureaus are appointed by and report to the city mayor. Financial resources for the bureaus are also provided at the local level. In China, the environmental impact assessment (EIA) system is dominated entirely by government agencies, without any forum and provision for public participation or consultation. All decisions in the process are made solely by bureau officials; no institutional channels exist for the general public and those who are affected by proposed projects to express their opinions, especially to raise objections.

3.0 EMPIRICAL ANALYSIS OF VARIATIONS IN POLLUTION STANDARDS AND FREQUENCY OF FIRM INSPECTIONS

This section presents how the firms' local conditions affect the pollution concentration standards and the number of inspections conducted on firms. We tested also some of the empirical implications derived from the theoretical model introduced in the previous section. We first describe the characteristics of the data involved in our study, and then we set up an empirical model.

3.1 DATA DESCRIPTION

Data were collected from three municipal environmental protection agencies. The agencies’ databases contain rich information that allows us to study this topic, such as firms’ age, number of employees, ownership, location, and economic and environmental performance.

Our dataset was supplied by City A’s Environmental Protection Bureau (AEPB), City B’s Environmental Protection Bureau (BEPB), and City C’s Environmental

Protection Bureau (CEPB)[3]. City A's industries are mainly composed of the food, medicine, chemical, automobile, textile, and electronics sectors. State-owned enterprises do not dominate the industry as private and foreign joint ventures have considerably increased in the past decade. City B is an important industrial center in China, being the transportation and commercial center of China's northeastern region. It focuses on heavy industry (particularly aerospace), machine tools, heavy equipment, defense, and, more recently, software, automotive, and electronics. Different from City A, state-owned enterprises constitute a large proportion of City B’s economy. City C, on the other hand, is the commercial and financial center of mainland China. It experienced rapid development beginning in the 1990s. It became a pilot area for integrated economic reforms. It has recorded double-digit growth for 15 consecutive years since 1992, thus becoming the center of finance and trade in the new China. In 2009, City C's total GDP grew to RMB 1.49 trillion (USD 218.26 billion); GDP per capita was RMB 77,564 (USD 11,361). The manufacturing and agricultural sectors accounted for 39.9 percent of the total output.

Since the data collected from CEPB did not include the number of inspections and the pollutant concentration standards, we excluded the CEPB plants in the analysis of number of inspections and pollutant concentration standards vis-a-vis firms’ characteristics and local conditions.

The data from AEPB and BEPB provided pollution and production information of 290 plants for the year 2002. Besides the plant-level data, local county level data on local economic development indicators were included. The plants in the sample are mainly the large chemical oxygen demand (COD) polluters belonging to the food, paper, medicine, and chemical sectors. They are located in 11 districts/counties of the two municipal cities (4 from City A, 7 from City B). Data on plant-level variables include the plants' output value, number of employees, age of plant, COD emission, sectors they belonged to, and ownership. The dataset included information on effective environmental regulations, such as COD pollutant concentration standards and number of inspections conducted on the plants. Moreover, local development indicators (i.e., GDP, population) capture the firms' local conditions.

Before presenting the model, some descriptive statistics of the sample are given in Table 1. First, we note that the plants in the sample were inspected quite frequently (8.58 times on the average in 2002), which indicates that the main purpose of the inspections by the environmental authorities is to verify the plants' pollution level (see Lin 2007 for this analysis). Second, the plants in the sample mainly belong to the food and chemical sectors, although the paper and medicine sectors are also represented by some large plants. Third, the three types of ownership (state-owned, collective, and joint venture) are almost equally represented. Fourth, one quarter of the plants were located in one particular county and the rest were evenly distributed across the other counties. The average county population is 1.2355 million and average county GDP per capita is 3.3768 thousand yuan.

[3] Although there are nothing confidential, the EPBs ask us not to put their names in publication.

Table 1: Descriptive statistics (annual data of 290 plants in City A and B)

Variable	Mean	Standard Deviation	Variable	Mean	Standard Deviation
Output value (10^7 yuan)	10.36	19.73	County (% the number of firms located in the county over total)		
Number of employees	393.98	271.20	$County_1$	7%	
COD discharge (tons)	8.86	18.28	$County_2$	7%	
Age of plant (decades)	2.4	1.31	$County_3$	25%	
Inspection (frequency)	8.58	5.05	$County_4$	9%	
Sector (%)			$County_5$	6%	
Food	37		$County_6$	5%	
Paper	9		$County_7$	10%	
Chemical	45		$County_8$	9%	
Medicine	9		$County_9$	4%	
Ownership (%)			$County_{10}$	12%	
State owned	30		$County_{11}$	6%	
Collective	40		Basic statistics for Counties		
Joint Venture	30		Population (million)	1.2355	0.3809
Urban (%)	66		GDP per capita (ten thousand, yuan)	3.3768	1.2054

3.2 MODELS AND RESULTS

Our objective is to analyze the process that influence the regulator to undertake effective environmental regulations. As discused in the previous section, we are interested in knowing how the frequency of plant inspection and pollution standards varied with the plants' characteristics and local conditions. Therefore, we tested the impact of the plants' characteristics and local conditions on two variables: pollution concentration standards and number of inspections. We ran two regressions, with the aforementioned two variables as dependent variables and the plants' characteristics and local conditions as independent variables.

As previously described, pollution standards vary with type of pollutant and the industrial sector to which the plant belongs. To avoid complications, the study focused on the standards for COD pollution. The other difficulty encountered has to do with the varying standards used. The data set involves plants from four different sectors; therefore we cannot directly compare the implementation of the regulations because the standards differed according to sector. For each sector, the central authority sets three levels of standards for COD pollutant (labeled as first, second, and third class from strict to moderate). However, the local environmental agencies in City A and City B, where the sample plants were located, only used either the first class or the second class standards for pollution emitted in the local waterway. Therefore, we considered a binary choice for the standard for COD pollutant in our sample. We assigned the value 1 for plants subjected to the stricter COD standard (first class standard) and 0 to the rest of the plants. A Probit model is used for the standard equation, as follows:

$$\text{Probabilty}(STA_i=1 \mid X_i;\ Y_i) = \varphi(c+A*X_i+B*Y_i) \qquad (1)$$

where STA is the standard dummy; X_i contains the plant i's basic characteristics: age of plant, number of employees, sector, and ownership; Y_i contains variables describing plants' local conditions: local population, GDP per capita, urban dummy, City A dummy, as well as the ratio of the plant's output to local GDP (to capture the relative importance of the plant to the local economy); A and B are coefficient matrices, and c is a regular constant term. φ is the cumulative distribution function of the standard normal distribution function, namely, with mean 0 and standard deviation 1. The Probit model estimates how the independent variables X_i and Y_i affect the probability of imposition of the stricter pollution standard (probability $STA_i=1$). The coefficient estimates are reported in Table 2.

The coefficients of the model are estimated using maximum likelihood techniques. That is, if the data set contains n observations, corresponding to the model above, the joint log-likelihood function is then:

$$\ln L(c,A,B) = \sum_{i=1}^{n}(STA_i \ln\varphi(c+A*Xi+B*Yi) + (1-STA_i)\ln\varphi(c+A*Xi+B*Yi))$$

.

The coefficient estimates (c, A, B) maximize the function. With the coefficients we then are able to estimate the marginal effect of the independent variables on the probability of imposition of the stricter standard. For instance, we can calculate the value c+A*Xi+B*Yi only count on the coefficients that are estimated to be significant. If the coefficient of urban dummy is significant, we can calculate the values c+A*Xi+B*Yi when the urban dummy takes the value zero and when the urban dummy takes the value one by holding others fixed. Since we assume φ is the cumulative distribution function of the standard normal distribution function, we then can estimate the probability of imposition of the stricter standard when the urban dummy takes the value zero and when the urban dummy takes the value one. The difference is the marginal impact of the urban dummy on the imposition of the stricter standard.

We expect age to be a key variable determining standard, in the sense that a less strict standard is expected to be imposed for plants with older technology and machines. The number of employees may capture the scale effect. Given the observation that the more polluting firms (i.e., more COD emissions) are not necessarily subjected to a stricter standard, we did not put plants' COD pollution on the right hand side of equation. Local population and urban dummies are used to measure how the local regulatory agencies care about the damage caused by the plants' pollution on public health.

The inspection equation is estimated by a multiple linear regression model of the form:

$$INS_i=c+A*X_i+B*Y_i+d*STA_i+f*COD_i+e_i \qquad (2)$$

where INS stands for number of inspections on plant i; and X_i and Y_i contain the same variables as the standard equation; we also included the standard dummy and COD pollution as regressors because we expect that the behavior of the enforcement agencies may be a function of the strictness of the standard and the level of pollution. The estimated results of the inspection equation are reported in Table 2.

We note that the plants' age has very significant impact on both the pollution standard and the number of inspections. Firms that are a decade older are approximately 13.84 percent less likely to be imposed the stricter standard but are subject to two times more inspections. This result confirms our expectation. Moreover, the state-owned and collective plants are less likely (approximately 42.18% and 19.53%, respectively) to be imposed the strict standards compared with joint-venture plants. This result may be due to the fact that the latter have more advanced technology than state-owned and collective plants. Further, stated-owned and collective plants have more bargaining power than joint-venture plants in environmental regulation (Wang 2002). Also, plants with stricter pollution standards were inspected more frequently (0.67 times more).

Table 2. Standard equation and inspection equation results (290 plants)

Independent variable	**STA**	**INS**
Age of plant	-	0.6585**
	0.7307***	(0.2875)
	(0.094)	
Number of employees	-0.0004	0.0004
	(0.0006)	(0.0015)
Food	0.1547	-2.2917**
	(0.3728)	(1.1506)
Paper	0.8901*	0.4842
	(0.4638)	(1.3757)
Chemical	0.1514	-0.2058
	(0.3736)	(1.1243)
State-owned	-	-0.5673
	1.0546***	(0.851)
Collective	(0.2891)	-1.2388*
	-0.4771*	(0.7154)
STA	(0.2551)	0.6746*
		(0.3519)
COD		0.0037
		(0.3519)
Urban		1.0439*
	0.3588*	(0.574)
Population	(0.2022)	1.2133*
	0.3816	(0.7007)
Output ratio	(0.2796)	0.2516**
	0.0008	(0.1117)
GDP per capita	(0.0361)	0.5167**
	0.1744**	(0.2282)

	(0.0821)	
City A	-0.1485	-0.6292
	(0.2124)	(0.5524)
Constant	0.8401	3.4599*
	(0.637)	(1.8714)
Puesto R-squared	0.4112	
R-squared		0.3165
Log likelihood	-758.96	
F test		4.74

*** at 99 level, ** at 95% level, ***at 90% level

The plants' local conditions are key factors in explaining the decision on standards and inspection activities by regulatory agencies. Plants located in urban areas are more likely (20.3%) to be subjected to stricter standards and more frequent inspections (approximately one more inspection) than those in other areas. Likewise, more inspections are allocated to plants whose emissions are likely to cause a higher level of damage (e.g., plants located in populated areas). Moreover, plants in counties with high GDP per capita are more likely to be subjected to stricter effective regulations (i.e., stricter pollution standard, 12.3% higher probability at 10% increase in GDP per capita) and more frequent inspections (approximately one half inspection more at 10% increase in GDP per capita).

4.0 EMPIRICAL ANALYSIS OF VARIATIONS IN LEVY RATES

In this section, we discuss how the effective levy rates differ according to the firms' local conditions (e.g., local population, share of output in the local GDP, and local GDP per capita) and characteristics (e.g., ownership, number of employees, and output). Since the data collected from AEPB and BEPB did not contain total paid levies, the firms in these cities were excluded from this particular study; only the data from CEPB were analyzed.

4.1 DATA DESCRIPTION

The CEPB database contained information on the characteristics of 385 firms, such as output value, number of employees, location, and sectors to which the firms belonged in the year 2007. The total and above-standard COD discharges of the firms and their investments on water pollution abatement are included in the dataset. Table 3 provides the descriptive statistics.

Table 3. Descriptive statistics (annual data of 385 plants in City C)

Variable and Definition	Mean	Standard Deviation
Output value (10^7 yuan)	217.60	161.78
Total COD discharge (tons)	39.64	257.48
Above the permitted COD discharge (kg)	1.33	5.81
Average levy rate (yuan/kg)	0.0065	0.0417
Water pollution abatement investment (10^7 yuan)	0.16	0.85
Firms located in urban area (%)	26.75	
Ownership		
State-owned (%)	9.87	
Collective (%)	34.8	
Joint venture (%)	55.33	
Sector		
Food and beverage (%)	6.5	
Textile (%)	9.4	
Furniture (%)	2.9	
Paper (%)	5.5	
Chemical (%)	18.2	
Rubber (%)	3.3	
Metal (%)	9.9	
Machinery (%)	41.6	
Concrete and ceramic (%)	2.9	
Number of firms	385	

The firms had an average output value of 2.2 billion yuan (about USD 320 million) and employed an average of 942 people. More than one quarter of the firms in the sample are located in urban areas. Of particular interest to the study, the average COD levy rate was 0.5907 yuan per kg. More than half (55.33%) of the sample were Sino-foreign joint venture firms; collective firms accounted for about one-third (34.8%); and state-owned firms, 9.87 percent . In terms of sectoral distribution, firms belonging to the machinery sector (41.6%) were the most numerous, followed by chemical (18.2%), metal (9.9%), and textile (9.4%).

4.2 MODELS AND RESULTS

To determine how the effective levy rates were affected by the firms' local conditions and characteristics, we set up an empirical model where we put average levy rate on the left hand side of the equation and firms' local condition and characteristics on the right hand side. That is,

$$Levy_i = c + A*X_i + B*Yi + e_i \qquad (3)$$

where $Levy_i$ refers to the levy rate of firm i, which is calculated by all the levies charged by EPB divided by the total COD discharge. Again, X_i and Y_i contain the variables of firms' characteristics and local conditions, respectively. The regression results are presented in Table 4.

Table 4. Effective levy equation results (385 plants)

Independent variable	**log(average levy rate)**
Output value	-0.0007
	(0.0029)
Number of employees	0.0028
	(0.0027)
Urban	0.0109**
	(0.0047)
Food and beverage	-0.0587***
	(0.0151)
Textile	-0.0787***
	(0.0149)
Furniture	-0.0784***
	(0.0179)
Paper	-0.0678***
	(0.0155)
Chemical	-0.0727***
	(0.0133)
Rubber	-0.0795***
	(0.0173)

Metal	-0.0760***
	(0.0141)
Machinery	-0.0779***
	(0.0131)
State-owned	-0.0066
	(0.0077)
Collective	-0.0006
	(0.0047)
Constant	1.0668***
	(0.0209)
R-squared	0.1207
F test	3.67

*** at 99 level, ** at 95% level, ***at 90% level

The result shows that the effective levy rate does not vary according to the firms' output level and number of employees. Moreover, the levy rates of state-owned and collective firms are not significantly different from those of joint venture firms. The coefficient estimates on firms' location (i.e., urban) is positive and significant, which implies that firms in urban areas are subjected to higher levy rates.

5.0 CONCLUSION AND POLICY IMPLICATION

In this report, we presented the results of an empirical study on factors that have significant impacts on the effective environmental regulations (i.e., the level of strictness of pollution standards, the number of inspections, and the effective levy rates) imposed on firms. The results show that environmental agencies take into account the firms' age and ownership when they impose pollution standards and undertake inspections. The firms' characteristics and local conditions likewise matter in determining their effective environmental regulations. For instance, plants located in urban and dense population areas and having higher GDP per capita face stricter effective environmental regulations; higher effective levy rates are also imposed on firms located in urban areas. These empirical results are consistent with our expectation.

Our results offer important insights on the regulators' behavior: environmental agencies do consider the public's interests when they determine regulations on the pollution produced by the plants. Effective environmental regulation is strongly influenced by the local costs of and benefits from the plants' pollution. This is consistent with the principle of environmental economics, wherein environmental regulation is the outcome of balancing the economic activity and environmental degradation due to the pollution by taking all benefits and costs into account. In this sense, this report complements similar studies that had been conducted in North America (Dion et al. 1998). As with its counterparts in the USA and Canada, the environmental regulators in China make regulatory decisions reflecting the plants' local conditions. Although the environmental regulations are set uniformly, the effective environmental burden of the firms' pollution varies according to their demographical characteristics and local conditions.

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Annex 1:

To illustrate, we compute the COD and TSS levies for a plant whose discharged water concentrations are 140g/l for COD (local standard=100g/l) and 140g/l for TSS (local standard=70g/l). The relevant ratios (Cji-Ci*)/Ci* are 0.4 for COD and 1 for TSS. The plant's discharge of wastewater W is 100,000 tons. Therefore, PCOD=W*0.4 =40,000; and PTSS=W*1 =100,000. The tax rates for the two pollutants are R1COD=RMB 0.05/ton.time; R2COD=RMB 0.18/ton.time; R1TSS=RMB 0.01/ton.time; and R2TSS=RMB 0.03/ton.time. The regulatory threshold parameters for the two pollutants are TCOD=20,000 and TTSS=800,000 given exogenously by the regulation; the fixed payment factors are L0COD=USD 2,600 and L0TSS=RMB 16,000. Since PCOD>TCOD and PTSS<TTSS, applying the formula, the potential levies are LCOD=L0COD+R1CODPCOD=RMB 4,600, and LTSS=R2TSSPTSS=RMB 3,000. Since the levy rate for COD is higher, the plant's water levy charge is RMB 4,600.The potential levy Lji is calculated for each pollutant i; the actual levy Lj is the greatest of the potential levies.