Industrial environmental performance in China: The impact of inspections

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December 1999

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ACKNOWLEDGEMENTS

We thank sincerely Zhenjiang Environmental Protection Bureau for allowing us access to the data necessary to perform the analysis presented in this paper. We also wish to thank Professor Genfa Lu (Department of Environmental Science and Engineering, Nanjing University) for his generous collaboration. We also thank participants of the workshop held in the Department of Environmental Science and Engineering of Nanjing University for their comments and suggestions. Our thanks to Mr. Craig Meisner and Mrs Ping Yun for their research assistance. All remaining errors remain our own.

Executive summary

In environmental economics, monitoring and enforcement issues have attracted relatively little research effort. Moreover, the bulk of the literature on these issues has been of a theoretical nature. Few have empirically analysed the impact of monitoring and enforcement activities on the environmental performance of polluters. Moreover, all existing studies have been performed in the context of developed countries. A purpose of the current paper is to partially fill this important gap by exploring the impact of inspections on the environmental performance of polluters in China. Our analysis also simultaneously examines the potential impact of pollution charges and citizens' complaints.

Our analysis of plant-level data from the city of Zhenjiang shows that inspections do have a statistically significant impact on the firms' environmental performance. In the current paper, our results suggest that pollution charges do not have a statistically significant impact on firms' performance. However, this result may simply be explained by the lack of variation in pollution charges within the city of Zhenjiang which therefore prevents us from effectively capturing the impact of pollution charges. Our results also demonstrate that complaints do impact inspections significantly. Given the impact of inspections on pollution, citizens' complaints therefore do have a significant impact on pollution control. These results may provide a key to China's future quality of environment.

Whether or not these results support that additional resources be devoted to monitoring activities cannot strictly be addressed with the data currently available. Indeed, in order to do so, there would be a need to compare the costs of performing additional inspections with the net benefits of reduced pollution emissions. However, given the high level of air and water pollution currently observed in Zhenjiang, given the impact that these may have solely on health and productivity losses, it is reasonable to speculate that inspections do increase social welfare in Zhenjiang. The results however suggest that citizens can also have an important impact on pollution (via inspections). Hence, this would suggest a greater role for the regulator to embark on information and education policies.

1. Introduction

Since the beginning of the 1970s, governments of developed and developing countries have enacted or amended a large number of environmental laws and regulations often directed at controlling the industrial emissions of air and water pollution. However, imposing a ceiling on a plant's emissions does not necessarily imply that emissions will fall and environmental quality improve. For the objectives of the regulation to be attained, the behaviour of the regulated community has to be monitored, and compliance with environmental standards has to be enforced.[1] While a large amount of resources is typically devoted to designing environmental regulations, and negotiating environmental standards with the regulated industries, it is generally acknowledged that resources devoted to monitoring and enforcement are insufficient relative to the complexity and extent of the task.[2]

While the monitoring of industrial polluters and the enforcement of compliance are both crucial components of a credible regulatory program, monitoring and enforcement issues have attracted little research effort. In a recent survey of the environmental economics literature, Cropper and Oates (1992) write: "The great bulk of the literature on the economics of environmental regulation simply assumes that polluters comply with existing directives." Moreover, most of the literature on these issues has been of a theoretical nature.[3]

On the empirical front, two broad questions have partially been addressed. A first question pertains to the impact of the regulator's behavior on the environmental performance of polluters. In particular, Magat and Viscusi (1990; henceforth MV), and Laplante and Rilstone (1996; henceforth LR) have examined whether or not *inspections* have an impact on the emissions of pulp and paper plants in the United States and Canada**,** respectively. MV (1990) have shown that inspections reduce permanently the level of emissions of plants by approximately 20%. LR (1996) have shown that not only inspections but also the threat of inspections reduce emissions by approximately 28%.[4] These two analyses also find that inspections induce more frequent self-reporting of emissions by the regulated plants. Hence, not only do inspections have an impact on the actual level of emissions of the plants, but they also provide regulators with a more accurate pollution profile of the plants. More recently, Nadeau (1997) has shown that inspections significantly reduce the duration of firms' violation of air pollution standards in the pulp and paper industry in the United States. These results have clear policy implications as to the importance of a credible monitoring strategy to create incentives for pollution control.

If inspections have an impact on the behavior of polluters and partly explain improvements in their environmental performance, a second question of interest thus pertains to the determinants of the regulator's monitoring strategy. Deily and Gray (1991, 1996), and Dion, Lanoie and Laplante (1998) have shown that regulators are sensitive to local environmental damages in their decision to inspect specific plants and, other things being equal, that greater inspection effort is allocated towards those plants whose emissions are likely to generate a higher level of damages. While this may be a desirable behaviour,[5] these authors also show that the monitoring and enforcement activities of regulators are also a function of variables pertaining to local labour market conditions (such as unemployment rate, and the importance of the plant in the local labour market). Regulators thus appear to show a reluctance to enforce standards in a way that may have an impact on employment.[6] .

Empirical studies on monitoring and enforcement issues have thus been of only recent interest and remain limited in numbers.[7] Moreover, they have been performed only in the context of developed countries: We are not aware of any empirical study on the impact and determinants of monitoring and enforcement activities of an environmental agency of a developing country at the plant level.[8] The current paper is a first step toward filling this important gap. Building upon MV (1990) and LR (1996), in this paper we analyse the role of inspections, pollution charges, and citizens' complaints as determinants of the environmental performance of industrial polluters in Zhenjiang, China.[9] Our analysis of plant-level data shows that inspections do have a statistically significant impact on the firms' environmental performance. In the current paper, our results suggest that pollution charges do not have a statistically significant impact on firms' performance. However, this result may simply be explained by the lack of variation in pollution charges within the city of Zhenjiang which therefore prevents us from effectively capturing the impact of pollution charges. Our results also demonstrate that complaints do impact inspections significantly. Given the impact of inspections on pollution, citizens' complaints therefore do have a significant impact on pollution control. These results may provide a key to China's future quality of environment. These results may provide a key to China's future quality of environment.

In the next section, we briefly describe the institutional and regulatory context currently in place in China. In section 3, we present the model we purport to test. In Section 4, the dataset and results are presented. We briefly conclude in Section 5.

2. Context

(a) *Growth and the environment in Zhenjiang, China*

China's industrial growth has been extremely rapid. In the 1990s, industrial output increased by more than 15% annually. Industry now accounts for approximately 45% of China's gross domestic product, and has provided a source of rapidly expanding income. However, serious environmental damage has accompanied this rapid growth. A large number of China's waterways are near biological death from excessive discharge of organic pollutants. In many urban areas, atmospheric concentrations of pollutants such as suspended particulates and sulfur dioxide routinely exceed World Health Organization safety standards by very large margins.[10] Chinese industry is a primary source of the environmental degradation noted in recent years. China's National Environmental Protection Agency (NEPA) estimates that industrial pollution accounts for over 70% of the nation's total emissions of pollution (NEPA, 1996).

Zhenjiang, with a population of approximately 3 million people, is an industrial city located on the South Bank of the Yangtze River. It is directly under the leadership of the Jiangsu provincial government. Given its location, with Nanjing lying west and Shanghai east, Zhenjiang has a key place in the economy of China and is an important hub of communication on the lower reaches of the Yangtze River. The Beijing-Shanghai Railway passes through the city. With its port and railway, Zhenjiang is a major land and water communications hub in China.

Zhenjiang's industrial growth has been extremely rapid during the period of China's economic reform. Over the course of the last decade, Zhenjiang's industrial output increased at an average rate of 9% annually. The industrial sector is the most important economic sector of Zhenjiang employing a large percentage of the total labor force. The industrial base is large and diversified. The Zhenjiang Economic Development Zone, created in October 1993, has already attracted over 170 firms, including 80 foreign investments. State owned enterprises do not dominate Zhenjiang industry as private investments have considerably increased in the last decade. Given its importance, the rapid growth of the industrial sector has contributed significantly to improving living standards. Average wage increased from Y 1 373 in 1986 to Y 3482 in 1993 (measured in constant Y of 1990). Zhenjiang's ninth Five-Year Plan (1996-2000) calls for further development of the chemical, paper making, building material and aluminum processing industries. However, as a result of this rapid expansion, environmental quality – both air and water ambient quality – has significantly deteriorated.

(b) *Environmental Protection in China*[11]

Environmental protection in China began to be the responsibility of the State in 1978 with Article 9 of Chapter 1 of the Chinese Constitution:

> The State ensures the rational use of natural resources and protects rare animals and plants. The appropriation or damage of natural resources by any organization or individual by whatever means is prohibited.

In accordance with the Constitution, the National People's Congress, the highest legislative authority of China, adopts in 1979 (on a trial basis) the Environmental Protection Law (EPL). The EPL is officially enacted in 1989. The purpose of the Law is clearly stated in its Article 1:

> This law is formulated for the purpose of protecting people's environment and the ecological environment, preventing and controlling pollution and other hazards, safeguarding human health and facilitating the development of socialist modernization.

The EPL provides the basic principles governing the prevention of pollution and environmental protection and imposes criminal responsibility for serious environmental pollution (Article 43):

> If a violation of [EPL] causes a serious environmental pollution accident, leading to grave consequences of heavy losses of public or private property or human injuries or deaths of persons, the persons directly responsible for such accident shall be investigated for criminal responsibility according to law.

An important pillar of China's pollution regulatory system is a pollution levy implemented nationally in 1982. Article 18 of the EPL specifies that:

> In cases where the discharge of pollutants exceeds the limit set by the state, a compensation fee shall be charged according to the quantities and concentration of the pollutants released. [12]

In China, the effective implementation of environmental laws and regulations, including the implementation of the pollution levy, is in large part the responsibilities of local people's governments. [13] Article 16 of Chapter 3 of the EPL indeed states that:

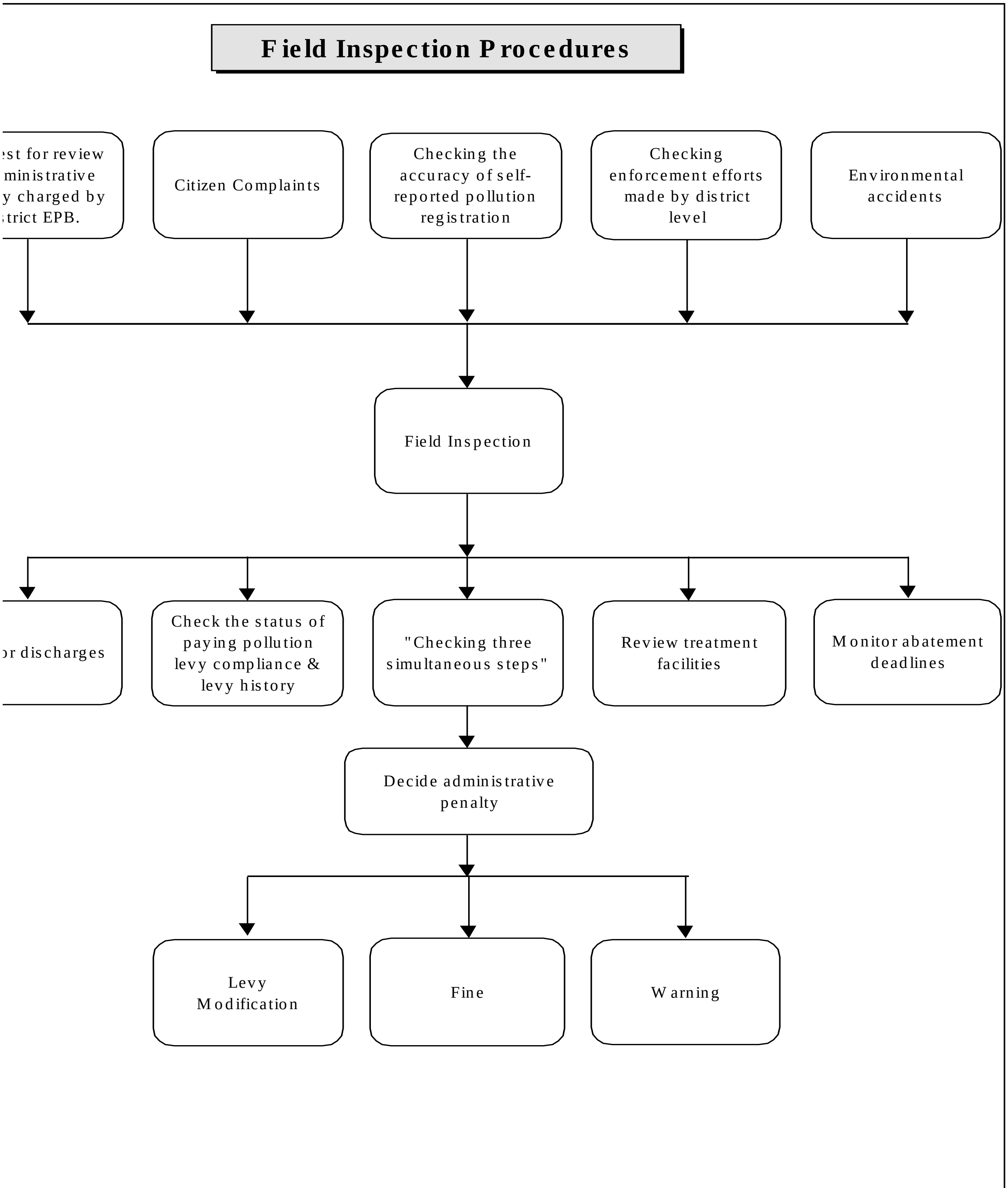
> the local people's governments at various levels shall be responsible for the environmental quality of areas under their jurisdiction and shall take measures to improve the quality of the environment.

As a result, Environmental Protection Bureaus (EPB) have been created at all levels of local governments, from provinces and counties.

Zhenjiang Environmental Protection Bureau (ZEPB) is thus at the apex of decision-making and interagency coordination on environmental policies in Zhenjiang. At a lower level, there are environmental protection bureaus in all the various districts of the municipalities. These district-level EPBs are also responsible for many activities pertaining to the actual implementation of the environmental regulations. Their activities include the collection of pollution charges and non-compliance fees, the monitoring of air and water ambient quality, and the monitoring and inspection of industrial facilities.

The monitoring and inspection of industrial facilities in Zhenjiang (and in all other EPBs in China), as indicated in Figure 1, follow a precise procedure. Apart from regular inspection activities, note that complaints made by citizens regarding environmental incidents may give rise to field inspections.[14] If the polluter is found at fault, various administrative penalties or warnings may then be imposed. These may also include the need for the polluter to install treatment facilities. In extreme cases, the plant may be ordered to cease and relocate its operations.

Figure 1


Field Inspection Procedures
est for review
ministrative
y charged by
strict EPB.
Citizen Complaints
Checking the accuracy of self-reported pollution registration
Checking enforcement efforts made by district level
Environmental accidents
Field Inspection
or discharges
Check the status of paying pollution levy compliance & levy history
"Checking three simultaneous steps"
Review treatment facilities
Monitor abatement deadlines
Decide administrative penalty
Levy Modification
Fine
Warning

3. Model

The general model we wish to test, for both air and water pollution, is similar in nature to the one developed by MV (1990) and LR (1996).[15] These authors have developed a structural model of pollution whereby inspections along with a number of structural variables (such as industrial sector of activity, size, location, and time) are determinant of pollution emissions. In the current paper, an important difference is the inclusion of the pollution levy as a determinant of environmental performance. In China, the probability of inspection and effective pollution levy together determine the expected penalty for non-compliance with the existing regulatory standards.

While we are generally interested in estimating the impact of inspections on the pollution emissions, a difficulty is that inspections at any given time *t* may themselves be a function of pollution at time *t* (that is, the regulator may observe pollution at time *t*, and then decide whether or not to inspect at time *t*). In other words, inspections may themselves be endogenous and correlated with the same variables which determine current pollution levels. If this is the case, least-square estimates will be biased in general. In fact, both MV (1990) and LR (1996) have rejected the hypothesis that inspections were exogenous. As a result, MV (1990) have included in their analysis a vector of only past inspections. LR (1996) on the other hand have preferred to estimate an inspection equations and to re-estimate their basic inspection model by instrumental variables using expected inspections as instruments. Interestingly, these last authors have found that the probability of an inspection in any given period is a decreasing function of past inspections – the regulator's monitoring strategy thus being akin to one of sampling without replacement.

Given these results, the basic system of equations of interest in this paper is of the following nature:

(1) $$INSP_{it} = c + a_1 Time + a_2 LcINSP_{i,t-1} + a_3 Lcc_{i,t-1} + a_4 P_{i,t-1} + d_i + v_{it}$$

(2) $$P_{it} = c + X_{it}\beta + Z_i\gamma + \delta_1 INSP_{it} + \delta_2\ LcINSP_{i,t-1} + \delta_3\ Lcc_{i,t-1} + \delta_4\ Le_{i,t-1} + \delta_5\ P_{i,t-1} + \alpha_i + u_{it}$$

where

i = 1, 2, 3,…, N stands for plants;

t = 1, 2, 3, …, T stands for time;

$INSP_{it}$ represents the number of inspections performed at plant i at time t; $LcINSP_{i,t-1}$ is cumulative inspections performed at plant i up to time t-1; $Lcc_{i,t-1}$ is cumulative complaint targeted at plant i up to time t-1; P_{it} is pollution emissions produced by plant i at time t; $Ll_{i,t-1}$ is the one period lagged effective levy, X_{it} is a matrix of time-varying variables, Z_i is a matrix of plant-specific time invariant dummies, d_i and α_i are firm specific effects and v_{it} and u_{it} are the usual error terms.

From the point of view of the environmental regulator, the pollution variable of interest is presumed to be the impact of its monitoring strategy on the compliance status of the regulated plants with the existing environmental standards. As a result, in the current paper, the endogenous pollution variable P_{it} is measured as the level of discharges relative to their respective standards. Water pollution is measured by discharges of total suspended solids (TSS) and chemical oxygen demand (COD). Air pollution is measured by discharges of total suspended particulates (TSP). In the case of water pollution, the effective levy is measured as the ratio of water levy charged to the amount of wastewater discharged. In the case of air pollution, the effective levy is measured as the ratio of air levy charged to total discharge of air pollutants. Cumulative complaints, also have been decomposed into water pollution related complaints (Lcw) and air pollution related complaints (Lca). These have been included in the water and air pollution estimation respectively.

X_{it}, the matrix of time-varying variables consists of the following variables: *Emp* (number of employees); and dummy variables to indicate the nature of ownership of the plant: *State* (state owned enterprise) or *Coll* (collectively owned enterprise). Z_i, the matrix of plant-specific time invariant variables consists of dummies to indicate a plant's industrial sector of activity. For water pollution, Z_i includes textile, petrol, tobacco, food, beverage, paper and chemical; for air pollution, it includes petrol, coal, construction, paper and chemical.

For the purpose of estimation, we have assumed that: (1) the firm specific effects are random; (2) the two error terms are uncorrelated and well behaved; (3) the lagged pollution variable is uncorrelated with the error term in the inspection equation and correlated with the corresponding error term in the pollution equation; (4) all the right-hand side variables in the inspection equation are doubly exogeneous – that is, uncorrelated with the firm specific effects as well as with the error term.

The system of equations (1) and (2) is recursive and dynamic. Since the model is recursive, we can proceed with the estimation equation by equation (see Lahiri and Schmidt, 1978) . The pollution equation being the one of interest, we transform equation (2) into the following equation in order to eliminate the individual effects:

$$\begin{aligned} \Omega^{-1/2} P_{it} &= \Omega^{-1/2} c + \Omega^{-1/2} X_{it}\beta + \Omega^{-1/2} Z_i \gamma + \Omega^{-1/2} INSP_{it}\delta_1 + \Omega^{-1/2} LcINSP_{i,t-1}\delta_2 \\ &+ \Omega^{-1/2} Lcc_{i,t-1}\delta_3 + \Omega^{-1/2} Ll_{i,t-1}\delta_4 + \Omega^{-1/2} P_{i,t-1}\delta_5 + \Omega^{-1/2} e_{it} \end{aligned} \quad (3)$$

where e_{it} is the new error term – that is the sum of the firm random specific effects (α_i) and the regular error term (u_{it}). The matrix omega is the appropriate matrix to eliminate the plants' individual effects. It is constructed as follows (see, for example, Ahn and Schmidt, 1995, p.18):

(4) $\Omega^{-1/2} = Q_V + \theta P_V$

with

(5a) $P_V = I_N \otimes l_T \, l_T^{'} / T$

(5b) $Q_V = I_N - P_V$

(5c) $\theta^2 = \dfrac{\sigma_u^2}{\sigma_u^2 + T\sigma_\alpha^2}$

For any integer m, let l_m be an m x 1 vector of ones. The idempotent matrix Q_v transforms the original variables into deviations from individual means and P_V transforms original variables into a vector of individual means.

4. Dataset and results

4.1 Dataset

In order to perform this analysis, a primary dataset was recently collected with detailed information on several hundreds industrial plants in Zhenjiang, covering the period 1993 to 1997. In 1997, the total number of plants included in our sample is 640. Of these, 26% are state owned enterprises, the majority being collectively-owned enterprises. Most of the plants in the dataset are medium and small enterprises, with only 4% of the enterprises being large. These large plants however, accounts for approximately one third of the total value of output of the enterprises in the dataset. A further breakdown indicates that the timber processing, the food processing and the petroleum processing industries represent the largest number of sectors in our dataset with 17.2%, 15.6% and 10.2% of the plants.

Table 1a and 1b describe the water (2a) and air (2b) pollution discharges of the firms in 1997. In brackets is the number of firms on which the entry has been computed. Note that a large proportion of the firms in the dataset have paid water levies, and therefore were not complying with the standards. The proportion of firms violating the air pollution concentration standards appear to be significantly lower.

Table 1a
Water discharge characteristics in 1997

Average discharges (kg/year)	
TSS	47,861 (530)
COD	48,591 (626)
Average concentration (mg/l)	
TSS	99 (503)
COD	280 (507)
Proportion of firms paying levy (%)	45

Table 1b
Air discharge characteristics in 1997

Average discharges (ton/year)	
TSP	136 (640)
Average concentration (mg/m3)	
TSP	572 (211)
Proportion of firms paying levy (%)	23

In 1997, the 640 enterprises were the object of 5287 inspections, most of them (99.4%) performed by the Zhenjiang Environmental Protection Bureau. These enterprises were also the object of 78 water related complaints, and 163 air related complaints.

4.2 Results

Given the presence of endogenous variables in the pollution equation (equation 2), the general method of moments (GMM) is an appropriate method of estimation to obtain consistent and efficient estimates. Thus, the GMM is applied to equation (3). The instruments being used are $(Q_v V, P_v V, P_v Z)$ [16] where the matrix V consists of X, $LcINSP_{i,t-1,,}, Lcc_{i,t-1}, Ll_{t-1}, Time$ and the constant term. GMM results from equation (3) for water pollution are presented in Table 5, and for air pollution in Table 6.

First, as Tables 5 and 6 indicate, the number of observations used is not the same across equations as a result of missing values in some variables. Second, all equations pass the test of over-identifying restrictions. This indicates that the instruments used are valid. Third, for both water and air pollution, the lagged dependent variable is a relatively good predictor of current pollution emissions. This variable partly reflects the fact that the installation of emissions control equipment is typically a process that requires a long time. To this extent, the lagged pollution variable could also be interpreted as a proxy for changes in the production technology. A similar result was obtained by MV (1990) and LR (1996). Their results were however somewhat stronger than those obtained here. This may be explained by a rapidly changing and growing industrial sector in China. Fourth, water and air related complaints do not appear to have a significant direct impact on pollution. Fifth, state and collectively owned enterprises appear to exacerbate water pollution, at least as far as COD is concerned.

Results of interest concern the impact of inspections and pollution levies. Inspections performed by the Zhenjiang EPB do have a statistically significant negative impact on both water (measured by TSS and COD discharges) and air pollution. The estimations reveal that inspections reduce water pollution by approximately 1.18% and 0.40% for TSS and COD, respectively, and air pollution by approximately 0.34%. These results are lower than those observed in the pulp and paper sector in Canada and the United States where inspections were shown to reduce water pollution by 28% and 20% respectively.

Observe however that the pollution levy does not have a statistically significant impact on pollution. This result differs somewhat considerably from the result obtained by Wang and Wheeler (1999) who used plant-level data across China. In that paper, the authors analyse the impact of the effective levy on pollution emissions in China and found the pollution levy to have a statistically significant impact on pollution emissions. These authors were unable to include inspections in their analysis. The results obtained in the current paper indicate that a main determinant of the expected penalty function in a city are inspections, and that variation in inspections dominate variations in pollution levy as determinants of environmental performance by industrial polluters in Zhenjiang. However, this difference in results pertaining to the impact of the pollution levy may simply be explained by the lack of variation in pollution levies within the city of Zhenjiang which therefore prevents us from effectively capturing the impact of pollution charges. Our results also demonstrate that complaints do impact significantly inspections. Given the impact of inspections on pollution, citizens' complaints therefore do have a positive and important impact on pollution control.

Table 5
Determinants of water pollution

	TSS	COD
INSP	-0.0500*** (0.100)	-0.0850** (0.033)
LcINSP	0.0092 (0.195)	0.0176 (0.131)
Lcw	-0.2293 (0.340)	-0.0433 (0.780)
Le	0.0026 (0.419)	-0.1511 (0.236)
Lagged dependent variable	0.9964** (0.036)	0.6800* (0.000)
Emp	-0.0004 (0.211)	-0.0008** (0.020)
State	0.3800 (0.415)	1.3950*** (0.056)
Coll	0.2137 (0.712)	0.7462** (0.032)
Textile	7.4556 (0.158)	4.7110 (0.140)
Petrol	-4.0784 (0.150)	-0.7307** (0.020)
Tobacco	-1.1711*** (0.062)	-54.0391 (0.155)
Beverage	-2.0485** (0.038)	0.4573 (0.545)
Food	-0.8097 (0.112)	-0.4784 (0.264)
Paper	-0.9390 (0.252)	0.8722 (0.673)
Chemical	-0.6761 (0.351)	-1.4565* (0.002)
Test Overid. Restr.	7.0918 (0.131)	1.9825 (0.852)
# of observations	649	736

Note: GMM is the method of estimation. GMM instruments are provided in the text. Variables are defined as in the text. Test Overid. Rest. tests the validity of overidentifying restrictions. Numbers in brackets are p-values. Robust standard errors are used throughout. (*), (**) and (***) mean significant at the 1%, 5% and 10% level, respectively.

Table 6
Determinants of air pollution

	TSP
INSP	-0.0328** (0.022)
LcINSP	0.0032 (0.621)
Lca	0.0100 (0.843)
Le	-0.1603 (0.168)
Lagged dependent variable	0.3423** (0.040)
Emp	-0.0002 (0.499)
State	-0.1381 (0.499)
Coll	0.0177 (0.945)
Petrol	-0.4518*** (0.092)
Coal	-0.1059 (0.749)
Construction	9.0519* (0.000)
Paper	-0.7835* (0.007)
Chemical	-0.8535* (0.002)
Test Overid. Restr.	7.3977 (0.286)
# of observations	396

Note: GMM is the method of estimation. GMM instruments are provided in the text. Variables are defined as in the text. Test Overid. Rest. tests the validity of overidentifying restrictions. Numbers in brackets are p-values. Robust standard errors are used throughout. (*), (**) and (***) mean significant at the 1%, 5% and 10% level, respectively.

5. Conclusion

Monitoring and enforcement issues have been the object of a very limited number of empirical analyses at plant level. In developing countries, the difficulties of accessing data may explain this state of fact. Given the very limited number of empirical analyses of the nature conducted in this paper, we hope to have provided a better understanding of the impact of the regulator’s monitoring and enforcement activities on the behavior of industrial polluters. Our analysis of plant-level environmental performance for the city Zhenjiang suggests that inspections do have a statistically significant impact on firms’ environmental performance, and are a better determinant of the firms’ performance than is the variation in pollution levies. However, it cannot be concluded from this analysis that pollution levies do not have an impact on firms’ environmental performance. Only a similar dataset covering numerous cities across China would allow us to delienate the effective impact of inspections and pollution levies on firms’ environmental performance in China. This is the object of ongoing research. Our results also demonstrate that citizens’ complaint are an important determinant of inspections, and therefore, via inspections, of environmental performance. Hence, this would suggest a greater role for the regulator to embark on information and education policies.

Whether or not these results support that additional resources be devoted to monitoring activities cannot strictly be addressed with the data currently available. Indeed, in order to do so, there would be a need to compare the costs of performing additional inspections with the net benefits of reduced pollution emissions. However, given the high level of air and water pollution currently observed in Zhenjiang, given the impact that these may have solely on health and productivity loss, it is reasonable to estimate that inspections do increase social net benefit in Zhenjiang.[17]

Further research in this field will prove to be crucial and provide key policy implications. In particular, it does appear of interest to examine more thoroughly the determinants of the monitoring activities performed by the environmental regulator as well as the impact of various enforcement actions on the environmental performance of polluters. These remain the object of continued research.

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[1] We define monitoring as the process of verifying the firm's status of environmental performance (e.g. compliance), and enforcement as the undertaking of actions (e.g. fines) to bring the firm to improve its environmental performance (e.g comply with environmental standards).

[2] Among others, see Russell (1990) and O'Connor (1994) for more details.

[3] See Downing and Watson (1974), Harford (1978), Linder and McBride (1984), Russell et al. (1986), Beavis and Dobbs (1987), Harrington (1988), Malik (1990), and Russell (1990). For a recent survey of the literature on monitoring and enforcement, see Cohen (1998).

[4] These two analyses examine the impact of inspections on water pollution emissions as measured by biological oxygen demand (BOD) and total suspended solids (TSS).

[5] Economists have greatly criticized environmental regulations that impose on polluters uniform environmental standards since such standards ignore that plants impose non-uniform environmental damages per unit of pollution. However, Dion et al. (1998) argue that the presence of uniform standards does not necessarily imply uniform compliance with the standards.

[6] Dion et al. (1998) thus argues that both the public interest theory of regulation and the economic theory of regulation contribute to explaining the decision of regulators to monitor the environmental performance of regulated plants.

[7] In their paper, Deily and Gray (1991) writes that this is “the *first* empirical study of the EPA’s enforcement activity at the plant level” (p. 260).

[8] Pargal and Wheeler (1996) have examined the impact of non-regulatory activities on environmental quality in Indonesia.

[9] Dasguta and Wheeler (1997) have analysed the determinants of citizens’ complaints in China and found that they were an increasing function of the levels of income and education.

[10] For more details, see Dasgupta et al. (1997) and World Bank (1997).

[11] This brief overview does not intend to provide a thorough description of environmental protection in China. For a comprehensive overview of environmental legislation and institutions in China, see Mei (1995) and Sinkule and Ortolano (1995).

[12] Note that the levy system formally requires that a fee be paid by any enterprise only on the quantity of effluent discharge that exceeds the legal standard. Furthermore, the pollution levy is actually paid only on the pollutant that exceeds its standard by the greatest amount, and not on all the pollutants that exceed the standards. For further details, see NEPA (1992).

[13] Wang and Wheeler (1996) have shown the effective implementation of the pollution levy at the provincial level to be a function of aggregate level of provincial income and education: the higher the level of income and education, the higher the effective levy.

[14] All Chinese citizens have a right to file complaints on pollution matters, and these have to be filed and dealt with in a very precise manner. Zhenjiang EPB is entitled to bring cases to court on behalf of the public.

[15] Our previous work with the Industrial Pollution Projection System (IPPS) does not suggest that there is a need to be concerned with a potential correlation between air pollution and water pollution.

[16] See Ahn and Schmidt (1995) for a thorough discussion on instruments.

[17] Dasgupta et al. (1997) provide estimates of abatement costs and health damages associated with air pollution in China.