REGULATORY INSPECTIONS, INFORMAL PRESSURE AND WATER POLLUTION
A SURVEY OF INDUSTRIAL PLANTS IN INDIA

by

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Abstract

This paper uses survey data from industrial plants to examine regulatory inspections and water pollution emissions in India, and to check whether the monitoring and enforcement efforts of provincial pollution control authorities are affected by local community characteristics that act as proxies for political power. At the same time, the paper tests for evidence of informal pressure on plants that would result in negotiated lower emissions. Two stage least squares estimation methods are used to take account of endogeneity in a model of simultaneous determination of inspections and emissions. The paper finds that high levels of pollution do elicit a formal regulatory response in the form of inspections in India. However, there appears to be little or no impact of inspections on emissions, underlining the institutional failures that Indian academics have been concerned about.

I. Introduction

Industrial plants face pressure to abate pollution from many sources, working through different channels. On the one hand there is regulation by local or central pollution control authorities, who can formally impose fines, closures or other types of punishment for violating regulatory provisions. On the other hand are communities, which seek compliance with locally acceptable norms or standards.

Many cases of direct negotiation and “Coasian” bargaining between plant managements and local inhabitants have been documented around the world.[1] These informal arrangements may rely upon reputational concerns, direct threats or social pressure. Of course, reputational and other concerns can play out through the market as well, e.g., through consumer pressure in export and domestic markets, or through the impact on stock prices, bank lending rates, etc.[2] This impact has sometimes been explicitly leveraged by regulators via public information campaigns and various types of “Green” labeling schemes.[3]

At the same time, it is recognized that formal regulation, especially the monitoring and enforcement of standards, tends to reflect the bargaining power of local communities and is not quite as uniform or blind as the law would imply. Regulators are not immune to the pulls and pushes of powerful interests at the community level. Especially in a democratic polity, local political power cannot be ignored when deciding where to target limited resources. Gray and Deily (1996) show that enforcement in the US steel industry is lower at plants which are large employers in the local labor market. Dion et al. (1997) find considerable local variation in the stringency of monitoring of compliance with uniform national standards in the pulp and paper sector in Quebec. There may be no objection on economic efficiency grounds if regulators end up focusing on areas where activism, political power, or incomes are high, since these would be the very areas which would have a higher valuation of environmental damages. While such outcomes tend to offend the sense of equity that is implicit in uniform national regulation, they are problematic only if they result in a diversion of resources from “objectively” serious environmental problems to more frivolous issues.[4] As is well known, it is entirely possible that the regulatory process might be “captured” by particular interest groups (Stigler 1971, Peltzman 1976).

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1 For instances see Pargal and Wheeler (1996), Hettige, Huq, Pargal and Wheeler (1996).

2 See Hamilton (1993), Arora and Cason (1996).

3 For example: the TRI in the USA, PROPER in Indonesia.

4 See for instance Dasgupta and Wheeler (1997).

Firms factor in local activism as well as the strength of likely regulatory pressures when making location, production, or pollution abatement decisions. For instance, studies on the exposure of different population subgroups to environmental pollution[5] have noted that hazardous waste generators in the US tend to be disproportionately located in disadvantaged areas, leading to questions of regulatory discrimination on income or racial grounds.[6] While discrimination has not been conclusively demonstrated by any study, Hamilton (1993) has shown that commercial hazardous waste generating firms do take explicit account of the ability of a community to organize politically, as proxied by voter turnout rates, when making capacity expansion decisions. Informal arrangements between plants and communities are, thus, likely to be complementary to existing formal regulation, and usually exist alongside the latter.

In this paper we use survey data from India to examine whether the monitoring and enforcement efforts of provincial pollution control authorities are affected by local community characteristics that act as proxies for political power. At the same time we test for evidence of informal pressure on plants that would result in negotiated lower emissions.

We follow the basic approach taken by Pargal and Wheeler (1996) in modeling pollution emissions as the equilibrium outcome of a demand for emissions or "use of environmental services" originating from industrial plants, and a supply of environmental services being provided by communities. The supply price of pollution is determined by the community's valuation of the damage caused by pollution and by its ability to extract recompense from the polluting plants, i.e., its bargaining power. We think that the negotiating strength of communities is likely to be highly correlated with income level, and correlates of income like literacy. In the absence of district level data on income, we have used an indicator of district development which incorporates literacy, urbanization, and other factors to proxy for negotiating power. The demand for environmental services from plants is a derived demand akin to other factor demands. Demand shift factors include plant characteristics, external pressure to abate and the prices of other inputs - all of which would affect the marginal cost of abatement.

5 See Gould (1986), Greenberg and Anderson (1984), Brooks and Sethi (1997).

6 Been (1994) has shown that race and poverty may be important factors in siting decisions for landfills and other undesirable entities. She also shows that the impact of such entities on disadvantaged communities is often exacerbated by the functioning of property markets.

This paper is organized as follows. Section II presents an overview of the state of environmental regulation in India. We present our model and econometric estimation framework in section III and describe the data in section IV. Estimation results are presented in section V, with section VI concluding.

II. Environmental regulation in India

There is a basic division of power between the centre and the states in India, reflecting the federal nature of the Indian Constitution. The mandate of the Central Pollution Control Board (CPCB) is to set environmental standards for all plants in India, lay down ambient standards, and coordinate the activities of the State Pollution Control Boards (SPCBs). The implementation of environmental laws and their enforcement, however, are decentralized, and are the responsibility of the SPCBs. Anecdotal evidence suggests wide variations in enforcement across the states. In fact it has been argued (Gupta 1996) that although states cannot compete by lowering environmental standards in order to attract new investment, they can get around this by lax enforcement.

The two main pollution control statutes in India are the Water (Prevention and Control of Pollution) Act of 1974, and the Air (Prevention and Control of Pollution) Act which came into being in 1981. Thereafter, Parliament passed the Environment (Protection) Act in 1986. This was designed to act as umbrella legislation for the environment, with responsibility for administering the new legislation falling on the Central and State Boards. The law prohibits the pollution of water bodies and requires that generators of effluent/ discharges get the prior consent of the SPCBs. This consent to operate must be renewed periodically.

SPCBs have the legal authority to conduct periodic inspections of plants to check whether they have the appropriate consent to operate, whether they have effluent treatment plants, take samples for analysis, etc.[7] Some of these inspections are also programmed in response to public requests and litigation. The penalty for non-compliance is fines and imprisonment, but until 1988 the enforcement authority of the SPCBs was very weak. It was limited to criminal prosecution (with its attendant delays) and seeking injunctions to restrain polluters. Now, however, SPCBs have the power to close non-compliant factories or cut-off their water and electricity by administrative orders. The *potential* cost to the plants of non-compliance is thus

[7] "...to inspect sewage or trade effluents, works and plants for the treatment of sewage and trade effluents... or in connection with the grant of any consent as required by this Act." Water (Prevention and Control of Pollution) Act, 1974.

not trivial, so there should be an incentive for plants to comply with the law. However, compliance depends on *both* monitoring and enforcement of the law by the SPCBs.

Since water pollution regulations have been on the books longest, and there are well known and relatively inexpensive means of testing these emissions, we decided to focus on water pollution monitoring in this paper. Also, we examine the impact of inspections on water pollution emissions to assess just how successful the laws are in their implementation. It is often the case that organizations measure "success" in achieving their policy goals in terms of an increase in spending or the number of actions taken, rather than outcomes. For instance, assessing performance by counting the frequency or absolute number of inspections rather than the resulting environmental quality would be valid if, indeed, inspections have an impact on emissions. In the Indian context, despite a strong legal framework and the existence of a large bureaucracy for dealing with environmental regulation, the public perception is that implementation remains weak.

Given the penalties in force for non-compliance in India and keeping in mind the extent of the SPCBs' powers, it should be emphasized that the impact of inspections on compliance will be only as strong as the threat of enforcement and punishment faced by the plant. In an environment of corrupt local inspectors or bureaucratic procedures that hamstring action against errant behavior, inspections alone are unlikely to be effective. Also, the reality is that resource constraints at the state level mean that environmental management often degenerates into crisis management.[8] Inspections are undertaken at the time that operating consent is granted, and thereafter usually only in response to complaints, accidents or other emergencies.

In our sample of 250 plants, 51 plants indicated that they had undertaken abatement in response to NGO pressure and 102 said they had done so in response to complaints from neighbouring communities. This led us to conjecture that there would be a limited plant level response to inspections alone.

III. Model and estimation

We assume a competitive industrial structure where firms take output and factor prices as given. Pollution emissions are modeled as another factor of production in an extended KLEM framework. Firms face a

8 Conversation with Utpal Mukhopadhaya, former Environment Secretary in Maharashtra, India.

potential penalty for polluting which is a function of regulatory and community pressure. This penalty is increasing in emissions levels, Z; in the intensity of the direct regulatory monitoring and enforcement effort, μ; and in community bargaining power, which is proxied by the level of development, d, of the district in which the plant is located. The expression $\phi(Z,d,\mu)$, where $\phi_Z>0$, $\phi_\mu \geq 0$, $\phi_d \geq 0$, is a reduced form representation of the total pollution penalty faced by the plant. Thus each firm minimizes costs as described below:

$$\underset{L,K,E,M,Z}{\text{Min}}\ p_L.L + p_K.K + p_M.M + p_E.E + \phi(Z,d,\mu),\ \text{ s.t. } y \leq f(L,K,E,M,Z;\ \theta)$$

where y is output, L, K, E and M refer to labor, capital, energy, and materials respectively. θ captures exogenous shift factors. From the Kuhn-Tucker conditions for cost minimization we obtain the usual marginal conditions as well as the following implicit equation for optimal emissions at an interior optimum: $\lambda f_X - p_X = 0$, for X=L, K, E, M and $\lambda f_Z - \phi_Z(Z,d,\mu) = 0$, where λ is the Lagrange multiplier.

Solving this system of equations, we get a reduced form expression for equilibrium emissions. At a given level of output, y, emissions are $Z^* = \psi(y, p_L, p_K, p_E, p_M; \theta, \lambda, \mu, d)$. Reflecting the fact that regulatory effort is not uniform but varies in accordance with different priorities, including the perceived magnitude of environmental damage, degree of political power etc., inspections or monitoring, μ, are modeled separately as $\mu = \gamma(Z,d;\delta)$ with δ being a set of shift factors.

Thus we model emissions as a function of factor prices, scale of operation, indicators of informal pressure, regulatory pressure as measured by inspections, and shift factors (plant age, firm characteristics like whether they export or not, and whether or not they are publicly traded, and sector). Plant inspections, in turn, are modeled as dependent upon expected emissions levels, the use to which the water in the effluent stream is put, plant age and size, state per capita GDP and extent of manufacturing activity as measured by the number of plants, and the district's level of development. The latter is our proxy for environmental awareness and activism in the plant's vicinity that might lead to increased inspections - in response to complaints or other types of citizen action.[9] Although inspections are expected to be a function of *expected* emissions levels, since past pollution levels predict current emission levels very well (Magat and Viscusi 1990), we have used current emission levels to proxy for expected emissions in the inspection equation.

9 Recent work (e.g. Hettige et al (1996)) has analyzed the role of community action in directly pressuring polluters in several countries of South and South-East Asia, and we conjecture that literacy, urbanization, and income levels may be valid indicators of the same phenomenon in our sample. These variables are subsumed in the district development index used in our analysis.

Our empirical specification is as follows.

(1) BOD emissions:

$Z = \beta_0 + \beta_1$ Size $+ \beta_2\, p_L + \beta_3\, p_E + \beta_4\, p_K + \beta_5 \mu + \beta_6$age $+ \beta_7$exporter $+\beta_8$employment share $+ \beta_9$sector $+ \upsilon$

(2) Inspections:

$\mu = \alpha_0 + \alpha_1 Z + \alpha_2$ state manuf. $+ \alpha_3$ per capita gdp$+ \alpha_4$ district development$+ \alpha_5$ age $+ \alpha_6$ size $+ \alpha_7$recipient water body used for bathing $+ \alpha_8$ recipient water body used by downstream industry $+\omega$

Here, υ and ω are error terms, assumed to be iid normal and uncorrelated across the equations. Given the possible endogeneity of inspections and emissions, OLS is expected to lead to biased results. We have hence used two-stage least squares (2SLS) for our analysis.

We are agnostic about the coefficient signs on factor prices, since they are inputs into both the production of the final output, and emissions abatement, and can therefore have opposing effects. Organic water pollution is usually due to greater materials intensity, so to the extent that different factors are substitutes or complements of materials in production we would get appropriate coefficient signs.

We suspect that labor is a large component of abatement in the Indian context and so wages would be expected to have a positive coefficient. But, to the extent that labor and materials are complements in production, a move away from materials intensive methods would lead to a decline in organic water pollution, leading to a negative relationship. Our initial hypothesis is that the production effect is likely to outweigh the abatement effect.[10] Abatement requires both capital and energy so price increases for these factors would be expected to lead to a decline in abatement and a consequent increase in emissions. If the relationship between materials and energy or capital is one of gross substitutability, this would also lead to a move towards more materials intensive production, which would reinforce the positive impact on emissions.[11]

Our prior hypothesis was that large plants are likely to be less pollution intensive than small primarily because of scale economies in abatement, but also since smaller plants might lack technical information and

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10 The argument on production is more compelling for materials prices - which we do not have. Instead, we have used sectoral dummies to capture the very different materials intensity of production in different sectors.

11 For a discussion of these issues in greater detail see Pargal and Wheeler (1996).

access to financial resources, especially if capital markets are imperfect.[12] It appears likely that more concentrated industries would be more resistant to regulation, but since we lack data on the market concentration rates in these sectors we cannot include a measure of market power in our regressions.

Recent work using US data has found that multi-plant firms are more likely to be compliant than single plant firms, partly because there may be spillovers of a non-compliant reputation across plants belonging to the same firms leading to more stringent enforcement of regulations (Gray and Deily 1996). Thus we expected multi-plant firms to be more likely to have lower emissions than single plant firms, ceteris paribus. As mentioned earlier, we expected sensitivity to environmental news, and hence greater compliance and lower overall emissions on the part of traded firms than non-traded. Finally, based on anecdotal evidence, we expected plants with a greater exposure to foreign ideas and influence, like exporters, to be more likely to be in compliance than domestically owned plants.

IV. Data

As described above, the source for all the plant-level data was a survey of industrial plants in 8 states of India conducted in early 1996. Its coverage was fairly good both in terms of sector and state-wise distribution. Leaving out the plants in the cement sector, Table 1 lists the distribution of plants by state and Table 2 the distribution of plants by sector. In addition, we used district and state level data on prices and socio-economic characteristics. Data sources are listed in Appendix Table 1A, and summary statistics on the variables used in our regressions appear in Appendix Table 2A.

Table 1.

State	Number of Plants
Andhra Pradesh	30
Delhi	12
Gujarat	45
Karnataka	24
Maharashtra	25
Tamil Nadu	36
Uttar Pradesh	58
West Bengal	20

[12] The survey does not cover the huge informal small scale sector in India since those plants rarely have the means to test effluent or install pollution control equipment, and therefore do not have an accurate idea of their emissions levels or compliance status.

Total	250

Table 2.

Sectors	Number of Plants
Leather	40
Oil and Petrochemicals	22
Paper	68
Iron and Steel	55
Synthetic Fibre	11
Textiles	54
Total	250

The two main plant level variables used in the study are emissions and inspections. We have focused on Biological Oxygen Demand (BOD), the most commonly used measure of organic water pollution in both industrial and developing countries.[13] It is usually measured by the amount (kg) of oxygen used over five days to completely oxidize the organic pollutants in the effluent. The monthly average 5-day BOD measure generated by each plant is used in the analysis. Our inspection measure is the *total number of inspections that each plant has been subject to between 1990 and 1994*. Table 3 provides the mean number of such inspections per plant in our sample in each state, along with the total number of large and medium plants in the state.

We have used the number of years the plant has been in operation to measure the age of the plant. The export variable is a dummy indicating whether the plant is an exporter or not.

Table 3.

State	Average number of inspections per plant between 1990 and 1994	Total number of plants in the state
Andhra Pradesh	44	15972
Delhi	11	3346
Gujarat	27	1104
Karnataka	15	5850
Maharashtra	36	15264
Tamil Nadu	43	15502
Uttar Pradesh	15	10124

[13] BOD measures the oxygen used during the breakdown of organic pollutants by naturally-occurring micro-organisms. This process removes dissolved oxygen from the water and can seriously damage some fish species as well as accelerate the growth of undesirable algae.

West Bengal	10	5679

Since data on per capita income or consumption at the district level was not available, we have used instead an index of district development which was created by the Centre for Monitoring the Indian Economy (CMIE). This is a weighted average of the value of sectoral output, the level of bank credit to each primary sector, labor force participation rates, savings rates, literacy and urbanization.[14] We expect it to be highly correlated with income.

We use per capita state domestic product to measure the overall level of development of the state, which is a proxy for state-level interest in environmental regulation. We expect more developed states to focus more on environmental regulation. The number of large and medium manufacturing facilities that are subject to regulation is used to indicate the size of the regulated manufacturing sector in the state. In the absence of relevant district level data on labor and energy prices, we have used the state level manufacturing wage and electricity tariff for industry. Given the substantial heterogeneity that exists across states (and homogeneity within states) in factor prices, our variables appear to be good proxies. The rate of interest is the state-wide average rate at which the firms can borrow.

[14] The population density of the district as well as the population in the surrounding community were considered as other possible proxies, but not used due to their high collinearity with the development index.

V. Estimation results

We feel strongly that the inspection and emissions equations are not independent. We expect high emissions levels to trigger inspections and a significant impact of inspections on emissions. Also, many of the same variables are expected to determine inspections as emissions. We have hence used two stage least squares methods to estimate both equations. We report both 2SLS and OLS estimation results in Tables 4 and 5 below. From the similarity of coefficient estimates under both OLS and 2SLS for the BOD equation, it appears that inspections are truly exogenous as determinants of BOD emissions levels. On the other hand, this is not the case for the inspections equation.[15] First stage regression results are reported in the Appendix (Tables 3A and 4A).

Table 4. DEPENDENT VARIABLE: LOG NUMBER OF INSPECTIONS

Independent Variables (in logs)	**OLS**		**2SLS**	
	Coeff.	T-stat.	Coeff.	T-stat.
BOD load	0.120	1.918*	0.235	2.116**
Output	0.024	0.345	-0.042	-0.516
Age of Plant	0.108	0.503	0.138	0.626
Development Index	0.669	4.299**	0.671	3.563**
Number of Plants in State	1.153	3.05**	1.027	2.697**
Per Capita State Domestic Product	0.361	0.718	0.571	1.039
Water Used for Bathing	0.786	2.872**	0.616	1.900*
Water Used for Industrial Purposes	-1.146	-2.741**	-1.323	-3.089**
Constant	-16.802	-3.185**	-18.224	-3.253**
Number of Observations	75		71	
R^2	0.37		0.36	

* * significant at 5% confidence levels
* significant at 10% confidence levels

The inspection equation indicates that inspections are focused on plants whose emissions levels are high, and whose effluent flows into water bodies which are used for non-industrial purposes.[16] Inspections also

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15 A Hausman test failed to reject the hypothesis of exogeneity for the two equations.

16 End-use of the water body receiving the effluent was classified among bathing, irrigation, drinking, fishing, industry, recreation, and other. The use for bathing was highly correlated with fishing (0.62), irrigation (0.31) and drinking (0.53), so we used a dummy for bathing in the analysis.

occur significantly more frequently in more developed districts. They are strongly positively associated with the size of the manufacturing sector as measured by the number of plants in the state and, unsurprisingly, are not related to plant characteristics like age and size once total emissions have been controlled for.

The large positive and significant elasticity of inspections with respect to the number of plants in the state indicates that the latter may be a structural determinant of funding for monitoring and enforcement. In other words, funding for inspectors and equipment appears to be allocated by state pollution control boards in line with the perceived magnitude of the regulatory problem. The strong positive relationship between inspection rates and district development is interesting, although not entirely surprising. The economic efficiency argument for targeting monitoring resources to areas where the valuation of damages and willingness-to-pay to avoid damage is relatively high has been mentioned earlier. In addition, it may well be the case that these areas are perceived as being more likely to complain or make use of political or other channels to pressure regulators to take action against polluters. If this were a diversion of regulatory resources away from legitimate problems it would be a concern on both ethical and economic grounds. However, from the results on load and end-use of effluent it appears that inspections do take place in response to the correct signals on environmental damage.

In this regard, the BOD equation is somewhat surprising since it indicates that total BOD emissions are unaffected by inspections.[17] This raises obvious questions about the nature of enforcement, including the level of fines and probability of punishment, as well as the possibility of corrupt inspectors. At the same time it supports the view of Indian analysts that abatement equipment is only activated when inspections are scheduled to occur.[18]

A particularly intriguing aspect is why inspections should be significantly higher in more developed districts. If this is in response to expectations or actual exertion of community pressure, as has been posited above, then, given the lack of a plant response to inspections, one wonders about the rationality of such expectations or such pressure. A somewhat depressing alternative explanation is that richer districts

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[17] The contemporaneous nature of this dataset leaves us with no way of assessing whether there is, in fact, a lagged impact with inspections affecting BOD emissions in the next period.

[18] Communication of Vandana Bhatnagar, TERI.

may be where opportunities for rent seeking by state inspectors are highest, resulting in perverse incentives to inspect (to say the least).

Returning to the estimation results, we note that BOD load is increasing in output, but at a decreasing rate, so that per unit output larger plants are cleaner than smaller ones. This is a very robust result and corroborates evidence from other countries. Plant age is not a significant variable.[19] The export dummy is negative and close to significance, indicating that foreign influence may not be as big an influence on clean production or abatement as has been hypothesized in the literature.[20] Again this is consistent with the findings of other research.

Table 5. DEPENDENT VARIABLE: LOG BOD LOAD

Independent Variables (in logs)	**OLS**		**2SLS**	
	Coeff.	t-stat.	Coeff.	t-stat.
Number of Inspections	0.165	1.368	0.279	1.168
Output	0.366	3.944**	0.368	3.898**
Age of Plant	0.287	1.041	0.264	0.931
Export dummy	-0.754	-1.600	-0.750	-1.598
Share of Employment	0.546	2.998**	0.523	2.683**
Development Index	0.247	0.638	0.204	0.556
State Rate of Interest	-10.481	-3.854**	-10.476	-3.765**
State Electricity Price	7.940	3.802**	7.487	3.1**
State Manufacturing Wage	-1.647	-2.200**	-1.465	-2.158**
Paper dummy	1.848	2.319**	1.868	2.305**
Textile dummy	-1.277	-1.948*	-1.229	-1.793*
Leather dummy	-0.324	-0.443	-0.228	-0.292
Constant	16.842	1.716*	17.080	1.685*
Number of Observations	71		71	
R^2	0.599		0.596	

* * significant at 5% confidence levels
*   significant at 10% confidence levels

19 A more accurate measure of age would be the vintage of capital. Although our data did include a measure of the average age of capital stock, too few plants reported it for us to be able to use it in our regressions. However, it was highly correlated (0.7) with plant age, so we may not be too far off in using it.

20 See, for instance, Eskeland and Harrison (1997).

The coefficient on the dummy for whether or not a plant is traded on the stock market is not significant, implying that market reputation concerns have yet to be translated into stock price effects in India. Since 37% of the plants in our sample are traded on Indian bourses, this points to the fact that environment related information is not used much by traders in India. This may also reflect the fact that environmental liabilities are (correctly) perceived to be insignificant. The coefficient on multi-plant status was not significant in the inspection equation. We hence dropped both the traded dummy and the dummy for multiplant status from the reported regressions.

State manufacturing wage is significantly negatively associated with BOD emissions indicating that labor and materials are complements in production, and that this effect outweighs any effect of lower wages on abatement effort. The elasticity of BOD emissions with respect to the statewide rate of interest is highly negative, indicating complementarity of capital and materials in production in the sectors being examined. The strong positive elasticity of BOD emissions with respect to electricity price implies a relationship of gross substitution between materials and energy that would reinforce the impact of energy prices on the running of abatement equipment.

Of the sectoral dummies included in the regression, paper is highly significant and positive, indicating that this is much dirtier than the other sectors, while textiles (which here includes spinning units as well as dying and finishing units) is relatively cleaner.

Coming to the location specific factors that might be expected to reflect informal pressure on plants, we find that BOD emissions are not affected by whether or not the plant is located in an area with high levels of development, as measured by the development index. These would be the very communities we would expect to lobby hard and negotiate forcefully for lowered emissions.

At the same time, plants that are seen to be big employers in the district, as measured by their share of total district employment, are significantly larger polluters than others. This supports the idea that these plants are subjected to no (or little) pressure from district and local organizations because of the huge leverage they have by virtue of their employment generating ability. As mentioned earlier, this is consistent with the findings of Gray and Deily (1996) who find that enforcement effort is less likely to be directed towards plants when the political costs in terms of unemployment are likely to be high.[21] Local employment share was not a significant determinant of the inspections equation, so we infer that in the BOD equation this variable reflects the level of local pressure alone.

VI. Conclusions

This paper shows that high levels of pollution elicit a formal regulatory response in the form of inspections in India. However, there appears to be no impact of inspections on emissions, underlining the institutional failures that Indian academics have been concerned about.[22] In the most positive interpretation, inspections are probably ineffective in bringing about desired changes in behavior because of bureaucratic or other problems in following through - the probability of enforcement is low and the penalty for non-compliance is not stringent enough to act as a deterrent. On a more pessimistic note, inspections in an environment of poorly paid inspectors with poor morale may be opportunities for rent seeking more than anything else.

We cannot come to a strong conclusion about the efficacy of inspections, however suggestive our initial results, simply because our data do not allow us to look at actual compliance or non-compliance, which are the relevant results of interest. In the absence of time series data we are also unable to infer a causal relationship between inspections and reduced emissions. An important task for future research would be to examine the impact of lagged inspections on emissions.

Our results on proxies for informal sources of pressure on industrial plants are ambiguous. Our work in other countries has indicated that communities are often able to pressure plants to reduce emissions and that better educated and higher income communities are better able to do so. However, we find little evidence in support of this thesis in this analysis of Indian manufacturing plants. At the same time we are bemused by the significantly higher level of inspections observed in more developed districts.

There are at least two possible explanations for why BOD emissions may be independent of the district development index. On the optimistic side, this may be the result of community activism being unrelated to levels of urbanization, income, and education so that dirty plants are targeted, irrespective of where they

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[21] Pargal and Wheeler (1996) find the opposite result on emissions for Indonesian plants that are large employers. Unlike this analysis, they do not control for formal regulation in that paper.

[22] Comment of Professor Murali Patibandla, Indian Institute of Management, Ahmedabad.

are located. Less sanguinely, this may be because direct community pressure on plants is not a major determinant of emissions reduction in our sample of Indian firms. In support of the latter thesis, we noted that pressure from neighbours and NGOs were not significant as predictors of lowered BOD levels in India although the plants in our survey identified them as being important factors in inducing abatement.

We have controlled for the impact of formal regulation on emissions, as measured by plant inspections. Since there does not appear to be any residual variation in emissions by location in our sample, but there is a large variation in the rate of inspection by location, we infer that the community pressure that exists is probably channeled through the formal mechanism rather than through direct negotiation with plants. It may well be that plants in India are less amenable to meeting with representatives of the community or that the community has trouble organizing itself to negotiate with plants. Also, our sample consists of large and medium sized enterprises which may be less susceptible to direct pressure than smaller entities. All in all, this analysis provides no evidence of successful informal pressure on plants in India. More ominously, the lack of an impact of inspections on emissions points to severe problems in the working of the formal regulatory system. Under these circumstances, the Indian public's recourse to Public Interest Litigation seems perfectly rational.

Our other findings are interesting because they support the plant level regularities in pollution control costs observed by other analysts.[23] The evidence that larger plants are relatively "cleaner" than smaller ones is consistent with findings in the rest of the world. Indian policy makers and regulators thus need to explicitly recognize the trade-off in environmental quality of the existing regulatory bias towards the small and medium scale sector.

[23] See, for instance, Dasgupta et al. (1996).

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Appendix

Table 1A. Data Sources

Variable	Source
Plant data	
BOD load (mg per month)	PRDEI Industrial pollution survey, 1996
Output (Rs. 1000)	PRDEI Industrial pollution survey, 1996
Total number of inspections (1990-94)	PRDEI Industrial pollution survey, 1996
Effluent use	PRDEI Industrial pollution survey, 1996
Age of plant	PRDEI Industrial pollution survey, 1996
Whether exporter	PRDEI Industrial pollution survey, 1996
District data	
District development index	CMIE: Profile of Districts
Plant employment share in districts manufacturing work force	PRDEI Industrial pollution survey, 1996 and CMIE: Profile of Districts
State data	
Total number of manufacturing plants in state	Annual survey of industries, 1992-93
State domestic product per capita (1992-93)	Economic Survey of India, 1994-95
State manufacturing wage (Rs/year) (1992-93)	Annual survey of industries, 1992-93
State rate of interest (percent)	PRDEI Industrial pollution survey, 1996
State electricity price (paisa/kilowatt hour)	TERI: Energy Data and Directory Yearbook, 1995-96

Table 2A. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Plant data					
BOD load (mg per month)	124	1.00E+09	7.52E+09	80000	8.10E+10
Output (Rs. 1000)	250	4.65E+08	2.27E+09	0	2.25E+10
Total number of inspections (1990-94)	243	27	30.48113	1	132
Water used for bathing purposes	250	0.088	0.283863	0	1
Water used for industrial purposes	250	0.132	0.33917	0	1
Age of plant	240	20.19583	20.69138	0	121
Whether exporter	233	0.300429	0.459432	0	1
District data					
District development index	250	4.843267	0.649739	3.688879	6.556778
Plant employment share in district manufacturing work force	244	0.00053	0.001348	7.09E-06	0.01331
State data					
Total number of manufacturing plants in state	250	11197.54	3940.71	3346	15972
State domestic product per capita (1992-93)	250	6512.528	1874.3	4280	11650
State manufacturing wage (Rs/year) (1992-93)	250	24489.75	5769.686	15832.35	38600.17
State rate of interest (percent)	250	18.22964	1.327959	14.7	20.02
State electricity price (paisa/kilowatt hour)	250	211.6532	21.85969	149.5	232.9

Table 3A. First stage regression results

DEPENDENT VARIABLE : LOG BOD LOAD

Variable (in logs)	Coef.	t stat
Output	0.499	3.58**
Age of Plant	0.425	1.456
Export dummy	-0.550	-1.165
Share of Employment	0.391	1.723*
Development Index	0.451	1.14
State Rate of Interest	-8.196	-1.622
State Electricity Price	8.334	3.638**
State Manufacturing Wage	-1.605	-1.56
Paper dummy	1.672	2.862**
Textile dummy	-1.214	-1.838*
Leather dummy	-0.110	-0.144
Number of Plants in State	0.214	0.398
Per Capita State Domestic Product	-1.156	-0.991
Water Used for Bathing	1.217	1.966*
Water Used for Industrial Purposes	0.160	0.281
Constant	10.849	0.797
Number of Observations	72	
R^2	0.511	

* * significant at 5% confidence levels
*   significant at 10% confidence levels

Table 4A. First stage regression results

DEPENDENT VARIABLE : LOG OF INSPECTIONS

Variable (in logs)	Coef.	t stat.
Output	-0.036	-0.559
Age of Plant	0.195	1.52
Export dummy	0.309	1.406
Share of Employment	0.290	2.835**
Development Index	0.454	2.494**
State Rate of Interest	0.395	0.212
State Electricity Price	2.475	2.548**
State Manufacturing Wage	-1.907	-3.751**
Paper dummy	0.457	1.773*
Textile dummy	-0.289	-1.093
Leather dummy	-0.766	-2.333**
Number of Plants in State	0.734	2.662**
Per Capita State Domestic Product	1.255	2.686**
Water Used for Bathing	0.575	1.683*
Water Used for Industrial Purposes	-0.904	-2.811**
Constant	-9.862	-1.362
Number of Observations	161	
R^2	0.287	

* * significant at 5% confidence levels
*   significant at 10% confidence levels