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The Drivers of Firms' Compliance to Environmental Regulations

The Case of India

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Abstract

Regulatory compliance is key in the fight against climate change and other environmental challenges. But regulatory agencies, especially in developing countries, are often hampered by their capacity to monitor and enforce standards and regulations against recalcitrant firms. There is now a big push toward self-reporting whereby the firms monitor and report on their compliance levels vis-à-vis the standards. This is seen as a way around the costs that agencies must incur if they were to scale up their inspections. In this paper, extensive firm-level data from India are used to compare the compliance level of firms when they are inspected by agencies versus the times when they self-report. Other factors that may determine regulatory compliance, such as age, size, sector, location, and so forth, are also examined. The results indicate that compliance rates are higher in the case of self-reporting than in the case of inspection, suggesting that there is a need to reform the self-report mechanism. Newer and privately owned firms are more compliant. There are also differences between complying with air and water pollution. Finally, the paper examines whether environmental monitoring through inspections leads to improvement in compliance levels, to assess the effectiveness of the regulations and inspections. The findings suggest that the increase in compliance is limited to a few industries.

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The drivers of firms' compliance to environmental regulations: the case of India

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1 Introduction

Regulatory compliance, especially by industries, is key in the fight against climate change and other environmental challenges. This is important since industrial pollution is not only responsible for a large share of the air and water pollution generated in most countries, but also accounts for a sizable share of carbon emissions. One of the biggest concerns in developing economies is that rapid economic growth can often be accompanied by a similarly rapid deterioration of the environment and an increase in pollution. The rapid economic expansion of the Chinese economy since 1990 significantly contributed to the country's worsening of environmental quality.

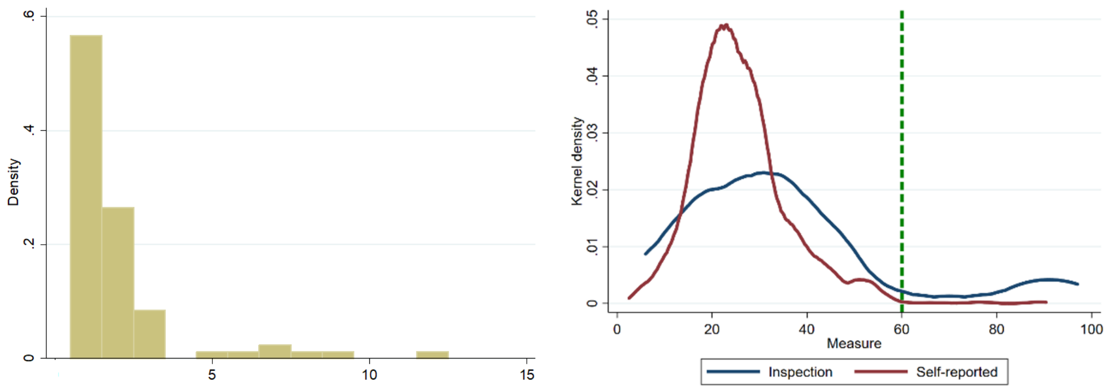
Existing evidence linking health to air pollution shows that sustained exposure to air pollution impacts life expectancy (Ebenstein, Fan, Greenstone, He, and Zhou, 2017). In India, it is estimated that emissions from coal-fired power plants caused 85,000 deaths in 2015 and will cause 400,000 deaths in 2050 if coal-fired generating capacity continues to expand (HEI, 2018). But there is also evidence of more direct implications of pollution on economic performance. For instance, outdoor air pollution severely affects the productivity of indoor workers (Graff-Zivin and Neidell (2012), Chang, Zivin, Gross, and Neidell (2016), Adhvaryu, Kala, and Nyshadham (2016), He, Liu, and Salvo (2016)). High levels of pollution persist despite strict emission standards on the books in most of the developing countries. Bombardini and B. Li (2020) find that the pollution content of exports affects pollution and mortality through pollution concentration.

Moreover, a recent World Bank report on global water quality finds that poor water quality is costing nations more than previously thought. It highlights that in middle-income countries, GDP growth falls by half in areas downstream of highly polluted water bodies (Damania and others, 2019). For countries like India that have been growing fast, this is a concern. However, Mani (2015) shows that low-cost policy options could significantly curtail environmental damage without compromising long-term growth objectives.

Improving the regulator's information can significantly contribute to reducing environmental deterioration through improved enforcement. But regulatory agencies in developing countries cannot often monitor and enforce regulatory standards against the recalcitrant firms. They also lack the necessary instruments such as penalties or fines to punish the noncomplying firms. For this reason, this paper focuses on better understanding the determinants of firm-level compliance with environmental regulations in a developing country like India under budget constraints that can limit enforcement capacity of environmental regulations on paper. This paper contributes to filling this important gap in the regulator's information on plant-level pollution.

Figure 1 from available data for India shows that regulators aggressively target discretionary inspections, to the degree that more than half of the inspected plants receive one or two inspections per year, while plants that are arguably expected to be the dirtiest receive more than ten. This suggests that regulators assign inspections where they expect to reduce pollution levels more severely. There is now a move towards encouraging the firms to self-report their compliance levels considering the capacity constraints of the regulatory agencies. Figure 1 also shows that the number of self-reports also varies widely across firms.

(a) Annual inspections by firm **(b) Inspection and self-report**



Note: (a) year 2013. (b) The air pollution measure indicator is PM2.5 ug/m3.

Figure 1: Annual inspections and differences between inspections and self-reported measures

High pollution levels persist in India despite having historically strict environmental laws. This means that the problem is more in the enforcement of environmental regulations rather than the regulations per se. How a firm's emission standards are enforced is the key, and the discretion of the regulators in this task can be very important when faced with budget constraints. Whether regulatory discretion helps or hinders enforcement is generally uncertain. While discretion can often be abused, it also allows regulators to use local information to strengthen enforcement. Duflo et al. (2018) experimentally doubled the rate of inspection for treatment plants and required that the extra inspections be assigned randomly. They found that treatment plants only slightly increased in compliance levels.

They also found that the regulators often aggressively target their discretionary inspections, to the degree that half of the plants receive fewer than one inspection per year, while plants expected to be the dirtiest may end up receiving up to ten or more. More importantly, they found that discretion in targeting helps enforcement. Inspections that the regulator assigns cause almost three times more abatement than would the same number of randomly assigned inspections. At the same time, the regulator's information on plant pollution is often found to be poor, and improvements in monitoring can significantly reduce emissions.

In this paper, a unique firm-level data set from India is used to compare and analyze the compliance levels of firms that are inspected versus the ones that self-report. Attempt is also made to identify other factors that may be influencing compliance levels such as size, sector, age, location, etc. The main objective of the paper is to broadly examine the drivers of compliance of firms with regards to environmental regulations. The analysis is based on unique information available on compliance as well as firm and location characteristics of 150 firms and inspection data for 5 years. As India is increasingly moving to encouraging self-reporting, the paper also compares the measurements of air and water pollution to see how these measures differ as reported in the inspection data and when they are self-reported by the firms.

While enforcement is seen as crucial for environmental quality, it is often found to be ineffective and wanting. Regulators are quick to blame resource constraints for not being able to carry out what is on their books. Others offer less charitable explanations, for example, that regulators with wide discretion choose not to enforce the given standards due to corruption, laziness, or incompetence (Stigler (1971), Leaver (2009)). In 1996, the High Court of Gujarat ordered the Gujarat State Pollution Control Board (GPCB) to install a third-party audit system wherein plants from polluting sectors must provide an annual audit report to GPCB. Duflo et al. (2013) evaluated a reform of this audit system and found that the third-party auditors were far more accountable to the regulator and less beholden to the plants and audits improved compliance and lowered pollution levels.

The rest of the paper is structured as follows: Section 2 presents the history of environmental regulation in India. Data and descriptive statistics are presented in detail in Section 3. Section 4 outlines the empirical approach and Section 5 presents the results. The conclusions are presented in Section 6.

2 History of Environmental Regulation in India

2.1 Legal Framework

India has several national-level policies governing environmental management, including the National Policy on Pollution Abatement and the National Conservation Strategy (1992) and Policy Statement on Environment and Development (1992). While these national policies are not judicially enforceable, they serve as guiding principles for the central and state governments to follow. The National Environment Policy (NEP) of 2006 is the most recent pronouncement of the government's commitment to improving environmental conditions while promoting economic prosperity nationwide. The NEP's broad environmental objectives include conservation of critical environmental resources, intra-generational equity, livelihood security for the poor, integration of environment in economic and social development, efficiency in environmental resource use, environmental governance, and enhancement of resources for environmental conservation. This policy promotes mainstreaming of environmental concerns into all development activities, advocating important environmental principles, and identifying regulatory and substantive reforms.

India has an elaborate legal framework with over 200 laws relating to environmental protection. Key national laws for the prevention and control of industrial and urban pollution include the following:

- Water (Prevention and Control of Pollution) Act of 1974, amended in 1988.
- Water (Prevention and Control of Pollution) Cess Act of 1977, amended in 1991
- Air (Prevention and Control of Pollution) Act of 1981, amended in 1987
- Environment (Protection) Act of 1986 (EPA)
- Public Liability Insurance Act of 1991
- National Environmental Tribunal Act of 1995
- National Environmental Appellate Authority Act of 1997

These Acts empower the central and state pollution control authorities to enforce emission and effluent standards for industries discharging pollutants into air and water. The Water Cess Act, on the other hand, stipulates the use of fees for water abstraction. The

Water Act vests regulatory authority in State Pollution Control Boards (SPCB) to establish and enforce effluent standards for facilities discharging pollutants into water bodies. The Air Act provides for the prevention, control, and abatement of air pollution.

With the framework of the Water Act and the Air Act, the central and state boards have the authority to issue consents to industries operating within designated air pollution control areas. The Central Pollution Control Board (CPCB) coordinates activities between the states and performs regulatory functions for union territories. The central and state boards are authorized to control domestic and industrial discharge via consents to establish (CTE) and consents to operate (CTO) and to advise state governments on the siting of industrial projects. States also prescribe emission standards for stationary and mobile sources. Under the Environment Protection Act, the central government sets national ambient and emissions standards, establishes procedures for managing hazardous substances, regulates industrial siting, investigates and researches pollution issues, and establishes laboratories. In recent years, the Supreme Court of India and some High Courts of the states have led the way in the enforcement of environmental laws through citizen-led public interest litigation (PIL) that has its legal basis in the constitutional right to a healthy environment.

2.2 Penalties for Non-Compliance

Under the Water Act, the Air Act, and the EPA, the pollution control boards have the authority to issue and revoke consents to operate, require self-monitoring and reporting, conduct sampling, inspect facilities, require corrective action, and prescribe compliance schedules. The enforcement powers also include emergency measures of disconnecting water or power supply and facility closure, for noncompliance which are widely used in some states. In case of violation of hazardous waste management rules, the SPCBs can, with CPCB approval, impose administrative fines for any violation of those rules. Other sanctions (fines and imprisonment) for violation must be pursued only under the criminal authority of the courts. All three laws also include provisions for citizens to bring legal actions. Citizens must provide the Central Government with 60 days advance notice of their intention to file a complaint to allow the government to take remedial action. Under the public interest litigation process, however, the Supreme Court of India and the High Courts have recently relaxed standing and other procedural requirements so that citizens may file suits by a simple letter without the use of a lawyer and appear before "green benches" (specially assigned environmental judges).

A key challenge for the SPCBs in enforcing the regulations is the lack of civil administrative authority (particularly, to impose administrative fines) which limits the effectiveness of their enforcement efforts and leads to over-reliance on the judiciary for enforcement. Filing criminal cases against violators in trial courts or reacting to PILs is a time-consuming, unpredictable, and ineffective enforcement mechanism. Criminal cases brought by SPCBs often have a low conviction rate (although that varies greatly between the states). Significant human and technical capacity constraints are also factors in terms of the effective execution of all compliance and enforcement related functions, especially at the state level.

Currently, India requires industries to monitor some compliance parameters through self-reporting. But that information is used only as an indicator of compliance. The government does not utilize it as direct evidence of a violation in the courts. Instead, the government relies solely on legal samples that are resource-intensive and time-consuming to collect; are frequently challenged for procedural deficiencies; and often are not representative of a facility's compliance status. Shifting the burden of compliance monitoring away from the government to the regulated community would enable the government to evaluate and determine compliance for a larger number of regulated sources on a more frequent basis in a more cost-effective manner (USEPA, 2005).

3 Data and Descriptive Statistics

3.1 Data

The data for the study were obtained from the Odisha State Pollution Control Board (OSPCB) for 150 key large and medium firms for the period 2009-2014. The board assesses compliance by a firm through onsite inspections as per the Air Act and Water Act. All large and medium firms and red category small-scale firms are inspected at least once every six months and once a year, respectively. OSPCB inspectors carry out two main types of inspections: (i) compliance evaluation inspections where a firm's pollution control facilities, monitoring methods, and records are examined, which amounts to verification of initial compliance by a firm, and (ii) compliance sampling inspections where air/water samples are collected onsite. Pollution control devices and testing procedures with the firm (if any) are also inspected. Such inspections check for continuing compliance by a firm.

A firm as defined here may have many factories/facilities in the same or different locations. Each facility may have various pollution endpoints such as stacks for air pollution or discharge points for water pollution. Although facilities are supposed to be inspected at least once every six months or a year, because of the limited capacity of the OSPCB, there is an element of randomness to how many times a facility gets inspected during the five-year period for which data were obtained. It is not obvious if the inspectors go more frequently to the facilities that do not usually comply or to the most polluting facilities or any other metric such as availability of an inspector in the regional office that determines the frequency of inspections. In addition to the inspected data, the firms are also required to submit self-monitored data. For example, the Air Act requires facilities to monitor pollutants such as sulfur dioxide, carbon monoxide, nitrogen oxides, particulates, and metals. Under the Water Act, facilities are required to monitor parameters such as total coliform, turbidity, pH, color, odor, taste, and pollutants such as phenolic compounds, pesticides, metals, fluoride, nitrate, chlorides, and sulfate. The monitoring frequency and methodology vary for each industry and type of pollutant. But the facilities are generally required to maintain records and report the information periodically to the pollution control board.

The following data were recorded from the OSPCB database (i) company id; (ii) monitoring point id; (iii) year started (age); (iv) industry; (v) products; (vi) company name; (vii) location name; (viii) sample date; (ix) inspection/self-reported; (x) environment category (air/water); (xi) indicator monitored (PM 2.5, Sox etc.); (xii) data value; (xiii) standard; (xiv) minimum; (xv) maximum; (xvi) monitoring frequency; (xvii) compliance ratio; (xviii) compliance status; (xix) district; (xx) employment; (xxi) output capacity; (xxii) output capacity units; and (xxiii) ownership (public/private). The summary statistics are given below.

While the SPCB's mostly rely on inspected data, increasingly, self-monitoring, record-keeping and reporting are being recognized by the Central Pollution Control Board (CPCB) as providing essential data to supplement and support inspections. This approach is well established and accepted in addressing environmental compliance and enforcement problems in many countries, such as the United Kingdom, Germany, the United States, Japan, Thailand, and others. In the United States, data gathered through self-monitoring are relied upon extensively to determine compliance and take enforcement actions. To ensure the integrity of the data, EPA requires facilities to self-certify their compliance annually and makes all

Industry	Ownership		Total
	Private	Public	
Aluminium	900	174	1074
Cement	1416	0	1416
Distillary	39	0	39
Ferroalloys	608	0	608
Mines	8717	3611	12328
Paper	307	0	307
Sponge iron	1187	0	1187
Steel	2319	149	2468
Sugar	162	49	211
Thermal power	1222	1009	2231
Total	16877	4985	21862

Table 1: Number of observations by industry and ownership

the underlying information publicly available. Company officials are personally liable for false reporting. Falsification of data is considered one of the most serious offenses and may be prosecuted criminally. Sanctions involving substantial penalties and imprisonment are available.

3.2 Summary Statistics

Table 1 provides some evidence that the regulator targets industries differently. Inspections seem to be directed towards firms that are potentially more pollutant. At the same time, table 1 also shows the differences in the ownership of the firms by industry.

Figure 2 goes deeper on this by showing the annual average number of inspections by industry in the Indian state of Odisha. Industries like mines receive much more inspections than the rest of the industries. Also, thermal power and steel receive more inspections than for instance sugar and distillery. This is in line with the intuition that certain industries are expected to be more pollutant than others.

Figure 3 shows that the compliance ratio varies by pollution category, either it is water or air pollution. This suggests that the challenges vary by the type of pollution at hand. Figure 3 also shows that firms tend to self-report to be more in compliance than what actual inspections find out to be true. This confirms that while self-reporting can be useful, it is far from being a perfect instrument given the institutional setup in India in which self-report cannot be used to punish firms.

Figure 4 adds to this evidence and shows that there are also differences in the compliance

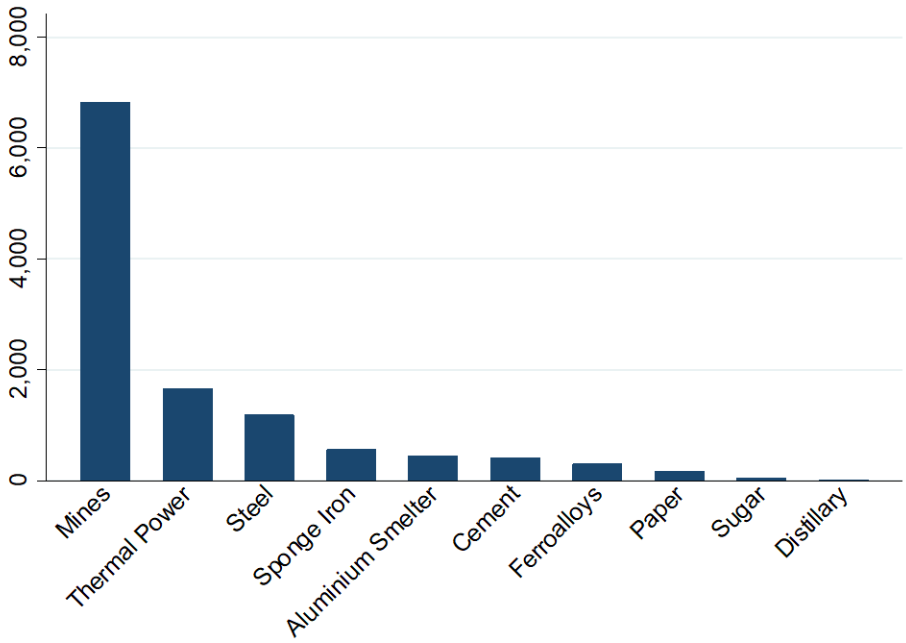


Figure 2: Number of inspections per year by industry

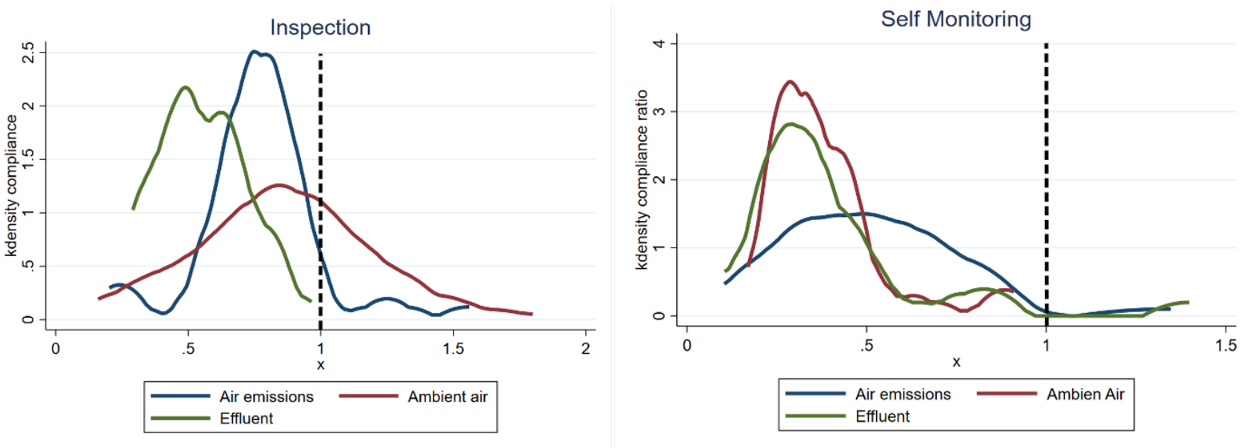


Figure 3: Compliance ratio by inspection mode

depending on the ownership of the firm and that ownership interacts with self-reporting. This opens the door to better understand the determinants of firms' compliance with environmental regulations.

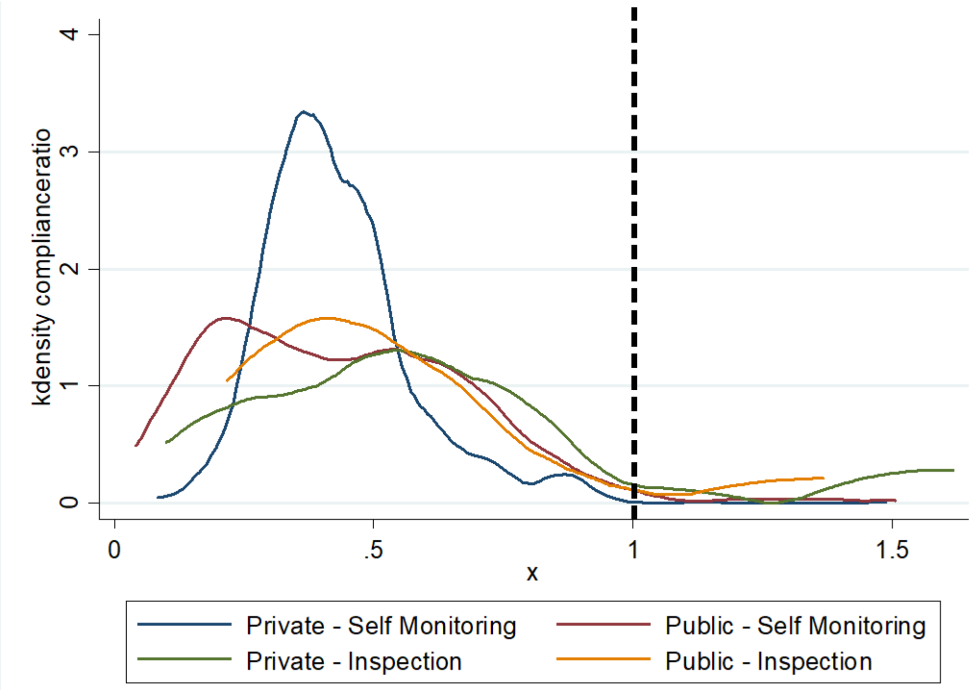


Figure 4: Compliance ratio by ownership and report mode (PM2.5 ug/m3)

Finally, Table 2 shows a summary of the results of the inspections and self-reports. Firms are found to be mostly in compliance, both in inspections and self-reports, given the environmental standards in place. The key will be to understand the drivers of compliant versus not compliant firms.

Compliance status	Inspection	Self-reported	Total
In compliance	3187	17565	20752
Not in compliance	813	297	1110
Total	4000	17862	21862

Table 2: Compliance by inspection/self-reported status

4 Empirical Strategy

In the standard economic model, a facility chooses its compliance level by balancing the expected costs of polluting with the expected benefits of doing so. This is consistent with the traditional law and economic framework that originated with Becker (1968) and Stigler (1970) and as summarized in Polinsky and Shavell (2000). A facility's environmental performance is thus defined by the marginal variable costs of abatement, as determined by technology, industrial characteristics, and other factors. If marginal abatement costs are small, facilities may maintain low emissions even in the absence of significant regulations. The benefits of pollution are determined by the level of monitoring and enforcement by the environmental agency. The harsher are the penalties associated with noncompliance, the lower will be the benefit of noncompliance. Community characteristics may also influence environmental behavior in several ways. For example, Pargal and Wheeler (1996) found statistically and economically strong relationships between the BOD pollution intensity of Indonesian industrial sources and income, education, and population density.

Locational characteristics may also correlate with political action or bargaining power more broadly, and facilities in wealthier, better educated, and more socially active neighborhoods may face greater incentives for pollution abatement. Pargal and Mani (1998) show how citizen activism can play a role in influencing a firm's location decision. Also, facilities that expect consumers to lobby for stringent environmental regulation might voluntarily incur the necessary costs to reduce current emissions if this reduction prevents consumers from lobbying in the first place. In other words, facilities accept increased current abatement costs to prevent even larger regulatory costs in the future. On the other hand, industries often lobby the governments to keep environmental regulations lax and often succeed in politically unstable environments (Damania, Frederickson and Mani, 2004). Site-specific factors may also relate to income, consumer purchasing power, and preferences, and therefore community composition may influence environmental performance (Arora and Gangopadhyay (1995), Kirchoff (2000), and Cavaliere (2000)). Another important determinant of environmental behavior is the firms' ability to influence future regulatory action. If the facility is a large employer in the area, it may have some leeway in terms of regulatory compliance. Ownership structure and investor pressure may also affect environmental performance in the traditional economic model. For example, public companies may be less inclined towards emissions reductions than privately-owned companies. Similarly, foreign companies may be more amenable to complying than domestic firms although some argue that foreign companies disregard local communities' preferences.

The paper focuses on understating the drivers of a firm's compliance, and especially to contribute to the value of regulatory discretion: estimates from environmental inspections and self-reports in India. Given the binary nature of "compliance," the paper estimates the effect on the probability of complying. For this purpose, the empirical strategy uses a probit estimator as follows:

$$P\left(y_{it}=1|x\right)=G(\beta_2 self+\beta_3 own+\beta_4 category+\beta_5 age+FE_{dist,year}+\varepsilon_{ijt}) \quad (1)$$

where G is a normal distribution. The variable "self" captures the differential compliance in self-reports and actual inspections. Important characteristics for policy insights are added like the private or public ownership of the firm, the "category", referring to air and water pollution differences, and the effect of the firm's age on compliance levels. Industry and year fixed effects are used except in the analysis to estimate industry-level regressions. Since in India self-reporting cannot be used to penalize a firm, one would expect higher levels of compliance.

5 Results

This section presents the results based on the inspection and self-reported data. One can start by studying the differences between both types of data to assess the validity of self-reported data. Once this characterization is done, it is easy to then carry out the analysis by differentiating both types of information.

5.1 Self-Reporting vs Inspection Data

Table 3 presents the regressions with the pooled data, using both inspection and self-monitoring data. In all regressions of the table, and in the pooled data, a dummy is used for self-reporting. This allows one to capture whether firms tend to report compliance more or less than when firms are inspected (note that the dummy for inspection data is omitted). Columns 1 to 6 sequentially add a different set of fixed effects to control for confounding factors. These include the air and water categories, district, industry, firm, and year fixed effects. The year fixed effects control for factors affecting the whole state, that is, all districts equally. The results are clear and robust to the inclusion of different sets of fixed effects. Firms tend to report being more in compliance than inspections find.

	(1) compliance	(2) compliance	(3) compliance	(4) compliance	(5) compliance	(6) compliance
Self reported	1.299***	1.240***	1.268***	1.174***	1.172***	1.177***
	(0.032)	(0.035)	(0.037)	(0.043)	(0.056)	(0.058)
Constant	0.829***	0.739***	0.912***	0.359***	0.112	0.138
	(0.023)	(0.029)	(0.036)	(0.082)	(0.745)	(0.749)
Category FEs	NO	YES	YES	YES	YES	YES
District FEs	NO	NO	YES	YES	YES	YES
Industry FEs	NO	NO	NO	YES	YES	YES
Firm FEs	NO	NO	NO	NO	YES	YES
Year FEs	NO	NO	NO	NO	NO	YES
Observations	21684	21684	21670	21670	16610	16574
Pseudo R^2	0.195	0.198	0.239	0.271	0.269	0.276

Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 3: Self-reporting vs inspection data

The fact that the firms are more in compliance when they self-report than when they are inspected can be rationalized through the costs the firms face when they are compliant with the environmental regulations. Nevertheless, it is intriguing since there is no penalty in India for noncompliance when the firms self-report. In the following analysis, the paper differentiates the data used in the estimation by inspections and self-reported data. Given the results in table 3, inspection data are more reliable, but carrying out the same type of analysis for the self-reported data will help to have a better idea of the kind of reforms that are needed in India's monitoring system. Even if firms over-report compliance in self-reporting, it still is important information about the behavior of firms regarding environmental regulations.

5.2 Water and Air Pollution

Next, the paper explores whether there is a higher rate of compliance with air or water environmental regulations. This is captured by including a variable equal to one when the measures are on air emissions data and omitting the water information variable. Table 4 shows that firms seem to comply more with air emissions than with water effluents when the information is self-reported, but inspections find that firms tend to be more in compliance with water regulations.

	(1) Self-repor	(2) Self-repor	(3) Insp	(4) Insp
Air category	0.632***	0.829***	-0.490***	-0.551***
	(0.068)	(0.087)	(0.062)	(0.068)
Firm FEs	NO	YES	NO	YES
Observations	16277	5624	3882	3638
Pseudo R^2	0.234	0.165	0.087	0.117

Note: All regressions include district, indicator and year fixed effects. Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 4: Categories water/air

Self-reported data suggest that firms declare more in compliance with air than water regulations. Given that the costs of not complying with each type of regulation might be very different, these results therefore call for the attention of the regulators on the kind of regulations and penalties imposed on firms in each case.

On the other hand, the interpretation of these results regarding the inspection data needs to consider two things: first, the ability of the regulator to inspect water regulations relative to air emissions might be different and this is probably is reflected in the results. And second, it is not possible to conclude that the regulators should focus more on one category versus the other, in air emission for instance. The standards might be different in both cases and what one can learn from these results is that given the level of standards with which firms must comply, they seem to comply more with air emissions standards.

The annex tables extend this analysis to the industry level, that is, these regressions are run for the inspection data at the industry level. The conclusion, in this case, is that the relative air/water compliance depends on the industry. Although overall facilities seem to comply more with air pollution standards, it is the case that industries are more compliant with water in sectors like in mines, paper, steel, and thermal. It seems that it is the opposite only in the case of the aluminum sector. In the rest of the industries, there is no significant difference in the relative compliance with the two categories. This provides more detail and suggests different strategies for regulators when inspecting different industries, always keeping in mind the standards in place and how they are applied to each industry.

5.3 Ownership

Another interesting question is whether the ownership, private or public, tends to influence the compliance of firms to environmental regulations. Table 5 presents the results keeping also the air category variable as a control. One finds that in general, privately-owned firms seem to be more in compliance than publicly owned firms when firms are inspected. Self-reported data, on the other hand, suggest that public firms tend to report to be more in compliance. This analysis requires considering that in some industries most of the firms are either privately or publicly owned (as the descriptive statistics showed). For this reason, it is important to carry out the same study at the industry level.

	(1) Self mon.	(2) Self mon.	(3) Inspection	(4) Inspection
Air category	0.829***	0.829***	-0.551***	-0.551***
	(0.087)	(0.087)	(0.068)	(0.068)
Private		-0.534*		1.535***
		(0.305)		(0.513)
Observations	5624	5624	3638	3638
Pseudo R^2	0.165	0.165	0.117	0.117

Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 5: Ownership

Carrying out the analysis at the industry level allows us to get more insight into these results. The annex tables present these results industry by industry. Industry-level regressions show that for some industries it is not possible to conclude if there exists a significant difference because there are not enough observations of the two types of firms. One also finds that in the case of the steel and sugar industries, with enough data of both types, there is a significant difference, with private firms being more in compliance. While one needs to be cautious in interpreting these results, this calls for the attention of public firm managers and regulators in better understanding of how the interaction between industry and ownership affects compliance. In some sectors with enough observations of both types of firms like aluminum and thermal, there is no statistical difference. The case of mines seems to suggest that public firms are more in compliance, but the results are weaker.

5.4 Age

Another important policy question is whether firms follow environmental regulations with regards to the age of the firm (Table 6). Starting with a linear inclusion of the age variable, one does not find any significance regarding age. Given that this might be due to age affecting compliance in a non-linear way, one could look this by adding a quadratic term. The non-linear term results suggest that compliance increases with age in inspections and that these increases in compliance are decreasing. In self-reported cases, the opposite seems to be the case, with older firms self-reporting to be less in compliance than newer firms.

	(1) Self mon.	(2) Self mon.	(3) Inspection	(4) Inspection
Age	-0.205	0.117	0.738	0.873*
	(0.198)	(0.207)	(0.518)	(0.530)
Age^2		-0.012***		-0.002**
		(0.002)		(0.001)
Private	-1.480**	-1.528**	3.728**	3.896**
	(0.671)	(0.674)	(1.638)	(1.663)
Air category	1.089***	1.022***	-0.523***	-0.524***
	(0.106)	(0.108)	(0.070)	(0.070)
Observations	4126	4126	3223	3223
Pseudo R^2	0.190	0.208	0.108	0.109

Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 6: Age

Extending this analysis to the industry level (Annex Table) suggests that there are only a few industries in which age has a significant effect on compliance. In steel, it seems to increase compliance, but it reduces it in sugar. In the rest of the industries, the results are either non-significant or weak.

5.5 Voter Turnout and GDP

Earlier literature suggests that public pressure is often more effective than the formal enforcement mechanism. This motivates one to explore the effect of civic activism on firms' compliance with environmental regulations. Civic activism is proxied here with voter turnout, and income per capita is also used as an explanatory variable. Table 7 shows that voter turnout has a significant and negative effect on compliance. The interpretation of this result is in line with the suggestions of the earlier literature. But it is important to understand the potential reason for the negative sign is that the larger the civic activism, the larger is the pressure for environmental regulations to be enforced. This implies that when there is more social pressure for environmental issues, authorities tackle more effectively these issues and find more environmental irregularities. No significance is found on the effect of GDP per capita when included with voter turnout but it is positive and significant when included without voter turnout. Regarding the self-reported data, one finds that the effect of voter turnout is the opposite, being positive. Following the previous analysis, one could argue that this is in line with the previous result suggesting that more social pressure leads the firms to self-report themselves to be more in compliance. In self-reported data, GDP per capita is only significant and positive when included with voter turnout.

	(1) Self mon.	(2) Self mon.	(3) Self mon.	(4) Inspections	(5) Inspections	(6) Inspections
Voter turnout	0.299***		0.299***	-0.203***		-0.203***
	(0.055)		(0.055)	(0.059)		(0.059)
GDP		47.271	161.248***		77.232***	2.469
		(44.509)	(49.098)		(28.071)	(35.454)
Air category	0.725***	0.829***	0.725***	-0.560***	-0.551***	-0.560***
	(0.090)	(0.087)	(0.090)	(0.068)	(0.068)	(0.068)
Observations	5624	5624	5624	3638	3638	3638
Pseudo R^2	0.179	0.165	0.179	0.120	0.117	0.120

Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 7: Voter turnout and GDP

5.6 Past Inspections

One final step in the analysis is to understand whether inspections have an impact on the compliance level with environmental regulations. Table 8 presents some interesting results. The number of inspections in the previous year has no significant effect on the compliance level when firms are inspected. When one includes the number of inspections during the current year, the effect is negative. This seems to be capturing the fact that the more inspected firms are generally expected to be more polluting. This also makes clear that the environmental regulation system can be improved to create positive dynamics that increase the compliance levels in India. One also finds that the current and past year number of inspections tend to increase the self-reported compliance level. This is intuitive given that firms feel the pressure of more inspections to report compliance.

	(1) Self mon.	(2) Self mon.	(3) Self mon.	(4) Inspections	(5) Inspections	(6) Inspections
N. inspections	0.001		0.057***	-0.013***		0.006
	(0.004)		(0.016)	(0.004)		(0.070)
N. past inspections		0.009	0.017*		0.006	0.007
		(0.009)	(0.010)		(0.004)	(0.023)
Air category	0.823***	0.779***	0.764***	-0.535***	-0.425***	-0.425***
	(0.090)	(0.122)	(0.122)	(0.068)	(0.081)	(0.081)
N	5624	2588	2588	3638	2350	2350
pseudo R^2	0.166	0.153	0.165	0.120	0.079	0.079

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 8: Past inspections

When this analysis at the industry level, as shown in the Annex Tables, one finds that the number of past inspections has a positive impact on compliance levels in the paper, sugar, and thermal industries. Give the non-significant results when controlling for industry fixed effects, this suggests that the positive effect of the previous inspection only happens in a few industries and that there is room for improvement in enforcing environmental regulations.

6 Conclusion

Regulatory compliance is the key in the fight against climate change and other environmental challenges. But regulatory agencies, especially in developing countries, are often hampered by their capacity to monitor and enforce standards and regulations against recalcitrant firms regularly. Therefore, there is now a big push towards self-reporting whereby the firms report on their compliance levels vis-à-vis the standards. This is seen as a way around the costs that agencies must incur if they were to scale up their inspections. This paper shows the most important determinants of firms' compliance with environmental regulations in India.

In this paper, firm-level data are used from India to compare the compliance level of firms when they are inspected by agencies versus the times when they self-report. The paper also looks at the other factors that may determine regulatory compliance such as age, size, sector, location, etc. Newer and privately-owned firms come out to be more compliant. There are also differences between complying with air and water pollution. Such a detailed characterization can help regulators facing budget constraints to better target the most polluting firms and maximize abatement.

The main takeaway from this paper is that regulator information can be improved through a clear understanding of firms' characteristics and how these characteristics affect the firm's probability to comply with environmental regulations. The paper finds that there is ample scope to improve the environmental regulation system to create positive dynamics that can then increase the compliance levels in India since more (past) inspections are found to increase the level of compliance in a few industries.

Firms are more in compliance when they self-report than when they are inspected, as expected, but the self-reporting system needs to be reformed to serve as a more accurate policy tool in environmental regulation. Self-reporting can potentially be a valuable instrument in the context of limited resources, but its design is weak in India. In the future, if there are similar levels of penalties for self-reported noncompliance as for inspections, one may potentially see the firms' compliance going up in general. Findings from the United States suggest that the firms that voluntarily disclose regulatory violations and commit to self-policing improved their regulatory compliance and environmental performance, suggesting that the enforcement relief they received was warranted. Collectively, our results suggest that self-reporting can be a useful tool for reliably identifying and leveraging the voluntary self-policing efforts of regulations.

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A Category by industry

	(1) Self-report	(2) Inspec	(3) Aluminium	(4) Cement	(5) Distillary	(6) Ferroalloys	(7) Mines	(8) Paper	(9) Sponge Iron	(10) Steel	(11) Sugar	(12) Thermal
Air category	0.829***	-0.551***	0.354*	-0.079	-0.627	-0.673	-0.606***	-0.970***	0.243	-0.492***	-0.022	-1.976***
	(0.087)	(0.068)	(0.200)	(0.467)	(0.437)	(0.514)	(0.191)	(0.376)	(0.751)	(0.107)	(0.242)	(0.239)
Observations	5624	3638	225	164	39	193	496	191	364	1456	158	352
Pseudo R^2	0.165	0.117	0.058	0.222	0.070	0.294	0.138	0.209	0.095	0.050	0.267	0.361

Note: All regressions include district, indicator and year fixed effects.
Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 9: Categories water/air by industry

B Ownership by industry

	(1) Aluminium	(2) Cement	(3) Distillary	(4) Ferroalloys	(5) Mines	(6) Paper	(7) Sponge Iron	(8) Steel	(9) Sugar	(10) Thermal
Private	-0.447	0.000	0.000	0.000	-1.161*	0.000	0.000	1.485***	1.935***	-0.359
	(0.275)	(.)	(.)	(.)	(0.643)	(.)	(.)	(0.517)	(0.385)	(0.620)
Air category	0.354*	-0.079	-0.627	-0.673	-0.606***	-0.970***	0.243	-0.492***	-0.022	-1.976***
	(0.200)	(0.467)	(0.437)	(0.514)	(0.191)	(0.376)	(0.751)	(0.107)	(0.242)	(0.239)
Observations	225	164	39	193	496	191	364	1456	158	352
Pseudo R^2	0.058	0.222	0.070	0.294	0.138	0.209	0.095	0.050	0.267	0.361

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 10: Ownership by industry

C Age by industry

	(1) Aluminium	(2) Cement	(3) Distillary	(4) Ferroalloys	(5) Mines	(6) Paper	(7) Sponge Iron	(8) Steel	(9) Sugar	(10) Thermal
age	0.472*	-0.141	-0.294	-1.072*	-0.001	-0.260	-0.015	0.183**	-1.356***	-0.163*
	(0.246)	(0.329)	(0.760)	(0.614)	(0.042)	(0.587)	(0.058)	(0.084)	(0.390)	(0.088)
own_private	-13.653**				-1.107			0.674	-53.642***	-2.961*
	(6.843)				(2.297)			(0.459)	(15.856)	(1.540)
category_air_emi	0.354*	-0.079	-0.627		-0.379*	-0.916**	0.235	-0.492***	-0.022	-1.976***
	(0.200)	(0.467)	(0.437)		(0.223)	(0.381)	(0.751)	(0.107)	(0.242)	(0.239)
Observations	225	74	39	124	335	120	347	1456	158	341
Pseudo R^2	0.058	0.008	0.070	0.208	0.151	0.333	0.099	0.050	0.267	0.363

Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 11: Age by industry

D Past inspections by industry

	(1) Aluminium	(2) Cement	(3) Distillary	(4) Ferroalloys	(5) Mines	(6) Paper	(7) Sponge Iron	(8) Steel	(9) Sugar	(10) Thermal
N. past inspections	-0.033	-3.757		0.251	-0.357	0.132**	0.357	0.003	0.649**	0.224**
	(0.330)	(428.896)		(0.270)	(0.552)	(0.052)	(0.289)	(0.002)	(0.262)	(0.099)
N	147	119	15	103	263	90	168	1177	100	168
pseudo R^2	0.023	0.276	0.031	0.157	0.145	0.166	0.107	0.023	0.178	0.320

Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$

Table 12: Past inspections by industry