# CHAPTER 5

# THE EMPIRICAL LITERATURE ON THE ENFORCEMENT OF INDUSTRIAL EFFLUENT STANDARDS

This chapter is the first chapter of the second part of my dissertation, whose objectives are to empirically examine the determinants of the allocation of inspections among industrial plants by the municipal and national governments in Montevideo, and to empirically test the effects of these inspections, fines and other intermediate enforcement actions on the reported levels of $BOD_5$ and the compliance status of industrial plants. As such, the present chapter reviews the empirical literature on the enforcement of industrial emission standards. The number of papers in this literature has grown steadily in the past decade. They basically deal with two issues: first, the effect of enforcement actions on levels of pollution, non-compliance and self-reporting; and second, the determinants of the allocation of enforcement actions among regulated plants. With respect to this second issue, the hypotheses tested have been mainly two: the existence of certain types of targeting on the part of regulators, and the role played by political considerations, such as local labor market conditions. I review each of these issues in the following three sections. After this, I present the incipient empirical literature in less developed countries. Finally I present the objectives of my empirical research and how my work differs from the existing literature.

## 5.1 THE EFFECT OF INSPECTIONS AND ENFORCEMENT ACTION ON EMISSIONS, VIOLATIONS AND SELF-REPORTING

Magat and Viscusi (1990) appear to be the first rigorous paper analyzing industrial water pollution enforcement policy. Since their data on inspections was more complete than on other enforcement actions, they chose to test the relationship between plant inspections and plant $BOD_5$ discharge levels. Their case study was the seventy-seven plants (out of 194) that periodically reported emissions in the pulp and paper industry in the U.S. The authors were aware of sample selection bias and took it into consideration in their conclusions. It is important to note that what Magat and Viscusi refer as discharge levels are actually reported discharge levels taken from the Discharge Monitoring Report that the plants sent monthly to the EPA or to a similar state office in cases when states have met federal criteria in order to be in charge of water pollution policy enforcement. Their results showed that one inspection in a given quarter reduced the level of quarterly average monthly emissions of BOD by 1,149 pounds, around 20% of the mean value of $BOD_5$ discharges. When interacted with the compliance status of the plant, inspections of non-compliant plants were 100% more effective than inspections of compliant plants, although confidence intervals for both variables overlapped. Variables capturing plant size, industry sector and region effects were statistically insignificant.

Inspections also had a significant effect on the compliance status of firms according to a second model they estimated. These authors found that if a plant had not been inspected in the previous quarter, its odds of being out of compliance doubled. Magat and Viscusi also tested for the effect of inspections on self–reporting. Using mean

differences between the number of non-reports in a four-month period before and after an inspection, they found that an inspection increased monthly reports by 0.1 reports.

Laplante and Rilston (1996) conducted a similar analysis to Magat and Viscusi's for the pulp and paper industry in Quebec, Canada. Their sample was composed of observations of 59 plants in the period 1985 – 1990. They found that both inspections and the "threat" of inspections (an instrumental variable used as a proxy for "expected inspection") had a "strong negative impact" on the level of emissions. Their results showed that past inspections reduced the level of reported $BOD_5$ emissions by 28% of the mean $BOD_5$ level discharged, as compared to the 20% obtained by Magat and Viscusi. They also found that inspections strongly improved the frequency of self-reporting. Their analysis differs from that of Magat and Viscusi in two ways. First, their database allowed them to calculate and measure the impact of inspections on the extent of violations, measured as the level of $BOD_5$ emissions relative to the standard for that plant. (Magat and Viscusi did not have information on the level specified in the permits held by the firms, just on the compliance status). Second, they repeated their analysis for Total Suspended Solids (TSS), with similar results.

Gray and Deily (1996) were the first to include enforcement actions (letters, phone calls and enforcement orders) in addition to inspections in the analysis. Their dependent variable was the compliance status of the plant, not its level of emissions or violations. They studied air pollution from the steel industry in the US and found that the total number of past enforcement actions, whether measured as inspections alone or total actions, did increase compliance.

Nadeau (1997) was the first to try to separate the effects of monitoring and enforcement activities ("administrative, civil, judicial, and penalty actions", p. 68). His objective was to estimate the effects of these actions on the duration of non-compliance. Nadeau found that "a 10% increase in monitoring activity leads to a 4.2% reduction in the time that a plant violates EPA regulations. A 10% increase in enforcement responses implies a 4-4.7% reduction in the length of violation" (p. 77).

Helland (1998) also dealt with $BOD_5$ emissions in industrial water pollution with quarterly data of 57 plants from the U.S. pulp and paper industry in the period 1990 to 1993. He found evidence that detected violations in the previous quarter and two quarters ago increased the probability of self-reporting by 9% and 8%, respectively. He also found that past violations, the age of the plants, the costs of compliance and liquidity constraints were the most important determinants of the probability of violation.

More recently, Gray and Shadbegian (2002) analyzed annual data between 1979 and 1990 for 116 pulp and paper plants in the US. Basically, they found that observable characteristics of plants are strongly related to their compliance behavior with air pollution regulations, and that enforcement actions are "at least somewhat effective". They also found that firms with relatively low levels of compliance with other regulations (water pollution, OSHA) were more likely to be out of compliance with air pollution regulations and were less responsive to enforcement actions.

Finally, Shimshack and Ward (2002) also analyzed the pulp and paper plants in the US, but included the spillover effects of the enforcement actions performed on other firms. They found that a fine had a considerable marginal impact, decreasing the statewide violation rate by two thirds. They also found that the deterrent effect of an

additional enforcement action on a specific firm was very low, and that the deterrent effect tends to decrease rapidly with time, suggesting that firms continuously update their beliefs regarding expected enforcement actions.

Since all of the above-mentioned papers use self-reporting emissions, the possibility of under-reporting becomes an important question. The previous empirical literature deals with this problem in several ways. Magat and Viscusi (1990) argued that this was not a serious problem in their analysis. Helland (1998) assumed its existence and constructed a statistical model to take care of undetected unreported violations. Laplante and Rilstone (1996) were the only ones that attempted to test for under-reporting by conducting a paired difference of means test between the levels of $BOD_5$ and TSS self-reported by the firms and those obtained through sampling inspections. These authors did not find statistical evidence of under-reporting, although the test was performed with only 54 observations. Shimshack and Ward (2002) opted for another approach because they did not have information on inspection samples. They included a dummy variable in the pollution equation telling whether the plant was inspected or not in a given month. According to the authors, a different-from-zero coefficient estimate for this variable, after correcting for past inspections and the probability of an inspection, would indicate an opportunistic behavior from the part of the firms. If positive, it would mean that the firm was under-reporting. But the authors did not explain what type of strategic behavior would be behind a negative sign. The final estimated coefficient had a positive sign, providing “weak” evidence for the presence of under-reporting.

## 5.2 TARGETING

In the theoretical literature of enforcing emissions standards, the issue of targeting some firms with greater monitoring or enforcement action has been addressed in two different ways. In a static version, a regulator interested in maximizing compliance subject to a given enforcement budget should target enforcement actions toward those plants with higher marginal abatement costs at the level of the standard (Garvie and Keeler, 1994). A dynamic version of targeting is due to Harrington (1988). In his model the regulator could achieve high levels of compliance even with restricted penalties by classifying firms in two groups (bad and good firms) according to their past compliance status. The regulator could target enforcement according to past violations.

Gray and Deily (1996) found that plants predicted to be in compliance faced less enforcement actions, but at the same time plants with a better history of compliance faced more enforcement actions. The latter result suggests that enforcers tend to concentrate their efforts on cutting emissions by those firms they know are more likely to react as a strategy to maximize the effectiveness of their actions.

Inspired by Harrington's model, Helland (1998) tested for "state-dependent" type of targeting. He found that the presence of a violation in the previous quarter and the failure to self-report were the most important determinants of inspections, increasing the probability of being inspected by 38% and 23%, respectively. Most importantly for his objectives, he found no evidence to support Harrington's hypothesis that firms not found in violation in the past are more likely to be in violation in the present.

## 5.3 POLITICAL CONSIDERATIONS IN THE DECISION TO INSPECT

Regulators may allocate monitoring and enforcement resources among firms according to political considerations. If this motivation is not taken into account, the regulator's actions may be interpreted merely as ineffective enforcement. Helland (1998) provided some insights into this issue. He found evidence that "violations did trigger a penalty phase as suggested by Harrington" (p. 151), but also that political considerations were important determinants of inspections (e.g., the possibility that the mill will be forced to shut down, per capita income of the surrounding community and the level of pollution in the surrounding community).

Along the same line, Deily and Gray (1991) found evidence that in the case of the emissions of the US steel industry, the EPA directed less enforcement effort toward those plants with a greater probability of closing, and those with a higher impact on employment in their communities. However, the magnitudes of the effects were not very high. For example, their estimation showed that a 10% increase in a plant's share of the local labor market decreased enforcement actions by 1.9%. Also, a 10% increase in the probability of closing decreased enforcement activity by 6.5%.

Dion, et al. (1998) noted that uniform emissions standards do not imply uniform levels of actual emissions, because the enforcement authorities are the ones that ultimately determine the actual level of emissions of plants by their allocation of inspections and enforcement actions among regulated firms. If these authorities approximately take into account variables such as the costs of compliance of different plants and the expected damage of each plant's emissions, they could substantially reduce

the actual cost-ineffectiveness and inefficiency of uniform emission standards. They used the same case study and partly the same database of Laplante and Rilstone. They found that a 1% increase in the plant's share of the employment in the local labor market increased the probability of being inspected by 0.11%. They argued that this result was consistent with the hypothesis that the bigger the plant's share of the local labor market, the more visible are the enforcers' inspections to the public, and as a result, the more often regulators would inspect bigger plants. According to the authors, the latter does not mean that the regulator was willing to impose more costly enforcement actions such as fines on those plants. Their second result was that the level of unemployment in a region decreased the probability of inspections for a plant.

## 5.4 LESS DEVELOPED COUNTRIES

Empirical analyses of regulators' effectiveness in industrial emissions control or the determinants of their allocation of inspections among firms are almost nonexistent in LDCs. Dasgupta, et al. (2001) and Wang et al. (2002) seem to be the only statistically rigorous examples.[37]

[37] Dasgupta, et al. (2000) conducted a statistical analysis of determinants of "environmental performance" in Mexico. Their work, however, is very different from the rest of the literature for two reasons. First, their data resulted from a survey of 236 plants. Plant managers/owners self assessed the compliance status of their plants on a five-point scale, and a plant was classified as compliant if it was "always" or "almost always" in compliance. The questionnaire was not designed to obtain information on the level of emissions. Second, the survey asked for the overall "environmental performance" of the plant. Consequently, answers referred to either water, air, toxic or non-toxic pollution.

Dasgupta et al. (2001) is also the first study to include levies as determinants of levels of emissions. They analyzed annual data on 640 industrial plants in the city of Zhenjiang in China, between the years of 1993 and 1997. Their main results are that inspections do have a "statistically significant" effect on firms' emissions of Total Suspended Solids (TSS) and Chemical Oxygen Demand (COD). Inspections on the margin reduced TSS and COD pollution by 1.18% and 0.4% relative to their mean values. These results are far less than the 20% and 28% obtained by Magat and Viscusi and Laplante and Rilstone for the US and Canada. For the case of Total Suspended Particulates (TSP, air pollution) the result was 0.34%. Second, pollution charges (fines) did not have an effect on pollution, although according to the authors this may have been the result of a lack of variation in pollution charges. Third, citizens' complaints did impact inspections "significantly" and therefore also pollution.

Wang, et al. (2002) used the same database as Dasgupta, et al. (2001) to test for the determinants of the enforcement activities of regulators. They found that private firms had less bargaining power, measured as the percentage of the levy actually paid relative to what they should have paid. They also found is that those plants with higher expenditures on pollution abatement paid lower levies. This result suggested that regulators might have been compensating firms for such investments.

There are a few other examples of empirical analyses of pollution regulation in LDCs. However, they have serious data limitations. Pargal, Mani and Huq (1997) estimated the impact of inspections and community characteristics (acting as proxies for political power) on water pollution in eight states of India. Their sample included 250 industrial plants surveyed in 1996, although they reported their results with 71

observations. $BOD_5$ emissions were measured as the monthly average $BOD_5$ generated by each plant. The variables "Inspections" was defined as the total number of inspections that the plant had been subject to in the period 1990 – 1994. One of their main results is that BOD emissions "are unaffected by inspections", a conclusion driven by the statistically insignificant nature of the "Inspections" variable in the BOD equation, rather than by the magnitude of the coefficient (a frequent interpretation in the paper). The authors recognized that this result is conditional on the nature of their database, which did not allow them to analyze the impact of lagged inspections. They also found little evidence of informal enforcement (as measured by the community characteristics proxy).

Gupta and Saksena (2002) attempted to estimate a relationship between inspections and compliance in the State of Punjab, India. Their database, however, was of poor quality because "there is no comprehensive database" in India according to the authors. In order to deal with this problem, the authors constructed a dependent dummy variable -for if the firm was in compliance with air and water pollution regulations. Compliance was determined using a simple majority rule: the plant was said to be in compliance if it was not in violation with air or water pollution in most of the available reports they have from inspections done on the firm in the previous five years. Their results (based on a panel with 117 observations) showed a negative impact of inspections on compliance, possibly as a result of endogeneity. Nevertheless, these results may be affected by the quality of the database. Other interesting results that these authors found are that firms that were required to install an effluent treatment plant and frequent violators were inspected more often and, on the other hand, firms with higher

maintenance costs of the treatment plant and higher rate of return were likely to get inspected less often.

In sum, Dasgupta, et al. (2001) and Wang et al. (2002) are the only examples of the literature being reviewed for the case of a LDC.[38] There is no example of this type of empirical work for Latin America.[39] This constitutes a very important shortcoming because Latin America has a long tradition of water pollution control laws based on uniform emissions standards, but both public opinion and authors that have analyzed environmental policy in the region (Russell and Powell, 1996; Eskeland and Jimenez, 1992; O'Connor, 1998; Tietenberg; 1996) have regarded them as poorly enforced, basically because of the lack of the necessary institutional capacity. At the same time, new regulations for other medias (like air) and new incentive-based instruments are being developed and implemented in some parts of the region. But no effort has been made to empirically test the effectiveness of regulators' actions in enforcing present emission standards. Such an effort would shed light on the issue of institutional capacity of a Latin American country to enforce environmental policies. In this respect, previous empirical analyses in the US, Canada and China are of little guidance for a Latin American country given the obvious differences in institutional capacities and, in the case of China, even political systems.

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[38] Pargal and Wheeler (1996) analyzed the effect of informal regulation, as opposed to formal inspections and other enforcement actions of regulators.

[39] Existing works (Blackman and Bannister (1998), Coronado (2001), Cruz and Uribe (2002), Escuela Superior Técnica del Litoral (2002) and Ferraz, et al. (2003) are not comparable because of data limitations. For example, some of them do not have information on emissions. Others do not have information on formal regulatory measures, and others lack both. Finally, all of them are cross-section studies.

## 5.5 OBJECTIVES

My work in the following chapters aims to fill this gap by examining the determinants of the allocation of inspections by the municipal and the national government among industrial plants in Montevideo, Uruguay, and by empirically testing the effects of (a) plant-level economic characteristics, and (b) monitoring and enforcement actions of both the municipal and state governments on industrial plants' emissions of $BOD_5$ in Montevideo, and their probabilities of being in violation. More specifically, in the second part of my dissertation, apart from the question about the determinants of the regulators´ allocation of inspections, I address the following questions: (1) How effective have inspections and the different enforcement actions of both municipal and state governments been in terms of reducing $BOD_5$ emissions? (2) How effective have inspections and the different enforcement actions of both municipal and state governments been in terms of the compliance status of firms? (3) Could enforcement be improved by substitutions between monitoring and enforcement actions? The latter question is relevant because inspections and orders are almost the only actions used by regulators; fines are rarely levied. If this is the expression of a strategy such as the one suggested by Garvie and Keeler (1994) in the presence of institutional and political "constraints", then a study like the one proposed here could estimate the effectiveness of such a strategy. Finally, since emissions are self-reported, I also perform some simple tests to explore the presence of under-reporting.

In addition to the fact that it is the first example of its kind in Latin America, my work differs from the previous ones in the following aspects. First, my work is the first to

include information on more than one input consumed in production, as well as information on technology adoption. In this respect, the present work offers a more complete picture of the production function of industrial plants. To illustrate the importance of this difference, in addition to controlling for the enforcement variables, Laplante and Rilstone (1996), for example, only controlled for regional effects and the types of papers produced by pulp mills. Dasgupta et al. (2001) only controlled for the number of employees, state or private ownership, and industrial sector. Shimshack and Ward (2002) only controlled for the type of pollutant ($BOD_5$ and TSS) and plant capacity.

Second, except for Dasgupta et al. (2001) and Shimshack and Ward (2002), who included random effects, my work differs from past papers because it includes fixed, plant-specific effects. The difference is important because not allowing for plant heterogeneity may produce biased estimates.

Third, the analysis is done in a particular time during which regulators relaxed emission standards and gave plants a considerable period to install an abatement technology. The objective of this measure was to decrease the plants' violation levels with emission standards. My work is therefore illustrative of the effectiveness in less-developed countries of this type of approach, by which regulators negotiate gradual abatement with industry sector instead of just applying penalties to violators.

Fourth, exactly after the end of the "grace period" that regulators gave firms, the industry sector entered a severe recession. Except for Gray and Deily (1991), my work also differs from the rest of the literature in this respect, because it examines the interaction between regulator and firms during a severe recession. The importance of this

difference is enhanced because of the less-developed country context, in which regulators may be more sensitive to the trade-off between protecting environmental quality and potential economic and social costs of doing so.

Fifth, this dissertation also allows conclusions about the effects of multilateral institutions, such as the Inter American Development Bank in this case, on environmental policy in less developed countries. This issue has not been addressed before but it is nevertheless extremely important given the lack of public resources and institutional capacity of these countries, both of which frequently make them dependent on the funds provided by these institutions to implement environmental policies.

Finally, a unique feature of this dissertation with respect to past empirical studies is the availability of four sources of information regarding levels of pollution. One is the level reported by industrial plants, another is the level sampled by the IMM, a third one is the level sampled by the DCA, and the fourth is the level sampled by SEINCO. This unique feature allows me to perform more than one test to explore the presence or absence of under-reporting and possible changes in the reporting strategies of firms through time.