FINANCIAL ASSISTANCE OF MULTILATERAL AID AGENCIES TO ENFORCE ENVIRONMENTAL REGULATIONS. IS IT EFFECTIVE?

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Abstract

This paper analyzes the effectiveness of the Industrial Pollution Reduction Plan undertaken by the municipal government of Montevideo, Uruguay, with funds from the Inter American Development Bank to increase the levels of compliance of industrial firms with effluent standards. The main results are the following: first, the Plan failed to increase the levels of compliance. Even more, the enforcement activity by the municipal and national governments has no statistically significant marginal effect on the *level* of BOD_5 reported by the plants. Finally, more than one third of the industrial plants may have under-reported emissions levels, on average.

Keywords: Less Developed Countries; Industrial Pollution; Emission Standards; Effectiveness; Enforcement

1. INTRODUCTION

In 1996 the Municipal Government (MUN) of Montevideo, the capital city of Uruguay, undertook the third stage of the Urban Sanitation Plan in order to extend the sewage system of the city. A loan provided by the Inter American Development Bank (IADB) financed the works.[1] As part of the condition to access this credit, Uruguayan authorities had to commit to increase the compliance levels with industry emission standards [29].[2] With this objective, the MUN implemented the "Industrial Pollution Reduction Plan" on March 1st 1997. [3] This Plan relaxed emissions standards and established a time schedule by which these standards would converge to the original levels in December 31st, 1999. The Plan was supposed to give the firms time to implement changes in abatement processes and technology. It therefore constitutes an excellent case to test Russell and Powell's [36] hypothesis that "there is little the outside world can do - even the multilateral aid agencies with their massive resources of money and expertise" if the local environmental authorities lack the will to impose current costs on the industry sector to enforce environmental regulations. This is the main objective of this paper.

In spite that several authors have acknowledged the lack of institutional capacity in less developed countries (see for example [36], [31], [12], [3] and [38]), there is a large disparity in the number of comprehensive empirical studies analyzing the effectiveness of environmental regulators' enforcement activity in developed and less developed countries. Most of the existing literature refers almost exclusively to reported emissions by the US and Quebec pulp and paper and the US steel industry [see [28], [10], [25], [16], [30], [19], [11], [17] and [37]). In fact, to my knowledge, the only examples of published papers for a less developed country that use a comprehensive database are a series of papers published by economists at the World Bank and colleagues dealing with industrial pollution in China. ([8], [40] and [41]).[4] To my knowledge, this

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[1] Contract signed in November 1996, Loan 948/OC-UR – Inter-American Development Bank.

[2] In July 1997, first month of our sample period, 76% of the levels of BOD_5 reported by the firms were above the emissions standards.

[3] Resolución Municipal Nº 761/96, Plan de Reducción de la Contaminación de Origen Industrial, February 26th, 1996.

[4] Other less-developed-countries (LDC) studies are cross-section studies without information on emissions ([2], [9], [6], [7], [18], [13], [32], [15]) or enforcement activities ([33]). Pargal, Mani and Huq [35] have information on both, but their information on inspections is the total number of inspections during the whole sample period, not by month, as it is the information of the dependent variable (BOD_5). Pargal and Wheeler [34] analyzed the effect of informal regulation, as opposed to formal inspections and other enforcement actions of regulators.

is the first paper to test the effectiveness of a compliance program promoted and financed by a multilateral aid agency in a les developed country. In order to fulfill this objective, in a first step I estimate the coefficients of the determinants of inspections of both the municipal and national governments. In a second step, I fit these equations to construct the "probabilities of inspection" that I use to estimate, in two separate equations, the effect of the enforcement actions and the Plan itself on the level o BOD5 emissions and the violation rate.

This paper differs from past empirical studies in two more aspects, as well. First, it incorporates the feature that industrial plants are subject to enforcement from both the municipal and national governments by using separate data on inspection and enforcement actions from both institutions. This may not be an issue in the US, for example, where "the EPA regional offices step in" in the states that decline the option to oversee compliance ([37]). In less developed countries such coordination may not be the norm. Instead, both national and municipal offices overlap in their monitoring activities. Second, the paper provides some simple tests for under-reporting and, unlike previous papers, concludes that it may be a present.

2. INDUSTRIAL EFFLUENTS CONTROL IN MONTEVIDEO, URUGUAY

Industrial effluents in Uruguay are regulated by uniform emission standards.[5] These standards are defined in terms of concentrations of pollutants in discharges. Industrial plants that discharge directly to water bodies face stricter standards than those that discharge to the sewage system.

Both the Municipal Government of Montevideo (Intendencia Municipal de Montevideo, MUN) and the national environment office (Dirección Nacional de Medio Ambiente, hereafter NAT), housed in the Ministry of the Environment, have jurisdiction over industrial water pollution control in the city. Nevertheless, coordination between these two authorities has been poor. In theory, the MUN is responsible for monitoring and enforcing emissions standards, while the NAT grants the Industrial Discharge Authorization when it determines that a firm has a treatment plant that enables it to comply with the emission standards. In other words, the NAT is in charge of "initial compliance", while the MUN is in charge of "continuous compliance". This institutional organization results from the historical evolution of water pollution legislation; the first regulations concerning industrial water pollution were born at the municipal level in the

[5] Decreto 253/79, "Normas para Prevenir la Contaminación de las Aguas"

sixties, almost twenty-five years before the creation of the Ministry of the Environment in 1990.[6] But it is also the result of an informal agreement between the NAT and the MUN that took place in 1995. In this agreement the NAT let the monitoring and enforcement of industrial effluents in Montevideo rest in the hands of the municipal government, while concentrating its own enforcement efforts in the rest of the country. The NAT would continue to be the office in charge of granting the emissions permits countrywide, including Montevideo. But while the division of responsibilities was clear in theory, coordination between the two offices remained poor in practice. First, the NAT continued to monitor plants even when they were not building treatment plants. Second, BOD_5 and Chromium emissions standards for wool washing firms and tanneries, respectively, converged to values at the end of the Industrial Pollution Reduction Plan that are higher than the initial ones. In other words, the municipal Industrial Pollution Reduction Plan relaxed the emissions standards of BOD_5 and Chromium for these two types of plants indefinitely. According to conversations with NAT inspectors, this inconsistency generate problems because firms argue that they are complying with municipal standards while the NAT requires them to meet emission standards set by the national decree. This issue is explained in more detail below.

The NAT's Division of Environmental Control (in charge of granting the discharge permits) is composed of only five persons. These five persons are not only in charge of monitoring and enforcing water pollution legislation, but also the rest of the national environmental regulations. Staffing is a bit better at the Industrial Effluents Unit of the MUN, where seven persons work, but they are only in charge of industrial emissions in Montevideo. These constraints motivated the mentioned agreement, aimed at saving scarce monitoring and enforcement resources.

It is important to note though that the lack of institutional capacity may have not been the only problem behind the low levels of industry compliance with emissions standards. The political will of at least some regulators to impose environmental costs on firms seemed unclear. Apart from the Plan itself, which was born to give the firms time to increase their levels of compliance with emission standards given "present reality of the industry", an important MUN official stated in an interview that although he was working at an environmental protection office, he was not willing to sacrifice Uruguayan industrial production by imposing environment-related costs on industrial plants. The official viewed the country's industrial sector as facing uneven competition from the developed world, and was more concerned with their importance as job

[6] "Ordenanza sobre la Disposición de Aguas Residuales de los Establecimientos Industriales del Departamento de Montevideo, Decreto Nº 13.982 de la Junta Departamental de Montevideo, 1967" [20], and "Reglamentación de la Ordenanza sobre la Disposición de Aguas Residuales de los Establecimientos Industriales del Departamento de Montevideo, Resolución Nº 16.277 del Intendente Municipal de Montevideo, 1968" [21].

creators in a very depressed national labor market. Things got tighter during 1999 when one of the most severe economic crises in Uruguayan history hit the industrial sector. The crisis ended in 2003.

Also, regulators imposed a small number of fines during the sample period, in spite of frequent reported violations. The MUN imposed only eleven fines and the NAT only five between May 1997 and October 2001. During this period the reported violation rate never decreased below 40%. The Industrial Pollution Reduction Plan ended in 1999, therefore the grace period implemented by the Plan cannot be the only reason for this particularly low number of fines. Another reason may be the lack of political will to impose costs of firms during the economic crisis that followed the Plan.

3. DATA

3.1 Information Sources

Every four months, the plants report to the Industrial Effluents Unit of the municipal government monthly levels of (1) production, (2) water consumed, (3) energy consumed, (4) number of employees and days worked, and (5) volume of emissions and concentrations of pollutants.[7] From all the pollutants reported I chose BOD_5. The reasons are mainly two: it is one of the most important industrial pollutants in the city and it is one that every plant has to report, regardless of its branch.[8]

At the same time, regulators conduct inspections to assess compliance. Two types of regular inspections exist: (a) sampling inspections, consisting of samples taken from the treatment plant's effluent, and also an evaluation of both the plant's performance and overall economic condition, and (b) non-sampling inspections, consisting of everything in (a) except effluent samples.[9]

I have three sources of information for variable construction. The first one is the Industrial Effluents Unit of the Municipal Government of Montevideo (MUN), from which I

[7] Some plants also report voluntarily to the national government Department of Environmental Control.

[8] It is also, together with Chromium, one of the two pollutants targeted by the MUN, in accordance with the Inter American Development Bank.º

[9] Possible reasons for not sampling are that a plant may not be working or discharging at the time of inspection. This poses a problem for national inspectors, who have rigid schedules in Montevideo because they must also inspect firms in the rest of the country.

obtain information on items (1) to (5) above, and on inspections and fines. The latter consist of the number of sampling and non-sampling inspections performed by the MUN per month per plant. Samples are measured in mg/l of BOD_5. Fines levied by the MUN consist of the number and amount of fines levied on each industrial plant per month. The sample period for all variables is July 1996 – October 2001, except for fines, which is May 1997 – October 2001.

The second source of information is the national government Environmental Control Division of the Ministry of the Environment (NAT). It provides the number and results (mg/l of BOD_5) of sampling inspections, the number of non-sampling inspections, the total number of compliance orders, and follow-up "fine threats" (a note communicating a potential fine) issued by NAT. Finally, it provides both the number and amount of fines per month per plant. The sample period for all NAT variables is July 1996 – October 2001.

The third source is the private consulting partnership, SEINCO, in charge of the Monitoring Program that the MUN implemented in 1999. Information for this source consists of the number and result of sampling inspections conducted by it between April 1999 and September 2001.

Overall, the data set includes 74 industrial plants in Montevideo. SEINCO inspected a total of 87 plants at least once. From these, I excluded one steel-plant because it declared it was not emitting BOD_5. The rest (12) were plants inspected by SEINCO during a short period of time to evaluate the possibility of including them in the Monitoring Program. One of the objectives of SEINCO was precisely to design a monitoring routine for the MUN, so SEINCO inspected some small plants in the city to evaluate the worthiness of including them in the list of plants that the MUN should inspect with some frequency. Nevertheless, the MUN had already made a decision with respect to these plants. The MUN did not consider them relevant in terms of pollution load, and therefore did not follow closely. Notwithstanding, some them sporadically report to the MUN. For both reasons, the scarce information on these 12 plants was not included in the data set. The 74 plants in the data set are responsible for more than 90% of the total industrial organic pollution in the city.

All plants in the sample are privately owned. Publicly owned industrial plants did not report emissions during the period. I use the sample of the 74 plants to study the determinants of the allocation of inspections. I dropped five plants to study the determinants of pollution and compliance because these five plants release effluents into the soil, and there are no emissions standards set for BOD_5 in this case. Table 1 presents the descriptive statistics for the reported input and pollution variables.[10] There are a couple of things to notice from Table 1. First, the mean value of mg/l of BOD_5 emitted is larger than the emission standards. These are: 60 mg/l for plants emitting directly into a water body, and 700 mg/l for plants emitting into the city sewage system. The median is 370 mg/l, almost 1/3 of the mean. This indicates that the distribution of emissions in the sample is skewed, with some plants driving the mean upward. The same can be said for the effluent flow, water consumed (tap or underground), electricity consumed and fuel consumed. Second, all variables have missing values, out of a total number of potential observations equal to 3,848 (52 months times 74 plants). I refer to this problem in the next section.

Table 1 here

Table 2 here

Table 2 shows the descriptive statistics for the monitoring and enforcement variables. The information is presented separately for the MUN, the NAT and SEINCO. "Sample inspections" are the total number of inspections in which the office in charge took an effluent sample. "Result" is the result of those samples. "Non-sample inspections" are the total number of inspections in which the office in charge did not sample effluents. "Total inspections" is the sum of sample and non-sample inspections. "Inspections" is a dummy variable equal to one is the office inspected plant *i, i=1,…,74* in month *t, t=1,…52*. The first thing to notice in Table 2 is that the NAT inspected fewer plants than the MUN: 61 plants the NAT vs. 74 the MUN. The MUN inspections were quite often. According to the frequency of inspections in this period, a plant had an 11.6% chance of being inspected by the MUN in a given month. Unluckily, the IMM did not have comprehensive data on compliance orders, postponements and fine threats, as the NAT did. "Compliance orders" are letters of warning sent to firms when a violation is discovered indicating that it has a period of time to correct the situation (usually a treatment plant operation failure) or it may be fined. "Postponements" are communications to firms giving them more time than the one originally given in the compliance order. "Fine threats" are notes sent to firms as a second warning, after the compliance order. Table 2 also shows that the MUN imposed eleven fines during the months of July 1997 and October 2001, while the NAT imposed 4. The fines imposed by the NAT were larger, though, as measured by October 2001 US dollars.

[10] Descriptive statistics for levels of production are not presented for space reasons.

Finally, the descriptive statistics for reported violations are presented in Table 3. Two variables were constructed. First, "Reported Extent of Violation", defined as reported emissions of BOD_5 (mg/l) minus the concentration standard, censored at zero; i.e., over-compliance results in a value of zero. Table 3 also includes descriptive statistics for "Compliance Status", a variable equal to one if the plant reported a violation and zero otherwise. The calculations are done using the original standards during the entire period and also using the laxer standards of the Industrial Reduction Plan during July 1997 – December 1999.

Table 3 here

Reported violations were frequent, even when measured as emissions in excess of the laxer Plan´s standards. Forty-one percent of the reported BOD_5 levels were out of compliance with these emission standards. The number of reported violations as a percentage of the number of reports never decreased below 25% in a given month in the case of the Plan's laxer standards and 41% in terms of the original standard.

3.2 Missing Values

The last column of Table 1 provides information on missing values for selected variables. Of 40,924 possible observations, 5,747 (14.0%) were missing. This happened either because a plant did not report during a given period (a "unit" non-report) or because the report had missing values for one or a subset of variables (an "item" non-report). There were a total of 62 unit non-reports over a total of 962 possible reports (74 plant times 13 four-month reporting periods). Six correspond to four plants that ceased production. Twelve correspond to reported "no-activity" periods of three different plants.[11] Sixteen correspond to three plants that started business in periods four, five, and nine, respectively. The remaining 28 correspond to "random" non-reports. At the same time, item non-reports are missing either because some firms report a specific variable unsystematically or because they do not report a specific variable in one month for no clear reason.

[11] I treated these as missing because sometimes firms sent letters to the MUN indicating that they were producing "very low" quantities and therefore it was not worth reporting emissions. In one case a letter was followed by three non-reports in the following periods without any clear information regarding exactly when production started again.

I cannot perform Verbeek and Nijman's [39] test for "ignorability" because I have zero observations for a "balanced" sub-panel; i.e., I have no month in which all 74 plants reported. Nevertheless, it could be said that the process generating the missing values (in the cases of unit non-reports) could be "non-ignorable", since it is, among other things, related to the level of production, as explained above. Nevertheless, I imputed values for item non-responses prior to estimation. These account for 61.1% of the total missing observations.

The literature proposes several methods for imputing missing values. (See [27] and [26]). I used an iterative Buck procedure [5] for each plant, as suggested by Beale and Little (1975). To do so, I constructed the following variables for each plant: (1) *WATER:* Underground and tap water consumption in m^3/month; (2) *ENERGY*: The sum of electricity and fuel consumed per month in mega joules; (3) *LABOR* = The total number of days worked in a month times the total number of employees in that month; (4) $POLLUTION = FLOW*BOD_5*1{,}000$: Total organic pollution discharged in (mg/day), where *FLOW* is the average flow level of discharges in m^3/day; and (5) *PRODUCTION* = Quantity produced by month. I do not use the monitoring and enforcement variables in this imputation.[12]

4. SPECIFICATION AND ESTIMATION ISSUES

4.1 The Inspection Equations

Because regulators neither coordinated monitoring efforts nor shared information on a regular basis about the result of their inspections, I estimate separate inspection equations for the MUN, the NAT and SEINCO. For each of the three agencies, the inspection equations are estimated both to explain the inspection strategy and to provide probabilities of inspection for the reported BOD_5 and violation equations.

Performing a Hausman specification test for plant-specific fixed effects, I reject the null hypothesis of a common intercept in the three cases. Therefore, I estimate a plant-specific fixed-effects model within a logit framework using the procedure suggested by Chamberlain. The model itself is referred to as conditional logit. In the procedure itself, however, fixed-effects are swept out or removed during estimation. This creates a problem because I needed intercepts` estimates to obtain predictions for

[12] A document describing the distribution of missing values per variable by industrial plant, the processes followed to impute for item non-responses in each plant, and the corresponding iteration procedures is available from the author upon request.

the probabilities of inspection. To overcome this problem, I use a logit model with no fixed effects (i.e., a model with a common intercept) to obtain the fitted probabilities of inspection. (Its results are not reported). I refer to this as unconditional logit.

4.1.1 The MUN Inspection Equation

The municipal government inspection equation is:

$$\begin{aligned} INSPMUN_{i,t} &= \gamma_i + \gamma_1 INSPMUNCUM_{i,t-1} + \gamma_2 INSPMUNOTHERCUM_{i,t-1} + \gamma_3 FINEDMUNCUM_{i,t-1} \\ &+ \gamma_4 INSPSEINCOCUM_{i,t-1} + \gamma_5 INSPNATCUM_{i,t-1} + \gamma_6 EANATCUM_{i,t-1} + \gamma_7 VOL_t + \gamma_8 DURINGPLANWITHOUTSEINCO_t \\ &+ \gamma_9 DURINGPLANWITHSEINCO_{tt} + \gamma_{10} RF_{i,t} + \gamma_{11} STREAM_{i,t} + \gamma_{12} CARRASCO1999_{i,t} + \eta_{i,t} \end{aligned} \tag{1}$$

where $i = 1, \ldots, 74$; $t = May\ 1998, \ldots, October\ 2001$; and γ_i and γ_1 through γ_{12} are parameters to be estimated. Also, γ_i is a plant-specific fixed effect, and $\eta_{i,t}$ is an error term, assumed to be identically and independently distributed with zero mean and to have a logistic distribution.

$INSPMUN_{i,t}$ is a dummy variable equal to one if plant *i* was inspected by the municipal government in month *t*; it is zero otherwise. $INSPMUNCUM_{i,t-1}$ is the cumulative number of inspections performed on the plant during the past twelve months. MUN´s inspectors indicated that they were following a sort of "sample without replacement" strategy.[13] $INSPMUNOTHERCUM_{i,t-1}$ measures the cumulative number of inspections performed by MUN in the remaining plants during the last 12 months. With MUN monitoring activities affected by budget constraints, the sign of this variable's coefficient is expected to be negative, indicating that the higher the number of inspections performed on other plants in the recent past the smaller the probability of this plant being inspected given the cost of monitoring campaigns. $FINEDMUNCUM_{i,t-1}$ measures the cumulative number of fines imposed against a plant during the

[13] I tried the cumulative number of inspections performed in the last six months instead of 12 months. The two models produce very similar results, but six-month lagged inspections were not statistically significant. The twelve-month lagged inspections were statistically significant and increased the goodness of fit of the model.

past 12 months. It is designed to capture the plant's level of cooperation with regulators.[14] The higher the cumulative number of fines, the lower the cooperation of the plant in the recent past.[15]

Another important determinant of municipal inspections was the Monitoring Program financed by IADB and performed by the consortium SEINCO. MUN took advantage of the program, saving on monitoring resources. $INSPSEINCOCUM_{i,t-1}$, measures this effect. It is the cumulative number of inspections performed by SEINCO on a plant in the last 12 months.

To capture the effect of monitoring and enforcement activity of the national government on inspection activity of the municipal authority, I included $INSPNATCUM_{i,t-1}$, the cumulative number of inspections, and $EANATCUM_{i,t-1}$, the cumulative number of compliance orders, fine threats, and fines issued by NAT during the previous 12 months.[16]

The Uruguayan industrial sector experienced a severe contraction during 1999 – 2001. As a consequence of this contraction, inspectors may have eased their enforcement pressure on plants, since it was precisely the "difficult economic times" that inspired the Industrial Pollution Reduction Plan. I included the monthly level of the industrial production volume index (VOL_t) to account for this.

$DURINGPLANWITHOUTSEINCO_t$ and $DURINGPLANWITHSEINCO_t$ are dummy variables included to capture the effect of the Industrial Pollution Reduction Plan implemented from March 1997 to December 1999, and whose objective was to give more time to plants to incorporate abatement technology. I included two dummy variables instead of only one to differentiate between the months of the Plan where SEINCO was inspecting from those where it was not. *DURINGPLANWITHOUTSEINCO* is equal to one during the months of the Plan when SEINCO was not inspecting, and zero otherwise. During these months the MUN inspectors conducted special IADB-financed monitoring campaigns due to the delay in the implementation of the Monitoring Program. *DURINGPLANWITHSEINCO* is defined similarly for the months in which SEINCO was inspecting.

Obtaining information from firms on a regular basis was a central issue in the new enforcement strategy implemented by MUN once it got the loan from IADB. As a result, failure

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[14] The inclusion of the cumulative number of detected violations instead of fines did not improve the fit of the model. Also, the cumulative amount instead of the cumulative number of fines did not change the results.

[15] This level of cooperation perceived by regulators is not only a function of the recent formal history of the plant. It also depends on non-quantifiable factors on which inspectors based their decisions. For example, sometimes inspectors are kept waiting at the plant entrance for the amount of time needed to make some quick cleanings and other measures (like diluting) to comply with the emissions standards.

[16] Separating EANATCUM into the cumulative number of compliance orders, the cumulative number of fine threats, and the cumulative number of fines did not improve the results.

to report in subsequent periods triggered inspections. So, I included the number of reporting failures in the previous two reporting periods ($RF_{i,t}$) as an explanatory variable.[17]

I included the dummy $STREAM_{i,t}$ to capture the effect that a plant emitting directly into waterways (value equal to one) vs. emitting into the sewage system (value equal to zero) might have on the probability of being inspected. Also, during 1999 the NAT performed special monitoring on plants in the Carrasco basin. I included the dummy $CARRASCO1999_t$ for this reason. It takes the value one during the months of 1999 that the campaign took place and zero in the remaining months. While I expect this variable to be more important in the NAT equation, I include it in the MUN equation to keep the specifications comparable.

Finally, three additional variables ideally belong in the conditional logit specification. They are PTY_i, $TANNERY_i$, and $WOOL_i$. MUN classified a plant according to its contribution to pollution. Categories were "Priority 1" and "Priority 2". Priority 1 plants are heavy polluters. In our sample, I have 25 Priority 1 plants, and they account for 80% of the industrial, organic, and metals pollution in the city. So, I created the variable PTY_i and set it equal to 1 if the plant was a Priority 1 plant and zero otherwise. Also, I created two dummy variables $TANNERY_i$ for tanneries and $WOOL_i$ for wool washers.[18] The municipal government, in accordance with the IADB, targeted its control efforts at two pollutants, Chromium and BOD_5. These two industries are the most important sources of these pollutants, respectively. Unfortunately, these three variables could not be included in the conditional logit specification because of a lack of within-plant variability. Linear combinations of the fixed effects with any of these three variables resulted in perfect collinearity. This is not a problem, however, with the unconditional logit.

4.1.2 The NAT Inspection Equation

The national government inspection equation is:

$$\begin{aligned}
&INSPNAT_{i,t} = \alpha_i + \alpha_1 INSPNATCUM_{i,t-1} + \alpha_2 INSPNATOTHERCUM_{i,t-1} \\
&+\alpha_3 EANATCUM_{i,t-1} + \alpha_4 INSPSEINCOCUM_{i,t-1} + \alpha_5 INSPMUNCUM_{i,t-1} \\
&+\alpha_6 FINEDMUNCUM_{i,t-1} + \alpha_7 VOL_t + \alpha_8 DURINPLANWITHOUTSEINCO_t \\
&+\alpha_9 DURINGPLANWITHSEINCO_t + \alpha_{10} RF_{i,t} + \alpha_{11} STREAM_{i,t} + \alpha_{12} CARRASCO1999_{i,t} + \upsilon_{i,t}
\end{aligned} \quad (2)$$

[17] In 1997 the MUN implemented a new enforcement strategy. It issued a fax to every plant explaining the new format of the four-month Reporting Form and communicated that the municipal government was undertaking a new plan for pollution control. For that reason, in the first reporting period I set the reporting failure history of every plant equal to zero as an indicator that a new enforcement period had begun.

[18] I included sector dummies in place of these two dummies to explore the results. The sector dummies were neither significant nor did they improve the fit of the model in the unconditional regression.

where i = 1, …, 74; t = May 1998, …, October 2001; and α_i and α_1 through α_{12} are parameters to be estimated. Equation (2) has a specification that is comparable to that of Equation (1). The explanatory variables were described above and their interpretation here is the same.

4.1.3 The SEINCO Inspection Equation

The SEINCO inspection equation is:

$$\begin{aligned} INSPSEINCO_{i,t} &= \beta_i + \beta_1 INSPSEINCOCUM_{i,t-1} + \beta_2 INSPSEINCOTHERCUM_{i,t-1} \\ &+ \beta_3 INSPMUNCUM_{i,t-1} + \beta_4 FINEDMUNCUM_{i,t-1} + \beta_5 INSPNATCUM_{i,t-1} + \beta_6 EANATCUM_{i,t-1} + \beta_7 VOL_t \\ &+ \beta_8 DURINGPLAN_t + \beta_9 RF_{i,t} + \beta_{10} STREAM_{i,t} + \beta_{11} CARRASCO1999_{i,t} + \delta_{i,t} \end{aligned} \tag{3}$$

where i = 1, …, 74; t = April 1999, …, October 2001; and β_i and β_1 through β_{12} are parameters to be estimated. The specification of the SEINCO inspection equation also matches those of the municipal and national governments. The only difference is that, for obvious reasons, I do not have observations for the during-plan period without SEINCO.

4.2 The Reported Pollution Equations

4.2.1 The Reported BOD_5 Equation

Equation (4) is a linear pollution equation in the spirit of [28], [25], and [8], where i = 1, …, 69; t = May *1998*, …, October 2001; and μ_i and λ_1 through λ_{17} are parameters to be estimated. The parameter μ_i is a plant-specific effect.

$$\begin{aligned} \ln(BOD5_{i,t}) &= \lambda_1 \ln(BOD5_{i,t}) + \lambda_2 DURINGPLAN_t + \lambda_3 PINSPMUN_{i,t} + \lambda_4 (PINSPMUN * DURINGPLAN)_{i,t} \\ &\lambda_5 PINSPNAT_{i,t} + \lambda_6 (PINSPNAT * DURINGPLAN)_{i,t} + \lambda_7 PINSPSEINCO_{i,t} + \lambda_8 (PINSPMUN * DURINGPLAN)_{i,t} \\ &+ \lambda_9 INSPMUNCUM_{i,t-1} + \lambda_{10} INSPNATCUM_{i,t-1} + \lambda_{11} FINEDMUNCUM_{i,t-1} + \lambda_{12} EANATCUM_{i,t-1} \\ &+ \lambda_{13} \ln(P_{q,t}) + \lambda_{14} \ln(LABOR_{i,t}) + \lambda_{15} \ln(WATER_{i,t}) + \lambda_{16} \ln(ENERGY_{i,t}) + \lambda_{17} EXPORTS_{i,t} + \mu_i + v_{i,t} \end{aligned} \tag{4}$$

I chose a fixed-effects model because I made inferences based on 69 specific plants that were not randomly selected from a large population. On the contrary, they were responsible for almost

90% of the industrial emissions in the city. Also, a Chow test rejected the null hypothesis of common constant term.

The level of reported BOD_5 (variable name $BOD5_{i,t}$) is expressed as a function of two sets of variables, one reflecting the marginal benefits and the other the marginal expected costs of pollution.[19] Marginal benefits of pollution are represented by the price of the final good ($P_{q,t}$) and the input variables $LABOR_{i,t}$, $WATER_{i,t}$, and $ENERGY_{i,t}$, in logs. Water is an input into production but is also an input into BOD_5 emissions' abatement through dilution. In fact dilution is prohibited by law, but it is a very cheap method to comply and it is very difficult to detect. So a negative sign in its coefficient estimate could indicate dilution of effluents. Marginal expected costs are represented by monitoring and enforcement variables. These consist of the probabilities of being inspected by the municipal and national governments and by SEINCO; i.e., by $PINSPMUN_{i,t}$, $PINSPNAT_{i,t}$ and $PINSPSEINCO_{i,t}$, respectively. These three variables were obtained by fitting the unconditional logit inspection equations. They are intended to capture the effect of future possible enforcement actions due to today's pollution decisions. They are also acting as instruments for actual inspections, although I do not believe endogeneity should be a problem here because the fixed effects capture the difference in levels of pollutions between different plants. The *PINSP* variables' coefficients are then measuring only the "slope" of the BOD_5 equation while the fixed effects allow for different "intercepts". Also, with respect to time, endogeneity should not be a problem either because BOD_5 levels are reported between one and four months after the inspection took place. Therefore, provided that there is no contemporaneous correlation between the error term in the pollution equation and the error terms in the inspection equations, these fitted values will be uncorrelated with $v_{i,t}$, and least squares will yield consistent estimates of the parameters in the pollution equation. I allow the marginal impacts of the probabilities of inspection on reported pollution levels to vary during and after the Pollution Reduction Plan. I also include a dummy variable $DURINGPLAN_t$. Its purpose is to test for the presence of different reporting or emitting behavior of plants during the plan, when emission standards were laxer. It also measures the success of the plan.

[19] The reason for estimating a reported BOD_5 equation, with the dependent variable in mg/l, is that emission standards are defined in terms of mg/l.

Because current pollution could be the result of past monitoring and enforcement actions, I also included the lagged values $INSPMUNCUM_{i,t-1}$, $INSPNATCUM_{i,t-1}$, $FINEDMUNCUM_{i,t-1}$, and $EANATCUM_{i,t-1}$.[20]

Finally, *EXPORTS* is the value of exports (in US$) over the six month period. I could not obtain exports on a monthly basis, so I assigned the same value in US$ for every month during the six month period for each plant. The idea is to capture if exporting plants pollute less due to foreign markets demand for lower levels of pollution.

Regarding the stochastic disturbance $v_{i,t}$, there are several possibilities pertaining to its behavior. Following Park, the panel structure of the errors can be: (1) panel heteroscedastic, (2) contemporaneously correlated and (3) common serially correlated or (4) plant-specific serially correlated. I addressed panel heteroscedasticity with three different tests: Bartlett, Levene, and Brown-Forsythe. All suggested rejecting the null hypothesis of panel homoscedasticity in favor of the alternative that not all plant-specific errors' variances are the same. I do not test for (2) because I have two plants with no contemporaneous observations. Nevertheless, assuming no contemporaneous correlation of the errors is justified because of the unbalanced nature of the panel, which greatly diminishes the number of observations to calculate the covariances and would produce an estimated residual covariance matrix formed by temporally mismatched sources. While the covariances estimates would be consistent (as the number of observations within cross-sections approaches infinity), they are not likely to be good estimates in this setting.

A Durbin-Watson test on the residuals of the original regression suggested rejecting the null hypothesis of no autocorrelation in favor of the alternative of first-order autocorrelation. A Chow test was used to test for plant-specific versus common autocorrelation of the errors. Test results indicated that the null hypothesis of common autocorrelation should be rejected in favor of the alternative hypothesis of plant-specific autocorrelation. Given this result, I opted to incorporate a lagged value of the dependent variable. The inclusion of a lagged dependent variable effectively eliminated the serial correlation of the errors.

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[20] Monetary fines were not the only penalty levied for not complying. Plants could also be temporarily closed. But neither the municipal nor the national government had trustworthy records of these measures and they were as uncommon as fines during the period. Another form of penalty was to make professionals in charge of treatment plants legally responsible for sending false reports. The objective was to persuade professionals about the dangers of falsifying information and to act on reluctant plants through them. Because high fines are rarely levied in less-developed countries where firms suffer from important cash flow constraints, these alternative penalties are easier to apply because they do not imply a cash payment. Unfortunately, it was impossible to measure their effects. Finally, $INSPSEINCOCUM_{i,t-1}$ (the cumulative number of past inspections by SEINCO) was originally included in this model but it was dropped due to its correlation of 0.91 with $PINSPSEINCO_{i,t}$.

Because our number of cross sections is 69 and the number of time periods is 42, our panel falls into the category of panels with a "two-sided small sample”. The problem with this type of panels (i.e.: T not short and N not large) is that the common methods to estimate dynamic panels (Anderson and Hsiao, Arellano and Bond, Blundell and Bond) are biased ([23], [24], [22], [14] and [4]). Bootstrapping is also recommended since none of the usual methods (including fixed effects) provide accurate estimates of the standard errors in these cases. Therefore I run a corrected version of the fixed effects model and bootstrapped the errors, both in Stata, using the “xtlsdvc” command recently developed by [4] for unbalanced panels.

4.2.2 The Reported Violation Equation

In order to test the effectiveness of regulators regarding the reported compliance status of plants, I estimated a conditional fixed-effects logistic model with the dummy $VIOL_{i,t}$ equal to one if the plant reported a violation as a dependent variable. The specification of this violation equation is exactly the same as the specification of the BOD_5 equation, just discussed. Reported violations were defined with respect to the laxer standards during the Pollution Reduction Plan.

5. RESULTS

I begin by presenting the results of the underreporting tests. Then I discuss the results of the inspection equations estimated for the MUN, NAT and SEINCO. Finally, I present the results of the BOD_5 and Violations equations.

5.1 UNDER-REPORTING

Is there any difference between the levels of BOD_5 sampled by regulators and those reported by the firms? Is this difference statistically significant? Is it economically significant? In this section I try to answer these questions.

First, despite having the information, I do not compare BOD_5 reported levels by the plants with the levels obtained by the three inspecting institutions in their sampling inspections because if plants are behaving strategically, they are going to report more when inspected.

Moreover, plants in Uruguay take a control sample at the time of a sampling inspection. Given that sampling is costly for Uruguayan firms (i.e., it is costly to send the sample to a laboratory to obtain the results), it is very possible that the results obtained in this control sample are the same that the plants report later to the MUN.[21]

The chosen way to explore for under-reporting is simply to present descriptive statistics of the difference-of-means and standard deviations of the BOD_5 reported levels when inspected and when not inspected (sampled or not), on a plant-by-plant basis. These statistics do not provide definite evidence of the presence or absence of under-reporting, but they make us suspicious given that more than a third of the plants reported less BOD_5 when not inspected than when inspected, on average. The econometric results of the following sections provide further evidence of under-reporting at the margin.

Doing the comparison on a plant-by-plant basis is important. Since inspections are not random, comparing means of the reported levels during the months in which they were not inspected and the months in which they were inspected across all plants would provide misleading results in favor of the presence of under-reporting on average. Also, I opted to present simple descriptive statistics of the differences of the means and standard deviations instead of formal statistical tests because the relatively low number of months in which the plants were inspected (as compared with the number of months in which they were not inspected) undermines the power of the tests.

Twenty-eight plants out the sixty-nine in the sample (41%) presented larger average levels of reported BOD_5 when inspected as compared to when not inspected by the MUN. The figure is 34% for the NAT, who inspected fifty-six plants and 33% for SEINCO, who inspected sixty-seven. The plants with larger average reported levels of BOD_5 when inspected by the MUN are also the plants with larger levels for the case of NAT and SEINCO, mostly. For the case of the MUN, the average difference between reported levels of pollution when not inspected and when inspected for plants that "under-reported" on average was 33% and the standard deviation was 26%. In the case of the NAT, the average difference was 75% and its standard deviation 94%, and 38% and 51% for the case of SEINCO. Therefore, I am suspicious that more than one third of the plants seem to be acting strategically (under-reporting). The extent of their under-reporting is not trivial, ranging from one third to three quarters, on average, according to the three inspecting

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21 This control sample is not mandatory in Uruguay, as it is in Canada, for example. Laplante and Rilstone (1996) compare the levels reported in the months in which the plants were inspected with the levels of the control sample. Therefore, plants in Canada apparently do not report the control sample as they possibly do in Uruguay.

institutions. This result is somewhat new in the literature. First, because the only papers dealing with a LDC (China) did not include any test for under-reporting. But second, and most importantly, all previous papers that did include some type of test did not find evidence of under-reporting. Giving compelling answers about the reason for this disparity is outside the scope of this paper because I have no possibility of controlling for all the possible differences between firms and between Uruguay and the US and Canada. But one possible explanation might be the differences in expected penalties faced by firms in the developed and the less developed world. The issue deserves future research given its obvious importance for policy recommendations.

5.2 INSPECTION EQUATIONS

In this section I present the estimating results of the inspection equations for each of the three different monitoring agencies. I report the results for the conditional (fixed-effects) logistic regressions but not for the unconditional logistic regressions.

5.2.1 MUN Inspection Equation

Results for the MUN inspection equation are presented in Table 4.

Table 4 should be put here

The most important results concerning the inspection strategy followed by the MUN are the following. First, the more inspections a plant received in the past 12 months, the lower is the probability of being inspected again in a given month. This reflects the sample-without-replacement inspection strategy mentioned by inspectors in interviews. But it also reflects budget constraints, as told by the negative effect of the number of inspections performed on the rest of the plants. Besides the effect is low, its sign says that the more the number of inspections in the other plants the lower the probability of being inspected.

Second, the MUN used SEINCO inspections as a substitute for their own, and started to monitor industrial plants more closely again after the end of the Plan. Third, results suggest that the MUN inspectors did not react to the economic situation of the industrial sector, according to the coefficient of the industrial volume index. But this result may be derived by the fact that when the MUN increased inspections (after the Plan) the Uruguayan economy was in the middle of a recession that had started at the end of 1999 and lasted until 2002. In other words, the MUN kept tight to the schedule of activities derived from the IADB loan (the Monitoring Program and the Pollution Reduction Plan) in spite of the economic situation of the firms.

Fourth, reporting failures (RF) are a better predictor of inspections than any monitoring and enforcement variable, except fines (and the special campaign before SEINCO appeared), as indicated by both the size of its coefficient and its statistical significance. Fifth, the MUN seems to be targeting plants emitting directly into a water body. Finally, the MUN did not react to the NAT campaign in the Carrasco stream in particular, or to the activity of the NAT in general.

5.2.2 NAT Inspection Equation

Results for the NAT inspection equation are presented in Table 5. After controlling for the special monitoring campaigns that took place in 1999 on the Carrasco stream, I find that the larger the number of inspections performed by the NAT on a given plant in the last twelve months, the lower is the probability of being inspected in a given month. Second, the larger the number of inspections performed by the NAT on the rest of the plants in the last twelve months, the lower is the probability of being inspected by the NAT in a given month. Explanations of these negative signs are similar to those given in the MUN case.

Table 5 should be put here

I also find a correlation between the number of past inspections of the MUN to a plant and the chance that the NAT inspects that plant. This correlation is significantly different from zero only at the 15% level, but it is positive. One expects a coordinated activity between a municipal and a national government trying to enforce the same emission standards, so as to observe a negative sign in coefficient estimate of the cumulative number of inspections of one office on the chance of being inspected by the other office. But on the contrary I observe a close to zero and insignificant effect of the NAT activity on the probability of being inspected by the MUN and a positive and almost statistically insignificant effect of the MUN inspections on the probability of being inspected by the NAT. Furthermore, another interesting result is the way the NAT seems to have reacted markedly to the activities related to the Monitoring Program and the Industrial Pollution Reduction Plan implemented by the MUN. First, it increased its monitoring frequency during the MUN Plan in a fashion that is only comparable to the way it increased inspections during its own campaign in the Carrasco stream. Second, it seems to have followed SEINCO activity somewhat, according to the estimated effect of past SEINCO inspections.

Finally, the national government inspectors did react to the economic situation of the firms according to the significant and positive effect of the industrial volume index. A possible interpretation for the difference between the MUN and the NAT in this respect is that the national government did not have a commitment with the Inter American Development Bank regarding industrial pollution, unlike the municipal government. Therefore, it could simply inspect less during recessions, as it seems to have done.

5.2.3 SEINCO Inspection Equation

Results for the SEINCO inspection equation are presented in Table 6. SEINCO inspections were very systematic. SEINCO did not take into account recent past inspections of the MUN or the NAT to decide who and when to inspect. The only variables that explain SEINCO inspections are past SEINCO inspections, in a sampling without replacement fashion. The timing of SEINCO inspections explains the signs of the coefficients of the industrial volume index and the DURINGPLAN dummy.

Finally, SEINCO also considered emissions directly into a water body to be an important variable in the allocation of inspections across plants. Although the variable is not significant at 18%, its coefficient is the second largest.

Table 6 should be put here

5.3 THE POLLUTION EQUATIONS

As explained earlier, I fit the three unconditional models of inspection to obtain "probabilities" of being inspected by each of the three inspecting institutions. These probabilities of being inspected are used as explanatory variables in the pollution equations to control for the behavior of plants regarding possible future monitoring and enforcement actions.

5.3.1 The BOD_5 Equation

Results for the BOD_5 equation are presented in Table 7. As explained before, the presented results were obtained running the corrected version of the LSDV estimator implemented by [4] in Stata. I used Anderson and Hsiao as the first step estimator, as suggested by [23].

Table 7 should be put here

The first thing that strikes one when examining the results in Table 13 is that none of the monitoring and enforcement variables of any of the enforcement institutions have a clear statistically significant effect on the reported level of BOD_5 of the plants. This is particularly true for the past activities of both the MUN and the NAT. These have marginal effects that are almost zero and very insignificant. Inspections, intermediate enforcement actions and fines of both regulators do not have an effect on the reported level of BOD_5 even in the short run. For the case of the probabilities of inspections, one can observe the larger the probability of being inspected by SEINCO or by the NAT, the smaller the level reported plants, both during and after the plan. Although not significantly different from zero, the pattern seems to be different for the MUN inspections. While during the plan the probability of being inspected has the expected negative sign, after the plan the larger the threat of being inspected the larger is the level of reported BOD_5 by the plant for that month. These results may not need to be surprising if one remembers that these are self-reported levels of BOD_5. Plants report to the MUN. A decrease in the reported levels of BOD_5 for larger threats of inspection by the NAT and SEINCO may be telling that plants correctly guessed that the MUN used SEINCO inspections as substitutes for their own, and that the NAT and MUN inspectors were not coordinated, and consequently under-report emissions to the MUN. Consistently, a positive coefficient might suggest that the plants decreased under-reporting as an effect of the increased inspection activity that the MUN displayed after the plan ended (supposedly with the objective of enforcing standards without tolerating violations). But, again, this supposed decrease in under-reporting is not statistically different from zero.

This result is somewhat surprising and different from previous empirical works. Almost every published paper in the matter found some negative effect (as expected) of enforcement actions on the levels of pollution. What account for this difference? It is impossible not to tight the answer to the less-developed-country context from where the results are obtained. For example, none of the previous papers questioned regulators' willingness to effectively enforce the emissions standards. Of course, there is little one can say about it with this type of empirical work, except that one is suspicious about it. But comparing descriptive statistics with the US case (taken from Shimshack and Ward [37]) might help. First, differences in budget constraints of enforcing offices might not be the complete story. The average inspection rate in the US was 12% per plant per month. This rate is similar to that of the Uruguayan municipal authorities (11%, although it was 5% for the NAT). Nevertheless, with a mean violation rate of 41% in Uruguay during the study period the number of fines applied by the Uruguayan authorities was 15, while with a violation rate of 11% in the US, authorities applied 24 fines. Furthermore, the average fine set by the US authorities was $48,000, while it was $1,400 for the MUN and $3,300 for the NAT. Maximum fines were, respectively $600,000, $3,000 and $4,500. These differences are not explained by differences in purchasing power or the time-value of money. Of course, part of these differences may be explained by the soft-enforcement period represented by the industrial pollution reduction Plan. But in any case, the monitoring and enforcement activities seem to have had no statistically significant effect on the reported level of pollution and in that respect they failed as a direct mechanism of enforcing compliance.

Monitoring and enforcement activities may have been more effective as indirect mechanism. According to the sign of the coefficient estimate of the DURINGPLAN dummy, reported pollution was larger during the plan than after the Plan. This result may tell that the Plan was successful in decreasing emissions in some way. The explanation given by MUN inspectors is that the Plan gave them an opportunity to convince industry managers to recruit professionals to be in charge of their treatment plants and to act on the incentives of these professionals at their work. This translated into changes in the abatement and production processes that had an effect on pollution levels. This may be true. Given that the starting situation was bad, even small, easily implementable corrections in the operation of the treatment plants may have had an effect on pollution levels. Even without investing in treatment technology, industries may have decreased pollution levels by operating their treatment plants in a better way. Nevertheless, with the type of information at hand I am unable to disentangle the real reason behind the negative sign of the DURINGPLAN dummy coefficient estimate. For example, a similar result would be obtained if an undetected increase in under-reporting occurred after the plan.[22] Another possibility is that

[22] Using only MUN inspections, the percentage number of plants (of those that were inspected and reported) that reported more during the months that were inspected as compared to the months in which they were not inspected, on average, was 36% during the Plan and 54% after the Plan. The average difference of BOD_5 reported levels when inspected and when not inspected for these plants was 35% during the Plan and 30% after the Plan. The standard deviation of these differences was 40% during the Plan and 33% after the Plan. Using only NAT inspections the percentage number of plants apparently under-

plants may have polluted more during the Plan to take advantage of the laxer standards. Finally, the most important problem for the interpretation of the results as a success of the Plan is that only eight plants adopted abatement technology during the period.

Another interesting result is the negative sign of the coefficient estimate of the variable WATER. As noted earlier, water is an important input in pollution abatement because emission standards are set in concentration terms. Therefore, although explicitly prohibited by law, diluting is an easy and cheap compliance strategy and at the same time very difficult to detect.

Finally, the dollar value of exports does not have any explanatory power on the level of emissions. It is very probable that what lies behind this result (contradicting the usual story) is that I do not disaggregate exports by destination. Almost half of the Uruguayan international trade was with Brazil and Argentina during the sample period; two countries with few environmental concerns, and certainly not comparable with those of the developed world.

5.3.2 The Violation Equation

Our main objective in this section is to answer the question "Do enforcement actions affect the probability of a violation?" To this end, I define the dependent variable as a dummy equal to one if the plant reported a violation. Violation is defined with respect to the laxer standards during the Pollution Reduction Plan. Results are presented in Table 8. This model discards 480 observations belonging to 15 plants that either complied or did not comply in every month and therefore did not add any likelihood to the conditional model. Twelve of these fifteen plants were plants that reported compliance during every month they informed. The rest reported a violation. Five of these 15 plants were plants that have larger average levels of reported BOD_5 when inspected in comparison with their reports when not inspected. This figure is similar to that

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reporting slightly decreased from 32% during the Plan to 29%. The average percentage difference of BOD_5 reported levels when inspected and when not inspected decreased more sharply from 70% to 32%. Nevertheless, the percentages are not strictly comparable because the NAT decreased markedly the number of plants inspected during and after the Plan. In this respect SEINCO is a better source for comparison. During the Plan, 34% of the 64 plants that reported and were inspected by SEINCO reported more during the months that were inspected as compared to the months in which they were not inspected. The average difference was 73% and its standard deviation was 90%. After the Plan, 49% of the 68 plants that reported and were inspected by SEINCO reported more when inspected as compared when not inspected. The average "under-reporting" was 34% and its standard deviation was 35%. These numbers are very similar to those obtained with the MUN inspections, although the average "under-reporting" in this case decreased more sharply. Therefore, on average, using MUN and SEINCO inspections, after the Plan ended the number of plants that may have behaved strategically (under-report) on average increased from 1/3 to 1/2, but the average "lie" and its standard deviation decreased.

of the whole sample. Therefore, under-reporting is not a bigger problem in this equation relative to the BOD_5 equation.

The most important results obtained are the following. The Industrial Pollution Reduction Plan dummy has a statistically insignificant negative coefficient, indicating that the Plan, whose objective was precisely to increase compliance, did not have an effect on the probability of violation.

Table 8 should be put here

Only the threat of an inspection by the national government has a statistically significant and strong effect on the reported violation status of plants. The effect seems to have been negative during the Plan, but positive and equally important after the Plan ended. Nevertheless, past inspections of both the MUN and the NAT seems to have decreased the probability of a reported violation. Both are not statistically significant at 15%, but their significance levels are smaller than the remaining enforcement variable. Interestingly, and puzzlingly, intermediate enforcement actions and fines have neither a statistically significant nor an important effect on reported status of compliance. Hence, there may be some enduring effect of the activity of inspectors not captured by subsequent enforcement actions. During inspections, form example, inspectors may point easy-to-correct problems to the plants' managers that may result in compliance improvement.

Finally, the dollar value of exports does not have any incidence on the reported compliance status. The same caveat about the destination of exports applies here.

As was the case in the BOD_5 equation, the lagged dependent variable is very statistically significant and its coefficient estimate is one of the largest. With plant specific fixed effects included in the equation this variable may be capturing the fact that plants may not be technologically equipped to change their compliance status from one month to the other. I do not have information on the number of industrial plants with proper effluents treatment plants. But according to interviews with inspectors most of them do not have one. This was one of the reasons for implementing the Plan in the first place. Therefore, considering that most of the seventy four plants did not have an effluent treatment plant, or did not have an adequate one, the number of plants that incorporated abatement technology during the period gives another indication of the magnitude of the success of the Plan: eight.

Because of the estimation techniques the number of plants used to estimate this violation equation (54) is not the same as the number of plants used to estimate the BOD_5 equation (69). Therefore, I have to be very careful with the comparison of results. Nevertheless, one thing that must be mentioned is that according to the DURINGPLAN dummy coefficient estimate, the Industrial Pollution Reduction Plan implemented by the MUN to increase compliance rates did not accomplish this goal. The simplest explanation for the negative sign of DURINGPLAN is that during the Plan emission standards were laxer than after the Plan. This fact outweighs the fact that emissions were also larger during the Plan. (Recall the positive effect of DURINGPLAN on reported BOD_5 levels). The result is extremely important because an increase in the levels of compliance of industrial firms with effluent standards was the main objective of the program undertaken by the MUN with funds from the Inter American Development Bank. According to this result, the program failed to accomplish this. This result may provide some evidence for Russell and Powell's [36] hypothesis that "there is little the outside world can do - even the multilateral aid agencies with their massive resources of money and expertise" if the local environmental authorities lack the will to impose current costs on the industry sector to enforce environmental regulations.

6. CONCLUSIONS

This study analyzes the effectiveness of environmental regulators activity in the capital city of a less developed country. It illustrates some characteristics of environmental policy in these countries that are not present in more developed ones, such as the influence of multilateral lending agencies on local environmental policy and regulators' unclear willingness to impose environmental costs on firms. The results are the following: first, more than one third of the industrial plants report larger levels of BOD5 when inspected as compared to when not inspected, on average. The extent of this under-reporting is not trivial, ranging from one third to three quarters of the levels of pollution found by regulators in inspections.

Another relevant finding regarding the inspection activity of enforcers is that the municipal government did not take into account the past history of the national government inspections to determine which plants to inspect or with what frequency. Nor do I find statistically significant evidence that the NAT took past MUN inspections into account directly. If it did, it increased inspections when the other inspected more often. (The coefficients estimates measuring these reactions are insignificant but positive). Furthermore, the NAT did follow the MUN inspection activity indirectly. First, it increased its monitoring frequency during the MUN Industrial Pollution Reduction Plan in a fashion that is only comparable to the way it increased inspections during its own special campaign in the Carrasco stream. Second, it seems to have followed SEINCO activity somewhat. These results are important because when enforcement is in charge of both local and national governments, coordination is crucial to increase effectiveness. I find that agencies are not coordinated. The NAT should have concentrated its monitoring resources on the rest of the country during the period when the MUN or SEINCO increased their inspection activity in the capital city of Montevideo in order to use scarce monitoring resources more efficiently. Nevertheless, the opposite was true. The NAT might have reacted as if it were competing for enforcement. This is undesirable because it undermines the cost-effectiveness of the enforcement policy.

As expected, municipal government (MUN) monitoring and enforcement activity was determined by the IADB-loan. The monitoring campaigns developed by the MUN and financed by the Inter American Development Bank during 1997 and 1998 resulted in an important jump in its frequency of inspections. Also, the MUN used the inspections of a private consortium (called SEINCO) as substitutes for their own during the IADB-financed Monitoring Plan. Finally, the MUN started to monitor industrial plants more closely again after the end of the Pollution Reduction Plan. On the other hand, the national government did not have a commitment with the Inter American Development Bank regarding industrial pollution, as did the municipal government, and at the same time it was politically accountable for the performance of the economy. Therefore, it could simply inspect less during months with low industrial activity, as it seems to have done. These results illustrates two characteristics of environmental policy in LDC that are not present in more developed countries: first, the influence of multilateral lending agencies like the IADB in shaping local environmental policy, and second, the goal of reducing unemployment rates and poverty is placed above environmental quality in the policy agenda of governments.

With respect to the effectiveness of this enforcement policy, results are no less illustrative. I find no statistically significant (at levels less than 30%) marginal effect of any inspecting or other enforcement activity of both the municipal and national governments on the level of BOD_5 reported by plants. Although not statistically significant at 15%, the threat of an inspection by SEINCO decreased the reported level of pollution, but I am unable to say if this is not more evidence of under-reporting. This result is somewhat surprising and different from previous empirical works. Almost every published paper on the matter found some negative effect (as expected) of enforcement actions on pollution levels. But none of them questioned the willingness of regulators to effectively enforce the emissions standards in the presence of other social needs (employment, poverty reduction) that they believe compete with environmental quality. Besides the Industrial Pollution Reduction Plan had some effect in reducing reported pollution levels, the lack of a clear effect of the enforcement activity of regulators may be evidence of this lack of willingness.

Another important result is that some sort of diluting may be taking place. Finally, the main objective of the Plan undertaken by the MUN with funds from the Inter American Development Bank was to increase the levels of compliance of industrial firms with effluent standards. Results suggest that the Plan failed to accomplish this in a direct way. This result may provide some evidence for Russell and Powell's [36] hypothesis that "there is little the outside world can do - even the multilateral aid agencies with their massive resources of money and expertise" if the local environmental authorities lack the will to impose current costs on the industry sector to enforce environmental regulations.

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Table 1: Descriptive Statistics for Reported Input and Pollution Variables

Sample July 1997 – October 2001 - Total Potential Observations: 3,848

Variable	Mean	Median	Std. Dev.	Missing Values
BOD_5 (mg/l)	1,031	370	2,334	952
Effluent flow (m^3/day)	203	52	453	1,034
Tap water (m^3/month)	3,848	784	8,271	638
Underground water (m^3/month)	2,793	750	4,873	1,279
Electricity (Kwh/month)	179,409	68,000	278,828	449
Fuel (m^3/month)	34	12	50	862
Days worked (per month)	22	23	4.6	594
Number of employees	122	60	276	342

Table 2: Descriptive Statistics for Monitoring and Enforcement Variables

Sample July 1996 – October 2001		MUN – 74 plants				NAT – 61 plants			
	Units	Mean	S.D.	Max.	Sum	Mean	S.D.	Max.	Sum
Sample Inspections	#	0.085	0.286	3	401	0.026	0.158	1	122
Result (BOD_5)	(mg/l)	1,582	3,894	49,925	-	1,102	1,720	10,400	-
Non-sample Inspections	#	0.031	0.212	6	148	0.019	0.137	2	89
Total Inspections	#	0.116	0.378	9	549	0.045	0.210	2	211
Inspections	0/1	0.106	0.308	1	502	0.044	0.204	1	207
Compliance Orders	#	-	-	-	-	0.024	0.155	2	112
Postponements	#	-	-	-	-	0.013	0.123	2	60
Fine threats	#	-	-	-	-	0.015	0.126	2	72
Fines	#	0.003	0.052	1	11	0.001	0.029	1	4
Fine ($)	$	1,404	1,050	3,000	15,450	3,375	750	4,500	13,500
Sample April 1999 – September 2001		SEINCO – 71 Plants							
Sample Inspections	#	0.180	0.384	1	666				
Results (BOD_5)	(mg/l)	1,184	2,545	38,000	(mg/l)				

Notes: (1) Observations for fines levied by MUN were available from May 1997 (3,996 observations).

(2) Statistics for amount of fines are based on non-zero observations.

(3) Fines are in October 2001 dollars.

Table 3: Descriptive Statistics for Reported Violations

	Reported Extent of Violation (Censored at zero)		Reported Compliance Status (Violation = 1, Compliance = 0)	
	Original Standards	Plan's Standards	Original Standards	Plan's Standards
Mean	641.5	338.8	0.54	0.41
Median	20.0	0.0	1.0	0.0
Maximum	38,143	17,125	1.0	1.0
Std. Dev.	1906.7	1124.1	0.50	0.49
Observations	2,699	2,192	2,699	2,192

Table 4: MUN Inspection Equation

Conditional (Fixed-effects) Logistic Regression

Dependent Variable: Inspected by the MUN dummy

Variable	Coefficient	Std. Error	P-value
# Insp. by MUN 12 last months on plant	-0.221***	0.067	0.001
# Insp. by MUN 12 last months on other plants	-0.023***	0.004	0.000
# Fines by MUN 12 last months on plant	1.105***	0.362	0.002
# Insp. by SEINCO 12 last months on plant	-0.179***	0.040	0.000
# Insp. by NAT 12 last months on plant	0.010	0.067	0.881
# IEA by NAT 12 last months on plant	0.071	0.070	0.315
Industrial Physical Volume Index	-0.000	0.008	0.995
DURINGPLAN WITHOUT SEINCO dummy	1.368***	0.293	0.000
DURINGPLAN WITH SEINCO dummy	-0.520	0.207	0.012
Reporting Failure dummy	0.474	0.201	0.018
STREAM dummy	1.078	0.768	0.161
CARRASCO Basin 1999 campaign dummy	0.124	0.414	0.764
Number of Observations	3066	Log like.	-829.00
LR statistic (12 df)	119.1	Pseudo R2	0.067
Prob > chi2	0.000		

Notes: Two-tailed. z-distribution used. One plant (42 obs) dropped due to all positive or all negative outcomes.

Table 5: NAT Inspection Equation

Conditional (fixed - effects) Logistic Regression

Dependent Variable: Inspected by the NAT dummy

Variable	Coefficient	Std. Error	P-value
# Insp. by NAT 12 last months on plant	-0.23***	0.088	0.009
# Insp. by NAT 12 last months on other plants	-0.05***	0.016	0.003
# IEA by NAT 12 last months on plant	-0.01	0.101	0.933
# Insp. by SEINCO 12 last months on plant	0.09	0.060	0.131
# Insp. by MUN 12 last months on plant	0.13	0.088	0.153
# Fines by MUN 12 last months on plant	0.12	0.533	0.827
Industrial Physical Volume Index	0.03*	0.013	0.056
DURINGPLAN WITHOUT SEINCO dummy	1.25***	0.436	0.004
DURINGPLAN WITH SEINCO dummy	2.00***	0.380	0.003
Reporting Failure dummy	-0.27	0.380	0.481
STREAM dummy	0.32	0.949	0.735
CARRASCO Basin 1999 campaign dummy	3.14***	0.499	0.000
Number of Observations	1974	Log likelihood	-363.27
LR statistic (12 df)	93.59	Pseudo R2	0.1141
Prob > chi2	0.000		

Notes: Two-tailed. z-distribution used. 27 plants (1134 obs.) dropped due to all positive or all negative outcomes.

Table 6: SEINCO Inspection Equation

Conditional (fixed - effects) Logistic Regression

Dependent Variable: Inspected by SEINCO dummy

Variable	Coefficient	Std. Error	P-value
# Insp. by SEINCO 12 last months on plant	-0.285***	0.051	0.000
# Insp. by SEINCO 12 last months on other plants	0.007***	0.001	0.000
# Insp. by MUN 12 last months on plant	-0.098	0.067	0.143
# Fines by MUN 12 last months on plant	-0.029	0.494	0.954
# Insp. by NAT 12 last months on plant	-0.005	0.072	0.943
# IEA by NAT 12 last months on plant	0.080	0.092	0.387
Industrial Physical Volume Index	-0.017	0.009	0.054
DURINGPLAN WITH SEINCO dummy	2.502***	0.156	0.000
Reporting Failure dummy	-0.243	0.262	0.354
STREAM dummy	1.711	1.303	0.189
CARRASCO Basin 1999 campaign dummy	0.279	0.394	0.478

Number of Observations	2130	Log likelihood	-872.78
LR statistic (10 df)	433.7	Pseudo R2	0.1990
Prob > chi2	0.000		

Notes: Two-tailed. z-distribution used. Three plants (90 obs.) dropped due to all positive or all negative outcomes.

Table 7: BOD5 Equation

Dependent variable: $Log(BOD_5)$		
Explanatory Variables	Coefficient	P-value
$Log(BOD_5)_{(t-1)}$	0.31***	0.000
DURINGPLAN dummy	0.18*	0.069
Prob. Insp. by MUN	0.42	0.574
(Prob. Insp. by MUN)*DURINGPLAN	-0.78	0.320
Prob. Insp. by NAT	-1.17	0.289
(Prob. Insp. by NAT) *DURINGPLAN	0.80	0.448
Prob. Insp. by SEINCO	-0.42	0.145
(Prob. Insp. by SEINCO)*DURINGPLAN	0.38	0.182
# Insp. by MUN 12 last months on plant	-0.02	0.454
# Insp. by NAT 12 last months on plant	0.02	0.428
# Fines by MUN 12 last months on plant	0.04	0.812
# IEA by NAT 12 last months on plant	-0.00	0.978
$LOG(P_q)$	0.06	0.801
LOG(LABOR)	0.61***	0.000
LOG(WATER)	-0.06*	0.067
LOG(ENERGY)	0.29***	0.000
EXPORTS	-1.62E-09	0.771

Table 8: Violation Equation

Dependent variable: Violation dummy

Variable		Coefficient	(P-value)
Plant violating previous month		1.01***	0.00
DURINGPLAN dummy		-0.33	0.44
Prob. Insp. by MUN		0.02	0.99
(Prob. Insp. by MUN)*DURINGPLAN		-0.35	0.91
Prob. Insp. by NAT		5.39	0.16
(Prob. Insp. by NAT) *DURINGPLAN		-10.34**	0.01
Prob. Insp. by SEINCO		-0.11	0.92
(Prob. Insp. by SEINCO)*DURINGPLAN		-0.07	0.95
# Insp. by MUN 12 last months on plant		-0.12	0.16
# Insp. by NAT 12 last months on plant		-0.11	0.24
# Fines by MUN 12 last months on plant		-0.19	0.76
# IEA by NAT 12 last months on plant		0.09	0.30
LOG(PQ)		-0.28	0.75
LOG(LABOR)		0.28	0.16
LOG(WATER)		0.10	0.36
LOG(ENERGY)		0.53***	0.01
EXPORTS		0.00	0.58
Pseudo R^2	0.11	Prob > chi2	0.00
LR chi2	160.15	Log likelih.	-678.4