137
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ANALYZING THE ENVIRONMENTAL PERFORMANCE OF THE BRAZILIAN INDUSTRIAL SECTOR

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ANALYZING THE ENVIRONMENTAL PERFORMANCE OF THE BRAZILIAN INDUSTRIAL SECTOR[1]

Ronaldo Seroa da Motta[2]

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SUMMARY

SINOPSE

Este estudo analisa os determinantes do desempenho ambiental na indústria brasileira. Para tal, usa a base de dados da Pesquisa sobre Gestão Ambiental da CNI, que cobriu 325 médias e grandes empresas para o ano de 1997. Usamos um indicador de desempenho composto de uma soma ponderada das práticas de controle ambiental adotadas para cada firma. Consoante com a literatura, os resultados também confirmam que as características da firma, tais como tamanho, natureza do capital, grau de exportação e pressão da comunidade são outros fatores influenciando o desempenho ambiental. Acima de tudo, observou-se que práticas indutoras de redução de custos e subsídios são igualmente importantes. Com base nesses resultados sugerimos a adoção de instrumentos regulatórios mais flexíveis que capturem as diferenças entre as firmas como também outros que acelerem a disseminação de práticas de gestão ambiental que sejam redutoras de custos.

ABSTRACT

This study will analyze the determinants of environmental performance in the Brazilian industrial sector. It uses a database conducted by the Brazilian National Confederation of Industries inquiring about questions on environmental management over 325 medium and large firms referred to the year 1997. We have been able to test a proxy of environmental performance, such as a weighted average number of environmental control practices. Consistent with results in the main literature, our study confirms that, apart from some expected characteristics of the firm, as size, sector and foreign ties, demands from communities and market incentives are also very influential determinants. Cost savings on inputs and subsidized credit are found equally important. Based on that, we recommend flexible instruments on pollution control that capture the firm's differentials in characteristics and compliance levels as well as dissemination of information on environmental control and related cost saving opportunities.

1 INTRODUCTION

The benefits of pollution control are usually widespread over the whole society. High transaction costs of assigning and securing property rights over most goods and environmental services make those suffering from harmful effects of pollution unable to seek full compensation against emitters. This is the typical case of a negative externality i.e., third party damages that market is not properly pricing.

If the benefits of pollution control, that is, the damages avoided, are lower than the respective private control costs, emitters will lack incentives to undertake it. So pollution control is a typical case of governmental intervention to correct a market failure. The classic paradigm for environmental policies is then based on the regulator (a principal) controlling private agents through regulation. Non-compliance with norms and rules dictated by the regulators is liable to sanctions.

The seminal work of Becker (1968) on general legal compliance stated that profit maximization would make agents equalize non-compliance and compliance costs at the margin. Compliance costs require that firms incur in expenditures to adjust themselves to the norms and rules set in the regulation.

Non-compliance costs are sanctions applied to the firm that has not made the required adjustment and depends on the level of the sanction weighted by the probability of being caught, that is, the expected sanction value. While sanction values are usually known (penalty value, closure costs etc.), the probability of being caught is not directly observed by firms. Regulators may play different strategies from low sanction values with high monitoring level to high penalties with low inspection rates. Firms will have their own expectations on the probability of being caught and make compliance decisions against their expected value of non-compliance costs.

This model should also apply to environmental regulation where norms and rules affect almost all production activities. Harrington (1988), however, analyzes the apparent paradox that in the US firms that tend to show high compliance rate despite the fact that the Environmental Protection Agency (EPA) is highly tolerant with non-compliers, and consequently expected sanction values are usually lower than non-compliance costs.

Harrington (1988) solves this paradox with a repeated enforcement/compliance game where EPA utilizes a state-dependent enforcement regime in which firms are classified in two groups according to their violation records in the last inspection period. In Group 1 are those not in violations in the last period and in Group 2 are those found in non-compliance. When firms are in Group 1, violations are monitored and sanctioned with much lower penalties than those in Group 2. So penalty in Group 2 is the expected high penalty plus the present value of returning to Group 1 in terms of laxer treatment when compared to Group 1? Harrington (1988) showed that in equilibrium, high compliance is compatible with low penalty and inspection rates, since the state-dependent regime creates inspection and penalty differentials working as incentives to firms in making efforts to be part of the good compliers in Group 1.

Deily and Gray (1991) focus on the role of the regulators so as to maximize net political support, as suggested by Stigler (1971), using pollution control data on the

US steel sector in the period 1977-1986 of declining sectoral activity. They found that in high-polluted and concentrated areas, regulators may gain political support from more enforcement, whereas firms that are major employers and likely to close are subject to less enforcement.

Following the principal-agent problem issues, Garvie and Keeler (1994), applying a Stackelberg sub-game with complete information, analyze how compliance is affected by the way regulators balance expenses on monitoring and actions to levy penalties and also by public consensus on the desirability for better environmental conditions. They also analyze private information problems when regulation is discretionary to equalize compliance costs across firms.

Literature also analyses how firms comply when they face public scrutiny. Afsah and Wheeler (1996) study how a 1995 program on information release about firms' environmental performance has largely contributed to high compliance rates in Indonesia where there is a weak formal enforcement regime.

However, Konar and Cohen (1997), applying an econometric model, undertake a similar analysis for the Toxic Release Inventory (TRI) , started in 1988 in the US, in which they found that negative media attention to firms' emission levels, after controlling for the firms' characteristics, particularly size, has not affected decisions on environmental compliance. That is, ability to comply dominates market incentives. Hamilton (1995), instead, found correlation between intense media exposure of high emitters and declining stock prices, analyzing the same program although controlling for exposure intensity.

Magat and Viscusi (1990) and Laplante and Rilstone (1996) deal with the endogeneity of regulation enforcement in compliance level decisions with two-stage regression. Theoretical models have also shown that market incentives are important and Reinhardt (1999) identifies how the managerial skills of firms and its rank in the market can be both influencing compliance.

Quantitative studies in developing countries have mostly addressed the effects of informal regulation, that is, how communities and non-governmental organizations (NGO) may affect the environmental performance of firms. The first approach was to regard informal procedures as a complement of weak formal enforcement. Local community members can act negatively against bad compliers in different forms, from political sanctions to boycotts. Pargal and Wheeler (1996) test this hypothesis for Indonesia using data on industrial wastewater. Apart from the importance of firms' characteristics, they found that there is high elasticity between emission and community income and education levels. Hettige *et al.* (1996) review studies on determinants of pollution abatement in South and Southeast Asia and found some similarities with the results in Indonesia regarding informal regulation. Panayotou, Schatzki and Limvorapitak (1997) analyzed environmental investments in Thailand and found that formal and informal pressures were influential on firms' decisions and Blackman and Bannister (1998) did the same for propane substitution in Mexico.

Nevertheless, these studies, by using community data and not actual observations on pressure levels, were not able to distinguish community action channeled through regulators, and thereby part of the regulatory procedures, from

the one that is directly engaged towards the firms. Recently, Dasgupta, Hettige and Wheeler (2000), based on a detailed field survey, analyzed how abatement control was determined in the Mexican industrial sector. They used indicators of self-evaluated performance with endogeneity for several environmental management variables and found again evidences on firms' characteristics but little on market incentives and none on informal regulation measured from responses of the survey. They suggest that indirect community pressure through regulators can be the case.

Ferraz and Seroa da Motta (2001) applied a model with endogenous non-compliance sanction, determined in two-stage regression, regressed against investment decisions. They relied on a database for the industrial sector of the State of São Paulo, the most developed region of Brazil. Results confirmed this indirect way with significant coefficients to ecological voting trends, number of NGOs and income levels in the sanction function. They also found evidences on firms' characteristics and market incentives, as, per example, high export sales, affecting environmental investments.

As can be seen from this short summary of literature review, environmental performance of the firms can be affected by their own characteristics (ability aspects), market opportunities (incentive aspects), regulatory procedures (sanction aspects) and community pressure (informal aspects).

This study will analyze the contribution of these factors in the Brazilian industrial sector, using data from a survey that indicates how medium and large firms apply environmental practices. Our results will confirm most of the finding of the previous study Ferraz and Seroa da Motta (2001) on Brazil's firms that was restricted to the State of São Paulo. In addition to that, our data base allowed us to look closer to market incentives, including the current governmental credit instruments.

Next section summarizes environmental regulation in Brazil. Then we describe how the econometric model was identified and discuss the results. Last section makes policy recommendations based on our results.

2 POLLUTION REGULATION AND ENFORCEMENT IN BRAZIL

In Brazil not only EPA but also any citizen can act against polluters for non-compliance. Anyone can denounce a polluter to the EPA and/or to the Public Prosecutor Office (MP).

Firms face two types of legal sanctions, namely: *a*) administrative fines imposed by state EPAs and *b*) remediation and clean-up legal sanctions imposed by the Judiciary. The payment of an EPA fine does not free firms from legal remediation sanctions and criminal charges.[1]

Environmental pollution control is decentralized to states[2] but non-compliance sanctions usually conform to the federal law in three levels: serious, mild and light.

1. A new environmental criminal law has been approved in the National Congress last year with very stiff sanctions, including imprisonment. However, its regulation is only due to next year.

2. Problems with transboundary pollution and rivers and ecosystems crossing more than one state are dealt by the engaged states led by the federal EPA.

EPA, however, in extreme cases, can set plant closure. Fine categories are defined in law but their interpretation and pecuniary charges are set by states on range values. Only very recently, states have revised upward these values, because they had been depreciated by inflation in the late eighties and early nineties.

Fine application follows some general procedures: *a*) warning; *b*) fine setting; *c*) the firm's defense of the fine; *d*) fine analysis; and *e*) fine application. In most states, the fine value is applied by the EPA and its analysis conducted, in severe cases, either by the Secretary of the Environment or by a state council linked to the State Secretariat of the Environment, where non-governmental environmental agencies and civil society (industrial associations, NGOs and academia) also have seats. If the fine is confirmed, firms can only appeal to the Judiciary. As can be seen, EPAs spend a great deal of work on sanction setting and analysis, which means that enforcement costs are not negligible.

When firms are caught on non-compliance status, apart from the fine, they are forced to return to compliance. However, agreements are usually set between violator and EPAs and/or Judiciary [called "term of behavior adjustment" (TAC)], which allows firms a grace period to achieve compliance. The contents of TAC often account for economic constraints faced by firms and the need to compromise with regional development goals that the firm's activities may be related to.

Firms undertaking activities with potential environmental impacts are required to have an environmental licensing granted on environmental criteria.[3] This permit to operate an industrial plant has to be obtained prior to operation and periodically renewed (4-5 years), [4] and is issued according to environmental impact assessment reports (EIA-RIMA). Licensing is analyzed by the state EPA but its issuing is often authorized by the Environment State Council. Licensing procedures are supported by a 1981 federal law, regulated in 1986 and revised in 1998. These legal bindings make mandatory Council's decisions on licensing, and are not disputable in judicial litigation, although failure to meet licensing requirements can be deferred with the TAC instrument. Since the installation of a firm is easily spotted, the monitoring of licensing is also easily undertaken. Moreover, licensing is mandatory for several entitlements of governmental incentives (fiscal and credit ones). Consequently, firms have learned that licensing is not easily avoided, and therefore, there is a very low proportion of firms with full non-compliance licensing status.

Public prosecutors do not have a budget for monitoring and their work consists of putting together a case with the collaboration of governmental and non-governmental organizations. Interesting to mention is that in Brazil, mostly due to acute social problems, violators are sometimes forced by judges to pay for social expenditures (from hospital building to food distribution) instead of full remediation or clean-up actions.

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3. Of course, political pressure, particularly on the State Governor, can force, in some cases, a high degree of relaxation. This is, however, more common on infrastructure projects with diffuse sources of degradation than on located industrial plants with an easily spotted source of emission.

4. Licensing is granted preliminary during plant project design phase and later for operation [licensing of operation (LO)] which is, in fact, the ultimate licensing status.

Firm's defense cost varies. In the case of sanctions, it can range from just a letter or a simple report contradicting the findings of the reported violations to a dense report with monitoring data. Judicial litigation is costly and often avoided unless in extremes cases of imprisonment and closures (which are also very rare). Although most fines applied are confirmed, firms have the incentive to avoid their payment since enforcement for administrative fines is rather weak.

The EPA fines are collected by the state treasury and usually funded in the EPA's budget. Not only their values are not high enough to motivate the treasury to allocate efforts on collection as well as it does not get a share on the resulting revenue. Nevertheless, fines are eventually paid since they will constitute a liability for firms as governmental debt and may jeopardize the firm's relationship with other governmental licensing and credit and fiscal benefits. On the other hand, EPAs do not follow-up fine payments that are totally controlled by the state treasury in a very non-systematic manner. On the other hand, judicial payments are relatively easier to enforce, although they may take longer to be set against firm due to judiciary procedures.

Each state is responsible for its own territorial monitoring on industrial sources. Systematic and randomly monitoring is rare. Monitoring is mostly driven by four factors: *a*) environmental harm potentiality and past behavior of firms; *b*) follow-up of licensing agreements and TAC; *c*) demand from public prosecutors; and *d*) community complaints on change of media environmental quality. The former two factors are endogenously defined by EPA whereas the latter two are defined outside.

Community denouncement is very common in Brazil and it can usually be made by a phone call. Once the case gets space in the news media, its priority on EPA strategies increases. NGOs are frequently a main source of pressure to denouncement, particularly those that are locally organized.

Since EPA managers can be prosecuted due to mandate failures and they are always facing a great deal of systematic monitoring inefficiency, they tend to give high emphasis to these denouncements. And, in fact, EPA performance is measured by its capability to act promptly against these notorious cases. Also, currently, public prosecutors have been imposing a great monitoring burden on EPA for their own actions.

Few states have implemented self-monitoring practices, although they have failed to implement efficient random field verification on firms under this system. Although there is no specific rule for lower fines for self-reported violations, EPAs tend to apply lower fines for self-reported violations. That is also true for violations by firms that are not in the self-reporting system, which, by any reason, report their violations (particularly the accident-related ones with "visible" consequences).

Media environmental quality has only recently been expanded. In case of water quality, due to the importance of hydroelectric energy generation in the country, monitoring is systematic in many states for certain basins covering mainly organic matters and suspended solids. Few major cities, with an acute air pollution problem, have systematic air quality monitoring as well as industrial zones have their own monitoring structure. Because of the lack of consistent and systematic media

monitoring, public perception (visual changes, smell, fish mortality, human health incidences, and so on) is the major indicator for denouncement and basis for EPA actions.

3 DATABASE ANALYSIS

This section presents details of the survey from which data for our study is based on and presents bivariate analysis of the variables that will be applied in our econometric model.

3.1 THE SAMPLE

In 1998 the Brazilian National Confederation of Industries [Confederação Nacional da Indústria (CNI)] undertook the "Survey on Environmental Management in Brazil" [CNI (1998)]. This inquiry, hereafter called CNI survey, was carried out in the period August-September 1998 inquiring the situation of respondents related to year 1997 and for some financial variables to 1996. Its main aim was to generate insights that would allow governmental and development agencies as well as the industries themselves and their institutions to evaluate strategies, policies and instruments to enhance environmental management.

The CNI survey covers the whole country and industrial sectors. Two types of questionnaires were adopted: *a*) a broad one applied to medium and large firms (27 questions) and *b*) a simplified one applied to small firms (10 questions).

The simplified version was necessary since small firms do not keep a wide variety of records, apart from the fact that they are responsible for a minor share of the industrial product, and consequently, of the total pollution generated in the sector.

The broad version of the questionnaire covered aspects related to economic and financial profile of the firm, environmental management practices, relationship with regulators and non-compliance sanctions and expectations on major environmental issues and policies. The simplified one addressed only a few economic information and some aspects of environmental practices.

To facilitate the filling out of the questionnaire and achieve a greater rate of responses, all economic and finance questions that could be informed in monetary terms, are indicated by brackets of percentage intervals related to some other variable, which could be one not inquired, such as percentage of total investments. Exceptions are for revenue and number of employees, which are given in continuous form. Since qualitative questions on environmental management are also in indicative form, our analysis will be heavily based on discrete variables. Although this is a drawback usually faced by most field surveys, such restriction reduces the analytical power of our exercises.

Responses in the questionnaire are related to the major production unit within the state where the firm is located. The size cut is the following: small firms: less than 100 employees; medium: between 100 and 499 employees; and large: over 500 employees.

The sample of 1,451 questionnaires was extracted from a population of 85,600 production units and each size cut was also represented by an aggregation of sectors (total of 23) and regions (total of four). Medium and large firms represent 14% of the number of the respondents. All sample characteristics and representativeness were made out from the database of the Ministry of Labor, which is based on a compulsory annual inquiry related to legal labor norms.

Due to the limitations of the small firm's questionnaire, we will proceed our analysis on the broad version only. Therefore, our study will be directly related to medium and large firms and will be based on an initial sample of 325 firms.

3.2 DEPENDENT VARIABLES

As already mentioned, we intend to analyze the factors influencing environmental performance in the Brazilian industrial sector. To carry this on, we need to select an indicator that measures this performance.

The most appropriate indicator for that purpose would measure firms' pollution impacts since performance, in this case, would be the balance between emission and assimilative capacity. A cross analysis of this indicator would give us the relative magnitude of the firm effort in pollution control against the rest of the sector. The measure of such indicators, however, is far from being trivial. Assimilative capacity is very difficult to measure because it varies locally and is pollutant-specific; emission, as well, is not always observed or reported and may take a form of different pollutants.

Not surprisingly, all studies addressing this issue of environmental control determinants have made use of this indicator, and proxies were utilized instead. These proxies could be broadly classified in three categories; namely: *a*) total emissions [Pargal and Wheeler (1996), Pargal, Mani and Huq (1997) and Konar and Cohen (1997)]; *b*) environmental investments [Panayotou, Schatzki and Limvorapitak (1997) and Ferraz and Seroa da Motta (2001); *c*) self-assessed compliance performance [Dasgupta, Hettige and Wheeler (2000)]; and *d*) environmental management system [Dasgupta, Hettige and Wheeler (2000)].

In this study, our database allows us to use proxies for environmental management system and investments.

4 IDENTIFICATION OF THE ECONOMETRIC MODEL

A polluting firm will minimize production costs equalizing compliance to non-compliance costs. Compliance costs can be measured by the efforts of the firm to comply with mandatory regulation.

The firm's compliance costs are given by its marginal pollution control cost that reflects its ability to comply in terms of the firm's characteristics (size, sector, origin of capital etc.) given by the vector *X*.

Non-compliance costs are avoided sanctions and losses of market premiums opportunities associated with high environmental performance.

Non-compliance faces costs due to penalties applied by regulators, payments resulting from judicial litigation from accidents and damages to third parties,

compensations to community members and foregone market premiums. So the non-compliance marginal costs related to the sanctions applied by regulators, whether resulting from the regulator's inspection or pressure from community members and NGOs, is given by the vector *E*.

The market incentives (export demand with tighter environmental restrictions, subsidized credit, certification etc.) to increase environmental performance due to their affects on competitiveness (on sales or costs) given by a vector *M*.

If so, environmental performance (EPI) can be presented in a reduced-form expressed as:

$$EPI = f(X, M, E) \quad (1)$$

The previous bivariate analysis gives us very interesting results on how the firm's characteristics, market incentives, formal regulation, and community affect, by themselves, our environmental performance indicator. To analyze how the interaction of these variables does affect environmental performance and how the effect of each one is conditional to the existence of the others, we can apply econometric techniques that will be discussed next.

We test our model to data considering the three indicators of environmental performance (PI) previously mentioned, namely:

1) The level of environmental control practices that firms have in place in the year 1997. This is a constructed index vector that gives log values of a continuous variable that reflects a number of practices adopted by each firm summed up by the respective value of $(1-p_i)$ where p is the sample average frequency of practice i. (that is: $\ln \Sigma (1-p_i)$). This variable then reflects the level of environmental management practices of the firm (EMP) that assigns high values for practices that are less frequent. Firms are differentiated by the adoption of less standard practices that may reflect a higher environmental performance.

2) The 1997 level of environmental investment ratio (EI97) is presented in 7 percentage brackets related to total investments undertaken in the year.

3) The 1997 level of environment-related operational costs ratio (EC97) is presented into 3 percentage brackets related to total operational costs.

As can be seen, the continuous variable on environmental practice index represents the current level of environmental management procedures built up over the years and it reflects the total current effort of the firm on environmental management. It has the feature of a stock, although measured in no monetary dimension, and we cannot assume a possible relation between the variable levels and the costs of implementation of such practices.

In the case of the discrete variables on environmental investment ratio to total investments, we are dealing with financial efforts of the firm to improve environmental performance that takes place in 1997. It has, therefore, a dimension of flow economic variable affected by the previous level of investments, that is, the stock of investments.

Although the discrete variable on environmental operational costs also refers to 1997, cost level is also related to the current stock of investments.

Recalling expression (1), the independent variables *X*, *M* and *E* represent the factors affecting the indicators above cited. In our econometric exercises, we can then determine how much each of these factors can explain the applied environmental performance indicator after controlling for the other factors.

As discussed earlier, for *M* and *E* we have two distinct types of information from the survey. For *M* we have answers that indicate export markets, subsidized credit and adoption of certification, and also answers indicating if market opportunities (cost reduction, export market, suppliers, buyers preferences and the firm's image) have motivated the adoption of environmental control practices. The former reflect events actually observed whereas the latter are based on expectations of the results stemming from the adoption of these practices. The observed variables are less sensitive to the respondent's biases whereas the motivations can reveal rational expectations that do not appear in the observed answers.

The same we find for sanctions. Respondents acknowledge if they were sanctioned and in another question, they indicate if environmental compliance requirements and the community's pressure were motivations for the adoption of these practices.

Although positive, no very high correlation was observed between actual and motivated data.[5] Actual events are usually more appropriate to estimate econometric relationships, but in our case motivations may be important variables to correlate the performance indicators representing average number of practices (EMP). Regarding non-compliance sanctions, as said before, the Harrington paradox is explained by the strategy of the firm to avoid penalties, so that EPA will take them to the high inspection rate group. Therefore, in this case motivation can be explanatory, and firms may anticipate investments, as they would not in the case of a sole penalty-oriented behavior.

Expectations on market incentives, such as: cost reduction and increases in market share, may also induce investments. However, most of them can be more easily observed than avoided penalties. Our motivation market variables include an important market incentive that is related to the improvement of the firm's image that is not easily measured, and is not captured in our observed variable.

EMP may thus reflect investments through time, spurred on by motivations, whereas yearly investments may be more affected by observed sanctions. We test this hypothesis running regressions for both 1997 EMP and investments.

It must be also noted that investments and practices led by one motivation may have resulted in one non-expected consequence. For example, the motivation of cost reductions and good image may enhance efficiency and marketing aspects inducing higher exports.

Finally, we have to acknowledge that our regressions based on reduced-forms will be affected by simultaneity between non-compliance sanctions and market

5. The highest correlation, around 0.35, was for motivations related to financing and sanctions.

incentives (for example, supply of credit and environmental restrictions on export markets) and our performance indicators. That is, decisions on environmental control are made simultaneously with stronger regulation pressure and supply availability of market incentives. Because of that, not all independent variables being used can be regarded as fully exogenous and may be correlated to the omitted variables that are also affecting the performance indicators and, consequently, biasing results.

To deal with that, we could apply a simultaneous equation model where each of these functions is jointly estimated. This is not an easy and trivial task but other studies on this subject [Ferraz and Seroa da Motta (2001) and Pargal, Mani and Huq (1997)], granted with more generous databases, have utilized two-stage models to control for simultaneity for, at least, one case of endogeneity. However, such approach is not undertaken here since we believe that our database does not have the variety of information in time and scope length to allow for that.

Tables 1 below presents and describes all variables applied in our econometric exercises. Due to the kind of questions applied in the survey, only size (lnemp) and average number of environmental practices (EMP) are continuous. Other variables are dummies, that is, they just indicate if the firm is or is not classified in the relevant situation.

We assume that the 1997 level of adoption of environmental control practices (EMP) is correlated to all the firm's characteristics, such as: size given by number of employees (lnemp),[6] origin of capital if it is national or international (intship); and sectors (green and brown).

We used total revenue (lnrol) and revenue per employee (rol/emp) but both did not work. We then used number of employees that is usually applied in the literature perhaps because revenue is a kind of information usually avoided or distorted by respondents.

In regard to sanctions and market incentives we tried both sets of observable and motivated variables. For actual observations, we used access to governmental credit (fin1997), export to Organization for Economic Co-operation and Development (OECD) (expOECD) and interest in certification (ISO14). Formal regulation and community pressure were all included in the variable sanction.

$$EMPa = f([lnemp, intship, green, brown]\ (X)\ , [fin1997, expOECD, ISO14]\ (M), [sanction]\ (E)) \quad (2)$$

6. As said in Section 3, we could use revenue figures but a reduced number of respondents gave this answer and we doubt its quality.

TABLE 1
INDEPENDENT VARIABLES

Variable	Characteristics of the firm		Expected sign
	Description		
lnemp	Number of employees in December, 31 st 1997	Log of number of employees	+
rol	Net revenue in December, 31 st 1997	Log of R$ revenue	+
green	Low polluting-sector	0-1 dummy (1 = yes)	–
brown	Medium polluting-sector	0-1 dummy (1 = yes)	–
red	High polluting-sector	0-1 dummy (1 = yes)	+
intship	Part of an international group	0-1 dummy (1 = yes)	+
envunit	There is an environmental management	0-1 dummy (1 = yes)	+
Variable	Market incentives		Expected sign
	Description		
fin1997	Access to subsidized credit to invest in 1997	0-1 dummy (1 = yes)	+
ISO14	ISO 14000 already certified or in process of in 1997	0-1 dummy (1 = yes)	+
expOECD	OECD and Asia export markets representing over 10% of total sales in 1997	0-1 dummy (1 = yes)	+
motFIN	Motivation to adopt environmental control practices related to requirements from governmental	0-1 dummy (1 = yes)	+
motCOST	Motivation to adopt environmental control practices related to production cost savings	0-1 dummy (1 = yes)	+
motEXP	Motivation to adopt environmental control practices related to competitiveness of exports	0-1 dummy (1 = yes)	+
motDEM	Motivation to adopt environmental control practices related to improvement in the quality of the produced goods	0-1 dummy (1 = yes)	+
Variable	Formal and informal regulation		Expected sign
	Description		
sanction	If the firm was sanctioned for non-compliance in 1997	0-1 dummy (1 = yes)	+
motEPA	Motivation to adopt environmental control practices related to licensing and inspections	0-1 dummy (1 = yes)	+
motCOM	Motivation to adopt environmental control practices related to community and NGO pressures	0-1 dummy (1 = yes)	+

In the second version we controlled for the variables related to motivations in avoiding sanctions as result from systematic regulators' inspections (motEPA), pressure from the community and NGOs (motCOM) and others related to the firm's competitiveness (motFIN, motCOST, motEXP and motDEM) replacing *M* and *E*. The equation is given by:

$$EMPm = f([lnemp, intship, green, brown]\ (X)\ ,\ [motFIN, motCOST, motEXP, motDEM]\ (M),\ [motEPA, motCOM]\ (E)) \quad (3)$$

Table 2 presents the results of both regressions for the indexes EMPa (with actual sanctions and market incentives) and EMPm (with motivations to avoid sanctions and capture market incentives). The first column for each regression shows full regression results, and the second only shows the variables that remained significant after progressive deletion of non-significant variables. In both cases, we applied the OLS model.

The model EMPm provides a higher robust fitting to the data, with adjusted $R^2 = 0.25$ in the final form, than the respective R^2 of 0.18 estimated in the form EMPa. Since size is a continuous variable in log form, its coefficients are direct elasticity values. The discrete variables show shifts in the function of the relationship between EMP and the continuous variables (only size in this case) over the medium values. That is, how EMP would change if the dummies took the value of 1. Note that the dummy variables in the regression are the ones that coefficients are related to the absent one.

TABLE 2
RESULTS FOR NUMBER ENVIRONMENTAL PRACTICE INDEX (EMP)

	EMPa	EMPa	EMPm	EMPm
lnemp	0.17	0.15	0.17	0.17
	(3.13)***	(3.23)***	(4.33)***	(4.37)***
intship	0.05	0.19	0.21	0.21
	(0.44)	(1.68)*	(1.91)*	(1.93)*
envunit	0.13		0.00	
	(1.07)		(–0.01)	
green	–0.18	–0.23	–0.24	–0.24
	(–1.32)	(–1.70)*	(–1.89)*	(–1.87)*
brown	–0.27	–0.31	–0.29	–0.28
	(–2.57)**	(–3.20)***	(–3.16)***	(–3.18)***
fin1996	0.35	0.31		
	(2.31)**	(2.15)**		
expOECD	0.03			
	(0.23)			
ISO14	–0.14			
	(–1.29)			
sanction	0.23	0.24		
	(2.29)**	(2.55)**	0.33	0.33
motFIN			(1.92)*	(1.96)*
motCOST			0.44	0.43
			(5.40)***	(5.38)***
motEPA			0.20	0.20
			(1.86)*	(1.89)*
motCOM			0.27	0.27
			(2.71)***	(2.74)***
motEXP			0.25	0.24
			(1.83)*	(1.87)*
motDEM			–0.01	
			(–0.13)	
AF8-cons	4.39	4.51	4.03	4.02
	(14.50)***	(16.85)***	(14.82)***	(14.95)***
Observations	169	201	241	242
R squared	0.20	0.18	0.25	0.25
Root MSE	0.62	0.64	0.63	0.63
Prob > *F*	0.000	0.000	0.000	0.000

Note: Robust t-statistics in parentheses.

* significant at 10%; **significant at 5%; and ***significant at 1%.

In both specifications size (lnemp), origin of capital (intship) and sanctions variables are significant and show the expected sign, confirming that larger firms, with foreign capital that either faced sanctions or wish to avoid them, tend to adopt a greater number of environmental control procedures. The size results confirm most of the hypothesis put forward in the previous section about plausible influence of these variables, assuring results found in other studies. As we can see in Table 2, size has quite similar elasticity in both models with 0.15 in EMPa form and 0.17 in the EMPm. In other words, 1% increase of the number of employees over the mean value is motivating 0.15% or 0.17% increase in the index of environmental practices.

Nevertheless, the relevance of foreign capital has been refuted in most studies that otherwise confirm the lower performance of state-owned companies. Since we do not cover public companies, and their role is quite small in Brazil today, we have been able to show this trend towards foreign-controlled companies. Although the significance of the intship variable is quite robust in EMPm, it only turns out significant in EMPa model when other non-significant variables are dropped out.

Sectoral characteristics are also relevant as the coefficient of green and brown sectors are in negative to the absent red sector. That is, as expected, less pollution-intense sectors require a lesser number of control practices than more pollution-intense ones. On the other hand, perhaps due to sector misclassification errors, green sectors coefficients are, in both models, slightly higher than the brown ones.

Centralized environmental management unit is not significant but is showing a positive sign. In turn ISO 14000 certification, although is also not significant, perhaps due to its recent introduction and adoption, is surprisingly presenting a negative sign.

Another important result is the positive and significant coefficient of access to public credit (fin1996) to finance environmental investments and the EPA sanction level (sanction) in the EMPa model.

In the EMPm model, not only motivations to access public credit (motFIN) and to avoid EPA sanctions (motEPA) are also positive and significant as well as their magnitudes are quite close to the similar ones in the EMPa.

Also in the motivation model, the coefficients of motivations to save production costs (motCOST), to attend demands from community and inspections (motCOM) are also positive and significant. However, motCOST is by far the largest coefficient followed by motFIN whereas the others are quite equivalent. Although the variable related to quality of produced goods (motDEM) is not significant, the other motivation results are closer to what one could expect on market influences on environmental performance.

However, it is interesting to note that access to governmental credit, conditioned to environmental compliance, is playing an important role in the environmental performance of the Brazilian industrial sector. This evidence will be stronger in the analysis of investments presented later.

Note that we do not control for informal negotiations between community and firms, but the significance and magnitude of motCOM is confirming that indirect

pressure from communities and NGOs is also relevant in the environmental performance of industrial firms.

In addition to that, differences in the magnitude of dummies' coefficients in the EMPm form, though not fully comparable, are indicating that sanctions from systematic regulator's inspections play a more important role than community pressure. These findings may suggest the confirmation of the Harrington paradox in environmental compliance in Brazil. Environmental management in industrial firms in Brazil is very concerned with trying not to be in the regulator's bad list and thereby facing a higher probability rate of inspections and high sanction levels.

The fact that firms are actually exporting to OECD countries, represented in the variable expOECD, did not show explanatory power in the EMPa model, although motivations to increase competitiveness did instead. This can be explained by the recent perception of environmental restrictions on the export markets.

It must be also noted that we do not observe in our database any variable that could be related to direct pressure from the community and NGOS to set informal negotiations and compliance with firms.[7] Previous studies done in Southeast Asia [Pargal and Wheeler (1996), Hettige *et al*. (1996) and Panayotou, Schatzki and Limvorapitak (1997)] have found evidences on this link. The indirect via way was, however, found in Mexico, other high-income level developing country, by Dasgupta, Hettige and Wheeler (2000), when they also applied a model based on environmental management system indexes. We expect that this indirect relationship is more plausible in Brazil, and it has already been confirmed in Ferraz and Seroa da Motta (2001), who analyzed the industrial environmental investment decision in São Paulo, the most developed state in Brazil.

Similar to our findings in the motivation form, the São Paulo study also found evidences that firms are capturing market opportunities, contrary to the findings of studies carried out in other developing countries based on environmental management and investments [Dasgupta, Hettige and Wheeler (2000) and Panayotou, Schatzki and Limvorapitak (1997)].

5 CONCLUSIONS

Apart from the firms' characteristics, our models were either based on actual data or on motivations regarding compliance with regulation and advantages taken from market opportunities resulting from sounder environmental performance. Therefore, we performed two different regression models for each performance indicator. One with actual data (subsidies, exports, certification and sanctions) and other regressing against equivalent facts expressed by motivations reflecting cost savings, competitiveness of exports, improvement of the quality of products, requirements to obtain subsidized credits and demands from regulators and community.

7. The best way to deal with this phenomenon would be an observed variable on direct negotiations. Another possibility often utilized in the literature is to rely on data from income, education and number of NGOs located in the neighborhood of the firm that are suppose to influence local pressure. We cannot assure, though, that such pressures would be directly negotiated with non-complier firms.

For each indicator we ran two models with each set of determinants. The most consistent results, however, were the indication that sanctions and demands from regulators are the most influential determinants in the adoption of practices. In the case of investments, the actual sanction is significant and motivation to meet EPA's demands is not. This may suggest that the Harrington paradox be also confirmed in Brazil, when firms build up their environmental control systems with motivations to avoid sanctions. When sanctions actually occur they become an important determinant in the investments, in order, perhaps, to change firms' classification as bad compliers, and avoid high enforcement sanctions.

The motivation to meet demands from local communities and NGOs is also relevant for the adoption of control practices, although with much lower influence than other types of motivations, particularly against the regulator's demands. However, we have not been able to verify whether the community demand is conveyed to firms directly or through regulators and prosecutors. The indirect way seems plausible and has already been confirmed in the state of São Paulo, in Brazil, where the most developed industrial sector is located, in a recent study by Ferraz and Seroa da Motta (2001).

Also consistent result in both models for EMP is that some characteristics of the firm, such as size and origin of capital, influence the firm's environmental behavior. Larger firms tied to foreign groups show higher index of environmental practices, which is to say that they tend to adopt more control practices than others do. This is not a surprise since they are just the ones that have the financial capability to do so.

Another interesting result is on the importance of motivations on cost savings and environmental requirements to access subsidized credit for the adoption of environmental practices. This can indicate that industrial firms in Brazil capture cost-effective environmental control opportunities and that requirements on compliance to access credits are creating incentives to better environmental control performance.

Despite the conventional wisdom that enforcement of regulation is weak in Brazil, our results are indicating that industrial environmental management in Brazil is highly affected by the level of sanctions and that there is a clear motivation to avoid sanctions. Based on these findings, regulators may follow strategies that would enhance compliance together with economic efficiency. To carry this on, we recommend:

a) To stimulate compliance-dependent regimes to allocate restricted budgetary resources that give firms a laxer treatment according to their previous compliance performance, and increase inspection and heavier sanctions to those regarded as bad compliers. In doing so, regulators may maximize their budgets in order to get higher compliance.

b) To devise alternative flexible types of sanctions that create a price for pollution and uses of natural resources in order to make it possible for firms to internalize compliance costs according to their own capability, provided the aggregate level of emissions or use is attained? This could be applied with either environmental taxes or tradable emission or the use of quotas. With these instruments, total compliance would be attained with lower total costs and, therefore, at higher

economic efficiency, apart from generating some level of revenue to be channeled to either reduce other tax payments (as the one on labor, per example) or even increasing budgets for monitoring and enforcement.[8]

c) To keep options of subsidized credits but in the way that they strengthen ties between access to this credit and compliance status. Nevertheless, it must be noted that subsidies divert resources from other governmental policies and that compliance, as demonstrated before, may be achieved with instruments that are neutral in fiscal terms.

d) To increase access to information on cost savings, and demand ecologically driven benefits attained with higher environmental performance and, therefore, reducing transaction costs of implementing procedures aimed at these targets.

e) To create mechanisms that facilitate local communities to access information about the firms' environmental performance and thereby add complementary efforts on enforcement. This can be done with low-cost initiatives, such as, inventory of pollution release and list of best or worse firms according to specific parameters on compliance status.

Although there will be a temptation to extrapolate these findings and recommendations to countries at the same institutional and economic development levels as Brazil, at least for their most developed regions, we would rather suggest a cautious approach. As said before, findings in the respective literature have found some crucial differences on the role of each determinant in regard to the country where the analysis is done. Therefore, it would be prudent to undertake equivalent research efforts on country-specific basis to verify how the pattern and trend of these determinants behave before policy prescription is recommended.

Even our study is not definitive and further analytical work should be promoted for Brazil in which a more detailed database could allow us to deal with simultaneity and endogeneity problems in modeling issues such as community strategies and regulator's behavior, to assure the application of sounder theoretic and econometric manners.

8. For a detailed analysis of these market-based instruments in environmental management in Latin America and the Caribbean, see Seroa da Motta, Huber and Ruitenbeek (1999).

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