Opportunities for Improving Environmental Compliance in Mexico

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1. Introduction:

Securing compliance with pollution regulations is a difficult task. Industry compliance with pollution regulations is far from universal, even in North America (Magat and Viscusi, 1990; Laplante and Rilstone, 1995; Dion, Lanoie and Laplante, 1996). In developing countries, where budgets for monitoring and enforcement of regulations are limited, compliance rates are often quite low (Hettige, Huq, Pargal and Wheeler, 1996). However, even in weakly regulated developing countries, plant-level environmental performance varies widely. Some plants clearly have adopted significant pollution control measures, and have better environmental performance than others. Reasons for these variations would provide policy makers in developing countries with much better specified options for pollution control. But data limitations have prevented systematic research on the variation in plant-level environmental performance as this necessary information is seldom gathered by regulatory agencies. This paper seeks to fill the gap drawing on a recent plant-level survey of Mexican factories.

Using recent plant-level survey evidence, this paper analyzes the process of environmental performance from the viewpoint of Mexican factories: compliant and non-compliant with environmental regulations. This paper is effectively a sequel to Dasgupta, Hettige and Wheeler (1998), and focuses on two critical questions: First, what policy relevant factors might have contributed to the observed differences in pollution from factories operating under the same regulatory regime? Second, why do some factories find it difficult and respond slowly to pollution control, while others respond quickly and effectively? Cluster analysis is used to identify dominant behavior variables by partitioning factories into compliant and non-compliant categories. The analysis has identified a number of significant performance variables distinguishing compliant and non-compliant categories, as well as obstacles perceived by non-compliant firms.

These findings have interesting implications for the regulatory agencies of Mexico, the World Bank and other development assistance institutions. For Mexican regulatory agencies, the results highlight the potential of programs that can increase the elasticity of non-compliant firms' response to regulations and thereby provide maximum leverage in their pollution control systems. The findings will also be of

importance for development assistance institutions such as the World Bank, in identifying projects and policy reforms that offer the optimum potential for reducing the plant-level gap in pollution control performance and improving environmental quality.

The remainder of this paper is organized as follows. Section 2 describes the survey that has been used for our analysis, and introduces the data. The analytical approach and results are discussed in section 3. Section 4 briefly concludes the paper.

2. The Mexico Survey of Industrial Polluters

During the past forty years, Mexico has built one of the largest industrial economies in the developing world. Until recently, however, pollution control regulation has received little attention. At the national level, an institutional response to the industrial pollution problem began in the late 1980's and has accelerated during the past few years. In its first phase of development, the national regulatory system has had an emphasis on command-and-control regulation. The environmental performance of polluters is evaluated according to compliance with numerous licenses and permits issued to each plant.

Environmental management in Mexico has been a multi-institutional administration. Different aspects of industrial pollution control have been the responsibility of different agencies within SEMARNAP. Of the principal units, Procuraduria Federal de Proteccion al Ambiente (PROFEPA) is in charge of factory inspections and enforcement of pollution regulations for toxic emissions. Although during the 1990's, PROFEPA expanded its activities from a few inspections per year to several thousand, as the Mexican pollution control system is still relatively new, many Mexican factories have not yet been inspected. Of the other principal units, the instituto Nacional de Ecologia (INE) is in charge of formulating national environmental regulation.

The data used for this paper were elicited from a large national survey of Mexican manufacturers carried out in the fall of 1995. The survey was designed by a World Bank team. The Monterrey Institute of Technology (MIT) conducted the survey, with the explicit support of Mexico's National Environment

Ministry, *Secretaria del Medio Ambiente, Recursos Naturales y Pesca* (SEMARNAP) and the Mexican National Association of Industries. The survey focused on four sectors which were estimated to generate between 75% and 95% of Mexico's total industrial pollution: Food, chemicals, non-metallic minerals, and metals. In-depth interviews were conducted at 236 facilities in medium, large-sized cities, and industrial corridors of Mexico. The sample was carefully selected to represent Mexican factories in a set of categories defined by sector, size class, and ownership. Information on distribution of survey respondents can be found in Table 1.

[Insert Table 1]

To minimize reporting bias, the survey was conducted only after agreement by all sponsors (the Government, the Bank and the Industries Association) that the MIT team would not reveal the identity of the plants surveyed or the respondents within the plants. Given this level of confidentiality, the survey provides very detailed information about environmental performance and its determinants including: plant, firm characteristics; sources of environmental information; the quality and cost of the relationship with regulators; obstacles faced and the measures taken by plant management to improve performance. [1]

As we had no access to independently audited data on pollution and regulatory compliance, this analysis of Mexican factories relies solely on self-reported survey information on environmental performance. Table 2 summarizes the survey respondents' assessment of their facilities' compliance with conventional regulatory standards as applied by Mexican environmental inspectors. With confidentiality reasonably well assured, 50% of survey respondents overall reported that their factories were not in compliance with environmental regulations. Only 10% rated their facilities as excellent (performance far more than necessary for compliance), and approximately the same proportion that rated their facilities as poor (never in compliance) and very poor (far below compliance; very damaging).

[Insert Table 2]

Recent work on industrial pollution in Asia and Latin America has suggested that the characteristics which best explain variations in plant-level environmental performance are: plant size, ownership, and sector of production; as plants and firms of different sector, size, and ownership generally assess enforcement probabilities and expected costs in different ways.

- Plant size: Generally the pollution load of a firm is closely related to, and grows with scale of operation, *ceteris paribus*. Studies of the relationship between plant size and pollution abatement have suggested scale economies in abatement. Scale also works through a 'visibility effect' (Pargal and Wheeler, 1996): larger polluters are generally more detectable by surrounding communities, and may well be under stronger pressure to abate.

- Ownership: Recent research in North America, Latin America and Asia (Laplante and Lanoie, 1994; Laplante, Lanoie and Roy, 1997; Dasgupta, Laplante and Mamingi, 1997) has shown that the environmental performance of a firm affects its stock price in both developed and developing countries. Publicly traded firms whose good performance is publicized receive premia in the market and bad performers are discounted. Since this provides an additional incentive to control pollution, one would expect publicly traded firms to have stronger environmental management than their privately held counterparts.

- Sector: Industry sectors vary significantly in their average pollution intensity of production (pollution per unit of output). Sectors such as metals and chemicals have the potential to generate much higher pollution per unit of output than industries that assemble electronics. Pollution abatement costs also differs widely across sectors of production (Dasgupta, Huq, Wheeler and Zhang, 1996; Hartman, Singh and Wheeler, 1997).

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[1] For the survey questionnaire with complete set of responses, see

[Insert Table 3]

The self-assessment of Mexican firms in our survey confirmed the expected variation in compliance pattern according to plant size, ownership, and sector of production. The proportion of non-compliant firms (documented in table 3) shows a variation in the 40-60% range in various sub samples. When classified by size, 54% of the respondents in small enterprises (with 16-100 employees) were not in compliance with environmental regulations, as opposed to 41% in large enterprises (with more than 250 employees). When classified by ownership, the proportion of non-compliant respondents was 60% in individually or family owned enterprises, as opposed to 42% in the publicly traded category. Variation was also found across different sectors of production. 52% of plants in food, 42% in chemicals, 45% in non-metallic minerals, and 59% in metal industries were not in compliance with regulations.

3. Dominant Partitioning Variables Based on Cluster Analysis

a) The Method:

After classifying the survey respondents into two groups: compliant and non-compliant, an attempt was made to identify the variables "dominant" in the formation of two groups. Variables were identified for which the responses were relatively homogeneous for members within the group of non-compliant firms and relatively heterogeneous between members of non-compliant and compliant groups. Using cluster analysis, the two following tests were performed to identify the dominant partitioning variables.

First, the population of all factories were considered with the assumption that with respect to each variable *i*, this population is normally distributed with mean μ_i and standard deviation σ_i. Further, it was assumed that the groups of compliant and non-compliant firms are samples taken from this normal population with group mean $\bar{x}_i$ and group standard deviation s_i. Then, the first test statistic $z_i = (\bar{x}_i - \mu_i) / (\sigma_i / \sqrt{n})$, with n = the number of factories in the previously defined cluster was computed. If for

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http://www.worldbank.org/nipr/work_paper/1877/survey/index.htm

one particular variable, a group has a high *z*- value, this distinguishes the variable from the population in general.

The second test was based on the modified chi-square statistic, defined as $C_i^2 = s_i^2 / \sigma_i^2$. If the C^2 value for a variable is low, this means that for this variable, the difference between the values within the group is small relative to that in the population. Such a variable indicates a common characteristic between factories in a group.

A variable is labeled "dominant" if it satisfies both tests at the 99% confidence level.

b) Results:

Cluster analysis results for Mexican firms not in compliance with environmental regulations are documented in Tables 4 and 5. These tables record the responses by which non-compliant firms are characterized ("dominant" variables): variables whose values are similar for the non-compliant plants in the sample, but quite different from the average value of all plants. Table 4 documents the dominant environmental performance variables, and Table 5 records the dominant obstacles perceived by the non-compliant firms at the 99% confidence level.

In response to the question regarding specific plans or steps taken to improve environmental performance since 1990, the efforts of non-compliant small firms in changing material use, changing production process, installation of end-of-pipe treatment equipment significantly fell short of the average responses of the firms included in the survey. Non-compliant individually/family owned businesses and non-compliant firms in the food industry also admitted their relatively low effort in changing material use in the past.

Regarding technical assistance on environmental aspects, responses revealed its uneven distribution across Mexican firms over the past two years. Evidence clearly indicates that non-compliant firms in the 'small' size, individually/family owned categories, and in chemical and metal industries received

comparatively less technical assistance over the past two years. Individual responses repeatedly highlighted environmental training, policy, administration, clean technology and audits as specific areas where technical assistance was lacking. In contrast, non-compliant firms in the publicly traded category and in the food industry, appearing as separate clusters, received relatively higher amounts of technical assistance especially for environmental policy over the past two years.

A similar remark can be made about the training programs in place to train general workers in environmental responsibilities in non-compliant enterprises. At present, non-compliant firms of 'small' size, in individually/family owned categories, and in the chemical and non-metallic minerals industries reported significantly fewer programs to train their general workers environmental responsibilities. Especially in the areas of general environmental training, waste management, and transportation their training efforts were lagging far behind. Among the non-compliant firms, publicly traded firms were the only exceptions, reporting significant number of general environmental training programs for their workers.

[Insert Table 4]

A number of questions were also included in the survey to elicit the firms' perception of the obstacles for improving environmental performance. Although all the responses were valuable sources of information, obstacles perceived by non-compliant firms (if there is any) are particularly useful from the regulators' standpoint. Table 3 records the dominant obstacles perceived by the non-compliant firms: external, internal as well as problems faced in environmental training programs and in gathering information.

[Insert Table 5]

From the list of twelve[2] possible *external* obstacles, non-compliant survey respondents significantly identified the importance of five. However, the perceptions of the respondents in this regard varied considerably. "High interest rates" were perceived as a significant obstacle by only 'small' non-compliant firms. On the other hand 'large' non-compliant firms pointed out "lack of environmental culture in Mexico" to be the most critical obstacle. "Government bureaucracy" was a significant obstacle for individually/family owned and publicly traded firms. "Scarcity of information regarding policy requirement" and "scarcity of resources for training" were perceived as obstacles by small, individual/family owned non-compliant firms and non-compliant firms in chemical and metal sectors. It is interesting to note that the surveyed non-compliant firms do not perceive environmental standards to be inappropriate for Mexico.

On the contrary, respondents' perceptions of the critical *internal* obstacles display a noticeable uniformity. The non-compliant respondents of different categories labeled four out of the eleven[3] listed internal obstacles as being critical. Out of the four obstacles, three overwhelmingly identified and blame the attitude of senior level-management: "lack of emphasis on environmental aspects", "higher priorities given to economic aspects", and "lack of training at management level". In addition to the attitude of senior management, only 'small' non-compliant firms identified a "lack of access to environmental consultants and counselors" as being another critical obstacle for improving their performance. Once again, it is interesting to note that non-compliant respondents did not cite a "lack of interest by workers in the environment" as being an important internal obstacle.

[2] Including high interest rates, government bureaucracy, scarcity of information regarding policy requirements, scarcity of information regarding appropriate technology, scarcity of resources, scarcity of resources for training, ineffective environmental regulations for training, ineffective environmental regulations, environmental standards inappropriate for Mexico, environmental standards inappropriate for local conditions, inconsistency among different governmental agencies and bias in enforcement of environmental regulations.

[3] Including the importance of economic priorities, lack of internal knowledge about appropriate technology, lack of training at management level, lack of emphasis by senior management on the environment, lack of emphasis by medium-level management on the environment, lack of interest by workers in environmental aspects, lack of training for workers, lack of access to environmental consultants and counselors, shortage of resources, unreasonable internal environmental standards and lack of incentives for environmental improvement.

In the context of environmental training, "dearth of suitable programs", "dearth of recognition of training", and "dearth of interest of the workers" were repeatedly cited as the most serious problems. Again, of the non-compliant firms surveyed, none of them considered the cost of training programs or shortage of instructors to be serious problems.

Finally, all the surveyed non-compliant firms, irrespective of size, ownership, or sectors of production reported facing significant difficulties in finding relevant information. Their responses indicate that although in the past their search for a system of environmental administration and technology for pollution control uniformly fell short of average query, all of them actively looked for information regarding environmental policy. Although follow-up questions were asked to identify specific problems faced in the information search, unfortunately no clear pattern emerged from their responses.

4. Conclusion

Survey evidence from Mexico revealed large observed differences in pollution from factories in the same industry, the same area, and operating under the same regulatory regime. While many factories have already adopted significant measures for pollution control, and are in compliance with environmental regulations, some factories make very little or no pollution control effort.

For any regulatory mechanism to be effective, regulators must have a clear understanding of the reasons behind variation in plant-level environmental performance, and especially of potential impediments, and their likely effects on pollution control behavior of plants. But systematic research on these issues is rare, even in industrial societies due to data limitations. Drawing on a recent plant-level survey of Mexican factories, this paper has identified a number of significant performance variables distinguishing compliant and non-compliant categories, as well as obstacles perceived by non-compliant firms. [4]

[4] Anonymous survey responses prevented us from an in-depth analysis of specific cases of non-compliance.

Regarding specific steps taken to improve environmental performance, responses revealed that the efforts of non-compliant firms in changing material use, changing production process, and installation of end-of-pipe treatment equipment significantly fell short of the average responses of all firms included in the survey. At present, non-compliant firms have significantly fewer programs to train their general workers environmental responsibilities. In the areas of general environmental training, waste management, and transportation training efforts are lagging far behind. Furthermore, there is evidence of an uneven distribution of technical assistance across Mexican firms over the past two years, with non-compliant firms receiving comparatively less technical assistance. Technical assistance was particularly lacking in the areas of environmental training, policy, administration, clean technology and audits.

Responses regarding external obstacles for improving environmental performance are varied. Scarcity of resources for training, government bureaucracy, high rates of interest, and a lack of environmental culture in Mexico have all been pointed out as existing external obstacles. In contrast, non-compliant respondents of different categories have uniformly labeled attitude of senior level-management: "lack of emphasis on environmental aspects", "higher priorities given to economic aspects", "lack of training at management level" to be the most critical internal obstacles. "Dearth of suitable programs", "dearth of recognition of training", and "dearth of interest of the workers" were repeatedly cited as the most serious obstacles for environmental training. Finally, all of the surveyed non-compliant firms reported facing significant difficulties in finding relevant information, especially information on environmental policy in Mexico.

Finally, I conclude with implications of the findings. For the World Bank and other development assistance institutions, these findings re-emphasize the importance of technical assistance projects, especially training and information dissemination. For Mexican regulatory authorities, the results highlight the potential of programs, which will provide maximum leverage in their pollution control systems. Clearly, the informational gap regarding policy seems to be a major problem of the system. Mexican environmental agencies should consider investing more in technical assistance, and environmental training programs targeted to non-compliant enterprises. Environmental education programs, with particular attention to senior managers have momentous potential in their pollution control system. In conclusion,

maintaining close contact with non-compliant firms, designing targeted programs and pursuing them systematically should increase non-compliant firms' responsiveness to regulations and promote a more effective environmental management in Mexico.

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Appendix:

Table 1: Distribution of Survey Respondents

	Food		Chemical		Non-Metallic Minerals		Metals	
	Individually /family owned	Public	Individually /family owned	Public	Individually /family owned	Public	Individual/family owned	Public
Small	13	4	14	5	20	6	18	5
Medium	9	10	11	7	8	4	12	3
Large	10	8	5	7	6	5	4	12

Table 2: Self-Assessed Environmental Performance

Environmental Performance	Number of Plants	% of Total
Excellent: Far more than necessary for compliance	23	10
Good: Almost always in compliance	96	41
Fair: Occasionally compliant	99	42
Poor: Never in compliance	10	4
Very Poor: Far below compliance; very damaging	8	3

Table 3: Environmental Performance by Size, Ownership, and Sector of Production

	Total	Small	Large	Individually/family Owned	Public	Food	Chemical	Metals	N M M
Total number of survey respondents	236	92	71	121	74	62	62	61	5
Number of respondents not in compliance with environmental standards	117	50	29	72	31	32	26	36	2
Proportion of respondents not in compliance with environmental standards	0.50	0.54	0.41	0.60	0.42	0.52	0.42	0.59	0

Table 4: The dominant variables for the clusters of firms not in compliance with environmental standards

Variables	Mexican industrial enterprises not in compliance with environmental stan							
	Total	Small	Large	Individuall y/family Owned	Public	Food	Chemical	Metals
Have plans/ have undertaken projects to improve environmental performance since 1990								
1. Have changed (eliminated/ reduced) material use		(-)		(-)		(-)		
2. Have changed process		(-)						
3. Have installed/ improved the efficiency of treatment equipment		(-)						
Have received technical assistance in last two years		(-)		(-)	(+)	(+)	(-)	(-)
1. for environmental training	(-)	(-)		(-)				(-)
2. for environmental policy					(+)	(+)	(-)	(-)
3. for clean technology				(-)				(-)
4. for environmental administration		(-)		(-)				
5. for audits		(-)						(-)
6. for analysis of waste					(+)		(+)	
Have training programs to train general workers environmental responsibility	(-)	(-)		(-)			(-)	
1. waste management	(-)			(-)			(-)	
2. transportation	(-)	(-)		(-)				
3. general environmental training	(-)	(-)		(-)	(+)		(-)	
4. health and industrial safety							(-)	
5. programs of environmental awareness				(-)				

The (+) and (-) refer to a positive and negative *Z*-value, respectively. Note that C^2 is always positive.

Table 5: Critical Obstacles for Improving Environmental Performance

Variables	Mexican industrial enterprises not in compliance with environmental standards								
	Total	Small	Large	Individuall y/family Owned	Public	Food	Chemical	Metals	No M M
External Obstacles:									
1. High interest rate		(+)							
2. Government bureaucracy		(-)		(+)	(+)				
3. Scarcity of information re: policy requirements		(+)		(+)			(+)		
4. Scarcity of resources for training	(+)	(+)		(+)				(+)	
5. Ineffective environmental regulations								(-)	
6. Ineffective environmental regulations			(+)						
7. Environmental standards inappropriate for Mexico				(-)		(-)		(-)	
Internal Obstacles:									
1. Economic priorities are more important	(+)	(+)		(+)			(+)		
2. Lack of training at management level	(+)			(+)				(+)	(+
3. Lack of emphasis on environment by senior management	(+)			(+)			(+)		(+
4. Lack of interest of workers in environmental aspects			(-)						
5. Lack of access to environmental consultants and counselors		(+)							
Have experienced difficulty finding information related to environment			(+)	(+)	(+)	(+)	(+)	(+)	(+
Had looked for information regarding									
1. Policy			(+)	(+)	(+)	(+)	(+)	(+)	(+
2. System of environmental administration			(-)	(-)	(-)	(-)	(-)	(-)	(-)
3. Technology to control pollution			(-)	(-)	(-)	(-)	(-)	(-)	(-)
Problems faced:									
1. Availability						(-)			
2. Not appropriate for their need						(-)			
3. Not available in Spanish			(-)						
4. Outdated	(-)							(-)	
Problems faced in environmental training									
1. Attitude of higher authorities						(-)			
2. Lack of programs				(+)	(-)			(+)	(-)
3. Shortage of instructors			(-)						(-)
4. Lack of recognition of training			(+)	(+)				(+)	
5. Lack of interest of the workers			(+)			(+)		(-)	

The (+) and (-) refer to a positive and negative *Z*-value, respectively. Note that C^2 is always positive