ECOLOGICAL ECONOMICS XX (2006) XXX–XXX

available at www.sciencedirect.com

SCIENCE DIRECT®

www.elsevier.com/locate/ecolecon

ANALYSIS

Environmental compliance by firms in the manufacturing sector in Mexico

Lata Gangadharan *

Department of Economics, University of Melbourne, VIC 3010, Australia

ARTICLE INFO

Article history:
Received 20 March 2004
Received in revised form
6 September 2005
Accepted 11 October 2005

Keywords:
Environmental regulation
Compliance

JEL classification:
Q20
O10

ABSTRACT

To date, little empirical evidence exists to help regulators understand why some firms comply even when there is little financial incentive to do so and others continually violate environmental regulations. This paper examines data on compliance with environmental regulations within the manufacturing sector in Mexico. The probability of complying depends, among other factors, on the kind of management practices of the firm and the level of environmental training. Some firms in the manufacturing sector over-comply with regulations. Our results show that providing environmental training to employees in the firm increases the probability of over-compliance. Local community has a positive impact on over-compliance; however, the magnitude of its impact is not as strong as is often suggested in the literature.

1. Introduction

Most regulatory policies targeted at the environment are based on the premise that firms would not undertake any environmentally beneficial projects without explicit pressure from the regulatory authority.[1] While this premise is true in a number of cases, there is growing evidence that many firms comply with environmental regulations even when these regulations are weak or non-existent. Studies assessing overall compliance rates have found that 60% to 80% of firms and individuals comply with environmental regulations and many voluntarily exceed the standards, despite low penalties (Arora and Cason, 1996; Harrington, 1988; Gangadharan, 2001). Why do firms comply with environmental regulations in the presence of low fines and not very frequent inspection rates? According to one explanation (Harrington, 1988), the enforcement process can be modelled as a dynamic game between the firm and the regulator where the firms that are caught to be in violation in one period are moved to a separate group in the next period in which they are subject to more frequent inspections and higher fines. Hence, firms have an incentive to comply in order to avoid being moved into the frequently inspected group. A second explanation is that firms comply and sometimes even over-comply to guide regulatory authorities to set higher standards for the whole industry, thereby increasing the costs of their rivals (Salop and Scheffman, 1983).

Yet another explanation that is gaining ground in recent years is that firms comply to gain reputation as an environmentally conscious organization. Arora and Gangopadhyay (1995) show that public recognition plays a very important role in the success of voluntary environmental programs. Arora

* *Tel.*: +61 3 8344 5408; fax: +61 3 8344 6899.
E-mail address: latag@unimelb.edu.au.

[1] This is because there is often a cost associated with undertaking an environmentally sustainable activity, which is borne by the firms alone but the benefits of this sustainable production are usually shared by society.

0921-8009/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolecon.2005.10.023

and Cason (1996) assess the factors that influence a firm's decision to participate in EPA's 33/50 program in the United States. They find that firms in industries that are closer to final consumers (proxied by normalized advertising expenditures) are more likely to participate in this voluntary program.

In developing countries, environmental regulations could be weak and not very rigorously enforced due to budget constraints, staffing deficiencies and corruption in the judicial system. Hence, in these countries, formal enforcement mechanisms might not work very well and it is important therefore to focus on other factors that can encourage compliance among firms.

In this paper, we use recent survey evidence from manufacturing industries in Mexico, to study the impact of different management practices, vintage of technology, level of environmental training and education of workers and the influence of community pressure on the probability of the firm complying with environmental regulations. Two recent papers, Wisner and Epstein (in press) and Dasgupta et al. (2000), examine the environmental performance of firms in Mexico using survey data made available by the World Bank. Wisner and Epstein (in press) analyze the impact of the North American Free Trade Agreement (NAFTA) on Mexican environmental performance and demonstrate that, as a result of NAFTA, Mexican firms altered their organizational dynamics, leading to better environmental outcomes. Dasgupta et al. (2000) explore the compliance decisions of the Mexican firms using a binary choice framework (comply or do not comply). This paper extends their work by developing a framework that can allow us to understand compliance decisions more fully. We use all of the available information on compliance by firms. In particular, firms can over-comply, comply or not comply with regulations. Compliance and over-compliance are different decisions for the firm and combining the two categories might not provide a complete picture. The decision to comply with regulations can be thought to be determined by regulatory laws, inspection rates and fines and penalties imposed by the regulatory authority. Over-compliance, on the other hand, can be thought to be related to firms projecting a green image to increase their market share, firms being influenced by local communities and neighbourhood groups, firms employing better educated and trained staff and also due to firms installing indivisible abatement technology which leads to more emission reduction than planned. This paper provides insights into the decision of firms to comply more than required with regulations, hence filling an important gap in the literature. In addition to using the information on compliance, this paper uses another measure of environmental performance to examine if firms would experience an increase in their environmental outcomes. In particular, an individual firm's commitment to improve environmental performance is examined to determine if firms voluntarily implement programs intended to enhance their environmental performance.

Hettige et al. (1996) find that many countries in Southeast Asia including Indonesia, Thailand and the Philippines suffer from poor environmental standards that are either weak or ineffectively enforced. A common perception is that a lack of enforced regulations in developing countries provides firms with no incentives to improve their environmental performance. If this were the case, then it would be expected that developing countries would become pollution havens for many multi-national companies. However, numerous studies have found that many firms still comply with regulations despite minimal enforcement and monitoring (Hettige et al., 1996; Hartman et al., 1997).

Recent research has identified a number of informal regulations that may promote environmental compliance. Where does the incentive to comply with regulations come from? One source identified is the capital market (Lanoie et al., 1998). The capital market if properly informed can play a significant role in pollution reduction by providing appropriate reputational and financial incentives. This possibility arises because capital markets can react either negatively to announcement of negative environmental incidents or positively to the announcement of positive environmental incidents (Dasgupta et al., 1997; Hamilton, 1995). Firms in developing countries could therefore face a cost of pollution in terms of lower stock prices, despite weak formal regulations. Firms' incentives to remain "clean" may also be due to pressure from communities and the incentive to uphold their reputations (Hettige et al., 1996; Pargal et al., 1997a). Pargal and Wheeler (1996) find that communities penalize dirty factories through informal regulations. In Indonesia, the pollution control agency initiated a program that rates and publicly discloses the environmental performance of Indonesian factories. This easy to interpret colour rating system has been very successful in improving environmental performance at a very low public cost. Following the success of this program, similar programs are being initiated in Philippines, Mexico and Colombia (Tietenberg and Wheeler, 2001). Another incentive to comply operates via the credit market. A number of studies show that banks are less likely to extend credit to firms with poor environmental records (Lanoie et al., 1998; Laplante and Lanoie, 1994).

This paper contributes to the literature in many ways. Firstly, understanding the motivation behind a firm's decision to not comply, comply or over comply with environmental regulations is of utmost significance. Separating out these categories of compliance and then focusing on over-compliance allows us to examine the reasons firms make these decisions. In addition to the decisions relating to compliance, this paper also exploits information on environmental improvements that can indicate whether firms have a long-term interest in the environment. Information on factors that drive firms in some cases to voluntarily improve their environmental standing has obvious advantages to policy-makers. In countries where environmental laws are weak, understanding the reasons why firms improve environmental performance can help us in formulating policies to encourage this trend. Research in this area has indicated the presence of informal regulations that provide incentives to minimize pollution; however, more research is needed as evidence is still scarce. Finally, the study on Mexico itself is also of importance. Mexico City has notoriously high pollution levels, with air pollution exceeding the legal safe standard 182 days during 1996 (Dasgupta et al., 2000), and this pollution poses a threat to human health.

This paper is organized as follows: Section 2 summarizes the data used in the analysis. Section 3 describes the estimation methodology employed to examine the data on

environmental compliance. Section 4 presents the results and Section 5 concludes with a discussion of the results.

2. Data and descriptive statistics

In this paper, we use data from a World Bank survey conducted in 1995 in Mexico, to examine the incentives that firms face to initiate environmental improvement programs and comply with regulations. The survey conducted at the plant level, focused on four sectors: food, chemicals, non-metallic minerals and metals, which are in total responsible for generating 75% to 95% of Mexico's total industrial pollution. This includes water pollution, air pollution, toxic residue and non-toxic residue. Detailed interviews were conducted at 236 plants, which were chosen to represent Mexican industries in a set of categories that were defined by sector, size class and location. The sample is well balanced with 62 plants in the food sector, 62 in the chemicals sector, 51 in the non-metallic minerals sector and 61 in the metals sector. The plants are also evenly distributed along the size scale, with roughly similar number in the large class and in the medium and small class. Size classes are defined by employment ranges, with small plants employing 16–100 employees, medium about 100–250 employees and large more than 250 employees. In the interview, the respondents were asked questions about compliance with environmental regulation and management. The survey was designed to obtain detailed information about the determinants of the firm's marginal abatement cost curve and the expected marginal penalty schedules. Dasgupta et al. (2000) provide an excellent summary of all the variables used in the survey.

As the data are self-reported, they rely on the honesty and accuracy of the individual firms surveyed. Hence, the data may be subject to upward bias, particularly so for variables like compliance with environmental regulations.[2] Compliance is divided into five categories and these are summarized in Table 1. Category 1 is defined in this paper as over-compliance and it represents 10% of the firms in the data. The firms in this category have exceeded the environmental requirements and claim to have established a world-class environmental program in their organization. Categories 2 and 3 are merged to obtain compliance (83% of the firms). Category 2 has firms that consistently observe Mexican environmental laws and category 3 has firms that usually observe the environmental laws, though they sometimes fail in specific points. Categories 4 and 5 are combined to obtain non-compliance (7% of the firms). These categories include firms that usually fail to observe environmental laws and firms that rarely observe the environmental laws, respectively.

The factors that affect the compliance decision of a firm are the following: the output produced by the firm summarized by the industrial sector that the firm is in (i.e., the sectoral composition of the firms). The firms are in the food, chemical, non-metallic minerals and metal sector, and each is represented by a dummy, with non-metallic minerals employed as the reference dummy. Some firms reward employees for their contribution towards environmental performance. This is represented by a variable defined as reward in the paper. Reward is equal to 1 if the firm rewards employees for environmental performance. It is argued that firms that give incentives to employees to improve environmental performance would have a higher probability of compliance. Whether a firm is part of a firm with multiple plants (multiplant=1 if firm has multiple plants) is another factor that could determine environmental compliance. Dasgupta et al. (2000) found that a firm, which is part of a multiplant organization, was related to larger environmental management effort. It is expected that the multiplant status allows the firm to undertake more abatement as it can exploit economies of scale. Ownership status of the plant is another relevant variable in this discussion. If the firm is publicly owned or publicly listed (ownership2), then it would be subjected to greater public scrutiny and would therefore be faster in adopting better environmental practises. Thus, publicly owned firms are anticipated to have a higher probability of complying with environmental regulations.

The environmental decisions made by the firms could also be influenced by the markets in which they sell their products. The survey contains information on whether the firms sell their products in international markets. Variables have been defined for sales within Mexico: Sal_Mexico, sales to Asia: Sal_Asia, sales to the United States and Canada: Sal_Usca, sales to Europe: Sal_eur and sales to other Latin American countries: Sal_laam. Sales in each of these markets are coded as 0 for a 0 percentage of the firm's products being sold in that market and 5 for a percentage between 76 and 100. We would expect to find that firms that have a large percentage of sales to more developed countries like United States, Canada and Europe would have a higher probability of complying with environmental regulations. This is due to the fact that consumers in developed countries usually have a higher preference for environmental quality and are often more aware of environmental issues. Hence, they would have a lower probability of buying products from firms that have a reputation of polluting the environment. This could be linked to the argument that the environment is a luxury good and only when individuals or countries have achieved a certain level of income they turn their attention to environmental issues (Grossman and Krueger, 1995 present evidence that some pollutants follow an inverted U-shaped curve with

Table 1 – Compliance (self-assessed measure)

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

[2] Dasgupta et al. (2000) suggest that the degree of upward bias in the Mexican data on self-assessment of compliance is not large. They compare the compliance rates with those from independent auditing of a large sample of Indonesian firms and find that the reported levels of compliance are reasonable. The analysis in this paper (following Dasgupta et al., 2000) focuses on relative performance of firms and not on the absolute levels of compliance.

respect to income, rising at lower levels of income and falling at higher levels).[3] In some cases, there are trade agreements that could prevent or make it very difficult for polluting firms to sell their products internationally. For example, the North American Free Trade Agreement between North America and Mexico has incorporated rules whereby abiding by environmental laws is necessary for firms to avoid sanctions.[4] This would put pressure on firms to improve compliance and encourage them to incorporate pollution prevention policies into planning and operation decisions within the firm. Wisner and Epstein (in press) find that Mexican firms that export to US and Canada are more environmentally responsive than those firms that sell their products domestically.

Similarly, the ownership of the firm: whether it is owned by Mexicans or by foreign companies is another variable that can have an impact on compliance decisions of firms. Firms located in Mexico that are subsidiaries or are controlled or owned by a foreign company could have access to superior abatement technology and could also be more sensitive to environmental concerns; hence, their environmental performance would be better. We define a variable (Mex_own) that is equal to 1 if the firm is Mexican owned and is equal to 0 if it is foreign owned. Of the firms surveyed, 173 firms were owned by Mexicans and 19 owned by foreign companies.[5]

To be able to capture the impact of the product market in a more direct manner, we also define a variable for sales to final consumers (Sal_Cons). This variable is coded from 0 to 5 (0 for 0% and 5 for 76–100%) depending on the percentage of sales by the firm to final consumers. Variables for sales to industrial consumers (Sal_Ind) and wholesalers or distributors (Sal_Wh) have also been defined with the purpose of comparing with the variable Sal_Cons. These variables reflect the product orientation of the firm. Firms that manufacture mainly for consumers rather than for industrial or wholesale consumption are in more direct contact with the public. Labatt (1997) shows that product orientation of the firm has an important role to play in reducing packaging waste, with consumer oriented firms observed to be more proactive in reducing the amount of waste. It is therefore expected that the higher the percentage of sales to final consumers, better is the environmental performance of the firm.

Other variables that can influence the compliance decision of the firm are whether the necessary technology required to undertake environmental improvements is available (Tech_avail=1 if the relevant technology is available) and assessment of the environmental impact of the firm (Cont_eval=1 if the firm has a procedure for continuous evaluation). The human capital employed by the firm have a very important role to play as well. The education level of employees (represented by the percentage of employees with more than primary education: Empsec) could have an impact on environmental performance of the firm. Training of employees performing tasks in the environmental section of the firm and in the other sections can be vital to the success of a lot of environmental programs. Training could be in areas of environmental management, environmental auditing, environmental law, risk analysis, handling of hazardous residue, industrial risk minimization and, in some cases, a Masters in Environmental Engineering. Some firms are active in providing training within the firm or providing access to training and it is expected that these firms would have a higher probability of being compliant. The variables defined to examine the effect of training are the following: Train_ne: environmental training available to employees not directly involved in the area of environment, Train_e: environmental staff received training since 1990, and Envman: have the staff in the environmental area been trained in the field of environmental management. There are some additional variables in the survey that address the question of management differences between different firms and the number of staff available to work in the environmental section. Variable Env_resp=1 indicates that in some firms, persons not assigned to the environmental sections have environmental responsibility and variable Oth_resp=1 indicates that employees have other responsibilities in addition to the environmental ones. Env_pers=1 represents the firms who have hired more employees in the environmental area.

Firms with newer technology could incur lower abatement costs as new machines might be more energy efficient and might incorporate measures to decrease polluting by-products. Variables Tech 80 (code for percentage of plant installed prior to 1980) and Tech 90 (percentage of plant installed since 1990) have been included in the empirical model to capture this effect. Compliance by firms is often affected by the inspection rates by the environmental agency. This is represented by the variable: Inspect=1, if the firm has been inspected by the authorities with regard to its environmental performance. Magat and Viscusi (1990) and Laplante and Rilstone (1996) show that inspections and the threat of inspections significantly reduce the absolute levels of water pollution emitted by the pulp and paper plants in the United States and Canada. Dasgupta et al. (1999) show that inspections significantly reduce industrial air and water pollution in China. Information barriers about environmental issues (for example, what the law requires and what kind of technology is available to improve environmental performance) are another reason why firms might not comply. This is included in the variable: Envinfo, which is=1 if firms find it difficult to obtain environmental information.

Local communities and neighbourhood groups are often argued to influence a firm's environmental record. Firms are concerned about public opinion as bad publicity could have an adverse effect on their product market and share market performance. Communities that are richer, better educated and have more access to information about the consequences

[3] In the early stages of economic development, a country would be unwilling to trade consumption for investment in environmental regulation; hence, environmental quality declines. Once the country reaches a threshold level of income, its citizens start to demand improvements in environmental quality and this leads to implementation of policies for environmental protection and eventually to reduction in pollution levels.

[4] In the early 1990s, the North American Free Trade Agreement brought to public attention the question of the impact of trade on environmental protection in countries with different levels of economic development. Critics feared that this trade agreement between North America and Mexico could lead to significant deterioration of the environment (Husted and Logsdon, 1997).

[5] The foreign and Mexican ownership information was missing for 43 firms. These have been coded as zero.

of environmental pollution find innovative ways of enforcing environmental norms. These communities would also be able to use available regulatory channels more efficiently. The survey asks questions on the extent of influence of neighbourhood and local communities in the firm's decision making on environmental issues. Information regarding the influence of industrial chamber and associations and the influence of legislative requirements is also obtained. All the data however is for one time period and some of these variables would start having an impact on the firm's compliance outcome after a lag. For example, we might observe that a firm with a bad environmental performance has stated that the neighbourhood and local community have been very influential in determining their actions regarding environmental issues. So the analysis of the data could, in some cases show a negative relationship between the community variable and the firm's compliance record, which might seem counter-intuitive. These variables (the community, business and legal variables) therefore could be endogenous. To correct for their potential endogeniety bias, however, we need good instruments (for example, variables lagged by a time period), which are difficult to find as all the data available to us are cross-sectional.

The firms in the manufacturing sector were surveyed in 1995: when the Mexican currency crisis was at its peak. This could potentially have had an impact on firms' decisions to comply with environmental regulation and also on other variables in the data set (in particular trade related variables). Due to the cross-sectional nature of the data, it is difficult however to estimate the magnitude and intensity of this impact on compliance.[6]

3. Estimation methodology

The decision to comply with environmental regulations is described by the following latent variable model.

$$C_i^* = X_i\beta + \varepsilon_i$$

C_i^* is the net benefit attained by firm i by over-complying with environmental regulations. X_i is a vector of firm characteristics that determine C_i^* and ε_i is a random error term. However, C_i^* is not observed—what we do observe is the following variable:

$$C_i = \begin{cases} 1, & \text{if the firm over} - \text{complies} \\ 0, & \text{otherwise} \end{cases}$$

This can be estimated using a binary logit model.

Now let us assume that C_i can take more values (over-comply, comply and not comply with environmental regulations):

$$C_i = \begin{cases} 0, & \text{if the firm does not comply} \\ 1, & \text{if the firm complies} \\ 2, & \text{if the firm over} - \text{complies} \end{cases}$$

In the multinomial logit estimation procedure, we can rewrite the above as follows:

(i) $C_i=0$: $C_i^* > \mu_1$ (firm does not comply)
(ii) $C_i=1$: $\mu_1 \geq C_i^* \geq \mu_2$ (firm complies)
(iii) $C_i=2$: $\mu_2 < C_i^*$ (firm over-complies).

In the above equations, μ_1 and μ_2 are unknown parameters. The estimated equation is given by:

$$C_i = X_i\beta + \varepsilon_i.$$

The reduced form parameters of this equation are estimated using maximum likelihood based on a multinomial logistic distribution of ε. Since the probabilities of being in the three states (i)–(iii) must add to unity for each firm, the multinomial logit strategy involves estimating two equations. In this study, we have normalized category (i), i.e. adopted the state of no-compliance as the baseline case in the multinomial logit regressions. The choices mentioned above can also be ranked in an ascending order from the viewpoint of social welfare. The welfare based ordering would be as follows: if firm does not comply ($C_i=0$), if it complies ($C_i=1$), if it over-complies ($C_i=2$). The equation is then re-estimated as an ordered logit model that respects this welfare ordering.

In addition to the data on compliance with environmental laws, we also examine if firms have implemented any improvement programs (with respect to their environmental performance) since 1990 or have plans to undertake improvements. Improve is defined to be a binary variable, with 0 representing the choice to not improve and 1 representing the choice to make improvements. This is estimated using a binary logit model. This variable captures the firm's commitment to have better environmental performance in the future.

Heteroscedasticity across observations can often be a concern with cross-section analyses; hence, the standard errors of the estimates reported in the paper are obtained using the White estimator, which corrects for heteroscedasticity.

4. Results

4.1. *Over-compliance*

Of particular interest in the compliance literature is the issue of over-compliance. Why do some firms comply more than required by law? To focus on the over-compliance decision of the firm, we examine the factors that determine whether firms comply more than required by legislation. Out of 235 firms in the data set, 23 firms over-comply with environmental regulations. Table 2 presents the logit estimates of the factors that determine the firm's decision to over-comply with environmental regulations. The last column in this table indicates the marginal effects of each of the explanatory variables. The model reported in Table 2 has a pseudo-R^2 of 0.68, a chi-squared (32) statistic of 102.10, with a probability (chi-squared>value)=0.000. In addition to these indicators of model quality, we also report the Hosmer and Lemeshow chi-squared statistic for binary choice logit models that assesses

[6] For more information on the Mexican Peso crisis of 1995, refer to Edwards (1998) and Frankel (2005).

Table 2 – Maximum likelihood estimates for binary logit model

Variable	Coefficient	Standard error	Marginal
Constant	4.26	5.06	
FOOD	−6.21 *	3.07	−1.25E−06
METAL	1.31	1.53	1.09E−06
CHEM	−3.04	2.12	−8.57E−07
REWARD	4.11 *	1.78	1.27E−05
MULTIPLT	8.12 **	3.07	2.05E−05
OWNSHIP1	2.85	2.63	1.57E−06
OWNSHIP2	3.70	2.64	5.39E−06
SAL_MEX	−1.63 *	0.76	−7.48E−07
SAL_ASIA	2.66	1.50	1.22E−06
SAL_USCA	−2.25 *	0.98	−1.03E−06
SAL_EUR	−2.52 **	1.03	−1.16E−06
SAL_LAAM	0.97	0.63	4.46E−07
MEX_OWN	−4.31 **	1.57	−1.08E−05
SAL_CONS	−3.30 **	1.26	−1.52E−06
SAL_WH	−0.21	0.41	−9.43E−08
SAL_IND	−1.35 *	0.65	−6.18E−07
TECHAVAL	0.84	2.16	3.12E−07
CONTEVAL	3.05	1.81	1.35E−06
EMPSEC	0.05 *	0.02	2.33E−08
TRAIN_NE	4.51 *	2.04	9.65E−06
TRAIN_E	0.26	1.69	1.19E−07
ENV_RESP	6.19 *	2.88	5.05E−06
OTHRESP	−0.82	1.98	−5.41E−07
ENV_PERS	−0.80	1.45	−3.81E−07
TECH80	−2.32 **	0.88	−1.06E−06
TECH90	0.06	0.34	2.56E−08
INSPECT	−6.05 **	2.45	−5.95E−05
ENVINFO	−2.18	1.88	−8.24E−07
COMMUNIT	5.55 **	2.18	6.93E−06
BUSINESS	−7.44 **	2.83	−2.33E−05
LEGAL	−1.72	1.77	−1.64E−06
ENVMAN	−3.48	1.93	−1.01E−06
Number of observations	235		
Log likelihood function	−24.24		
Restricted log likelihood	−75.29		
Chi-squared (32)	102.10		
Prob(chi-squared>value)	0.000		
Hosmer-Lemeshow chi-squared (4)	2.5		
Psuedo-R^2	0.68		

Dependent variable: over-compliance (=1 if firm over-complies and 0 otherwise).
Robust standard errors: corrected for heteroscedasticity.
* Denotes a coefficient that is significantly different from zero at 5%.
** Denotes a coefficient that is significantly different from zero at 1%.

the match between actual and predicted values. This statistic suggests that the model is appropriate and has the ability to predict the dependent variable accurately. The Hosmer-Lemeshow chi-squared=2.5, large values of this statistic would imply that the model is inappropriate.

The logit estimates indicate that firms in the food industry have a lower probability of over-complying as compared to the reference category of non-metallic minerals. Firms that give a reward to their employees, financially or otherwise, for their contribution to the environmental performance of the firm exhibit a significantly higher probability of over-compliance. Similarly, firms with multiple plants have a higher probability of over-compliance. This is expected as firms that have a multiplant status have the ability to undertake more abatement by perhaps buying cleaner machines and also by initiating a progressive environmental management strategy in their firm.

An increase in the firm's domestic sales reduces the probability of over-compliance. An increase in sales to the United Sates, Canada and Europe also decrease the probability of over-compliance. Mexican ownership of firms significantly decreases the probability of over-compliance. An increase in sales to final consumers and to industries decreases the probability of over-complying.

If the firm has a procedure in place for continuous evaluation of environmental impact, then over-compliance is significantly higher. When the percentage of employees with more than primary education is higher in firms, then the probability of over-compliance increases. When the staff not directly involved in the area of the environment are given environmental training, then the probability of over-compliance increases. Similarly, when staff not assigned to environmental sections are given environmental responsibilities, then again the probability of over-compliance is high. These management policies increase awareness of environmental issues in the firm and also motivate people to do better than what the law requires. The vintage of the technology used by the firms matters: when the percentage of plant installed prior to 1980 is higher, then probability of over-compliance is lower. Installation of newer technology seems to increase the probability of over-compliance. This could also be an indicator of indivisibilities in the abatement technology. Newer technology could be so efficient that it leads to more pollution reduction than required or planned by the firm. Inspection by environmental authorities reduces the probability of over-compliance.[7] It is possible that inspection is targeted towards firms that have a record of non-compliance; hence, inspection could be an endogenous variable. Pargal et al. (1997b) estimate a simultaneous equation model taking into account the endogeniety of the inspections variable and use data on industrial water pollution from India to find that in their sample, the frequency of inspections have no impact on the level of emissions of firms. Local community has a positive influence on environmental over-compliance, whereas industrial associations and business have a negative impact on over-compliance.

4.2. *Multinomial compliance choice*

Table 3 presents the multinomial logit regression estimates for (a) the case where the firm complies and (b) where the firm over-complies with regulations. The choice category of no compliance has been adopted as the baseline category for normalization. This model has a pseudo-R^2 of 0.54 and a chi-squared (58)=171.51 with a probability (chi-squared>value) =0.00. The corresponding marginal effects of each covariate on the probability of belonging to each of the three categories are presented in Table 4.

[7] Though environmental regulations have been strict in recent years in Mexico, in 1995, due to the Mexican currency crisis, enforcement was more lax.

Table 3 – Maximum likelihood estimates for multinomial logit model

Variable	Prob(Y=1)		Prob(Y=2)	
	Coefficient	Standard error	Coefficient	Standard error
Constant	−1.38	2.73	−2.83	4.77
FOOD	−0.68	0.99	−3.86[a]	2.11
METAL	−2.74[*]	1.26	−1.85	1.69
CHEM	−1.03	0.77	−2.86[a]	1.60
REWARD	2.41	1.53	4.86[**]	1.87
MULTIPLT	−0.97	0.73	4.88[*]	2.11
SAL_MEX	0.16	0.31	−0.32	0.50
SAL_ASIA	1.06	1.18	2.11	1.66
SAL_USCA	0.33	0.45	−1.41[a]	0.87
SAL_LAAM	1.85[a]	1.09	2.22[*]	1.16
MEX_OWN	−1.14	1.14	−3.68[**]	1.46
SAL_CONS	−0.08	0.31	−1.93[**]	0.75
SAL_WH	−0.29	0.30	−0.39	0.41
SAL_IND	−0.29	0.30	−1.02[*]	0.51
TECHAVAL	1.28[a]	0.74	1.59	1.78
CONTEVAL	3.14[**]	1.03	5.86[**]	1.71
EMPSEC	0.00	0.01	0.04[a]	0.02
TRAIN_NE	0.95	0.98	3.35[*]	1.62
TRAIN_E	0.77	0.85	2.07	1.46
ENV_RESP	−0.91	0.74	3.42[a]	1.91
OTHRESP	2.38[*]	1.07	2.26	1.79
ENV_PERS	0.27	0.70	0.11	1.22
TECH80	−0.12	0.24	−1.54[**]	0.58
TECH90	−0.11	0.22	−0.14	0.36
INSPECT	1.07	0.81	−3.01	1.89
ENVINFO	0.12	0.68	−1.31	1.50
COMMUNIT	−0.20	0.71	2.55[a]	1.43
BUSINESS	0.76	0.76	−3.99[*]	1.89
LEGAL	0.93	0.84	−0.06	1.66
ENVMAN	−0.17	1.50	−2.09	1.90
Number of observations	235			
Log likelihood function	−74.14			
Restricted log likelihood	−159.90			
Chi-squared (58)	171.51			
Prob(chi-squared>value)	0.000			
Psuedo-R^2	0.54			

Dependent variable: compliance (can take values: 0: not comply, 1: comply and 2: over-complies).
Robust standard errors: corrected for heteroscedasticity.
a Denotes a coefficient that is significantly different from zero at 10%.
[*] Significantly different from zero at 5%.
[**] Significantly different from zero at 1%.

The results from the multinomial logit model, for determining the impact on the probability of compliance, indicate that the firms in the metal industry have a lower probability of compliance as compared to the firms in the non-metallic industry. A higher percentage of sales to other Latin American countries leads to a marginally higher probability of compliance (statistically significant at 10% level) with environmental regulations. Unlike in Wisner and Epstein (in press), we find that market forces: driven by exports to the US and Canada are not as strong in explaining compliance behaviour of firms. The coefficient of the variable—sales to the United States and Canada is positive in explaining compliance; however, it is not statistically significant. One of the reasons for this could be that the survey was conducted in 1995—the year in which Mexico experienced its largest macroeconomic (peso) crisis. Many firms went bankrupt and those that did not were severely hit. Exports were cheaper and firms in US and Canada were perhaps willing to ignore environmental criteria that year in exchange for low prices. Another reason for not finding a stronger impact of this variable could be that firms in Mexico could be selling to local branches of multinational companies and not to other firms in foreign markets.[8] Dasgupta et al. (2000) also do not find a significant link between compliance and exports to OECD countries. Availability of appropriate abatement technology and continuous assessment of environmental performance increases the probability of compliance. Giving employees different kinds of responsibilities (environmental in addition to their other responsibilities) seems to increase the probability of compliance.

Turning towards the factors that determine over compliance, we find that the results, not surprisingly, are very similar

[8] Wisner and Epstein (in press) report that the pull effect of the United States and Canada market could be understated as some firms sell to multinational enterprises in the local market, which then export to other countries.

Table 4 – Maximum likelihood estimates for multinomial logit model: marginal effects

Variable	Prob(Y=0)	Prob(Y=1)	Prob(Y=2)
FOOD	7.15E–03	−7.01E–03	−1.34E–04
METAL	2.88E–02	−2.89E–02	3.66E–05
CHEM	1.08E–02	−1.07E–02	−7.79E–05
REWARD	−2.53E–02	2.52E–02	1.05E–04
MULTIPLT	1.02E–02	−1.04E–02	2.47E–04
SAL_MEX	−1.73E–03	1.75E–03	−2.05E–05
SAL_ASIA	−1.12E–02	1.11E–02	4.45E–05
SAL_USCA	−3.45E–03	3.53E–03	−7.31E–05
SAL_LAAM	−1.94E–02	1.94E–02	1.68E–05
MEX_OWN	1.20E–02	−1.19E–02	−1.08E–04
SAL_CONS	8.50E–04	−7.72E–04	−7.81E–05
SAL_WH	3.02E–03	−3.01E–03	−4.42E–06
SAL_IND	3.00E–03	−2.97E–03	−3.11E–05
TECHAVAL	−1.35E–02	1.35E–02	1.34E–05
CONTEVAL	−3.31E–02	3.29E–02	1.16E–04
EMPSEC	1.47E–05	−1.64E–05	1.72E–06
TRAIN_NE	−9.97E–03	9.87E–03	1.02E–04
TRAIN_E	−8.12E–03	8.06E–03	5.51E–05
ENV_RESP	9.59E–03	−9.77E–03	1.82E–04
OTHRESP	−2.51E–02	2.51E–02	−4.24E–06
ENV_PERS	−2.87E–03	2.87E–03	−6.62E–06
TECH80	1.30E–03	−1.24E–03	−5.99E–05
TECH90	1.21E–03	−1.21E–03	−1.10E–06
INSPECT	−1.12E–02	1.14E–02	−1.72E–04
ENVINFO	−1.24E–03	1.30E–03	−6.03E–05
COMMUNIT	2.10E–03	−2.22E–03	1.16E–04
BUSINESS	−8.03E–03	8.23E–03	−2.01E–04
LEGAL	−9.79E–03	9.83E–03	−4.14E–05
ENVMAN	1.81E–03	−1.73E–03	−8.12E–05

Dependent variable: compliance (can take values: 0: not comply, 1: comply and 2: over-comply).

to that in Section 4.1. In brief, the estimates show that the policy of giving a reward for environmental performance increases the probability of over-compliance compared to the no-compliance baseline. Similarly, if the firm has a multi-plant status, it has a higher probability of being over-compliant as compared to the baseline category. Firms that sell to consumers in Latin America have a higher probability of over complying. Firms that are owned by Mexicans have a lower probability of over-complying. Firms that have a higher percentage of sales directed towards final consumers have a lower probability of over-complying. Availability of appropriate technology seems to lead to a higher probability of over-compliance and so does the continuous assessment of the environmental impact of the plant, relative to the baseline category.

A higher percentage of employees in a firm with more than primary education leads to a higher probability of that firm over-complying. When environmental training is available to employees not directly involved in the area of environmental management, then the probability of over-compliance is higher, relative to the baseline category of no-compliance. The vintage of the technology in the firm has the expected effect, as when the percentage of plant installed before 1980 increases, there is a decrease in the over-compliance probability of a firm. Neighbourhood and local communities seem to have a positive impact on over-compliance probabilities of firms. Finally, the compliance choices that a firm faces can also be ranked with respect to social welfare. To estimate this choice model, we use an ordered logit specification. The estimates from this model are very similar to the multinomial logit results. They are not presented in the paper but are available on request.

4.3. *Improvements in environmental performance*

Another variable of interest is whether the firm has any plans to improve environmental performance or has carried out improvement programs since 1990. Examining this variable helps us in understanding the firm's interest in making

Table 5 – Maximum likelihood estimates for logit model

Variable	Coefficient	Standard error	Marginal effects
Constant	−5.06*	2.23	
FOOD	0.61	0.83	1.55E–02
METAL	−1.16	1.15	−5.63E–02
CHEM	0.14	0.67	3.98E–03
REWARD	−1.73*	0.82	−9.38E–02
MULTIPLT	−0.08	0.57	−2.50E–03
OWNSHIP1	−0.01	1.15	−1.91E–04
OWNSHIP2	−0.53	1.12	−1.78E–02
SAL_MEX	0.26	0.25	7.86E–03
SAL_ASIA	2.59	1.80	7.84E–02
SAL_USCA	0.38	0.31	1.16E–02
SAL_EUR	0.01	0.51	2.68E–04
SAL_LAAM	0.50	0.36	1.50E–02
MEX_OWN	0.74	0.92	2.67E–02
SAL_CONS	−0.26	0.22	−8.02E–03
SAL_WH	−0.13	0.21	−3.79E–03
SAL_IND	−0.06	0.23	−1.77E–03
TECHAVAL	1.60**	0.61	8.00E–02
CONTEVAL	1.65**	0.64	6.64E–02
EMPSEC	−0.02[a]	0.01	−5.86E–04
TRAIN_NE	3.37**	1.21	8.44E–02
TRAIN_E	0.68	0.70	2.15E–02
ENV_RESP	1.41	0.62	5.29E–02
OTHRESP	1.59	1.17	9.23E–02
ENV_PERS	0.77	0.62	2.38E–02
TECH80	0.18	0.18	5.48E–03
TECH90	0.29	0.20	8.88E–03
INSPECT	0.26	0.70	8.51E–03
ENVINFO	−0.14	0.58	−4.22E–03
COMMUNIT	0.69	0.61	2.15E–02
BUSINESS	−0.69	0.61	−2.08E–02
LEGAL	0.88	0.78	3.63E–02
ENVMAN	0.23	1.12	6.62E–03
Number of observations	235		
Log likelihood function	−57.67		
Restricted log likelihood	−111.83		
Chi-squared (32)	108.34		
Prob(chi-squared>value)	0.000		
Hosmer-Lemeshow chi-squared (3)	1.87		
Psuedo-R^2	0.48		

Dependent variable: improve.
Robust standard errors: corrected for heteroscedasticity.
a Denotes a coefficient that is significantly different from zero at 10%.
* Significantly different from zero at 5%.
** Significantly different from zero at 1%.*

dynamic changes to its management strategy and indicates whether it has a sustained interest in environmental practices. Decision to improve is a binary variable: with 0, representing the choice to not improve and 1 representing the choice to make improvements. Results from this binary logit model are presented in Table 5. This model has a pseudo-R^2 of 0.48 and a chi-squared (32) = 108.34 with probability (chi-squared > value) = 0.000. It has a Hosmer-Lemeshow chi-squared (3) = 1.87, which is used to measure goodness of fit in binary choice models and this indicates that the model is appropriate.

The logit estimates show that technology being available and continuous assessment of the performance of the plant leads to a higher probability of improvements being carried out by the firm. The marginal results indicate that these factors can increase the probability of improvements by 8%. Providing environmental training and responsibility to all employees, even those who do not work in the environmental management area increases the probability of improvements being carried out by the firm by about 8%. Strangely, rewarding employees for environmental performance decreases the probability of improvements being carried out by the firm. A possible reason for obtaining this counter-intuitive result is that the firms that have instituted this reward policy might be the ones who have bad environmental records and are now trying to motivate their employees to take environmental implications into consideration. Hence, this negative relationship in the data between reward and environmental improvements could be due to endogeniety issues, which could be corrected for if we had access to long-term data or had other relevant variables that could be used as instruments. Another explanation is that the firm's decision to reward their personnel for environmental performance could be a substitute for implementing environmental improvements in their plant. If the firm is budget constrained, then the manager might decide to gives small rewards to individual employees rather than spend large sums of money in pollution reducing technology. A higher percentage of employees in a firm with more than primary education also surprisingly leads to a lower probability of improvements being undertaken in the firm. Dasgupta et al. (2000) however find that education encourages greater management effort. Education in their analysis is an explanatory variable in both the compliance equation and the environmental management equation and seems to be exerting an influence via the management equation but not via the compliance equation.[9] The community and business variables do not play a significant role in influencing the probability of improvements.

5. Discussion

In recent years, there has been a lot of awareness and discussion about environmental performance of firms in developing countries. Firms' decision regarding compliance can be explained in various ways. Some firms comply due to the fear of inspections and fines; others comply as they want to project an environmentally responsible image to their consumers and shareholders. This paper examines data on compliance by Mexican manufacturing sector firms. Though Wisner and Epstein (in press) and Dasgupta et al. (2000) examine firm level data from Mexico to understand this issue, their emphasis and methodologies are significantly different, hindering a full comparison of results across papers. Some comparisons made wherever appropriate in the paper show that most of the results are consistent across studies. The emphasis and contribution of this paper has been on determining factors that lead firms to comply more than legally required with regulations, an issue that is often overlooked in the literature.

Over-compliance by firms in the sample considered in this paper is observed to be influenced by positive factors (for example, rewards and training) more than negative factors (like inspections). Rewarding environmental performance increases the probability of over-compliance. These rewards are given to employees based on environmental performance measures, on suggestions for environmental improvements or for observance of internal auditing. They can take financial forms or they could also be in the form of recognition within the firm. Providing environmental training similarly leads to an increase in the firm's probability of over-compliance with environmental regulations.

Community variables are influential in increasing the likelihood of over-compliance. These variables are statistically significant in increasing the probability of over-compliance, though the magnitude of their effects is not very big. The data that we examine in this paper deals with air pollution, water pollution, toxic and non-toxic residue, and some of this pollution is perhaps not easy to identify. Communities usually pay particular attention to firms whose pollution activities are more visible. Researchers who have found that community pressure can have an enormous impact on the firm's incentive to reduce emissions have often focused on one kind of pollution being emitted by firms (for example: Pargal and Wheeler, 1996 examine the extent of water pollution generated by industries). As the data are aggregated for different kinds of pollution indicators in this paper, it is difficult to capture the impact of collective action by communities. We therefore find that the community variables though statistically significant do not have economically significant coefficients.

As the data are cross-sectional, it is difficult to examine the dynamic nature of the environmental performance of firms. A few of the variables used in the paper are endogenous and this could lead to some bias in the estimated coefficients. To be able to determine the exact causal relationship between compliance and some of these potentially endogenous variables, we need access to panel data, which is not available at this point of time.

Notwithstanding the limitations of the data, the results show that some factors are very robust in explaining the compliance decisions of firms. The environmental training provided to employees working in the firm is observed to be very important in improving environmental performance. The

[9] Dasgupta et al. (2000) conduct a two-stage estimation exercise, with management indicators and compliance decisions as the dependent variables in the first and second stages, respectively, to understand the impact of different factors on compliance.

implication of this is that environmental policymakers should put more emphasis on providing and in some cases subsidizing environmental training to employees in developing countries. Training would increase the stock of human capital by improving information flows and increasing morale. It would also have the ability to create positive externalities and spillovers and would therefore be expected to lead to better economic and environmental outcomes for the firm and for society. These kind of informal and voluntary schemes can be initiated with modest public funds and are a valuable addition to the policy toolkit of regulators.

Acknowledgement

Financial support was provided by the Melbourne Research Development Grant Scheme. Part of the work on this paper was done while visiting the Economics Department at Purdue University.

REFERENCES

Arora, S., Cason, T., 1996. Why do firms volunteer to exceed environmental regulations? Understanding participation in EPA's 33/50 program. Land Economics 72 (4), 413–432.

Arora, S., Gangopadhyay, S., 1995. Toward a theoretical model of voluntary overcompliance. Journal of Economic Behavior & Organization 28, 289–309.

Dasgupta, S., Laplante, B., Mamingi, N., 1997. Pollution and Capital Markets in Developing Countries. World Bank, Washington, DC.

Dasgupta, S., Laplante, B., Mamingi, N., Wang, H., 1999. Inspections, Pollution Prices and Environmental Performance: Evidence from China. World Bank, Washington, DC.

Dasgupta, S., Hettige, H., Wheeler, D., 2000. What improves environmental compliance? Evidence from Mexican industry. Journal of Environmental Economics and Management 39 (1), 39–66.

Edwards, S., 1998. The Mexican Peso crisis: how much did we know? When did we know it? The World Economy 21 (1), 1–30.

Frankel, J., 2005. Contractionary currency crashes in developing countries. The 5th Mundell-Fleming Lecture, IMF Annual Research Conference.

Gangadharan, L., 2001. Compliance in environmental markets. Applied Economics Letters 8, 641–644.

Grossman, G., Krueger, A., 1995. Economic growth and the environment. Quarterly Journal of Economics 112, 353–377.

Hamilton, J.T., 1995. Pollution as news: media and stock market reactions to the toxic release data. Journal of Environmental Economics and Management 28 (1), 98–113.

Harrington, W., 1988. Enforcement leverage when penalties are restricted. Journal of Public Economics 37, 29–53.

Hartman, R., Huq, M., Wheeler, D., 1997. Why Paper Mills Clean Up: Determinants of Pollution Abatement in Four Asian Countries. World Bank, Washington DC.

Hettige, H., Huq, M., Pargal, S., Wheeler, D., 1996. Determinants of pollution abatement in developing countries: evidence from south and southeast Asia. World Development 24 (12), 1891–1904.

Husted, H., Logsdon, J., 1997. The impact of NAFTA on Mexico's environmental policy. Growth and Change 28 (1), 24–48 (Winter).

Labatt, S., 1997. Corporate response to environmental issues: packaging. Growth and Change 28 (1), 67–92 (Winter).

Lanoie, P., Laplante, B., Roy, M., 1998. Can capital markets create incentives for pollution control? Ecological Economics 26 (1), 31–41 (July).

Laplante, B., Lanoie, P., 1994. Market response to environmental incidents in Canada. Southern Economic Journal 60, 657–672.

Laplante, B., Rilstone, P., 1996. Environmental inspections and emissions of the pulp and paper industry in Quebec. Journal of Environmental Economics and Management 31, 19–36.

Magat, W., Viscusi, W., 1990. Effectiveness of the EPA's regulatory enforcement: the case of industrial effluent standards. Journal of Law & Economics 33, 331–360.

Pargal, S., Wheeler, D., 1996. Informal regulation of industrial pollution in developing countries: evidence from Indonesia. Journal of Political Economy 104 (6), 1314–1327.

Pargal, S., Hettige, H., Singh, M., Wheeler, D., 1997a. Formal and informal regulation of industrial pollution: comparative evidence from Indonesia and the United States. World Bank Economic Review 11 (3), 433–450 (September).

Pargal, S., Muthukumara, M., Huq, M., 1997b. Inspections and emissions in India: puzzling survey evidence on industrial water pollution. World Bank, Washington, DC.

Salop, S., Scheffman, D., 1983. Raising rivals' costs. American Economic Review (Paper and Proceedings) 73 (2), 267–271.

Tietenberg, T., Wheeler, D., 2001. Empowering the community: information strategies for pollution control. In: Folmer, H., Gabel, H.L., Gerking, S., Rose, A. (Eds.), Frontiers of Environmental Economics. Edward Elgar Publications.

Wisner, P., Epstein, M., in press. Push and pull impacts of NAFTA on environmental responsiveness and performance in Mexican industry, Management International Review.