WHAT DRIVES VOLUNTARY ECO-CERTIFICATION IN MEXICO?

Forthcoming in *Journal of Comparative Economics*

Allen Blackman
(corresponding author)
Resources for the Future
1616 P Street, N.W.
Washington, DC 20009
(202) 328-5073
blackman@rff.org

Santiago Guerrero
Agricultural and Resource Economics
University of California, Berkeley
207 Giannini Hall, #3310
Berkeley, CA 94720
(510) 642-3345
sguerreroe@gmail.com

Draft: August 2011

Acknowledgments: Funding for this research was provided by Resources for the Future and the Swedish Research Council Formas through the program Human Cooperation to Manage Natural Resources (COMMONS). We are grateful to Bidisha Lahiri, Marisol Rivera, and Carlos Muñoz for help obtaining, cleaning, and assembling our data; Bidisha Lahiri and Billy Pizer for assistance with econometrics; the editor, two anonymous reviewers, Dietrich Earnhardt and seminar participants at Kansas University and the University of Michigan for helpful comments and suggestions. Remaining errors are our own.

WHAT DRIVES VOLUNTARY ECO-CERTIFICATION IN MEXICO?

Abstract: Advocates claim that voluntary programs can help shore up poorly performing command-and-control environmental regulation in developing countries. Although literature on this issue is quite thin, research on voluntary environmental programs in industrialized countries suggests that they are sometimes ineffective because they mainly attract relatively clean plants free-riding on prior pollution control investments. We use plant-level data on some 59,000 facilities to identify the drivers of participation in the ISO 14001 certification program in Mexico. We use data on the incidence of regulatory fines to proxy for environmental performance. We find that regulatory fines spur certification: on average, a fine roughly doubles the likelihood of certification for three years. Hence, the program attracts relatively dirty plants and at least has the potential to improve environmental performance. We also find that plants that sold their goods in overseas markets, used imported inputs, were relatively large, and were in certain sectors and states were more likely to be certified.

Key words: voluntary environmental regulation, duration analysis, Mexico

JEL codes: Q56, Q58, O13, O54, C41

1. Introduction

Many of the world's worst environmental problems are now found in developing countries, not industrialized ones. For example, the five cities with the most severe sulfur dioxide air pollution and those with the worst particulate air pollution are in Asia, Latin America, the Middle East (Baldasano et al. 2003). To address such problems, regulators in developing countries, like their counterparts in industrialized countries, have relied principally on emissions standards, technology standards, and other command-and-control policies. Unfortunately, these policies have not been particularly successful. The reasons are well known (Russell and Vaughan 2003; Eskeland and Jimenez 1992). Written regulations are often riddled with gaps and inconsistencies. Environmental regulatory agencies lack funding, expertise, and personnel. And perhaps most important, the political will to allocate scarce resources to environmental protection and to enforce environmental regulations is often limited.

Faced with these challenges, stakeholders in developing countries are increasingly experimenting with policies that do not depend directly on regulators to issue mandates, monitor compliance, and sanction violations. Instead, they provide incentives for voluntary emissions reductions, including positive publicity, pollution control subsidies, and regulatory relief. For example, in Colombia and Chile, dozens of high-profile voluntary agreements between environmental authorities and industry have been signed over the past 15 years (Blackman et al. 2009; Jiménez 2007). The hope is that policies like these will sidestep the institutional and political constraints that have undermined command-and-control policies (World Bank 2000).

Although increasingly common, we know little about voluntary initiatives in developing countries, including what drives participation and whether participation spurs improvements in environmental performance. Empirical studies—particularly rigorous ones—are rare. A recent review of the nascent literature on the topic found only a handful of published articles, most of which were qualitative case studies (Blackman 2010).

The much larger literature on voluntary environmental initiatives in industrialized countries raises serious questions about whether participation actually generates environmental benefits. A particular concern involves one of the three main types of voluntary initiatives—programs administered by regulatory authorities or nongovernmental organizations that invite firms to meet established environmental performance criteria.[1] Research suggests that the environmental benefits of these voluntary environmental programs (VEPs) are sometimes, although not always, undermined by selection effects—that is, by their tendency to mainly attract firms that are either already relatively clean or becoming cleaner for reasons unrelated to the program (Vidovic and Khanna 2007; Morgenstern and Pizer 2007).[2] Such firms have clear incentives to join VEPs: the costs are relatively low because few additional pollution control investments are required to meet the program's environmental performance criteria, and the benefits can be significant. Firms that join for these reasons are said to

[1] Prominent examples in the United States are the Environmental Protection Agency's 33/50 and Climate Wi$e programs. The two other main types of voluntary regulation are agreements negotiated between regulatory authorities and firms, and unilateral commitments undertaken by firms (Lyon and Maxwell 2002).

[2] The evidence on whether VEPs in industrialized countries spur improved environmental performance is quite mixed. For recent reviews, see de Leon and Rivera (2009), Koehler (2008), and Lyon and Maxwell (2008).

"free-ride" on unrelated investments in pollution control (e.g., Lyon and Maxwell 2008; Alberini and Segerson 2002).

Yet findings from studies of VEPs in industrialized countries may not generalize to developing countries, for at least two reasons. First, the socioeconomic context in which VEPs are implemented is different in industrialized and developing countries. Second, the aims of VEPs differ. In industrialized countries, VEPs are generally used to encourage firms to overcomply with mandatory regulations—that is, to cut emissions below legal limits (Lyon and Maxwell 2002; Koehler 2008). In developing countries, by contrast, VEPs are generally used to help remedy rampant noncompliance with mandatory regulation (Blackman 2008 and 2010). Because rigorous studies of developing-country VEPs are scarce, additional research is needed to determine whether the drivers of participation and impacts on environmental performance are the same as in industrialized countries.

Toward that end, the present paper examines the drivers of Mexican participation in the International Organization for Standardization (ISO) 14001 program, the voluntary environmental program with the largest number of participating plants worldwide. We are particularly interested in determining whether certified plants tend to be already clean—that is, to free-ride on prior unrelated investments in pollution control. Our analysis uses much of the same plant-level data, and some of the same methods, as Blackman (2010), an analysis of a Mexican voluntary initiative called the Clean Industry Program including data on the incidence of regulatory fines, which is used to proxy for both regulatory pressure and plants' environmental performance.[3]

[3] The Clean Industry program is state-run initiative that provides a temporary enforcement amnesty and public recognition for plants that voluntarily submit to an environmental audit and correct all deficiencies it

Our results suggest that the program does attract relatively dirty firms under pressure from regulatory authorities. Therefore, ISO 14001 certification at least has the potential to improve environmental performance. We also find that plants that sold their goods in overseas markets, used imported inputs, were relatively large, and were in certain sectors and states were more likely to be certified.

The remainder of the paper is organized as follows. Section 2 provides background on the ISO 14001 program. Section 3 reviews the relevant literature. Section 4 discusses our data and variables. Sections 5 presents our duration model. The last section sums up and discusses policy implications.

2. BACKGROUND

ISO issued its 14001 series certification for environmental management systems (EMSs) in 1996 and revised it in 2004. As of December 2007, more than 150,000 facilities in 148 countries had been certified (ISO 2009). To obtain ISO 14001 certification, which is valid for three years, plants must meet five criteria that together constitute a "plan-do-check-act" cycle. They must

- define an environmental management strategy;
- make a concrete plan to implement it (plan);

---

identifies. Blackman (2010) and the present study differ in three important respects. First, the two studies examine different VEPs. Prima facea, there are a number of reasons to expect the drivers of participation for each initiative to differ. The Clean Industry program is a state run VEP focused on identifying and reducing noncompliance while ISO 14001 is a private sector initiative that has broader environmental performance goals. Second, the empirical strategies used to identify the effect of regulatory pressure on participation differ. Blackman (2010) estimates a third-order polynomial that maps out the relationship between a continuous time-since-last-fine variable and the probability of participation. The present paper relies on a set of dichotomous dummy variables. Third, the research questions in the two papers differ. Blackman et al. (2010) focuses on both the drivers of VEP participation and on the effect of VEP participation on regulatory performance. The present paper focuses on the first question.

- implement the policy and document the results (do);
- conduct periodic internal performance audits (check); and
- take corrective action to promote continual improvement (act).

An independent third-party auditor approved by ISO must verify that these criteria have been met. Plants need not meet hard performance targets to be certified: in general, certification requirements focus on procedures rather than outcomes. A supposed requirement for ISO 14001 certification is compliance with all applicable local environmental regulations. However, the stringency with which plants are held to this and other ISO 14001 criteria vary across countries and within them (Nel and Wessels 2010). The cost of certification can be quite substantial. They include the costs of third-party audits, creating a new EMS or modifying an existing one, and continually implementing that EMS. In the United States, audit costs range from $239 to $1,372 per employee, and implementation costs range from $29 to $88 per employees (Darnall and Edwards 2006).

ISO 14001 certification in Mexico grew from zero plants in 1998 to 525 by the end of 2005 (*Contacto* 2005). However, the majority of these 525 plants were state-owned electric generating units (owned by *Comisión Federal Electricidad*) and petroleum refineries and distribution terminals (owned by *Petróleos Mexicanos*). We do not include these plants in our analysis because our data on plant characteristics (described in Section 4.1) are restricted to private sector facilities. In addition, the drivers of ISO 14001 certification and environmental performance likely differ for publicly owned and privately owned plants. Figure 1 presents data on ISO 14001 certification by sector and year between 1999 and 2005 for the sample of 194 plants included in our empirical analysis.[4] It shows that the lion's share of certifications in this period were in the manufacturing sector and occurred in 2004 and 2005.

[Insert Figure 1 here]

3. LITERATURE

This section reviews econometric studies—from developing countries and industrialized countries—of the drivers of participation in various VEPs and ISO 14001 specifically.

3.1. Developing-country studies

To our knowledge, only five econometric studies of developing-country VEPs have been published, two of which examine ISO 14001. Given this small number of studies, it is not yet possible to generalize about the drivers of participation in developing-country VEPs, including ISO14001. The only universal result is that large enterprises are more likely to participate.

Among the three studies that do not focus on ISO 14001, Blackman et al. (2010), analyzes Mexico's Clean Industry program that provides a temporary enforcement amnesty and public recognition for plants that voluntarily submit to an environmental audit and correct all deficiencies it identifies. The authors find that plants fined for regulatory violations were more likely to subsequently join the program, as were plants that were relatively large, trading in overseas markets, and selling to the government.

[4] The selection of the sample is discussed in Section 3.1.

Rivera (2002 and 2004) analyzes Costa Rica's voluntary Certification for Sustainable Tourism program for hotels. He finds that hotel size, government monitoring, trade association membership, and location near national parks drove participation.

Of the two studies of ISO 14001 in developing countries, Christmann and Taylor (2001) examine the self-reported "future likelihood" of attaining ISO 14001 certification for a sample of Chinese firms. They find that plants that were large, multinational owned, and selling to industrialized countries were more likely to be certified. Finally, Montiel and Husted (2009) analyze ISO 14001 and Clean Industry certification in Mexico and find facilities trading in overseas markets and linked to a trade association were more likely to be early adopters. Our study differs from Montiel and Husted's in a number of respects. Most important, we focus on determining whether and how environmental performance and regulatory pressure affect participation in ISO 14001, and use regulatory enforcement data to proxy for these drivers. Monteil and Husted, by contrast, do not consider either driver and do not use such data. Also, we focus on ISO 14001 certification, while Montiel and Husted's dependent variable identifies plants participating in either ISO 14001 or the Clean Industry program.[5]

3.2. Industrialized-country studies

3.2.2. Voluntary environmental programs other than ISO 14001

Empirical research on VEPs other than ISO 14001 in industrialized countries suggests that pressures applied by regulators, markets, and civil society drive participation, as does variation in transaction costs associated with joining these programs

[5] In addition, Monteil and Husted (2009) use a different sample and econometric model.

(for reviews, see Kohler 2008; Lyon and Maxwell 2002).

A prominent theme in the literature is that firms participate in VEPs to preempt more stringent mandatory regulation or to soften enforcement of existing regulation (Segerson and Miceli 1998; Maxwell et al. 2000). Empirical evidence for this effect mostly comes from the 33/50 program of the U.S. Environmental Protection Agency (EPA).[6] For example, Khanna and Damon (1999), Videras and Alberini (2000), Sam and Innes (2008), and Vidovic and Khanna (2007) all find that firms named as potentially responsible parties at a higher-than-average number of Superfund sites were more likely to join. Closely related to the hypothesis that regulatory pressure drives firms into voluntary programs is the notion that firms join to obtain preferential treatment from regulators. For example, Cothran (1993) and Decker (2003) find that firms obtain permits for new facilities more quickly if they have engaged in voluntary abatement.

Market incentives also may motivate VEP participation. Theory suggests that firms may voluntarily improve their environmental performance to attract “green” consumers (Arora and Gangopadhayay 1995), and some empirical evidence from VEPs supports this hypothesis. For example, Arora and Cason (1996) and Vidovic and Khanna (2007) show that firms with a higher ratio of advertising expenditures to sales were more likely to join EPA’s 33/50 program.

Finally, pressures generated by communities, trade associations and nongovernmental organizations may create incentives for firms to join VEPs. For example, Khanna and Damon (1999) find that facilities belonging to the Chemical Manufacturers Association were more likely to join EPA’s 33/50 program.

---

[6] Launched in 1991, the 33/50 program required participants to pledge to cut their emissions of 17 high-priority toxic chemicals by 33 percent by 1992 and by 50 percent by 1995.

The transaction costs associated with joining VEPs inevitably vary across firms because firm characteristics, including human capital, differ. This variation helps explain participation (Delmas and Marcus 2004). For example, Blackman and Mazurek (2001) find that transaction costs associated with participating in EPA's Project XL averaged more than $450,000 per firm, varied considerably across firms, and deterred some firms from participating.

3.2.3. ISO 14001 certification

Although several papers examine the drivers of ISO 14001 certification, only a handful test for the effects of past environmental performance and regulatory pressure. All focus on U.S. manufacturing facilities (but use different samples and measures of environmental performance). Most but not all of these studies find that dirtier plants are more likely to be ISO 14001 certified. Darnall (2003) finds that plants in violation of hazardous waste and atomic energy regulations are more likely to be certified. King et al. (2005) find that plants with toxic emissions higher than the average for their size and sector are more likely to be certified. And Potoski and Prakash (2005) find that plants with higher emissions of conventional air pollutants are more likely to be certified. Toffel (2007) reaches a different conclusion, however. He finds that although plants with higher absolute toxic emissions are more likely to be certified, the opposite is true of plants with higher emissions per unit of output. Finally, Potoski and Prakash (2005) find an inverted U relationship between compliance with Clean Air Act regulations and ISO certification: plants never in compliance and those always in compliance are more likely to be certified than those that are sometimes in compliance.

Although limited, the evidence on the effect of regulatory pressure on ISO certification consistently suggests a positive correlation. Using data on Japanese manufacturing plants, Arimura et al. (2005) find that plants subject to environmental performance standards and input taxes are more likely to be certified, and Potoski and Prakash (2005) find that plants inspected more often are more likely to be certified.

As for nonregulatory drivers of certification, virtually all econometric studies of ISO 14001 adoption test for the effect of firm size and conclude it is positively correlated with certification (Arimura et al. 2005; King et al. 2005; Nakamura et al. 2001; Nishitani 2009; Potoski and Prakash 2005). Finally, most studies test for the effect of sales to foreign buyers and virtually all conclude it, too, is positively correlated with certification (Arimura et al 2005; Bansal and Hunter 2003; King et al. 2005; Nishitani 2009).

4. DATA AND VARIABLES

4.1. Data

Official Mexican plant-level census data are not available. We constructed a plant-level data set from four sources. The first is a list of all 525 Mexican facilities that obtained ISO 14001 certification through December 2005, along with the plant's location and the year (but not date) of certification. This list was compiled from an annual registry published by *Contacto* magazine.[7]

The second data source is the July 2004 System of Mexican Business Information (*Sistema de Información Empresarial Mexicano*, SIEM). The Mexican Ministry of Economics compiles and maintains SIEM and uses it to promote Mexican commerce. By

[7] Unlike lists of Mexican ISO 14001 plants available on internet sites, *Contacto* includes plant location data needed to merge our four data sets.

law, all private sector Mexican plants are required to provide basic data to SIEM. The database is constantly updated to include new entrants and omit plants that have exited the market. It is not time specific—that is, it does not indicate when plants entered SIEM or whether their characteristics subsequently changed. SIEM contains basic information on more than half a million facilities throughout Mexico, more than three-quarters of which are small-scale retail operations. The data include geographic location, sector, gross sales, accounting capital, and whether the facility exports, imports, and is a government supplier. Our SIEM data contain 528,618 records. However, the lion's share of these enterprises were small-scale retail operations—"mom-and-pop" corner shops and the like—with no history of ISO 140001 certification and, more importantly, no prospect of such certification. To avoid creating a control sample principally consisting of such enterprises, we dropped all plants in sectors (defined by six-digit North American Industrial Classification Codes) that were not already represented in the ISO-14001 database—that is, that did not already have a history of ISO 14001 certification. This step eliminated approximately 80 percent of the plants in the SIEM data.[8]

Our third data source is a 2009 registry of fines levied by the Federal Environmental Attorney General's Office (*Procuraduría Federal de Protección al Ambiente*, PROFEPA) within the Ministry of the Environment, which is responsible for monitoring and enforcement of most environmental regulations. This registry contains records of every PROFEPA fine between January 1992 and December 2009, including the amount and date of the fine. It has data on 44,008 plants. We use these data to proxy

[8] This adjustment changes the question addressed by our duration model from, "for all private sector Mexican plants, what plant characteristics drive ISO 14001 certification?" to, "for all private sector Mexican plants in sectors with at least one ISO 14001-certified plant, what plant characteristics drive certification?"

for regulatory pressure and for environmental performance, the implicit assumption for the latter being that dirty plants are fined more often than clean ones. Proxies are needed because to our knowledge, reliable, directly measured data on environmental performance simply do not exist at the national level.

Our final data set is a 2007 list of 3,850 Mexican *maquiladoras* obtained from a commercial registry (Mexico's Maquila Online Directory 2007). Designed to take advantage of relatively inexpensive Mexican labor, *maquiladoras* are foreign-owned assembly plants that import inputs and export outputs without paying tariffs or duties.

We merged information on certification from the ISO 14001 database, plant characteristics from the SIEM and *maquila* databases, and fines from the PROFEPA database to create the plant-level data set used in the econometric analysis. Because the four databases do not have a common numerical code identifying individual plants, we merged them by nonnumerical identifiers—plant name, state, and *municipio* (county).[9] These nonnumeric data did not uniquely identify plants. For example, in the SIEM data, multiple records have the same plant name, state, and *municipio.* To avoid incorrectly matching records, we dropped all records that were not uniquely identified. This resulted in a loss of 5 to 20 percent of the records in each data set. The end result was a sample of 59,149 plants, of which 194 were ISO 14001 certified and 58,955 were not.

4.2. Variables

This section discusses the independent variables used in the econometric model. We focus first on time-varying variables and then on the time-invariant variables.

[9] Using finer geographical identifiers (e.g., city) proved to be impractical because of a lack of uniformity across the databases.

4.2.1. Time-Varying Independent Variables: Fines

Of the potential drivers of ISO 14001 certification, we are particularly interested in regulatory pressure and environmental performance. To proxy for these factors, we construct a set of dummy variables indicating how recently the plant has been fined. They are the only time-varying independent variables in our econometric model. Before defining these variables, we briefly present summary statistics on PROFEPA fines between 1992 and 2005 (Table 1). In our entire sample of 59,149 plants, 2 percent were fined. Of the 1,100 plants that were fined, the average number of fines was two per plant, and the average fine was 54,000 pesos (approximately US$5,400).

[Insert Table 1 here]

Table 1 shows that ISO 14001-certified plants were fined far more often than uncertified plants: 30 percent of certified plants were fined versus only 2 percent for uncertified plants. Hence, there appears to be a simple correlation between fines and ISO 14001 certification. However, this correlation does not necessarily imply causation, for at least two reasons. First, it may have been generated by underlying differences in plant characteristics. For example, it could simply reflect a tendency for large plants to be fined and also to obtain ISO 14001 certification. Second, it does not take into account the intertemporal relationship between these events. For example, it lumps together cases in which a fine was followed by certification 1 year later and cases in which a fine was followed by certification 10 years later, even though the former are more likely to reflect actual causation. As discussed below, our econometric model addresses both of these issues: it controls for a variety of underlying plant characteristics and takes into account the intertemporal relationship between fines and certification.

We include four fines variables in the duration model. FINE_1YR is a dichotomous dummy variable that identifies plants fined in the year prior to the current year, FINE_2YR is a dummy variable that identifies plants fined in the year two years prior to the current year, and FINE_3YR is a dummy variable that identifies plants fined in the year three years prior to the current year. Finally, FINE_3YR_PLUS is a dummy variable that identifies plants fined more than three years prior to the current year. We do not include a fine dummy variable for the current year to avoid conflating cases where a fine precedes ISO certification with cases where it follows certification.

4.2.2. Time-Invariant Independent Variables

Table 2 lists the time-invariant independent variables in the econometric model and presents sample means for the entire sample, the subsample of certified plants, and the subsample of uncertified plants.

[Insert Table 2 here]

EXPORT is a dummy variable identifying plants that export at least some of their products. We expect EXPORT to be positively correlated with the probability of certification. Almost 90 percent of Mexican exports are sold in the United States (Clifford 2001). U.S. consumers, including buyers of intermediate products, may be more concerned about the environmental performance of Mexican firms than are domestic consumers.

IMPORT is a dummy variable identifying plants that import at least some of their products. We expect IMPORT to be positively correlated with certification because plants that import may be better integrated into the global economy and therefore may have better access to pollution prevention and control technology.

MAQUILA is a dummy variable identifying *maquiladoras.* Of the sample plants, 1 percent are *maquiladoras.* We expect MAQUILA to be positively correlated with certification for the same reasons that we expect EXPORT and IMPORT to be positively correlated, and because *maquiladoras* are often required to meet company-wide international standards for environmental performance (Garcia-Johnson 2000; Hutson 2001).

GSUPPLIER is a dummy variable identifying plants that sell their products to the Mexican government. We expect GSUPPLIER to be positively correlated with the probability of certification because government entities that purchase products from private sector suppliers may have bureaucratic incentives to favor suppliers that are ISO 14001 certified.

Two sets of dummy variables—on sales and capitalization—measure plant size. SA_0_3M is a dummy variable indicating that the gross revenue of the plant falls between zero and 3 million pesos (approximately US$300,000). The other two sales dummies have a similar interpretation. CAP_0_900K is a dummy variable indicating that the capitalization of the plant falls between zero and 900,000 pesos (approximately

US$90,000). The other two capitalization dummies have a similar interpretation.[10] Empirical research suggests that large plants are more likely to participate in voluntary regulatory programs (Lyon and Maxwell 2002; Kohler 2008). Participation inevitably involves fixed transaction costs that arise from, among other things, meeting new bureaucratic requirements. These fixed costs generate economies of scale (Blackman and Mazurek 2001).

Nine dichotomous dummy variables identify the plants' economic activity. These sector fixed effects are drawn from the 17 sector categories in the SIEM dataset. Our set of 194 ISO 14001 certified plants had no private sector plants in six of these categories. Therefore, as discussed in Section 4.1, we dropped all observations in these six sectors from our data set, effectively eliminating the corresponding sector dummies from the regression model.[11] In addition, to make the model estimable, we dropped two additional sector dummies that were nearly perfectly correlated with the dependent variable—that is, dummies for sectors that included only one ISO certified plant.[12] The three sectors with the greatest number of sample plants in the entire merged data set are commercial retail (SECTORD3, 20 percent), industrial manufacturing (SECTORD6, 19 percent), and professional-scientific-technical (SECTORD16, 16 percent), which together constitute 55 percent of the sample. Presumably, plants in some sectors have stronger incentives to obtain ISO 14001 certification than others. These may be sectors that are particularly

[10] The SIEM data do not include the actual values of sales or capital for each plant, only ranges of these variables into which the actual values fall.

[11] Specifically, we dropped plants in Sector 1 (agriculture, livestock, forestry, fishing, and hunting), Sector 5 (electricity, water, and gas), Sector 11 (waste management, remediation), Sector 12 (entertainment, culture, and sports), Sector 13 (health and social assistance), and Sector 14 (educational services).

[12] Specifically, we dropped plants in Sector 4 (construction) and Sector 10 (temporary lodging, food and beverage preparation).

dirty and sell to consumers who are particularly concerned about environmental performance.

Finally, 21 location fixed effects dummy variables identify the state where each plant is located. To make the model estimable, starting with 31 states plus the Federal District, we dropped 16 state dummies that were perfectly or near perfectly correlated with the dependent variable—that is, dummies for states in which zero or one plant in our merged data set were ISO 14001 certified between 1999 and 2005.[13] Presumably, plants in some locations have stronger incentives to obtain ISO 14001 certification than others. For example, these may be locations where consumers are particularly concerned about environmental performance.

5. ECONOMETRIC MODEL

This section discusses the empirical strategy for our participation model and presents our results.

5.1. Empirical Strategy: Duration Analysis

We use a duration model to analyze ISO 14001 certification. Such models are used to explain intertemporal phenomena, such as the length of time that patients with a life-threatening disease survive, and the length of time that industrial facilities operate before adopting a new technology.[14] Duration models estimate a hazard rate, h, which may be interpreted as the conditional probability that a phenomenon occurs at time t

[13] Specifically, we dropped dummies for Baja California Sur, Campeche, Chiapas, Colima, Durango, Guerrero, Hidalgo, Michoacán, Morelos, Nayarit, Oaxaca, Quintana Roo, Sonora, Tabasco, Veracruz, and Zacatecas.

[14] For an introduction, see Kiefer (1988).

given that it has not already occurred and given the characteristics of the unit of analysis (patient, plant) at time t. The hazard rate is defined as

$$h(t, \mathbf{X_t}, \beta) = f(t, \mathbf{X_t}, \beta)/(1- F(t, \mathbf{X_t}, \beta)) \qquad (1)$$

where $F(t, \mathbf{X_t}, \beta)$ is a cumulative distribution function that gives the probability that the phenomenon (death, adoption of a technology) has occurred prior to time t, $f(t, \mathbf{X_t}, \beta)$ is its density function, $\mathbf{X_t}$ is a vector of explanatory variables related to the characteristics of the unit of analysis (which may change over time), and β is a vector of parameters to be estimated. In this paper, to analyze ISO 14001 certification, the hazard rate is the conditional probability that a plant in our data set obtains certification at time t, given that it has not already been certified and given the characteristics of the plant at time t.

In duration models, the hazard rate is typically broken down into two components. The first is a baseline hazard, $h_0(t)$, that is a function solely of time (not of any explanatory variables) and that is assumed to be constant across all plants. The baseline hazard captures any effects not captured by explanatory variables, such as the diffusion of knowledge about ISO 14001 certification or changes in macroeconomic conditions. The second component of the hazard rate is a function of the explanatory variables. Combining these two components, the hazard rate h(t) is written

$$h(t) = h_0(t)\exp(\mathbf{X_t}'\beta). \qquad (2)$$

The vector of parameters, β, is estimated using maximum likelihood.

A duration framework is appropriate for analyzing the effect of fines on ISO 14001 certification for two reasons. First, it explicitly accounts for the intertemporal relationship between these phenomena, which (as discussed above) helps determine whether fines actually cause certification. Second, it avoids the problem of right censoring that would arise in a cross-sectional probit or logit model if some plants that were not certified in December 2005 (when our panel ends) subsequently joined the program. A duration model circumvents this problem by estimating the conditional probability of certification in each period.

We use a Cox (1975) proportional hazard model. There are two broad approaches to specifying duration models. One is to make parametric assumptions about the time-dependence of the probability density function, $f(t, \mathbf{X_t}, \boldsymbol{\beta})$. Common assumptions include exponential, Weibull, and log-logistic distributions. Each assumption implies a different shape for the baseline hazard function, $h_0(t)$.[15] A second general approach is to use a Cox (1975) proportional hazard model, which does not require a parametric assumption about the density function. This feature accounts for the popularity of the Cox model among economists, and it is the reason we choose it. We use years as our temporal unit of analysis. Although we know the day on which plants were fined, we know only the year in which plants were ISO 14001 certified.[16]

[15] For example, an exponential probability density function generates a flat hazard function, $h_0(t)$. The implication is that the probability of obtaining ISO 14001 certification (apart from the influences of regulatory activity and plant characteristics) stays the same over time. A log-logistic probability density function, on the other hand, generates a hazard function that rises and then falls.

[16] As a result, in some years multiple plants are certified in the same year. Such "ties" create a complication because estimating the duration model requires identifying the number of plants still at risk of being certified each time a plant joins. If more than one plant is certified in the same period, the size of the risk pool in each period is not clear. We use the Breslow (1974) method for ties. In addition, our use of years as a temporal unit of analysis raises questions about whether time aggregation bias is a problem and whether a discrete-time representation might be more appropriate. In general, however, time aggregation bias is a problem only when hazard rates are high and/or the periods of measurement are long—that is, when a large

Finally, note that although plants can and do obtain ISO 14001 certification more than once, our duration model seeks to explain the decision to obtain certification for the first time. As is standard practice with duration models, observations (here, plants) are dropped from the regression sample after their first "failure" (here, certification).

5.2. Results

We discuss results for the time-varying and time-invariant independent variables separately.

5.2.1. Time-Varying Independent Variable: Fines

Table 3 presents regression results for the Cox proportional hazard model. Because the hazard function given by equation (2) is nonlinear, the estimated coefficients do not have a simple interpretation (technically, they can be interpreted as the effect on the log hazard rate of a unit change in the explanatory variable at time t). Exponentiated coefficients, however, can be interpreted as the hazard ratio—that is, the ratio of the hazard rate given an increase in an explanatory variable at time t (a unit increase in a continuous variable or a change from 0 to 1 of a dichotomous dummy variable) relative to the baseline hazard rate at time t. A hazard ratio greater than unity indicates that an increase in the explanatory variable increases the hazard rate relative to the baseline. For example, a hazard ratio of 2 means that an increase in the explanatory variable doubles the hazard rate relative to the baseline.

---

number of failure events in a given interval begins eroding the underlying population of units at risk of failure (Petersen 1991). This is not the case in our sample: the number of plants obtaining certification in any given year is always quite small relative to the number of uncertified plants.

[Insert Table 3 here]

Three of our four fine variables—FINE_1YR, FINE_2YR, and FINE_3YR—are significant at the 5 percent or 1 percent level, and one—FINE_3YR_PLUS—is not significant. The hazard ratios for FINE_1Y, FINE_2YR, and FINE_3YR indicate that a fine assessed one or two years before the current year increases the probability that a plant will obtain ISO 14001 certification in the current period by a factor of 1.8, and a fine assessed three years before the current year increases this probability by a factor of 2.0. The lack of significance of FINE_3YR_PLUS indicates that a fine assessed more than three years prior to the current period does not affect the probability of certification. We tested, and were unable to reject, the hypothesis that hazard ratios for the three significant fines variables are equal. Therefore, the appropriate interpretation of our results is that a fine within three years of the current year increases the probability of certification by roughly a factor of two, but a fine that is more distant in time has no effect.[17]

A potential concern about our analysis is that the FINE variables could, in principle, be endogenous if they are correlated with unobserved plant characteristics that affect certification.[18] Although such endogeneity cannot be ruled out, it is unlikely to be

[17] We tested an alternative specification in which we replaced the three significant fines dummies—FINE_1Y, FINE_2YR, and FINE_3YR—with a single dummy, FINE_1_3YR, equal to one if a plant was fined in any of the three years prior to the current year. The results (available from the authors upon request) are qualitatively identical to those in Table 3: the new dummy has a hazard ratio equal to 2.033 and is significant at the 1% level; FINE_3YR_PLUS is insignificant; and results for the remaining covariates are virtually unchanged.

[18] For example, aside from our sector dummies, our covariates do not include a precise measure of the complexity of the production process, so complexity is partly unobserved. It could be that complex plants are more likely to be fined because they have a higher potential for violating environmental regulations and are also more likely to obtain ISO 14001 certification because they tend to employ educated and sophisticated managers. If this were actually true, then fines would be endogenous.

driving the observed correlation between fines and certification. The reason is that endogeneity would be unlikely to generate the intertemporal response function implied by the results for our FINE variables—namely, an effect of fines on the probability of certification that diminishes the more distant in time was the fine, i.e., after three years. Instead, endogeneity would generate a response that did not change over time. Hence, our results suggest a causal relationship between fines and ISO 14001 certification.[19]

5.2.2. Time-Invariant Independent Variables

The hazard ratios for EXPORT, IMPORT, and MAQUILA are greater than unity and significant at the 10 percent, 1 percent, and 1 percent levels, respectively. They indicate that plants selling their goods in overseas markets were 1.6 times more likely to obtain ISO certification, those that import foreign inputs were 2.5 times more likely, and those that were *maquiladoras* were 2.9 times more likely, all other things equal. The hazard ratio for GSUPPLIER is not significant.

Estimated hazard ratios for the sales and capital dummies suggest that larger plants were more likely to join the program. The reference groups for these dummies are plants with less than 3 million pesos in sales and those with less than 900,000 pesos in capital. The hazard ratio for SA_12MPLUS is significant at the 1 percent level, indicating that plants with more than 12 million pesos in sales were 2.8 times more likely to be

[19] Intraclass correlation is a second potential concern. Some plants in our regression sample are owned by the same firm. Presumably, in some cases, the decision to become ISO 14001 certified is made at the firm level. But in other cases, it is clearly made at the plant level—some plants owned by the same firm do not make the same certification decision. In cases where the certification decision is made at the firm level, our data may exhibit intraclass correlation. Ideally, we would correct for this correlation using clustered standard errors. However, we are not able to do that for two reasons. First, we cannot reliably identify cases where the certification decision is made at the firm versus the plant level. Second, our indicator of common ownership is unreliable. The only data we can use to determine whether plants share a common owner is their names. But in some cases, plants with different names are owned by the same parent firm.

certified than those in the reference group, all other things equal, and the hazard ratio for CAP_5M_PLUS is significant at the 1 percent level, indicating that plants with more than 5 million pesos in capital were 2.6 times more likely to be certified, all other things equal. These results comport with previous studies of voluntary programs that generally find larger facilities are more likely to participate.

For the sector fixed effects, the reference group comprises plants in the 2 sectors (among the 10 represented in our regression data) in which ISO certification is limited: Sector 4 (construction) and Sector 10 (temporary lodging, food and beverage preparation). Our regression results indicate that, compared with plants in these sectors, those in Sector 6 (industrial manufacturing) were 3.7 times more likely to be certified, and those in Sector 8 (mining) were 12.0 times more likely, all other things equal.

For the state fixed effects, the reference group comprises plants in 16 states in which ISO certification is limited: Baja California Sur, Campeche, Chiapas, Colima, Durango, Guerrero, Hidalgo, Michoacán, Morelos, Nayarit, Oaxaca, Quintana Roo, Sonora, Tabasco, Veracruz, and Zacatecas. Our regression results indicate that, compared with plants in these states, those in Coahuila, Mexico State, Puebla, Querátaro, and Tamaulipas were more likely to be certified and those in Jalisco were less likely.

6. Discussion

Our duration model results raise questions about the internal consistency of our arguments, the validity of our proxy for environmental performance, and our estimation strategy. The first question is, if environmental regulatory pressure in developing countries is generally weak, as we assert in Section 1, how could it have driven ISO

14001 certification in Mexico? Indeed, available evidence suggests that regulatory pressure in Mexico was weak during our study period (Brizzi and Ahmed 2001; Gilbreath 2003; OECD 2003). We believe the explanation has to do with PROFEPA's monitoring and enforcement strategy. PROFEPA has an explicit, written policy of targeting large facilities in particularly dirty sectors, such as manufacturing and mining (DOF 1990, 1992; Quezada 2005). Our duration analysis shows that these same types of plants tend to get ISO 14001 certified. Specifically, we find that plants that were large and in the manufacturing and mining sectors (Sectors 6 and 8) were particularly likely to get ISO 14001 certified. Hence, although PROFEPA monitoring and enforcement may have been weak for the average facility, for the types of plants getting ISO certified, it was significantly stronger. Our fines data reflect this disparity. The incidence of fines among all plants during our study period was 2 percent, but the incidence among large plants (more than 12 million pesos in capital) in the manufacturing and mining sectors was 23 percent. A complementary explanation for our finding that regulatory pressure drove ISO 14001 certification in Mexico is that such certification relies on carrots as well as regulatory sticks to entice participants, including economic incentives created by buyers. As a result, even relatively weak regulatory pressures might trigger a decision to obtain certification.

A related issue question concerns our assumption that the incidence of PROFEPA fines proxies for plants' environmental performance—that is, that dirty plants are fined more than clean ones. Unfortunately, this assumption is not testable because to our knowledge, reliable direct measurements of environmental performance in Mexico do not exist at the national level. However, on their face, the summary statistics in Table 1 raise questions about the validity of this assumption. Specifically, the fact that only 2 percent of our sample plants were fined during a period characterized by (reputed) widespread regulatory noncompliance might be seen as evidence that the allocation of fines among plants was based on unobserved political economy variables, not environmental performance. Although the effect of such unobserved variables on PROFEPA fines cannot be ruled out, this hypothesis is less likely in light of PROFEPA's targeting strategy. As just noted, the incidence of fines among the type of plants PROFEPA targets was 23 percent, more than an order of magnitude higher than the incidence of fines among all plants. This statistic is more consistent with the assumption that PROFEPA fines reflect plants' environmental performance.

A final question is whether our results are affected by fact that ISO certification is a relatively rare event in our data—roughly 0.3 percent of our sample plants were certified. To our knowledge, the effect of rare events on dichotomous choice estimators has not received much attention.[20] To test whether this characteristic of our sample affects our results, we reestimated our duration model with two subsamples defined in such a way that certified plants are less rare. The first subsample included only those categories of plants most likely to be certified—large plants (more than 12 million pesos in sales) in the manufacturing and mining sectors (Sectors 6 and 8). The 2,060 plants meeting these criteria accounted for 130 of the 194 ISO certifications in the full sample of 59,149 plants. In this subsample, 6% of plants were ISO certified. The duration results using this subsample are qualitatively identical to and quantitatively very close to those from the full sample (Table 4). Note that this exercise also provides reassurance that our

[20] Some research has shown that it affects the consistency of logit models (Jin et al. 2005; King and Zeng 2001).

results are robust to multicollinearity among our fines, size, and sector regressors that stems from PROFEPA's targeting policy. By construction, this subsample eliminates such multicollinearity. The second subsample includes all of the 194 certified plants and a random sample of approximately 10% of all of the uncertified plants. The duration results using this subsample (which are available upon request from the authors) also are qualitatively identical to and quantitatively very close to those from the full sample.

7. Conclusion

We have used data on some 59,000 industrial facilities and other business in Mexico to identify the drivers of participation in the ISO 14001 certification program for EMSs. We have been particularly interested in the effects of PROFEPA fines, which proxy for both regulatory pressure and environmental performance. We have used duration analysis because it explicitly accounts for the timing of the dependent variable (certification) and the main independent variable of interest (regulatory fines) and because it controls for right censoring. Our results indicate that fines motivate participation in the program. The magnitude of the effect is economically significant: on average, a fine roughly doubles the likelihood of joining the program for three years. We also find that, all other things equal, plants are more likely to participate if they sell their goods in overseas markets, use imported inputs, are *maquiladoras,* are large (as measured by gross revenues or capitalization), and are in certain sectors and states.

What are the implications of our results for the debate about the use of VEPs in developing countries? They provide grist for both advocates and detractors. For advocates, one interpretation of our results is that in Mexico, compared with plants with similar characteristics (size, sector, location, etc.), ISO 14001-certified plants are more likely to have been recently fined. If one accepts that fines proxy for environmental performance, that in turn implies that plants getting ISO 14001 certified tend to be dirty relative to similar plants—that is, they tend not to be already clean plants free-riding on unrelated investments in pollution control. Although one would hope that ISO certification causes these dirty plants to improve their environmental performance, this conclusion does not necessarily follow. Hence, by demonstrating that relatively dirty firms tend to obtain ISO 14001 certification in Mexico, our analysis establishes a necessary but not sufficient condition for the program's generating environmental benefits. Further research on plants' postparticipation environmental performance is required to determine whether ISO certification actually improves plants' environmental performance. Indeed, an empirical study that rigorously evaluated the impact on environmental performance of ISO 14001 (or another VEP) in a developing country would be an important contribution and is a goal for future research.

But our results, in of themselves, also support a more pessimistic interpretation. Advocates assert that VEPs can help spur pollution control in developing countries with weak command-and-control regulatory regimes. But we find that in Mexico, command-and-control regulation was a key driver of participation in ISO 14001. This finding casts doubt on VEPs' ability to substitute for weak regulatory capacity.

References

Alberini, A., and K. Segerson. 2002. Assessing Voluntary Programs to Improve Environmental Quality. *Environmental and Resource Economics* 22(1–2): 157–84.

Arimura. T.A. Hibiki, and H. Katayama. 2005. Is a Voluntary Approach an Effective Environmental Policy Instrument? *Journal of Environmental Economics and Management* 53: 281–95.

Arora, S., and T. Cason. 1996. Why Do Firms Volunteer to Exceed Environmental Regulation? Understanding Participation in EPA's 33/50 Program. *Land Economics* 72: 413–32.

Arora, S., and S. Gangopadhayay. 1995. Toward a Theoretical Model of Voluntary Overcompliance. *Journal of Economic Behavior and Organization* 28: 289–309.

Baldasano, J.M., E. Valera, and P. Jiménez. 2003. Air Quality Data from Large Cities. *The Science of the Total Environment* 307: 141–65.

Bansal, P., and T. Hunter. 2003. Strategic Explanations for the Early Adoption of ISO 14001. *Journal of Business Ethics* 46(3): 289–99.

Blackman, A. 2008. Can Voluntary Environmental Regulation Work in Developing Countries? Lessons from Case Studies. *Policy Studies Journal* 36(1): 119–41.

———. 2010. "Alternative Pollution Control Policies in Developing Countries." *Review of Environmental Economics and Polic*y 4(2): 234-253.

Blackman, A., and J. Mazurek. 2001. The Cost of Developing Site-Specific Environmental Regulations: Evidence from EPA's Project XL. *Environmental Management* 27(1): 109–21.

Blackman, A., T. Lyon, E. Uribe, and B. van Hoof. 2009. Voluntary Environmental Agreements in Developing Countries: The Colombian Experience. Report. Washington, DC: Resources for the Future. June.

Blackman, A., B. Lahiri, B. Pizer, M. Rivera Planter, and C. Muñoz Piña. 2010. "Voluntary Regulation in Developing Countries: Mexico's Clean Industry

Program.” *Journal of Environmental Economics and Management* 60(3): 182-192.

Breslow, N.E. 1974. Covariance Analysis of Censored Survival Data. *Biometrics* 30: 89–99.

Brizzi A., and K. Ahmed. 2001. Sustainable Future. In in M. Guigale, O. Lafourcade, and V.H. Nguyen (eds.) Mexico: A Comprehensive Development Agenda for the New Era. Washington, DC: World Bank.

Christmann, P., and G. Taylor. 2001. Globalization and the Environment: Determinants of Firm Self-Regulation in China. *Journal of International Business Studies* 32(3): 439–58.

Clifford, R. 2001. Growth and Competitiveness. In M. Guigale, O. Laforcade, and V.H. Nguyen (eds.), *Mexico: A Comprehensive Development Agenda for a New Era.* Washington, DC: World Bank, Chapter 2.

Contacto de Unión Empresarial. 2005. Edición Especial. Mexico, D.F.

Cothran, M.C. 1993. Pro-Active Environmental Activity Eases Permitting Process. *Journal of Environmental Permitting* 2: 293–300.

Cox, D. 1975. Partial Likelihood. *Biometrika* 62: 269–76.

Darnall, N. 2003. Why Firms Certify to ISO 14001: An Institutional and Resource Based View. Academy of Management Proceedings One: A1–A6.

Darnall, N., and D. Edwards. 2006. Predicting the Cost of Environmental Management System Adoption: The Role of Capabilities, Resources, and Ownership Structure. *Strategic Management Journal* 27: 301–20.

Decker, C. 2003. Corporate Environmentalism and Environmental Statutory Permitting. *Journal of Law and Economics* 46: 103–29.

deLeon, P., and J. Rivera (eds.) 2009. *Voluntary Environmental Programs: A Policy Perspective.* Rowman & Littlefield: Lanham, MD.

Delmas, M., and A. Marcus. 2004. Firms’ Choice of Regulatory Instruments to Reduce Pollution: A Transaction Cost Approach. *Business and Politics* 6(3): 1–20.

Diario Oficial de la Federación (DOF). 1990. Listado de Actividades Altamente Riesgosas por los Efectos que Puedan Generar en el Equilibrio Ecológico y en el Medio Ambiente. March 28.

Diario Oficial de la Federación (DOF). 1992. Segundo Listado de Actividades Altamente Riesgosas por los Efectos que Puedan Generar en el Equilibrio Ecológico y en el Medio Ambiente. May 4.

Eskeland, G., and E. Jimenez. 1992. Policy Instruments for Pollution Control in Developing Countries. *World Bank Research Observer* 7(2): 145–69.

Garcia-Johnson, R. 2000. *Exporting Environmentalism: US Multinational Chemical Corporations in Mexico and Brazil*. Cambridge, MA: MIT Press.

Gilbreath, J. Environment and Development in Mexico: Recommendations for Reconciliation. Washington, DC: Center for Strategic and International Studies.

Hutson, A. 2001. ISO 14001 and the Automobile Industry in Mexico. Master's thesis. Nicholas School of Environmental and Earth Sciences, Duke University, Durham, NC.

International Organization for Standardization (ISO). 2009. The ISO Survey–2007. Available at http://www.iso.org/iso/survey2007.pdf.

Jiménez, O. 2007. Voluntary Agreements in Environmental Policy: An Empirical Evaluation for the Chilean Case. *Journal of Cleaner Production* 15: 620–37.

Jin, Y., R. Rejesus, and B. Little, 2005. Binary Choice Models for Rare Events Data: A Crop Insurance Fraud Application. *Applied Economics* 37: 841-848. .

Khanna, M., and L. Damon. 1999. EPA's Voluntary 33/50 Program: Impact on Toxic Releases and Economic Performance of Firms. *Journal of Environmental Economics and Management* 37: 1–25.

Koehler, D. 2008. The Effectiveness of Voluntary Environmental Programs—A Policy at a Crossroads? *The Policy Studies Journal* 35(4): 689–22.

Kiefer, N. 1988. Economic Duration Data and Hazard Functions. *Journal of Economic Literature* 26: 646–79.

King, G. and L. Zeng. 2001. Logistic Regression in Rare Events Data. *Political Analysis* 9(2): 137-163

King, A., M. Lenox, and A. Terlaak. 2005. The Strategic Use of Decentralized Institutions: Exploring certification with the ISO 14001 Management Standard. *Academy of Management Journal* 48(6): 1091–106.

Koehler, D. 2008. The Effectiveness of Voluntary Environmental Programs—A Policy at a Crossroads? *The Policy Studies Journal* 35(4): 689–722.

Lyon, T., and J. Maxwell. 2002. Voluntary Approaches to Environmental Regulation: A Survey. In M. Frazini and A. Nicita (eds.), *Economic Institutions and Environmental Policy*. Aldershot and Hampshire: Ashgate Publishing.

———. 2008. Environmental Public Voluntary Programs Reconsidered. *The Policy Studies Journal* 35(4): 723–50.

Maxwell, J., T. Lyon, and S. Hackett. 2000. Self-Regulation and Social Welfare: The Political Economy of Corporate Environmentalism. *Journal of Law and Economics* 43(2): 583–618.

Mexico's Maquila Online Directory. 2007. Available at http://www.maquiladirectory.com/.

Montiel, I. and B. Husted. 2009. The Adoption of Voluntary Environmental Management Programs in Mexico: First Movers as Institutional Entrepreneurs. *Journal of Business Ethics* 88: 349-363.

Morgenstern, R., and W. Pizer (eds.). 2007. *Reality Check: The Nature and Performance of Voluntary Environmental Programs in the United States, Europe, and Japan*. Washington, DC: Resources for the Future Press.

Nakamura, M., T. Takahashi, and I. Vertinsky. 2001. Why Japanese Firms Chose to Certify: A Study of Managerial Responses to Environmental Issues. *Journal of Environmental Economics and Management* 42(1): 23–52.

Nel, J. and J. Wessels. 2010. How to Use Voluntary, Self-Regulatory and Alternative Environmental Compliance Tools: Some Lessons Learnt. *Potchefstroom Electronic Law Journal* 13(5): 48-78.

Nishitani, K. 2009. An Empirical Study of the Initial Adoption of ISO 14001 in Japanese Manufacturing. *Ecological Economics* 68: 669–79.

Organization for Economic Co-operation and Development (OECD). 2003. OECD Environmental Performance Reviews: Mexico. Paris: OECD Environment Directorate.

Petersen, T. 1991. Time-Aggregation Bias in Continuous-Time Hazard-Rate Models. *Sociological Methodology* 21: 263–90.

Potoski, M., and A. Prakash. 2005. Covenants with Weak Swords: ISO 14001 and Facilities' Environmental Performance. *Journal of Policy Analysis and Management* 24(4): 745–69.

Quezada, J.E. 2005. Underattorney of Industrial Inspections, Procuraduría Federal de Protección al Ambiente. Telephone interview, Mexico City, October 4.

Rivera, J. 2002. Assessing a Voluntary Environmental Initiative in the Developing World: The Costa Rican Certification for Sustainable Tourism. *Policy Sciences* 35: 333–60.

Rivera, J. 2004. Institutional Pressures and Voluntary Environmental Behavior in Developing Countries: Evidence from the Costa Rican Hotel Industry. *Society and Natural Resources* 17: 779-797.

Russell, C., and W. Vaughan. 2003. The Choice of Pollution Control Policy Instruments in Developing Countries: Arguments, Evidence and Suggestions. In *International Yearbook of Environmental and Resource Economics,* vol. VII. Cheltenham, UK: Edward Elgar.

Sam, A., and R. Innes. 2008. Voluntary Pollution Reductions and the Enforcement of Environmental Law: An Empirical Study of the 33/50 Program. *Journal of Law & Economics* 51(2): 271–96.

Segerson, K., and T. Miceli. 1998. Voluntary Environmental Agreements: Good or Bad News for Environmental Protection? *Journal of Environmental Economics and Management* 36: 109–30.

Toffel, M. 2007. Resolving Information Asymmetries in Markets: The Role of Certified Management Programs. Harvard Business School 07-023.

Videras, J., and A. Alberini. 2000. The Appeal of Voluntary Environmental Programs: Which Firms Participate and Why? *Contemporary Economic Policy* 18(4): 449–61.

Vidovic, M., and N. Khanna. 2007. Can Voluntary Pollution Control Programs Fulfill Their Promises? Further Evidence from EPA's 33/50 Program. *Journal of Environmental Economics and Management* 53: 180–95.

World Bank. 2000. *Greening Industry: New Roles for Communities, Markets, and Governments.* New York: Oxford University Press.

Table 1. PROFEPA Fines, 1992–2005

Sample ➔ ⬇		***All***	***ISO 14001 participants***	***ISO 14001 nonparticipants***
All plants		(n = 59,149)	(n = 194)	(n = 58,955)
	Fined	1.77%	29.90%	1.86%
Fined plants		(n = 1,100)	(n = 58)	(n = 1,042)
	Total fines	2,065	117	1,948
	Average fines/plant	1.88	2.02	1.87
	Average fine (pesos)	53,544.42	31,628.27	54,774.87

Table 2. Time-Invariant Independent Variables and Sample Means

Variable	**Explanation** (all are 0/1 dummy variables)	**All** (n = 59,149)	**ISO 14001 participants** (n = 194)	**ISO 14001 nonparticipants** (n = 58,955)
EXPORT	exporter	0.1010	0.7320	0.0989
IMPORT	importer	0.1328	0.8041	0.1306
GSUPPLIER	government supplier	0.0820	0.1600	0.0818
MAQUILA	maquiladora	0.0098	0.3351	0.0087
SA_0_3M	gross revenue 0–3 million pesos	0.8571	0.1959	0.8593
SA_3M_12M	gross revenue 3–12 million pesos	0.0681	0.0825	0.0681
SA_12M_PLUS	gross revenue 12 million pesos +	0.0748	0.7216	0.0726
CAP_0_900	accounting capital 0–900K pesos	0.8200	0.2320	0.8220
CAP_901_5M	acc. capital 900K–5 million pesos	0.0850	0.0670	0.0851
CAP_5M_PLUS	acc. capital 5 million pesos plus	0.0949	0.7010	0.0929
SECTORD2	commercial wholesale	0.1117	0.0412	0.1119
SECTORD3	commercial retail	0.2018	0.0103	0.2024
SECTORD6	industrial manufacturing	0.1922	0.8660	0.1899
SECTORD7	information, mass media	0.1256	0.0103	0.1260
SECTORD8	mining	0.0010	0.0206	0.0009
SECTORD9	other services not gov't activities	0.0071	0.0103	0.0071
SECTORD15	real estate services	0.1115	0.0103	0.1118
SECTORD16	professional, scientific, technical	0.1552	0.0103	0.1557
SECTORD17	transport, mail, services	0.0314	0.0103	0.0315
STATE_AGU	Aguascalientes	0.0107	0.0361	0.0107
STATE_BCA	Baja California	0.0250	0.1392	0.0247
STATE_CHI	Chihuahua	0.0403	0.1082	0.0401
STATE_COA	Coahuila	0.0226	0.0722	0.0225
STATE_DIF	Distrito Federal	0.2561	0.0670	0.2567
STATE_GTO	Guanajuato	0.0397	0.0309	0.0398
STATE_JAL	Jalisco	0.1496	0.0258	0.1500
STATE_MEX	Mexico State	0.1009	0.1598	0.1007
STATE_NUL	Nuevo Leon	0.0733	0.0773	0.0733
STATE_PUE	Puebla	0.0227	0.0464	0.0226
STATE_QUE	Querétaro	0.0108	0.0515	0.0106
STATE_SLP	San Luis Potosi	0.0069	0.0103	0.0069
STATE_SIN	Sinaloa	0.0122	0.0103	0.0122
STATE_TAM	Tamulipas	0.0154	0.0876	0.0152
STATE_TLA	Tlaxcala	0.0052	0.0155	0.0052
STATE_YUC	Yucatán	0.0200	0.0103	0.0198

Table 3. Regression Results for Cox Proportional Hazard Model with Full Sample (dependent variable = 0/1 indicator of ISO 14001 certification in year t; t = 1992–2005; n = 59,149)

Variable	Haz. Ratio	S.E.	Variable	Haz. Ratio	S.E.
FINE_1YR	1.8258**	0.4875	STATE_AGU	2.2464	1.1338
FINE_2YR	1.8292**	0.4735	STATE_BCA	1.6280	0.6449
FINE_3YR	2.0070***	0.5004	STATE_CHI	1.5367	0.6213
FINE_3YR_PLUS	1.0873	0.2590	STATE_COA	2.3077**	1.0024
EXPORT	1.5608*	0.3989	STATE_DIF	0.6017	0.2623
IMPORT	2.5381***	0.7342	STATE_GTO	1.1354	0.5913
GSUPPLIER	1.2481	0.2749	STATE_JAL	0.3631*	0.1997
MAQUILA	2.8967***	0.6058	STATE_MEX	2.5553***	0.9551
SA_3M_12M	1.3236	0.4390	STATE_NUL	1.7507	0.7344
SA_12M_PLUS	2.7774***	0.7779	STATE_PUE	2.9635**	1.3846
CAP_901K_5M	0.8709	0.2947	STATE_QUE	2.5301**	1.1552
CAP_5M_PLUS	2.6023***	0.6503	STATE_SLP	2.2977	1.7929
SECTORD2	0.9719	0.7770	STATE_SIN	2.6196	2.0393
SECTORD3	0.2313	0.2323	STATE_TAM	3.3432***	1.4087
SECTORD6	3.6985*	2.7236	STATE_TLA	2.4845	1.6751
SECTORD7	0.4056	0.4080	STATE_YUC	1.6571	1.2942
SECTORD8	12.0884***	10.9616			
SECTORD9	4.6766	4.7298			
SECTORD15	0.3707	0.3728			
SECTORD16	0.3933	0.3955			
SECTORD17	0.8748	0.8891			
Log Likelihood	-1623.7582				

***Significant at 1% level; **significant at 5% level; *significant at 10% level.

Table 4. Regression Results for Cox Proportional Hazard Model with Restricted Sample[a] (dependent variable = 0/1 indicator of ISO 14001 certification in year t; t = 1992–2005; n = 2,060)

Variable	Haz. Ratio	S.E.	Variable	Haz. Ratio	S.E.
FINE_1YR	1.8081**	0.5511	STATE_AGU	0.9007	0.5373
FINE_2YR	1.7134*	0.5170	STATE_BCA	0.6442	0.2595
FINE_3YR	1.8096**	0.5277	STATE_CHI	0.6904	0.2901
FINE_3YR_PLUS	1.0416	0.2905	STATE_COA	1.2291	0.5536
EXPORT	1.8228*	0.5838	STATE_DIF	0.4656*	0.2134
IMPORT	3.1874***	1.3944	STATE_GTO	0.7065	0.4168
GSUPPLIER	0.9980	0.2715	STATE_JAL	0.1188***	0.0915
MAQUILA	2.3760***	0.5814	STATE_MEX	1.0171	0.4088
SECTORD8	4.1216***	2.2594	STATE_NUL	0.8150	0.3474
			STATE_PUE	0.8953	0.5881
			STATE_QUE	0.8620	0.4400
			STATE_SIN	4.3686*	3.4191
			STATE_TAM	1.2594	0.5587
			STATE_TLA	1.0960	0.8577
Log Likelihood	-929.93903				

[a]Plants with more than 12 million pesos in sales in sectors 6 and 8.
***Significant at 1% level; **significant at 5% level; *significant at 10% level.

Figure 1. Within-Sample ISO 14001 Certification in Mexico,
by Year and Sector (n=194)