

Corporate Environmental Management: Regulatory and Market-based Incentives

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The corporate approach to environmental protection has been evolving from a regulation-driven reactive mode to a more proactive approach involving voluntarily adopted management practices that integrate environmental concerns with traditional managerial functions. A behavioral model of firm decision-making is developed to obtain econometrically testable hypotheses of the factors influencing firms to undertake proactive environmental management. These hypotheses are tested using survey data for a sample of S&P 500 firms. The analysis shows that economic factors such as the threat of environmental liabilities and high costs of compliance with anticipated regulations as well as market pressures on firms that produce final consumer goods and have large capital-output ratios play a statistically significant role in inducing corporate environmentalism among these firms. Additionally, high costs of off-site transfers of toxic releases and public pressures on firms with high on-site toxic emissions per unit output are significant in influencing the adoption of innovative environmental management practices.

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The U.S. has traditionally relied on mandatory command and control environmental regulations to protect environmental quality. While this has helped protect the environment, it has resulted in a policy framework that is inflexible and costly and whose effectiveness in further improving the environment may be diminishing (see Esty and Chertow, 1997). This realization has led to increasing use of market-based instruments, like marketable emissions permits, public disclosure of environmental information and voluntary programs, that seek to provide flexibility to firms to choose their methods of pollution control (National Center for Environmental Economics, 2001). Of these incentive based instruments, information disclosure and voluntary programs encourage non-mandatory actions by firms to control their pollution.

Provision of information about the environmental attributes of products and environmental performance of firms, by the regulatory agency to the public, such as through the Toxics Release Inventory (TRI)¹, has the potential to trigger product and capital market reactions and community actions that can create market based incentives for firms to improve their environmental performance. Additionally, voluntary programs that seek to engage firms in self-regulation are becoming a major policy tool for the USEPA. In 1999, there were 54 such programs at the federal level, up from 28 just 3 years earlier (NCEE, 2001). These non-mandatory approaches are considered by many policy analysts as launching the “next generation of environmental policy” that goes beyond a confrontational “government-push” approach to relying on proactive efforts by firms themselves and on active public involvement, by citizens and communities, in environmental protection (Esty and Chertow, 1997).

This trend towards self-regulation is also evident in the growing number of “business-led” initiatives being taken by firms to develop environmental management systems (EMSs) to systematically integrate environmental considerations into their production decisions. Several

firms (3M, Dow Chemical, Dupont, AT&T) have crafted environmental programs to prevent pollution by redesigning products and processes (Schmidheiny, 1992; Batie, 1997), others are voluntarily seeking ISO 14001 certification by adopting standardized practices for environmental management and eco-labeling of products (Kuhre, 1995). EMSs represent an organizational change within corporations and a self-motivated effort at internalization of environmental concerns into the objectives of the firm. This has sparked interest in EMSs among policy makers since they reflect a fundamentally altered corporate view of environmental concerns. Two reports released by the USEPA (1999a,b) state that the agency plans to promote the adoption of EMSs (to complement the existing regulatory system in the U.S.) through offers of technical assistance, recognition and other benefits to achieve environmental protection goals, improve compliance, and prevent pollution. The interest in investigating the potential of EMSs as a policy tool can be inferred from the broad participation in the 1999 National Research Summit on EMSs organized by a multi-state working group (MSWG, 1999) of eleven state environmental agency officials and the USEPA that highlighted the need for more research on factors that motivate firms to adopt EMSs and on the extent to which EMSs can be relied upon to lead to environmental improvement².

Anecdotal evidence indicates that the state and federal regulatory climate, environmental concerns among consumers, reputation with shareholders and the public are motivating corporate environmentalism³ (Florida and Davison, 2000). The growing stringency of environmental regulations during the 1980's, rising costs of compliance with inflexible technology-based regulations and threat of liability for environmental damage led many firms to examine the environmental impact of their products and processes. Concerns about the adverse effects on a firm's reputation, if perceived as environmentally unfriendly, are becoming important for firms⁴. Public opinion polls show growing environmental consciousness among consumers but there is

mixed evidence about the extent to which this has led to a willingness to pay a premium for products with an environmental label (Cairncross, 1995; Gutfield, 1991). Most companies, however, expect that when goods are comparably priced, environmental attributes can break the tie. As a result, companies are increasingly using environmentalism as a marketing tool (Hoffman, 1997). Several studies show that investors react negatively to public disclosures about poor environmental performance reported in the TRI, resulting in significant abnormal stock market returns for firms (Hamilton, 1995; Khanna et al., 1998). Bankers are recognizing that they might be held legally responsible for environmental mistakes of their corporate borrowers. As a result, they are beginning to include environmental considerations in their lending decisions and viewing poor environmental performers as financially risky (Hoffman, 1997).

However, very few studies have systematically analyzed the factors that are motivating firms to adopt an EMS (see survey by Khanna, forthcoming). This paper seeks to fill that gap by developing a behavioral framework to provide econometrically testable hypotheses about the economic incentives motivating firms to adopt an EMS. In particular, the empirical analysis here seeks to quantify the extent and relative importance of external pressures from consumers, investors and a competitive market, and of regulatory pressures from existing and anticipated mandatory regulations faced by firms in inducing them to undertake environmental management. This analysis is based on survey data on EMSs and observable firm-specific characteristics for a sample of S&P 500 firms. The EMSs of these firms consist of multi-faceted efforts to varying degrees to proactively manage their impact on the environment. These efforts include conducting internal environmental audits, linking employee's compensation in part to environmental performance, centralizing decisions with environmental implications higher up in the corporate hierarchy, and applying the principles of Total Quality Management (TQM) to environmental management. This paper focuses on analyzing the observed diversity in the comprehensiveness

of the EMS adopted by firms rather than the decision to adopt individual practices because there are synergistic relations between these practices and an individual practice by itself may achieve little (Cairncross, 1995)⁵. Firms are therefore more likely to be choosing a system of practices rather than a practice by itself.

A growing theoretical literature on environmental self-regulation demonstrates that firms may have incentives to voluntarily improve their environmental performance because it can lead to private benefits in the form of direct or indirect payoffs (see Segerson and Li, 1999; Lyon and Maxwell, 1999). These benefits could arise from the potential to preempt the threat of mandatory standards (Segerson and Micelli, 1998) and to shape future mandatory standards by voluntarily over-complying (Lutz, Lyon and Maxwell, 2000). Maxwell, Lyon and Hackett (2000) study the incentives and welfare implications of self-regulation by firms to preempt consumer groups from lobbying for more stringent abatement regulations. Arora and Gangopadhy (1995) demonstrate conditions under which consumer willingness to pay premiums for environmentally friendly products leads firms to overcomply with environmental standards. This paper analyzes the extent to which firm behavior actually reveals that firms perceive these benefits from being environmentally friendly and respond by improving their environmental management.

Much of the existing empirical literature has focused on explaining the decision by firms to participate in voluntary programs established by the USEPA such as the 33/50 program (Arora and Cason, 1995,1996; Khanna and Damon, 1999), Green Lights, WasteWise (Videras and Alberini, 2000) and the Climate Challenge Program in the U.S (Karamanos, 2000) that provide visible benefits to participants through public recognition and technical assistance. Henriques and Sadorsky (1996) is one of the few studies examining the motivations for environmentally friendly organizational changes within firms where direct benefits are not as evident as through participation in voluntary programs. They analyze the adoption of a single practice, an

environmental plan, by firms using perceived pressures, from consumers and regulations, ranked in importance by firms, as explanatory variables.

From an environmental policy perspective, it is also important to explain the observed diversity in the scope of the EMSs adopted by firms and to examine the types of firms that are more likely to feel various regulatory and market based pressures and demonstrate environmental stewardship in response to public policy and stakeholder concerns. This would enable the design and targeting of policy initiatives towards firms less likely to be self-motivated towards environmental management. This paper uses a broad range of observed characteristics of firms to examine the relative strengths of various incentives for different types of firms to be proactive to varying levels. Section 2 provides the conceptual framework that underlies the empirical analysis. This framework allows for several sources of incentives for a profit-maximizing firm to adopt an EMS and generates empirically testable hypothesis about a broad set of explanatory variables. The validity of these hypotheses and the assumptions that generate them are tested using the empirical method and data described in Sections 3 and 4 respectively. Section 5 presents the discussion of results of the empirical analysis and is followed by the conclusions.

2. CONCEPTUAL FRAMEWORK

Consider a firm that uses a pollution generating input x (such as chemicals) and capital equipment k to produce output y . The effectiveness with which input x is used during the production process is represented by ϕ . Output y produced by the firm is a function of the amount of input used effectively in production (ϕx) and of the stock of capital k :

$$y=f(\phi x, k); f_x>0, f_k>0, f_{xx}<0, f_{kk}<0 \quad (1)$$

where ϕ is assumed to be a function of the technological knowledge t of the firm and a scalar measure q of the quality of environmental management and is represented by:

$$\phi = \phi(q, t); \phi_q > 0, \phi_t > 0, \phi_{qq} < 0, \phi_{tt} < 0 \quad (2)$$

As ϕ increases, the input is utilized more effectively during production and therefore input-waste and the amount of pollution associated with given levels of input-use decreases. For simplicity, pollution (waste) generated, z , is represented as an inverse function of ϕ and a direct function of x as follows:

$$z = x/\phi \quad (3)$$

Using (3) to substitute for x in (1), output levels can be expressed as follows with z being now considered as a factor of production:

$$y = f(\phi^2 z, k) \quad (4)$$

We assume that the firm is operating in a monopolistically competitive industry with $n=1 \dots N$ firms that are producing a product that is homogeneous in all other respects but differs in the environmental friendliness of the process used for its production. The firm faces an inverse demand curve that is a function of the aggregate output of the industry and the environmental practices adopted by the firm and is represented by $P(Y, q)$ where $Y = \sum_{n=1}^N y_n$. This implies that a firm can shift the demand curve it faces to the right by adopting environmentally friendly management practices, thus $P_q > 0$. The magnitude of P_q , however, could vary across firms. Firms that are producing final goods and dealing directly with consumers may perceive larger benefits from “green consumerism” than those producing intermediate goods. The relevant issue here is not whether consumers are indeed able to differentiate products based on the environmental practices followed by firms but whether firms perceive that to be the case and therefore seek to build an environmentally friendly reputation.

The firm is assumed to be a price-taker in the input market. The per unit cost of the variable input is w . The annualized cost of capital is $r(q)$ and is assumed to be a decreasing function of a firm’s quality of environmental management. A number of studies have shown that investors react negatively to disclosures about poor environmental performance by firms and that

this leads to a significant negative impact on the stock market returns of the firms which is likely to raise their cost of raising capital in the market (Hamilton, 1995; Konar and Cohen, 1997; Khanna, et al., 1998). This observed negative reaction is possibly because investors view firms that are not environmentally friendly as being more risky since they are more likely to face penalties due to enforcement actions and greater pressure from the USEPA to implement strategies for reducing their waste generation in the future and a greater risk of environmental liabilities and lawsuits (GAO, 1994). Such firms are likely to have a higher cost of raising capital in the market. We therefore assume that firms with poor environmental management practices have to pay a higher price for borrowing capital, therefore $r_q < 0$.

Proactive environmental management imposes costs of training employees in reducing waste, improving monitoring and supervision and conducting audits to track input flows and waste generation. These costs are likely to increase at an increasing rate as the quality of environmental management improves. These costs are represented by $V=V(q)$; $V_q > 0$, $V_{qq} > 0$.

The regulatory benefits from adopting an EMS, such as the potential to reduce the threat of liabilities and costs of compliance with existing or anticipated regulations are likely only if firms go beyond adoption of EMS and demonstrate superior environmental performance. These costs are assumed to be a function of the volume of pollution generated and are represented by, $C=C(z)$, with $C_z > 0$, $C_{zz} > 0$. Uncertainty about the imposition of regulations or liabilities is denoted by ρ which represents the probability of a firm being regulated or held liable. The expected cost of mandatory regulation is then $\rho C(z)$.

The price elasticity of demand is defined as $\eta = -\frac{dY}{dP} \frac{P}{Y} > 0$. The elasticity of output with respect to pollution is defined as $\varepsilon_{yz} = \frac{dy}{dz} \frac{z}{y} > 0$. The elasticity of ϕ with respect to q is

defined by $\varepsilon_{\phi q} = \frac{d\phi}{dq} \frac{q}{\phi} > 0$. It measures the responsiveness of input productivity to an

improvement in the quality of environmental management. The share of the n th firm's output in total industry output is represented by $s = y_n/Y$.

We assume that the firm has Cournot conjectures about the impact of its production on the aggregate production of the industry. It chooses the optimal level of managerial quality and pollution level to maximize its profits, assuming a fixed level of capital stock k and technical knowledge t in the short run. The firm's decision-making problem is represented as follows:

$$\begin{aligned} \text{Max } \Pi &= P(Y, q) f(\phi^2 z, k) - w\phi z - r(q)k - V(q) - \rho C(z) \\ \text{where } \phi &= \phi(q, t) \end{aligned} \quad (5)$$

The first order necessary conditions for maximization are as follows, after rearranging terms and substituting in the elasticities defined above:

$$\frac{\partial \Pi}{\partial q} = 0 \Rightarrow \frac{2P(1-s/\eta)y\varepsilon_{yz}}{q} + \frac{P_q y}{\varepsilon_{\phi q}} = \frac{V_q}{\varepsilon_{\phi q}} + \frac{wx}{q} + \frac{r_q k}{\varepsilon_{\phi q}} \quad (6)$$

$$\frac{\partial \Pi}{\partial z} = 0 \Rightarrow P(1-s/\eta)y\varepsilon_{yz} = [w\phi + \rho C_z]z \quad (7)$$

Equations (6) and (7) show that the firm chooses the level of q and z that equates the marginal benefits of each with its marginal costs. The marginal benefits from q arise indirectly from its contribution to the marginal revenue product of z and directly because it could allow the firm to charge a higher price for its product and also reduce the cost of capital and the effective cost of the polluting input x by increasing the efficiency of its use. The marginal cost of increasing q is represented by V_q which is expected to increase as q increases. Equation (7) shows that the firm chooses z to equate its marginal revenue product to its marginal cost which depends on the marginal cost of compliance and liabilities. We solve for w from (6) and

substitute in (7) to obtain the following expression that shows the determinants of the level of q chosen by a firm:

$$q = \frac{[\rho C_z z / y + P(1 - s / \eta) \epsilon_{yz}] \epsilon_{\phi q}}{(V_q / y) + (r_q k / y) - P_q} \quad (8)$$

This expression leads to the following testable hypotheses regarding the determinants of the quality of the EMS of a firm.

Hypothesis I: The greater the threat of environmental liabilities and the higher the costs of compliance with mandatory regulations faced by a firm, the higher the quality of its environmental management.

As shown in equation (8), as the cost of environmental liabilities and the cost of compliance with mandatory regulations increases so do the incentives to increase q and reduce waste generation. The expected marginal costs of liabilities increase either because of increased likelihood of being held liable or larger fines. The costs of complying with mandatory regulations are expected to be higher when these regulations specify inflexible performance standards or technology standards, when the likelihood of the implementation of such regulations is high and the penalties for non-compliance are high.

Hypothesis II: The greater the benefits perceived in the form of higher output price and a lower cost of capital, the higher the quality of the firm's environmental management system.

The greater the marginal effect of poor environmental management on lowering output price ($P_q > 0$), the greater are the incentives for improving q . Firms that expect output price to be responsive to their EMS are more likely to adopt a higher quality EMS. The impact of the cost of capital on incentives to raise q is measured by the term $r_q k / y$ in the denominator (8). Assuming that investors react negatively towards firms that are not using environmentally friendly practices and thus the sign of r_q is negative, we would expect that firms where capital is less productive, or

that are using a larger amount of capital per unit of output and therefore incurring a high cost of capital per unit output have greater incentives to increase q .

Hypothesis III: The impact of industry concentration on incentives for higher quality environmental management is ambiguous.

Equations (6) and (8) show that on the one hand, firms in industries that are less concentrated (have a smaller s) have a greater incentive to raise q . The marginal benefit of increasing the productivity of z by adopting an EMS, is lower in a concentrated industry relative to a competitive industry. This is because as the monopoly power of a firm increases the marginal revenue product of z decreases relative to its value of marginal product in a competitive industry. On the other hand, the marginal benefit of increasing the productivity of z is higher for a firm that is producing a larger output, as shown by the first term on the left hand side of (6) and by (8). A monopolist can be expected to produce a larger output than an individual firm in a competitive industry, with all per unit costs of production being the same, and thus the monopolist is expected to gain more at the margin from raising q . The net impact of industry concentration on incentives for increasing q is, therefore, ambiguous.

The literature analyzing the effects of market structure on innovation has also yielded ambiguous predictions (see survey by Cohen and Levin, 1989). Arrow (1962) demonstrates that a firm's gain from a cost-reducing innovation at the margin are larger in an industry that is competitive than under monopoly conditions. This is because with a downward sloping demand curve the marginal benefit from a cost reducing innovation that lowers the marginal cost and increases output is less than the average benefit and while a competitive firm facing a fixed price receives the average benefits a monopolist receives the marginal benefit. On the other hand, Denicolo and Delbono (1999) show that the benefits of a small cost-reducing innovation are proportional to the output of the innovator which is likely to be larger for a monopolist than for

an individual firm in a competitive industry.

Hypothesis IV: Firms that have a lower marginal cost of environmental management, larger pollution-output ratios and a higher responsiveness of ϕ to q are more likely to have a higher quality of environmental management.

From equation (8) we see that the benefits of improving q are larger for firms that have a higher z/y ratio. Firms with poor environmental performance are, therefore, more likely to undertake environmental management. Firms facing a lower marginal cost of improving q , V_q , are also more likely to have a higher q . Finally, firms that have a high level of technical knowledge that allow changes in management practices to be accompanied by larger increases in the effectiveness of input-use, resulting in a high $\varepsilon_{\phi q}$, are more likely to benefit by adopting a higher quality of environmental management.

3. EMPIRICAL METHODOLOGY

We now develop an empirical method to examine the determinants of the dependent variable, the unobserved quality of the environmental management system of the firm. We proxy this unobserved quality by the observed number of environmental practices adopted by a firm, which is an indicator of the comprehensiveness of its environmental management system. The discrete non-negative nature of the observed variable generates non-linearities that make the usual linear regression models inappropriate, because some of the basic assumptions such as the normality and homoskedasticity of the residuals or the linear adjustment of the data are no longer fulfilled. The use of linear regression methods with a discrete non-negative dependent variable would result in inefficient, inconsistent and biased estimates (Cameron and Trivedi, 1998). Two alternative approaches are applied here to deal with the discrete nature of the dependent variable. In the first approach, the count of practices adopted by a firm is used as a cardinal measure of

quality of management. In the second approach, the count of practices adopted is used to obtain an ordinal measure of the quality of management.

The Poisson regression model is one way to deal with a cardinal measure (based on the count of practices adopted) of the quality of environmental management. The scalar dependent variable is the observed number of occurrences (practices adopted) by the n th firm, $w_n=0,1,2..J$.,. The Poisson model stipulates that each w_n is drawn from a Poisson distribution with parameter λ_n which is linearly related to a vector of regressors, v_n , such that $\lambda_n = \beta'v_n$ and the

$$\text{Probability}(w_n) = \frac{e^{-\lambda_n} \lambda_n^{w_n}}{w_n!}, \quad w_n = 0,1,2,\dots,13 \quad (9)$$

The Poisson regression model, however, is restrictive in that it assumes that the conditional variance of the distribution is equal to the conditional mean (Greene, 1993). The Negative Binomial is less restrictive than the Poisson distribution in that it allows for over-dispersion. Cameron and Trivedi (1990) have proposed a test for over-dispersion in the Poisson model that involves testing

$$H_0: \text{var}[w_n]=\lambda_n \text{ against } H_1: \text{var}[w_n]=\lambda_n+\gamma g(\lambda_n). \quad (10)$$

If the over-dispersion parameter γ is significantly different from zero it implies the validity of the negative binomial model. The marginal effect of the Poisson model measures the change in the conditional mean λ_n if the m th regressor changes by one unit, and is given by $\hat{\beta}_m \hat{\lambda}_n$.

Unlike the Poisson model that treats the count of practices adopted as being the result of discrete choices, the ordered probit (OP) model considers the count of practices adopted as being generated by a continuous process of improvement in an unobserved latent variable (environmental management quality) that on crossing a threshold leads to a new practice being adopted (Greene, 1993). The OP introduces a latent (unobserved) random variable, ϖ_n^* , that

represents the quality of the environmental management system of the n th firm, as a function of a vector of independent variables, v_n .

$$\bar{\omega}_n^* = \beta'v_n + \xi_n \text{ where } \xi_n \text{ is } N[0,1]. \quad (11)$$

The observed discrete variable w_n is generated from the unobserved $\bar{\omega}_n^*$ in the following way:

$$\begin{aligned} w_n &= 0 \text{ if } \bar{\omega}_n^* \leq 0 \\ &= 1 \text{ if } 0 < \bar{\omega}_n^* \leq \alpha_1 \\ &= 2 \text{ if } \alpha_1 < \bar{\omega}_n^* \leq \alpha_2 \\ &\vdots \\ &= J \text{ if } \alpha_{J-1} \leq \bar{\omega}_n^* \end{aligned} \quad (12)$$

where J now represents the categories into which firms can be grouped based on the number of practices adopted. The α 's are threshold variables or cut-off points that generate the categorical variables, with α_0 normalized to zero. The OP estimates the probability that the quality of a firm's environmental management system lies within one of the J categories:

$$Pr[\alpha_j < \bar{\omega}_n^* \leq \alpha_{j+1}] = \Phi(\alpha_{j+1} - \beta'v_n) - \Phi(\alpha_j - \beta'v_n) \quad (13)$$

where Φ is the standard normal cumulative density function. The parameters $\alpha_1, \dots, \alpha_{J-1}$ and the vector β are estimated using maximum likelihood. The marginal effect of a change in the m th regressor on the probability of belonging to the j th category is: $[f(\alpha_{j-1} - \beta'v_n) - f(\alpha_j - \beta'v_n)]\beta_m$ where $f(\cdot)$ is the standard normal density.

4. DESCRIPTION OF DATA

Primary data on management practices used in this study are obtained from the Corporate Environmental Profile Directories 1994 and 1995, compiled from a survey of S&P 500 firms conducted by the Investor Research Responsibility Center (IRRC). The survey inquires about the adoption decision of firms for a variety of environmental management practices, such as, number

of environmental staff, environmental auditing and reporting procedures, described below. Environmental performance data are primarily obtained from the Toxics Release Inventory (TRI) database that contains facility-level information on on-site releases and off-site transfers of chemical-specific toxic pollutants. The TRI, first released in 1989, is mandated by the Emergency Planning and Community-Right-to-know Act of 1986 and requires production facilities to report annual quantities of on-site toxic emissions to air, water and land and underground injection and the quantities of off-site transfers on a chemical-specific basis. Financial information about firms is obtained from the publicly available Standard & Poor (S&P) 500 and Super Compustat databases which provide company specific information on all publicly traded firms that file 10-K forms with the Securities and Exchange Commission.

Of the 500 firms included in the IRRC survey, only firms that responded to the survey in 1994 and 1995 and reported to the TRI and for which financial data are available are included in this study. This results in a sample of 176 firms for 1995 and 159 firms for 1994. All time dependent explanatory variables are measured with a five-year lag to avoid endogenous regressors since adoption of some practices may have occurred prior to 1994 or 1995.

Variable Construction

The dependent variable in this study is the adoption of an EMS, defined as a system of 13 practices that indicate multifaceted efforts, that are proactive and anticipative in orientation, targeted towards improving environmental performance. The practices are listed in Table 1 and include having an environmental policy, training and rewarding workers to find opportunities to prevent pollution, setting corporation-wide internal standards that are maintained even by facilities in other countries with lower environmental standards, undertaking internal environmental audits to identify opportunities for preventing pollution and ensuring that

manufacturing operations are in compliance with regulatory requirements. Some firms also adopted the philosophy of TQM, that seeks to minimize quality defects while making continuous efforts at improving performance across the firm's activities, to improving environmental management. Firms may also choose to set aside funds to reduce their risks of future environmental liability costs and buy insurance to cover liability or remediation costs of environmental incidents. The adoption decision of each practice is represented by a dummy variable as described in Table 1.

As shown in Table 1, 92% of the firms have a formal environmental policy while 70% apply TQM principles to environmental management. Other practices, however, are adopted less frequently, with less than 40% of firms having a uniform corporate-wide environmental standard and regularly releasing environmental reports to the public. Of the firms included in the two-year sample, 156 firms had observations for both years. Over the two-year period, 62 of these firms increased the number of practices they adopted, while 12 firms decreased the number of practices adopted. Of the 335 observations over the two-year period, 17% indicated an adoption of less than 3 practices, while 38% indicated adoption of 4 to 7 practices. The mode of the distribution is 9 practices and less than 2% of firms adopted all 13 practices.

We find that the adoption decisions for these practices were positively correlated with each other indicating that these practices are complementary to each other rather than substitutes for each other. For example, firms adopting TQM were more likely to have an environmental policy, corporate standards, provide environmental performance related compensation to employees and conduct environmental audits. We, therefore, use a summated scale, by summing the dummy variables indicating adoption of the various practices to obtain a total score for each firm, which is used as an indicator of the quality or comprehensiveness of a firm's environmental management system. The explanatory variables are categorized into those proxying regulatory

pressures, market based pressures and firm-specific characteristics. These variables are described below and their descriptive statistics are provided in Table 2.

Regulatory Pressures

We proxy the impact of existing and anticipated mandatory environmental regulations using several explanatory variables. The potential threat of liability is expected to be higher for firms with a larger accumulated NUMBER OF SUPERFUND SITES for which a firm is named as a potentially responsible party under the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (as in Khanna and Damon, 1999; Videras and Alberini, 2000). These data are obtained from the Site Enforcement Tracking System (USEPA, 1996). Facility-specific data are aggregated to the parent company level by obtaining the list of subsidiaries and divisions of each parent company from various Corporate Directories⁶.

The impact of existing mandatory regulations on incentives for proactive environmental management are captured by the civil penalties and inspections received by firms to enforce compliance. Several major environmental statutes, such as the Clean Air Act, the Clean Water Act, and RCRA have provisions for severe penalties in cases of violations of regulations, releases of hazardous pollutants and record keeping violations. Firms are also subject to periodic inspections to enforce compliance with mandatory regulations. Firms that have received civil penalties for not complying with mandatory regulations are presumably the ones that have high costs of compliance; hence they prefer to risk being penalized rather than be in compliance with regulations. Such firms may also consider themselves as having a higher likelihood of receiving penalties in the future if they do not make efforts to improve their environmental performance. Data on the civil penalties received by a firm under 10 different environmental statutes were obtained from the IRRC directory. The variable CIVIL PENALTY is a dummy variable equal to

1, if the firm received at least one civil penalty for violation with any of the environmental statutes. The variable INSPECTIONS represents the number of inspections made on firms to investigate compliance with various environmental statutes such as the Clean Air Act, Clean Water Act, and the Toxic Substances Control Act. Information on inspections is obtained from USEPA's publicly available database IDEA, Integrated Data for Enforcement Analysis⁷ which is a comprehensive source of information on compliance records and penalties imposed on all regulated facilities in the US.

To capture the stringency of the existing regulatory environment for a firm we use the ratio of Pollution Abatement Costs and Expenditures for the industry to total industry shipments (PACE/INDUSTRY SALES) at the two-digit SIC level as an explanatory variable. Pollution capital expenditures include expenses associated with the purchase and expansion of plant and equipment used to control air and water pollutants and solid waste. Abatement costs consist of all costs and expenses necessary to operate and maintain pollution abatement equipment. The value of total industry shipments is defined as the receipts for all primary and secondary products manufactured and shipped, services rendered and resale of products bought and resold without further processing. Firms that belong to industries that are heavily regulated as indicated their PACE to industry output ratio are likely to have high costs of compliance and greater incentives to improve their environmental management. These data are obtained from the Annual Survey of Pollution Abatement Costs and Expenditures compiled by the Bureau of Census (1989,1990).

In order to proxy the incentives to seek strategic advantages over competitors by reducing emissions of hazardous air pollutants ahead of time through improved environmental management, we construct the ratio of hazardous air pollutants to on-site toxic releases (HAP/ON-SITE RELEASES) as in Khanna and Damon (1999). Title III of the 1990 CAA Amendments has listed 189 toxic chemicals that will be regulated under the National Emission

Standards for Hazardous Air Pollutants (NESHAP). Firms have been aware since 1990 that air emissions of these chemicals will be subject to Maximum Available Control Technology (MACT) standards that would be based on emissions levels already achieved by the best-performing similar facilities (USEPA, 2000). Reducing these pollutants ahead of time using flexible methods is expected to lower the future costs of compliance and may also give the firm a strategic advantage relative to its competitors if its performance influences the standards that are set for other firms. We would, therefore, expect that firms with a larger ratio of HAP to on-site toxic discharges are more likely to adopt a comprehensive EMS. The data on HAP emissions by firms were obtained from the TRI after aggregating across all chemicals categorized as HAP and across all facilities belonging to a parent company.

Market Pressures

Market pressures emanate from consumers, investors and competing firms. Firms that produce final goods and are in closer contact with consumers are likely to feel greater pressure or benefit more from improving their environmental friendliness. Thus, strategic considerations to improve market share or charge premium prices from green consumers may motivate corporate environmental management among some firms⁸. We use the 4-digit secondary SIC code of the sample firms to classify them into final goods and intermediate goods. Firms are represented by a dummy variable FINAL GOOD equal to 1, if that firm is primarily selling final products such as pharmaceutical preparations, cosmetics, and food products consumed directly by consumers. It also includes retail stores, restaurants and banks that provide direct services to consumers.

Firms with a higher capital stock per unit output are more likely to be concerned about negative investor reactions about their environmental practices and performance. We proxy this impact by the SALES-ASSET ratio for the firm and expect that firms with a higher value of this

ratio will have lower incentives to adopt a more comprehensive environmental management system. The impact of market structure of the industry on incentives for environmental management is measured by the Herfindahl-Hirschman index (HHI), which equals the sum of the squared percentages of market shares of each firm in the industry (as in Arora and Cason, 1995). A high value of HHI implies that the industry is more concentrated and less competitive than one with low HHI. The impact of exposure to global competition and greater pressure to differentiate its products on a firm's incentives for adopting an EMS is captured by the ratio of its facilities that are in foreign countries to its total facilities (MULTINATIONAL STATUS). A count of the number of U.S. and non-U.S. facilities for each parent company is obtained from various Corporate Directories.

Firm-specific Characteristics

As suggested by the theoretical analysis, firm-specific characteristics, such as its pollution-output ratio, technical knowledge and the cost of improving environmental management are also expected to influence the quality of environmental management.

Data on all the various types of pollution generated by firms were not publicly available. The only information available at a facility and chemical-specific level is on the volume of toxic releases emitted and reported to the TRI. Each facility is identified by its name, its primary SIC code, its parent company name and a Dun and Bradstreet (D&B) number assigned to each parent company. We used this information to group facilities by their parent company and aggregate toxic releases to air, land, water and underground injections of all TRI chemicals by each facility of a parent company to obtain on-site toxic releases at the parent company level. We aggregated all off-site transfers for energy recovery, recycling, treatment and disposal to obtain off-site transfers. We distinguish between on-site discharges and off-site transfers because on-site

discharges represent emissions into the environment, while off-site transfers represent end-of-pipe abatement and disposal of waste. To allow for their differential impact on incentives for environmental management, while controlling for firm size, we use ON-SITE RELEASES/SALES and OFF-SITE TRANSFERS/SALES as explanatory variables.

The technology of the firm and its cost of improving environmental management are proxied by two variables, technical knowledge and age of assets. Firms that are more innovative are more likely to have the knowledge to implement changes in process and product design to accompany their adoption of innovative management practices and achieve the benefits of input cost savings and reduced waste. Technical knowledge of firms is measured by their annual R&D expenditures (as in Khanna and Damon, 1999; Videras and Alberini, 2000). We also use the age of assets as a proxy for the cost of replacement of equipment that may be required to improve the process and product design to realize the benefits of environmental management. Firms with older assets are expected to face lower costs of replacement than firms with newer assets and may thus be more willing to take a proactive approach towards the environment. The variable AGE OF ASSETS is measured by dividing the total assets of a firm by its gross assets (Khanna and Damon, 1999). Total assets are defined as current assets plus net property plant and equipment plus other non-current assets. Gross assets are defined as total assets plus accumulated depreciation on property, plant, and equipment. Age of assets takes a value between 0 and 1, with higher values indicating newer plant and equipment with more current assets and smaller accumulated depreciation.

5. RESULTS

We estimate two alternative specifications to analyze the factors motivating corporate environmental management with both the Poisson model and the OP model (Table 3). Model I examines the effects of existing regulations on incentives for environmental management

[columns (1) and (2)], while Model II also examines the effects of anticipated regulations on HAP [columns (3) and (4)]. The estimate of γ in (10) is statistically insignificant at the 1% level in both the count data models estimated indicating that the data fail to reject the null hypothesis regarding the validity of the Poisson model. The validity of the Poisson model relative to the Negative Binomial distribution for this model is also confirmed by the log-likelihood ratio test statistic that is insignificant at the 1% level. A Lagrange-multiplier test rejects the presence of heteroscedasticity in all the OP specifications. Likelihood ratio tests reject the null hypothesis that all slope coefficients in any of the regressions estimated here are jointly equal zero. All test statistics are reported in Table 3. The marginal effects using parameters estimated with Model II using the Poisson specification and the OP model are presented in Table 4. The threshold coefficients or α 's for the OP specifications should exhibit the following relationship, $\alpha_1 \leq \alpha_2 \leq \dots \alpha_{j-1}$, and they must be positive. Failure to exhibit any of these conditions would imply specification error of the model. We find all threshold coefficients to be positive and statistically significant at the 1% level in each of the three models. They are not reported here for brevity.

All of the regression models estimated here are consistent in showing that firms facing a stronger threat of liabilities and of high costs of compliance with anticipated HAP regulations were significantly more likely to adopt a more comprehensive EMS. The threat of liabilities, proxied by the number of Superfund sites for which firms are potentially liable, and the ratio of HAP to on-site toxic releases, have a positive impact but at a diminishing rate on the quality of EMS adopted by firms. We also find that firms in industries that were more highly regulated as reflected in higher pollution abatement cost expenditures per unit sales were significantly more likely to seek innovative ways to improve their environmental management. These results are consistent with other studies such as Videras and Alberini (2000) and Khanna and Damon (1999) that find that the threat of liabilities, proxied by the number of Superfund sites for which firms

are potentially liable, motivated participation in the 33/50 and WasteWise programs. Firms emitting a larger ratio of HAP to 33/50 Releases were also more likely to participate in the 33/50 program (Khanna and Damon, 1999). Henriques and Sadorsky (1996) find that perceived regulatory pressures by firms were important in motivating them to develop an environmental plan. However, we also find that not all types of regulatory pressures lead firms to adopt an EMS. The threat of penalties for non-compliance with existing environmental statutes or inspections to ensure compliance with them were not significant motivators of EMS adoption. This indicates that the incentives for the adoption of an EMS were not stemming from the need to improve compliance with existing regulations but to reduce the threat of liabilities and stringency of anticipated regulations in the future.

Among market pressures, we find that firms that are selling final goods and thus in closer contact with consumers are more likely to have a more comprehensive/higher quality environmental management than firms in intermediate good industries. This indicates that expectation of gains from differentiating their products or establishing an environmentally friendly reputation did motivate EMS adoption by firms producing final goods. Furthermore, firms that have a high capital-output ratio, or a low sales-asset ratio, and thus are likely to be more affected by high costs of capital due to potentially negative investor reactions to poor environmental performance, are also more likely to adopt a more comprehensive EMS. Although we find that the effect of competitiveness of the industry on pressures to adopt an EMS is insignificant, firms with a stronger multinational presence are more likely to adopt a comprehensive EMS. This indicates the incentives provided by competition and need for product differentiation at the global level for adopting an EMS.

Among the firm-specific attributes, we find that firms with larger on-site releases per unit sales but smaller off-site transfers per unit sales were more likely to have a comprehensive EMS.

Firms with low off-site transfers per unit sales could be either those that generate waste that is unsuitable for end-of-pipe abatement or disposal or find that the costs of doing so are relatively high. Our results suggest that these firms are more likely to be seeking other innovative strategies for reducing waste generation. Firms with larger on-site releases per unit sales were more likely to adopt a comprehensive EMS either to offset adverse public reactions generated by public disclosure of TRI or to preempt or shape any future regulations on toxic releases. The result that firms with poor environmental performance are more likely to adopt proactive strategies to reduce pollution is consistent with other studies. This was a characteristic of firms that participated in the 33/50 program (Khanna and Damon, 1999; Arora and Cason, 1995, 1996), and the Climate Challenge program (Karamanos, 2000). We also find that firms that are more innovative as indicated by their R&D expenditures and likely to have the knowledge and capability to find innovative solutions to their environmental problems were more likely to adopt a comprehensive EMS. Additionally, firms with older equipment were more likely to undertake environmental management possibly because it was less costly for them to replace old equipment with newer less pollution intensive equipment.

Table 4 shows the effect of a one standard deviation change in each of the continuous explanatory variables at the mean values of those variables on the expected number of practices adopted. The marginal effects of the dummy variables are measured for a change from 0 to 1 in those variables. These effects are estimated using the coefficients estimated with Model II assuming a Poisson model. They show that a one standard deviation increase in the number of Superfund sites and the ratio of industry PACE-Sales, proxies for regulatory pressure, increases the expected number of practices adopted by 0.5 and 0.4 respectively. A one-standard deviation increase in the ratio of HAP to on-site releases increases the expected number of practices adopted by 0.4. A firm producing final goods is likely on average to adopt 1.8 practices more

than other firms and an increase in the ratio of facilities in foreign countries increases the expected number of practices adopted by 0.5.

The estimated coefficients and threshold levels from the OP model are used to estimate the impact of a one standard deviation change in the explanatory variables from their sample mean level on the probability that an average firm would adopt more than 7 (the average number) practices. For dummy variables, the percentage change in probability is estimated for a change in the variable from a value of 0 to 1 (as in Greene, 1993). The parameter estimates obtained here indicate that an increase in the number of Superfund sites increases the probability of an average firm adopting at least 7 practices by 10%, while an increase in the ratio of PACE/industry sales increases that probability by 8%. A 10% increase in R&D expenditures would increase the likelihood of this firm adopting more than 7 practices by 10%. An increase in the ratio of HAP to on-site releases increases the probability of adopting 7 or more practices by a small amount of 1.3%. This effect is larger at lower values of the ratio because the incremental effect of the variable is decreasing. An average firm producing final goods has a 24% probability of adopting more than 7 practices. A one standard deviation decrease in the sales-asset ratio would increase the probability of adopting more than 7 practices by 5.5%.

Policy Implications

These findings suggest that both the threat of regulations and liabilities as well as the opportunities for winning customer and investor good will and increasing market share globally through product differentiation are driving corporate environmental management. To identify the relative extent to which various factors were influential in motivating corporate environmental management, we predict the number of practices adopted and the probability of adopting more than 7 practices using low and high range values of the explanatory variables shown in Table 5

The low and high values chosen here represent minimum and maximum values of the explanatory variables for the sample of firms considered in this study.

We find that the number of practices adopted by a firm that faced low regulatory and market pressure, low costs of off-site transfers and did not generate on-site toxic releases is likely to be less than 1 and its probability of adopting more than 7 practices is close to zero. The expected number of practices a firm facing strong regulatory pressures proxied by a high number of Superfund sites, high PACE/sales ratio and high HAP-On-site releases ratio would adopt is 1 and the probability of adopting more than 7 practices is less than 1%. This indicates that while regulatory pressures created positive incentives to undertake corporate environmental management, the effect on the number of practices adopted and on the probability of adopting a comprehensive EMS was fairly weak. The incentives created by contact with final consumers and strong multinational presence, although stronger than those due to regulatory pressures, would still lead to the expected number of practices adopted being less than 2 and the probability of adoption of more than 7 practices being less than 1%. In contrast, firms with high capital assets per unit sales (that is, low sales-asset ratio) that are more exposed to adverse impacts from shareholder reactions to their environmental image faced stronger incentives to undertake environmental management. The most important motivators for corporate environmental management, however, are high levels of on-site releases per unit sales and low levels of off-site transfers per unit sales. This indicates that the potential for adverse public pressure in response to information about poor environmental performance and the high costs or other barriers to waste treatment and disposal at the end-of-the-pipe are motivating firms to be more innovative about managing their environmental impacts.

This analysis has several implications for public policy that seeks to encourage business-led environmental management as a supplement to existing mandatory regulations. Several

theoretical studies have suggested that the threat of mandatory regulations or the potential to shape future regulations is motivating self-regulation by firms (Segerson and Miceli, 1998; Lutz, Lyon and Maxwell, 2000). The analysis here shows that while the potentially high costs of compliance with existing and anticipated regulations as well as the threat of liabilities are inducing firms to be more proactive about managing their environmental impacts, these pressures are not as strong as the non-regulatory pressures, from consumers, investors and communities. Among these, it is dependence on capital markets, concerns about public reputation and the adverse effects on it of information about environmental performance and high costs of disposing of waste off-site that provide stronger incentives to adopt a broad-based EMS than consumer pressure and pressure from global competition. This indicates that public policy can influence adoption of comprehensive EMSs by firms by providing information about the environmental performance of firms to the public, public recognition to firms with EMSs, and educating the public about the adverse effects of various pollutants, while maintaining stringency of the regulatory framework that imposes high costs of pollution on firms.

6. CONCLUSIONS

There is growing evidence of a transformation in the corporate response to concerns for environmental protection away from an adversarial approach based on a view of environmental costs as non-productive towards one of corporate environmentalism. Firms are crafting environmental management systems to anticipate and address environmental problems. There is, however, considerable diversity in the comprehensiveness or scope of these systems across firms. This paper develops a behavioral model of firm decision making to obtain econometrically testable hypothesis about the factors influencing the quality of a firm's environmental management system. The theoretical analysis here suggests that firms facing higher costs of

compliance with mandatory regulations, higher potential liabilities and green preferences from consumers and investors are more likely to have a higher quality of environmental management. Moreover, firms that have larger levels of pollution per unit output and are more innovative are also more likely to adopt a higher quality environmental management system.

The empirical analysis supports several of the hypotheses generated by the behavioral model. It demonstrates that the adoption decision of firms was motivated by rational economic self-interest. In particular, it shows that concerns about environmental liabilities and the threat of high costs of compliance with anticipated and existing mandatory regulations have a statistically significant influence on the incentives for corporate environmental management. Anticipated HAP regulations appear to provide strategic incentives for firms with a large portion of HAP to other toxic releases to adopt environmental management practices ahead of time and possibly influence the MACT standards to be set. This analysis suggests that the incentives for adoption of an innovative environmental management system do depend on the existence of a regulatory framework that would penalize poor environmental performance. However, the adoption of an EMS appears to be geared more towards dealing with anticipated environmental issues rather than as a reaction to improve compliance with existing regulations. A credible threat of stringent regulations in the future for many currently unregulated pollutants can play an important role in making firms proactive in their environmental management to avoid those costs of compliance.

However, the analysis here also shows that the incentives created by the threat of liabilities and mandatory regulations are not as strong as those created by market pressures. Firms that rely more strongly on the capital market, produce final goods and face greater global competition are more likely to adopt a comprehensive EMS. The most important motivators of EMSs appear to be high costs of off-site transfers of toxic releases and public pressures on firms with high on-site toxic emissions per unit output.

¹ The TRI is a database of emissions of over 300 toxic chemicals generated by each manufacturing facility in the US, mandated by the Emergency Planning and Community Right to Know Act of 1986.

² Further information can be found at <http://www.mswg.org>. Other participants at the summit included institutions such as the Brookings Institution, the National Academy of Public Administration and the Council of State Governments. The USEPA has also sponsored the creation of a National Database on EMS that will include information on various aspects of EMS implementation by 100 volunteer facilities in the U.S. to understand their costs and benefits to firms and society (<http://www.eli.org/isopilots.htm>).

³ Internal memos from Amoco cite several reasons for adopting proactive environmental management practices: “Environmental concerns are gaining increasing support from the public and political institutions. This support is evidenced in many ways, including several resolutions from Amoco shareholders, recent public opinion polls, and comments by both Republican and Democratic pollsters, and more recently by the efforts of the Coalition for Environmentally Responsible Economies to enlist investors who control more than \$100 billion to support only those companies that subscribe to a list of principles of environmental protection. Fundamentally this means that instead of the use of government command and control types of influence, we can expect people to act more directly on Amoco by way of shareholders and customers” (Hoffman, 1997).

⁴ To offset the expected negative publicity likely to be generated by release of its TRI emissions, Monsanto’s Chairman announced the “Monsanto Pledge” the day before the TRI was to be publicly released for the first time in 1986. The company pledged to reduce its worldwide air emissions of toxic chemicals by 90% by the end of 1992 and then continue to work towards the ultimate goal of zero emissions (Cairncross, 1995).

⁵ For example, environmental audits by themselves are only a means to examine performance and unless accompanied by adoption of other practices, such as a broad-based commitment from the management to provide the resources and incentives to employees to prevent pollution, are likely to be ineffective in improving environmental performance. Hence a decision to conduct environmental audits is likely to be accompanied by the adoption of other related practices as well.

⁶ These include Ward’s Business Directory and the Directory of Corporate Affiliations.

⁷ <http://www.epa.gov/oeca/idea>

⁸ For example, the chemical industry has attempted to develop green markets by instituting the Responsible Care trademark. This trademark is of greater value to firms that have frequent consumer contact and produce final goods as compared to those that produce intermediate products.

Table 1 Description and Adoption of Environmental Management Practices

Variable	Mean Values	Description of the Variable (1=yes; 0=no)
Staff	0.47 (0.50)	Firm has an environmental staff of more than 50
Directors	0.46 (0.50)	Firm has more than 3 environmental directors
Policy	0.92 (0.28)	Firm has a formal written policy and codes of conduct on environmental issues
Corp. Stds.	0.39 (0.49)	Firm applies uniform standards to environmental practices worldwide
TQM	0.70 (0.46)	Firm applies total quality management philosophy to environmental management
Payments	0.61 (0.49)	Firm provides incentive compensation to employees whose efforts lead to achievement of specific environmental goals
Audits	0.90 (0.29)	Firm conducts audits to assess compliance with environmental regulations
Suppliers	0.52 (0.50)	Firm evaluates its environmental risks when selecting its suppliers
Partners	0.39 (0.49)	Firm evaluates its environmental risks when selecting its partners
Clients	0.11 (0.31)	Firm evaluates its environmental risks when selecting its clients
Report	0.37 (0.48)	Firm regularly releases reports about its environmental performance and activities
Reserves	0.47 (0.50)	Firm sets aside funds to cover the costs of penalties for environmental violation or remediation activities
Insurance	0.44 (0.50)	Firm purchases insurance to meet unexpected environmental liabilities

Standard Deviations are in parenthesis

Table 2. Descriptive Statistics of Variables

Variable^a	Mean	Description of the Variable
Environmental Management	6.75 (3.25)	Count of environmental management practices adopted
Civil Penalty	0.69 (0.46)	Firm has received a civil penalty for non-compliance for one of 10 environmental statutes (1=yes; 0=no)
Inspections	33.73 (52.2)	Number of inspections to investigate compliance with existing regulations
No. of Superfund Sites	13.35 (17.45)	Accumulated number of Superfund sites for which the firm is listed as a potentially responsible party
HAP-On-Site Releases	0.39 (0.31)	Ratio of hazardous air pollutants targeted by NESHAP to on-site releases emitted by the firm
On-site Toxic Releases-Sales ('000lbs/\$Million)	1.36 (3.59)	Ratio of on-site toxic releases to net sales
Off-site Transfers-Sales ('000lbs/\$Million)	0.24 (0.55)	Ratio of off-site transfers to net sales
Final good	0.60 (0.49)	Firm sells a final good or service (1=yes; 0=no)
HHI	826.16 (720.1)	Herfindahl-Hirschman index of the 4-digit primary SIC code
Multinational Status	0.44 (0.28)	Ratio of facilities in foreign countries to all facilities of a firm
Age of assets	0.77 (0.10)	Ratio of total assets of a firm to its gross assets
R&D (\$ Billion)	0.29 (0.69)	Annual expenditures on research and development by firm
PACE-Sales	0.81 (0.78)	Ratio of Pollution abatement and control expenditures to Sales, both at the 2-digit SIC level
Sales-Asset	1.11 (0.49)	Ratio of sales to total assets owned by the firm

Data on number of practices adopted are for 1994-1995. All explanatory variables are for 1989- 1990.

Table 3. Determinants of Corporate Environmental Management

Indep. Variables	Model I		Model II	
	Poisson	OP	Poisson	OP
Intercept	2.04 (0.21)***	2.41 (0.69)***	1.97 (0.21)***	2.29 (0.70)***
A. Existing or Anticipated Regulatory Pressure				
Civil Penalty	0.42E-01 (0.54E-01)	0.48E-01 (0.14)	0.33E-01 (0.54-01)	-0.29E-01 (0.15)
Inspections	0.19E-03 (0.53E-03) ⁺	0.16E-02 (0.17E-02)	0.27E-04 (0.54E-03)	0.12E-02 (0.17E-02)
Industry PACE-Sales	0.093 (0.032)***	0.28 (0.10)***	0.080 (0.033)**	0.26 (0.10)**
No. of Superfund sites	0.63E-02 (0.29E-02)**	0.20E-01 (0.10E-01)**	0.54E-02 (0.30E-02)*	0.18E-01 (0.41E-02)*
No. of Superfund sites squared	-0.61E-04 (0.35E-04)*	-0.16E-03 (0.13E-03)	-0.51E-04 (0.35E-04) ⁺	-0.14E-03 (0.13E-03)
HAP-On-Site Releases	-	-	0.57 (0.28)**	1.28 (0.80)*
HAP-On-Site Releases squared	-	-	-0.62 (0.29)**	-1.50 (0.91)*
B. Market Pressure				
Final goods	0.27 (0.50E-01)***	0.59 (0.14)***	0.27 (0.50E-01)***	0.61 (0.14)***
HHI	0.53E-04 (0.32E-04)*	0.83E-04 (0.98E-04)	0.5E-04 (0.32E-04) ⁺	0.82E-04 (0.96E-04)
Multinational status	0.28 (0.85E-01)***	0.61 (0.24)***	0.28 (0.86E-01)***	0.60 (0.24)**
Sales-Asset	-0.17 (0.53E-01)***	-0.29 (0.14)**	-0.17 (0.53E-01)***	-0.28 (0.14)**
C. Firm Attributes				
On-site Toxic Releases-Output Ratio	0.11E-01 (0.59E-02)**	0.29E-01 (0.17E-01)*	0.15E-01 (0.62E-02)**	0.37E-01 (0.18E-01)**
Off-site Toxic Releases-Output Ratio	-0.15 (0.50E-01)***	-0.37E-01 (0.14E-01)**	-0.16 (0.50E-01)***	-0.39E-01 (0.15E-01)***
Age of assets	-0.61 (0.23)***	-1.50 (0.67)**	-0.60 (0.23)**	-1.38 (0.70)**
R&D expenditures	0.84E-01 (0.33E-01)***	0.39 (0.12)***	0.84-01 (0.34E-01)**	0.36E-03 (0.13E-03)***
γ	0.8E-02(0.01)		0.5E-02(0.01)	
Log likelihood values	-825.46	-766.32	-823.16	-764.18
χ^2 [d.f.] {p-value}	182.7[13]{0}	157.7[13]{0}	187.29[15]{0}	161.99[15]{0}
χ^2 [1] {p-value}	0.23 {0.63}		0.12 {0.73}	
χ^2 [d.f.] {p-value}		3.24[3]{.50}		3.36[3]{.50}

Standard errors are in parentheses. Degrees of freedom (d.f.) are in square brackets. χ^2 is a test for all slope coefficients jointly equal to zero. P-value is in curly brackets. ***Statistically significant at the 1% level. **Statistically significant at the 5% level; *Statistically significant at the 10% level. ⁺Statistically significant at the 20% level. χ^2 [1] is a test for the null hypothesis that the Poisson model is appropriate. χ^2 [10] is a test for all slope coefficients jointly equal to zero. χ^2 [d.f.] {p-value} is a test for heteroscedasticity in the ordered probit model.

Table 4: Marginal Effects on Count and Probability of Adoption of Environmental Management Practices

	Poisson Model	Ordered Probit
Independent Variables	Marginal Effect on Expected Number of Practices Adopted	% increase in Probability of Adopting 7 or more practices
A. Regulatory Pressure		
Civil Penalty	0.23 (0.36)	1.46
Inspections	0.009(0.004)	2.46
No. of Superfund sites	0.48 (0.26)*	9.92
HAP-On-Site Releases	0.42 (0.25)*	1.17
Industry PACE-Sales	0.42(0.17)**	7.98
B. Market Pressure		
Final goods	1.84 (0.34)***	23.65
HHI	0.28(0.18)	2.64
Multinational status	0.51 (0.16)***	6.45
Sales-Asset	-0.56 (0.18)***	-5.45
C. Firm Attributes		
On-site Toxic Releases-Output	0.35 (0.15)**	5.16
Off-site Toxic Releases-Output	-0.58 (0.19)***	-8.36
Age of assets	-0.42 (0.16)**	-5.58
R&D expenditures	0.39 (0.16)**	9.55

Marginal effects of a change in each explanatory variable on the expected number of practices adopted are estimated using the parameters estimated using the Poisson model II. These effects are estimated at the average number of practices adopted, 6.75 and for a one standard deviation change in the continuous variables and for a change from 0 to 1 for the dummy variables. Standard errors are in parentheses. ***Statistically significant at the 1% level. **Statistically significant at the 5% level; *Statistically significant at the 10% level. Marginal effects of a change in each explanatory variable on the probability of adoption of 7 or more practices are estimated using the parameters estimated using the Ordered Probit model II. These effects are estimated for a one standard deviation change in the continuous variables from their mean values and for a change from 0 to 1 for the dummy variables.

Figure 1: Determinants of the Comprehensiveness of Environmental Management

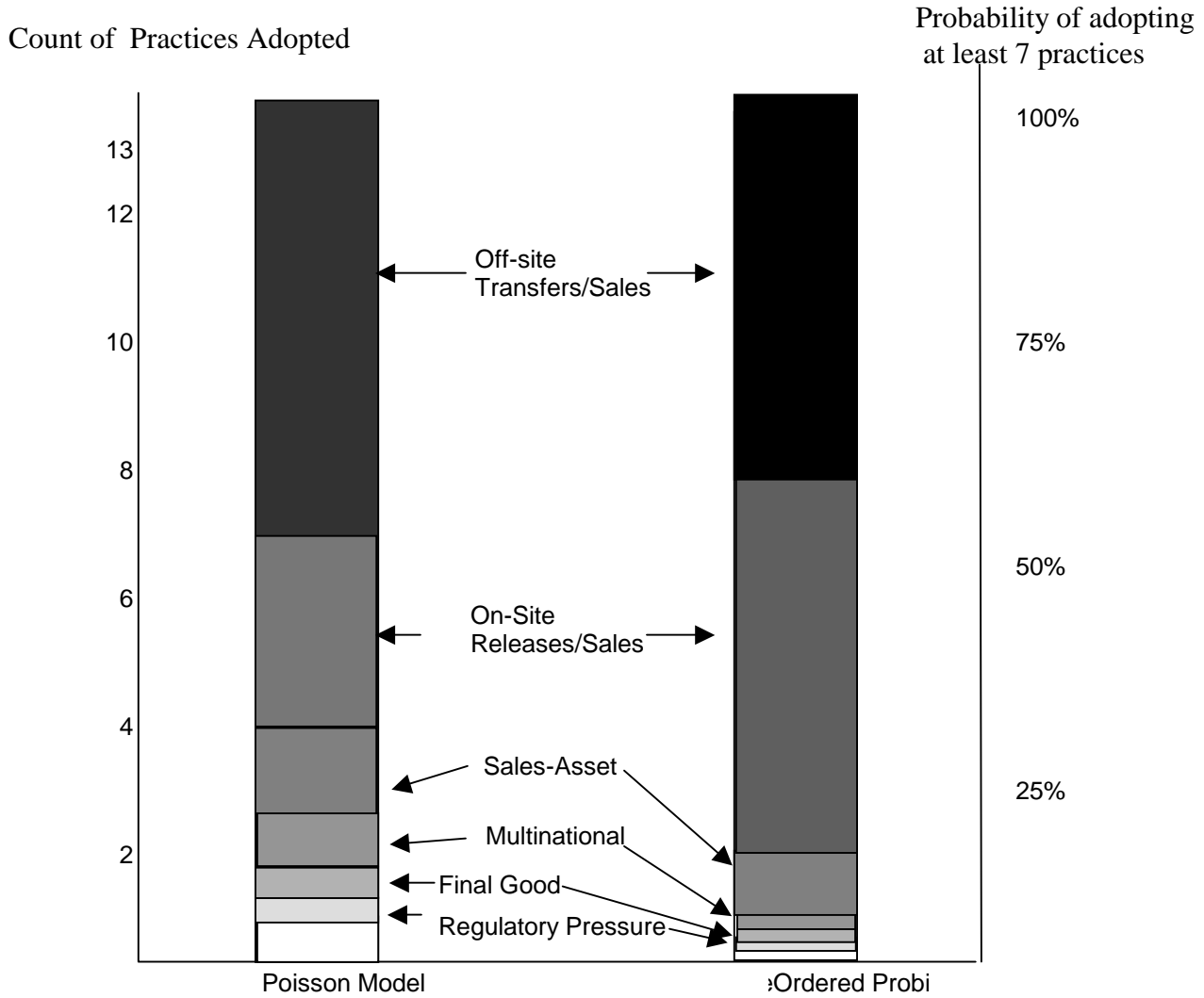


Table 5: Simulation Values for Exogenous Determinants of Corporate Environmental Management

	Superfund Sites	HAP-On-site	PACE -Sales	Final Good	Multinational Status	Sales-Asset	On-Site Releases-Sales	Off-Site Transfers - Sales
Low	0	0	0	0	0	4.46	0	4.77
High	120	1	2.1	1	1	0.29	36.37	0

Other variables held constant: Age of Assets=0.99; R&D=0.29; HHI=826, Civil Penalty=1; Inspections=33.73

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