Impact of Government-Sponsored Pollution Prevention Practices on Environmental Compliance and Enforcement: Evidence from a Sample of US Manufacturing Facilities

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Abstract

A two-way fixed effects Poisson model is used to investigate the impact of 43 EPA-sponsored pollution prevention (P2) practices on compliance and enforcement for a sample of facilities in the US manufacturing sector. I find that P2 adoption reduces environmental violations in three industries while increasing violations in two others. P2 adoption also spurs fewer enforcement actions in three industries. I further partition the P2 practices into three categories based on their approach to improve environmental performance. In doing so, I find that practices that involve changes in operating procedures--about a third of adopted P2 practices--such as instituting a self-inspection and monitoring program to discover spills or leak sources, improving maintenance scheduling and/or labeling procedures, are effective in reducing violations while practices that involve equipment or material changes are not. I also find that adopters of practices that require changes in either procedures or manufacturing equipment--about half of adopted practices--are rewarded with a more cooperative treatment of environmental infractions with fewer enforcement actions.

Keywords: Pollution Prevention Act, P2 practices, compliance, enforcement, Poisson models

JEL Codes: Q53, L51, C23

I. Introduction

Voluntary pollution prevention by private firms has become an integral part of contemporary U.S. environmental policy. The passage of the Pollution Prevention Act (PPA) in 1990 established a federal policy that prioritizes pollution prevention (P2) practices over downstream waste treatment activities. The PPA defines a P2 practice as "any practice which (i) reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and (ii) reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants." Examples of P2 practices include equipment and raw material modifications such as installation of a vapor recovery system, substituting less toxic solvents for hazardous solvents; procedural changes such as setting up a clearinghouse to exchange materials that otherwise would be discarded, self-inspection and monitoring program to discover spills or leak sources. The Toxics Release Inventory (TRI) contains information on the adoption of 43 voluntary P2 practices by US facilities since 1991(see Table 1).

The government's hope with the passage of the PPA is to induce voluntary corporate environmental investments that spur source reductions for the targeted pollutants. The benefits of P2 adoption may also spill over to non-target pollutants since most of the P2 practices entail comprehensive changes in operating procedures or the production process. Furthermore, P2 adoption may infuse a pollution prevention ethic within corporate management that prompts employee training programs and other investments in waste prevention that lower releases across all media, thereby reducing environmental violations.

Therefore the main objective of this study is to explore empirically if the adoption of EPA-sponsored voluntary P2 practices works to improve compliance with environmental law.

To prompt the adoption of P2 practices, the EPA has imbedded in its enforcement settlement process the option of reducing penalties against violators who voluntarily perform P2 activities above and beyond the mandatory actions required to correct the violation (USEPA, 1998; Burnett, 1998). Additionally and consonant with the enforcement theory (Maxwell and Decker, 2006), the EPA may have rewarded P2 adopters with a more relaxed regulatory regime, reducing the frequency of costly environmental inspections and enforcement actions. Therefore a second objective is to explore the effects of P2 adoption on the regulator's enforcement of environmental law.

A number of studies have sought to explain why profit-driven firms voluntarily agree to adopt costly environmentally friendly programs and whether such programs have succeeded in reducing pollution from levels that would otherwise have been produced. Most of the empirical research focuses on firms' participation in the EPA's 33/50 program (Arora and Cason, 1995, 1996; Khanna and Damon, 1999; Videras and Alberini, 2000; Gamper-Rabindran, 2006; Vidovic and Khanna, 2007; Sam and Innes, 2008), the Green Lights and Waste wise programs (Videras and Alberini, 2000), the Climate Challenge program (Welch et al., 2000); and the adoption of Environmental Management Systems such as Total Quality Environmental Management (Anton et al. , 2004; Uchida and Ferraro, 2007; Sam et al., 2007). The 33/50 program is the EPA's first formal effort to achieve voluntary pollution reduction by regulated firms. However, the 33/50 was limited in its scope (it targeted only 17 chemicals out of more than 650 in the TRI database) and in time (from 1991 to 1995).

Voluntary pollution reductions may also be induced by factors other than participation in a government-sponsored program. For example, Bandyopadhyay and Horowitz (2006) find that facilities located in richer communities significantly overcomply with water pollution regulations. McClelland and Horowitz (1999) also report anecdotal evidence that overcompliance is driven by community pressure and a desire for a less adversarial relationship with regulators.

More closely related to this work are papers that examine the impact of voluntary environmental investments by private firms on their compliance rates. Using a sample of more than 3,700 US facilities regulated under state and federal air pollution laws, Potoski and Prakash (2005) find that the adoption of the ISO 14001 environmental management standard elicits reduced spells of environmental noncompliance. In the same realm, Dasgupta et al. (2000) find that adoption of the ISO 14001 standard led to higher self-reported compliance rates for a cross section of Mexican manufacturing facilities.[1] Stafford (2003) finds that facilities located in a state that has a voluntary P2 program are less likely to be in violation of state hazardous waste regulations. Using a cross section of plants in four US manufacturing industries, Decker (2005) finds that facilities in the Chemicals and Pulp and Paper industries with lower TRI to plant capacity ratios, i.e. more environmentally efficient plants, are less likely to be targeted for inspections related to Clean Air Act (CAA) regulated releases. It is argued in Decker (2005) that since most of the TRI chemicals are not regulated, lower TRI releases can be interpreted as the outcome of firms' voluntary investment in abatement

[1] ISO 14001 environmental management standard consists essentially of identifying the environmental attributes of the firm's products, formulating an environmental policy statement based on the gathered information, developing environmental performance targets, establishing an Environmental Management System (EMS) to achieve the stated goals, and undertaking periodic evaluations of the EMS to ensure its effectiveness. See e.g., Dasgupta et al. (2000) or Protoski and Prakash (2005), or www.iso.org for a more extensive discussion of ISO 14001.

technologies. This logic is undermined, however, by the fact that a number of TRI chemicals are directly regulated under the CAA or the Clear Water Act for example (http://www.epa.gov/tri/chemical/94regmat.pdf). Not accounting for the presence of these regulated chemicals in the TRI data may confound the econometric results, making meaningful inference difficult.

The present study differs significantly from these efforts in that I examine the effects on environmental compliance and enforcement of a diverse set of 43 EPA-sponsored (but voluntary) P2 practices which are adopted by facilities in order to continuously reduce waste generation of some 650 toxic chemicals in the TRI database. These practices differ considerably in their approach to reduce pollution. As can be seen from Table 1, some of the practices require changes in operational routines; others require investment in cleaner technologies while others require modifications or substitution of raw materials. To gauge which of these approaches to pollution prevention is more effective at improving compliance, I follow Deltas et al. (2006) and partition the 43 P2 practices into three categories based on their functional attributes. The empirical analysis is undertaken using a panel of 1,424 US facilities whose parent companies are S&P 500 firms operating in the manufacturing sector over the period 1991 to 2004. In studying the effects of P2 adoption on environmental compliance and enforcement, I also control for potential impacts of environmental constituencies (using a time-series of state-level Sierra Club membership) and several other explanators drawn from related work.

The econometric results indicate that the effect of P2 adoption on compliance and enforcement varies by industry and by the attributes of the P2 practices. Specifically, I find that P2 adoption reduces violation rates in three industries (Paper and Allied Products, Primary Metal Industries, and Electrical Equipment and Components) while increasing violations in two others (Paper and Allied Products, Transportation equipment). P2 adoption is also associated with fewer enforcement rates in three industries (Fabricated metal products, Transportation equipment, and Measuring and analyzing instruments). Moreover, I find that P2 practices that entail changes in operating procedures yield fewer violations across all industries while P2 practices that involve equipment or material changes do not. I also find that regulators afford adopters of P2 practices that involve a change in either procedures or manufacturing equipment a more cooperative treatment of infractions with fewer enforcement actions.

The remainder of the paper is organized as follows. Section II discusses hypotheses on the effects of P2 adoption on environmental compliance and enforcement that are tested in the paper. In sections III and IV, I discuss the data and the econometric specifications. Section V presents the estimation results. Section VI concludes.

II. Hypotheses

Enacted in 1990, the Pollution Prevention Act established pollution prevention as the first option of pollution abatement; the adoption of P2 practices is however voluntary. The government's policy shift toward voluntary pollution reductions by profit-seeking firms is predicated on the expectation that P2 adopters will invest to re-engineer their products, re-design their production processes, and improve operating procedures in order to reduce pollution at the source therefore lower their cleanup and regulatory compliance costs. Even when P2 practices are not targeted at chemicals that are directly regulated, their adoption can heighten environmental consciousness within corporate management, which in turn can bring about increased investments in waste prevention for all pollutants and reduced environmental violations. Anecdotal evidence indicates that P2 adopters have undertaken significant investments to implement their P2 practices (The National Pollution Prevention Roundtable (NPPR), 1997). I therefore hypothesize that facilities that adopt P2 practices are less likely to violate environmental regulations than facilities that do not.

Hypothesis I: Facilities that adopt P2 activities experience fewer environmental violations.

However, this logic may not reflect the trade-offs that confront capital constrained firms with competing investment alternatives. For example, firms may have to decide how many resources to invest; alternately, in (1) waste prevention efforts that reduce emissions of targeted toxic chemicals which are mostly unregulated, and (2) environmental compliance activities that reduce emissions of regulated pollutants. Since the implementation of P2 practices often requires costly investments, it might crowd out financial and human resources that could otherwise have been devoted to improving compliance.

Hypothesis II: The adoption of more P2 practices yields a redirection of resources away from compliance activities and, therefore, leads to more environmental violations.

Furthermore, the 43 P2 practices in the TRI database that are considered in this study differ significantly in their approach to reduce pollution. Following Deltas et al. (2006), I disaggregate the P2 practices into three broad categories. The first category consists of practices that require the implementation of operating procedures such as instituting a self-inspection and monitoring program to discover spills or leak sources, improving maintenance scheduling, training of employees--who are likely more familiar with the facility's processes and procedures--in order to improve environmental performance. I posit that the implementation of such facility-wide changes elicits lower violation rates because the benefits (lower emissions) are likely to spill over to non-target, regulated pollutants as well.

<u>*Hypothesis III:*</u> *The adoption of P2 practices that involve procedural changes lowers violations rates.*

The second category consists of practices that focus on investment in environmentally friendly equipment such as the installation of a vapor recovery system, overflow alarms/automatic shutoff valves, or a rinse system. The third and final category consists of practices that involve material modifications such as increasing purity of raw materials, input material substitutions, modifying product design. Unlike practices centered on procedural modifications, practices based on equipment or material changes are generally costly to implement (Khanna et al., 2005). Faced with limited resources, managers may therefore choose to adopt such practices only to lower releases of the targeted TRI chemicals, which are mostly unregulated. Their adoption could conceivably worsen compliance; the reason (per *Hypothesis II*) is that the costs of purchasing and maintenance of new environmentally friendly equipment or material may crowd out financial resources that could otherwise be used to improve compliance.

The EPA and its state branches have sought to encourage and facilitate the adoption of P2 activities in two ways. First, many state agencies have instituted Pollution Prevention Regulatory Integration initiatives via which inspectors identify and promote appropriate P2 activities that may ease firms' compliance with environmental laws (Ohio EPA, 2005; NPPR, 1997). Second, the EPA has embedded in its enforcement settlement process the option of reducing fines against violators who voluntarily adopt supplemental environmental projects, which are voluntary P2 activities designed to remedy violations (EPA, 1998; Burnett, 1998).

If successful, these initiatives should increase adopting facilities' compliance rates and relieve their regulatory burden. It is noted however, firms may adopt P2 activities simply to portray themselves as environmentally responsive, therefore reaping the benefit of free publicity afforded to all adopters without devoting the adequate financial and human resources for these activities to be effective.[2] In addition to the reduction of penalties for adopters of supplemental environmental projects, the EPA may reward P2 adopters with less scrutiny in its enforcement of pollution control laws, reducing the frequency of costly environmental inspections and enforcement actions. Thus, I anticipate that facilities that adopt P2 activities experience fewer enforcement actions.

Hypothesis IV: Facilities that adopt P2 practices experience fewer enforcement actions

Furthermore, I do my best to control for variables that have been posited in extant literature to affect compliance and enforcement behavior. Such variables serve as necessary controls, but not as tests of any one theory per se. Because many of these variables could impact both compliance and enforcement decisions, I discuss their role in both regression equations together. First, with the reduced informational asymmetries between polluters and communities, fostered in part by the creation of the TRI in 1988, facilities may prevent environmental interest groups from lobbying lawmakers for tighter and costlier regulations by reducing their violations rates. Firms may also be the potential object of boycotts organized by environmentally conscious consumers and environmental interest groups (Henriques and Sadorsky, 1996; Baron, 2001; Innes, 2006; Sam and Innes, 2008). For example, over the recent past, environmental and animal rights activists have successfully challenged large,

[2] The EPA rewards P2 adopters by making their involvement known to the general public via press releases, awards, and other means of public recognition (http://www.epa.gov/p2/pubs/awards.htm).

powerful firms such as McDonalds and Home Depot using boycott tactics.[3] A good compliance record may allow firms to deter such organized hostile action. This potential motive for environmental compliance is likely to be greater in states with larger environmental constituencies. In these states, the public sensitivity to a facility's pollution is likely to be greater, as are environmental groups' incentive and ability to successfully lobby the government for change and/or to organize a boycott. Therefore, I hypothesize that facilities in states with higher numbers of environmental constituents as proxied by per-capita Sierra Club membership are more likely to be compliant with environmental laws. Similar logic may explain why penalties are higher against facilities operating in states with larger environmental constituencies (Sam and Innes, 2008). To test for these potential effects of environmental constituencies on both compliance and enforcement, I use the per-capita Sierra Club membership in a facility's home state (SIERRA).

Second, larger facilities, with deeper pockets, may be more compliant with environmental laws in order to avoid potential liability for harm caused. Such incentives will be greater in states that levy strict liability for environmental harm, as opposed to negligence liability (Alberini and Austin, 1999). Additionally, enforcement actions may be higher against facilities operating in such states. I attempt to capture the liability motive for compliance and enforcement using two variables; one for facility size proxied by TRI releases

[3] In 1999, McDonalds agreed to significant reforms in its supplier protocols for handling chickens after boycott actions by the animal rights group PETA (People for the Ethical Treatment of Animals); Burger King and Wendy's quickly followed suit. Also in 1999, Home Depot agreed to phase out products using old growth timber and to give preference to timber certified by the Forest Stewardship Council; other major home improvement retailers, as well as home builders, have since made similar commitments.

(TRI), and dummy variable taking a value of one if a plant's home state has a strict liability statute (STRICT).[4]

Third, I posit that firms that have adopted Environmental Management Systems (EMS) to systematically and continuously eliminate or attenuate the adverse effects of their products and services on the environment are less likely to violate environmental regulations hence should experience fewer enforcement actions. Total Quality Environmental Management (TQEM) represents the most comprehensive EMS; it views pollution as quality defect that must be continuously reduced through the development of products and processes that minimize waste generation at source. Facilities whose parent companies have adopted TQEM may therefore be more likely to identify opportunities for waste reduction and select cost-effective activities for reducing pollution thus lowering violations and enforcement actions. Dasgupta et al., (2002) report that EMS adoption increased compliance rates for a sample of Mexican facilities. The salutary effects of TQEM on violation and enforcement rates are likely stronger for facilities with larger toxic releases. I therefore consider an interaction between TRI emissions and the TQEM adoption dummy.

I include additional explanatory variables known to be relevant for compliance and enforcement activity. In particular, for the county in which a facility operates I have the time-varying attainment status (NONATTAIN, a dummy variable that equals one if the EPA deems the county to be out of attainment with clean air laws), county population density (DENSITY) and unemployment rate (URATE). I also include one and two-year lagged count of facility enforcement actions (ENF_{it-1} and ENF_{it-2}) as explanators of environmental violations. Several studies have examined the effects of enforcement activity on compliance rates (e.g, Gray and

[4] Arguably, a better measure of facility size would be its workforce or sales. There is no sales data to my knowledge at the facility level. Marketing Economics Inc has facility level employment data but only up to 1993 (Decker (2005)).

Deily, 1996; Stafford, 2002, 2003; Shimshack and Ward, 2005). These studies find that higher enforcement/inspection actions raise compliance rates. Per prior work (see e.g Grey and Deily, 1996; Stafford, 2002; Sam and Innes, 2008), lagged violations, specifically one and two-year lagged count of facility-level violations ($VIOL_{it-1}$ and $VIOL_{it-2}$), are included as explanatory variables in the enforcement equation. In examining the potential role of P2 activities in spurring fewer violation and enforcement rates, I allow for differences in their impact across industries by interacting the P2 dummy with each of the 12 dummies corresponding to the industries (two-digit standard industrial classification codes) most represented in my sample (see Tables 2 and 3).

III. Data

Several data sources are combined in this study. From the EPA's Toxic Release Inventory (TRI), I obtained facility-level data on chemical releases, primary standard industrial codes (SIC), parent company names, facility locations, and P2 adoption. Section 6607 of PPA mandates all facilities to report their P2 activities on an annual basis for each toxic chemical used. The P2 practices that are used in this study are specifically adopted to reduce TRI toxic chemicals. Many TRI chemicals are regulated under the CAA and CWA and other federal programs but most of them are not regulated. Facility-level government enforcement actions and compliance status are obtained from the Integrated Data for Enforcement Analysis (IDEA) database. IDEA provides a comprehensive report on government inspections and enforcement actions for all regulated facilities. The Sierra Club provided data on its annual membership at the state level for the period 1991-2004. County annual unemployment rates (1991-2004) and state GDP growth rates (1991-2004) are obtained from the Bureau of Labor Statistics (U.S. Department of Labor) and the Bureau of Economic Analysis (U.S. Department of Commerce), respectively. County attainment status (whether a facility's home county is designated by the EPA to be out of attainment with clean air laws) is obtained from the EPA website (www.epa.gov/oar/oaqps/greenbk/). County population density (2000) is obtained from the U.S. Census. Data on EMS adoption is obtained from a survey of S&P 500 firms between 1992 and 1996 by the Investor Research Responsibility Center (IRRC).[5] In the survey, respondents indicate whether they have adopted each of a number of different environmental policies (Anton et al., 2004). The EMS variable, TQEM, is a dummy that takes the value of one is a facility's parent company has adopted TQEM at any period between 1992 and 1996 and zero otherwise.[6]

The sample of facilities is obtained by the intersection of (i) the S&P 500 (those firms that responded to the IRRC surveys) and (ii) firms in the manufacturing industries responsible for the bulk of TRI releases (belonging to SIC codes 20-39). Merging the environmental datasets and allowing for lagging gives an unbalanced panel of 1,424 facilities over the period 1991-2004 for a total of 7,689 facility-year observations. Table 3 presents variable definitions and descriptive statistics for our sample.

Before turning to the econometric estimation, let us examine a few coarse trends from the data. Figure 1 depicts the evolution of average annual violations by P2 adopters vs. non P2 adopters for the period 1991-2004 for the two-digit SIC codes represented in the sample. Plots for SICs 26 (Paper and allied products), 29 (Petroleum and coal products), 30 (Rubber and plastic products), 36 (Electrical equipment and components), and 38 (Measuring and

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[5] I am indebted to Madhu Khanna for providing the data on EMS adoption.

[6] Since the decision to adopt *TQEM* is not likely to be made year to year and even if a firm were to de-adopt *TQEM*, the culture and organizational practices are likely to persist, I assume that there is no de-adoption of *TQEM* during the sample period.

analyzing instruments) show that facilities in these industries that have adopted P2 activities have fewer violations of environmental regulations than facilities that did not for most the period of study (1991-2004). The opposite is observed for and SIC 39 (Miscellaneous manufacturing industries) facilities. For SICs 28 (Chemicals and allied products) and 34 (Fabricated metal products), adopters and non-adopters of P2 practices have comparable violation rates on average during the first 10 to 11 years following the passage of the PPA. It is also noted that P2 adopters and non-adopters in SIC 33 (Primary metal industries) have near identical violation rates for entire period of study except for 2004. There is no discernable pattern of lower or higher violations rates by P2-adopters relative non-adopters over the length of this study emerging from the remaining plots. Thus, a coarse examination of the data provides some preliminary confirmation of this paper's main conjecture (*Hypothesis I*) for facilities in SICs 26, 29, 30, 36, and 38. The question of particular interest in this paper is whether the lower violation rates observed in these five industries can be attributed to P2 adoption alone. The answer to this question requires a careful econometric analysis of the data that pays attention to potential sample selection among other issues.

IV. Econometric Specification

I estimate two equations, a violation equation and an enforcement equation, in order to test the empirical validity of the hypotheses discussed above. Both equations give rise to a number of econometric issues. First, the dependent variables $VIOL_{it}$ and ENF_{it}--contemporaneous facility-level violations and enforcement rates, respectively--take a count data form, with discrete and predominantly small values. For violations, 51.5% of the data are zeroes, 17.67% are ones, 13.16% are twos, and 17.67% are threes or higher. For enforcement, 62.35% of the data are zeroes, 14.24% are ones, 11.1% are twos, and 12.31% are threes or more. Thus both distributions give a clear indication of a count. I therefore restrict the estimation to Poisson models which account for the discrete nature of the data.

Second, facilities that adopt voluntary P2 practices may not constitute a random sample; there may be unobserved cross-sectional (facility) heterogeneity that simultaneously affects the decisions to adopt a voluntary P2 practice and compliance behavior. For example, a firm whose managers/stakeholders are environmentally inclined might experience fewer violations therefore fewer enforcement actions even absent the adoption of EPA-sponsored P2 practices. Similar logic applies to enforcement. Failure to account for such factors could lead to a biased and inconsistent estimate of the effect of P2 adoption on environmental compliance and enforcement. Given the panel nature of the data, sample selection effects can be mitigated by including facility and time fixed effects in the regressions in order to control for omitted time-invariant characteristics and facility-invariant context variables that may be correlated with the P2 dummy (see e.g.,de Janvry et al., 2006; Sanyal and Menon, 2005; and Duffalo, 2005). Consequently, I specify a two-way (facility and time) fixed effects Poisson regression model to obtain consistent parameter estimates. Let *n* be the number of facilities and *T* the length of the time series, the econometric model is specified as

$$\begin{aligned} &Y_{it} \rightarrow \text{Poisson}\left(\hat{\lambda}_{\text{it}}\right) \text{ with} \\ &\hat{\lambda}_{it} = \alpha_i \lambda_{it} = \exp(X_{it}\beta_1 + \tau_i + \sum_{s=1}^{T-1} \delta_s d_s),\ \text{i} = 1,2,....,\text{n};\ \ \text{t} = 1,2,......,\text{T}. \end{aligned} \tag{1}$$

where the dependent variable Y_{it} is either VIOL_{it} or ENF_{it}; X_{it} is a vector of design variables posited to explain Y_{it}, d_s is a time dummy for year s, β_1 is a parameter vector conformable to the design vector X_{it}, $\alpha_i = \exp(\tau_i)$ is a facility-specific non-random intercept, and the δ's are coefficients for the time dummies. It can be shown (Cameron and Trivedi, 1998) based on (1) that the conditional joint density for the i^{th} observation is

$$P\left[Y_{i1,}Y_{i2,}.........Y_{iT} \mid \sum_{t=1}^{T} Y_{it}\right] = \frac{\Gamma\left(\sum_{t=1}^{T} Y_{it} + 1\right)}{\prod_{t=1}^{T} \Gamma(Y_{it} + 1)} \prod_{t} \left(\frac{\hat{\lambda}_{it}}{\sum \hat{\lambda}_{is}}\right)^{Y_{it}}$$

Note that the facility fixed effects as well as all time-invariant variables are eliminated from the conditional density since they appear in both the numerator and denominator of the last term. Assuming that conditional on facility and time fixed effects the P2 adoption variable is exogenous, the parameters (β_1, and the δ_s) can be estimated consistently by maximizing the conditional log-likelihood function

$$L_C(\beta_1, \delta) = \sum_{i=1}^{n} \log \Gamma\left(\sum_{t=1}^{T} Y_{it} + 1\right) - \sum_{i=1}^{n} \Gamma(Y_{it} + 1) + \sum_{t=1}^{T} Y_{it} \log\left(\frac{\exp(\beta_0 + X_{it}\beta_1 + \tau_i + \sum_{s=1}^{T} \delta_s d_s)}{\sum_{s=1}^{T} \exp(\beta_0 + X_{it}\beta_1 + \tau_i + \sum_{s=1}^{T} \delta_s d_s)}\right)$$

The two-way fixed effects model will not correct the endogeneity of P2 adoption if there are time *and* facility-varying unobservables that impact both the decision to adopt and violation rates. I test for selection effects by implementing Terza's 1998 two-step estimator which accommodates an endogenous dummy regressor for count data. The sample selection coefficient on the Terza regressions is found statistically insignificant with p-values of .56 and .96, respectively, for the baseline model (model 1) in Tables 4 and 5. I therefore proceed with the two-way fixed effects model.

Third, similar to prior work (Gray and Deily, 1996; Nadeau, 1997; Stafford, 2002, 2003), emissions are posited to contemporaneously explain compliance and enforcement rates. However, there conceivably exists the potential for their endogeneity. For example, as argued above, facilities whose managers or parent company managers are more environmentally conscious may be more likely to comply with mandatory regulations and also more likely to reduce unregulated TRI chemicals. If the unobserved effects that explain both compliance/enforcement decisions and TRI emissions are facility-specific or time-specific, then the two-way estimation framework will correct the endogeneity problem. Nonetheless, I test for endogeneity of TRI releases using the Hausman test.[7] Failing to reject the null of exogeneity in any of the models, I proceed under the maintained hypothesis that contemporaneous TRI releases are exogenous in my empirical framework.

Fourth, the fixed effects model does not account for the fact that there are repeated measurements over time on the same facility, which is a likely source of auto-correlation of the residuals for a given facility. I compute and report bootstrapped standard errors for the parameter estimates which are valid in the presence of any serial correlation and heteroskedasticity.[8]

V. Regression Results

For each of the two equations estimated in this study, I present the results of three fixed effects Poisson models in order to control for potential endogeneity of P2 adoption and distinguish between the effects of P2 practices across functional attributes industries. Model 1

[7] I use the number of toxic chemicals used by a facility in its production process, CHEMS, and its square as the identifying instruments for TRI releases. As CHEMS is highly correlated with TRI releases and should not be correlated with compliance except indirectly via TRI emissions, I can reasonably interpret the Hausman statistic as a test of exogeneity. The estimation results for the first stage TRI emissions show that facilities using more chemicals have higher emissions as indicated by a positive and significant coefficient on CHEMS; but this effect is subject to “diminishing returns” with a negative and statistically significant coefficient on the square of CHEMS. These results are available upon request. For both compliance and enforcement equations, the Hausman test statistics are well below the critical value for a 5% significance level which is 3.84, hence the test fails to reject the null of exogeneity of TRI releases.

[8] Specifically, I obtained 200 bootstrap samples (of 1424 facilities each) from the data and constructed standard error estimates for the parameters from the resulting distribution of bootstrapped parameter estimates.

captures adoption effects with a dummy variable, denoted P2, which indicates contemporaneous adoption of at least one P2 practice. Model 2 separates adoption effects by industry with interactions of the P2 dummy in model 1 with the 12 industries (2-digit SIC) most represented in the study sample (see Tables 2 and 3). The third model (model 3) breaks P2 adoption into three dummies that represent the three functional attributes discussed above: whether the P2 practice involves a procedural change (P2PROC), or a change in equipment (P2EQUIP), or a change in materials (P2MAT). For each model, I also add 13 time (year) dummies to capture year-specific effects. Each of the three models is estimated assuming that the count of violations follows a Poisson process with individual (facility) effects that are fixed.

1. The compliance equation. Table 4 presents estimation results of the compliance equation. In all three models, the time dummies are all statistically significant and show an upward trend in environmental violations. The results do not indicate that P2 adoption prompts significant reductions in environmental violations across all industries; the coefficient of the P2 dummy is positive but statistically insignificant in model 1 with a proportional marginal effect of 2.63% (p-value = 0.39).[9] Hence model 1 does not lend support to my main conjecture (*Hypothesis I*). This result, in and of itself, does not show ineffectiveness of P2 adoption in attaining its ultimate goal of reducing emissions of targeted chemicals since most TRI chemicals are unregulated, but it suggests that the benefits derived from P2 adoption, if any, do not spill over to regulated pollutants. Further investigation of the impact of P2

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[9]These numbers are obtained by dividing the marginal effect of P2 adoption obtained from model 1 (0.044) by the average number of violations per facility per year (1.7). I also estimated all three models using the count of adopted P2s and its interactions with the nine two-digit SIC dummies most represented in the sample in lieu of the adoption dummy. The results are qualitatively similar to the ones with the P2 dummy and are available upon request.

adoption on TRI releases would constitute a valuable contribution. Furthermore, the use of a single variable to explore the impact of P2 adoption for all facilities, as done in model 1, may mask differences in the impact of the P2 program across industries and attributes of P2 practices. To discern between impacts across industries, I replaced the P2 variable in model 1 with a set of 12 interactions of the variable P2 with two-digit industry codes for industries represented in my sample. The results (models 2) show that P2 adoption has the expected (per *Hypothesis I*) negative and statistically significant impact on violations for three industries in the manufacturing sector which are Paper and allied products (SIC 26), Primary metal industries (SIC 33), and Electrical equipment and components (SIC 36). Table 6 presents the proportional marginal effects of P2 adoption on violation rates for the 12 industries. The proportional marginal effects are obtained by dividing the marginal effect of P2 adoption for each industry by the corresponding industry's average annual environmental violations. P2 adoption is estimated to lower violation rates by 19% for facilities in SIC 26, 17% for facilities in SIC 33, and 27% for facilities in SIC 36. These reductions are both statistically and economically significant. Conversely, P2 adoption is estimated to increase violation rates by 24% for SIC 28 (Chemical and Allied Products) facilities, and 16% for SIC 37 facilities. A possible explanation for this outcome (per *Hypothesis II*) is that P2 adoption in these industries (SICs 28, and 37), to the extent that facilities take it seriously, diverts scarce financial resources away from compliance activities to the implementation of costly P2 practices that focus on chemicals not directly regulated. In such scenario, P2 adoption may work to reduce emissions of the targeted chemicals while worsening firms' compliance with mandatory environmental regulations.

Model 3 partitions the 43 P2 practices into the three previously defined categories in order to assess if the impact of P2 practices depends on their approach to improve compliance. In my sample, on average thirty percent of adopted P2 practices require procedural changes (first category), eighteen percent require equipment/technology modifications (second category), and thirty two percent involve material substitution/changes (third category). The raining P2 practices could not be unambiguously classified into any of the three groups and therefore are omitted from the regression analysis as in Deltas et al. (2006). The results in model 3 show that the coefficient on P2PROC is negative and statistically significant; the proportional marginal effect (marginal effect divided by average number of violations) of P2PROC indicates that the adoption of an additional P2 practice that involves facility-wide changes operating procedures reduces violations rates by about 13.5% for all industries, giving evidence in support of *Hypothesis III*. Conversely, the coefficients of P2EQEUIP and P2MAT are statistically insignificant indicating that the impact of P2 practices in the other two categories (equipment and material changes), if any, are limited to targeted and mostly unregulated chemicals. Since all P2 practices in this study are adopted to reduce emissions of mostly unregulated toxic chemicals, the econometric results suggest that only practices in the first category yield positive spillover effects on the emissions of regulated pollutants in the manufacturing sector.

Other important results emerge from Table 4. In particular, I find evidence that facilities are motivated to lower violation rates in order to preempt lobbying or boycott campaigns by environmental constituencies which might result in additional regulation (with a statistically significant negative coefficient on SIERRA). However, the preemption effect is subject to diminishing marginal return with a positive and statistically significant coefficient on the square of SIERRA. Still, the estimated marginal effect of SIERRA (evaluated at its sample mean) is negative, yielding reductions in the number of violations of 0.34 or 20% based on the average annual number of violations for all facilities in the manufacturing sector. Furthermore, all three specifications show that TQEM adoption is found to be effective at lowering violation rates for dirtier facilities with higher TRI as posited in the paper, with a negative and statistically significant coefficient on the interaction between TQEM and TRI. Consonant with prior work (e.g, Stafford, 2002), I also find that facilities with higher emissions (TRI) have a higher violation rates. In addition, I find that prior enforcement actions spur subsequent reduced violations with a two-year lag, and that one-year lagged enforcement actions are associated with more violations. Helland (1998) also finds a similar result and argues that violators need one year to come to compliance because violations generally stem from inadequate environmental technologies which may require a significant amount of time to be corrected. Other determinants for violations are county unemployment rates, county density and attainment status with clean air laws. Finally, the results show that facilities in counties with higher unemployment are less likely to violate environmental standards. The opposite is observed for facilities in counties deemed by the EPA out of attainment with clean air laws.

2. The Enforcement equation. The results of the enforcement equation are presented in Table 5. Enforcement actions are important because they represent the prospect for potentially costly disputes between a facility and government regulators. Even actions considered minor in and of themselves are notices that, if regulators are not quickly satisfied with compliance measures, can be followed by costly legal disputes, remedies and penalties.[10] Hence, a

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[10] Enforcement actions can range from notices of violation to administrative orders for compliance to initiations of civil lawsuits to filing criminal charges against responsible firms and individuals

potentially important reward to P2 adoption may be the prospect of a less adversarial relationship with environmental regulators that results in fewer enforcement actions. I find that enforcement actions have trended upwards perhaps to match the increase in violation rates over time documented in Table 4.

Turning to the qualitative results, I find in all three models that a facility's history of environmental violations is positively associated with subsequent government enforcement actions, consonant with Harrington's targeting model (1988). Facilities in strict liability states are more likely to receive an enforcement action. In addition, the results show that facilities in higher unemployment counties are less likely to receive an enforcement action. Surprisingly, I find that enforcement rates tend to fall when there is more environmentalist pressure on facilities, as measured by the Sierra Club variable (SIERRA); environmental pressure thus substitutes for government enforcement activity in promoting environmental objectives.[11] Perhaps more importantly for the purpose of this paper, I find no evidence in favor of the "regulatory responsiveness" theory (Maxwell and Decker, 2006); P2 adoption is not associated with a statistically significant reduction in regulatory scrutiny on average for the manufacturing sector, based on model 1. This result is in contrast to Sam and Innes's (2008) finding that regulators rewarded 33/50 program participants by reducing inspections and enforcement actions. There are two key differences between the 33/50 and the P2 programs that may explain these different conclusions. First, the 33/50 program was the EPA's first formal effort to achieve voluntary pollution reductions by regulated firms. To induce 33/50

(www.epa.gov/region9/enforcement). Beyond legal costs, costs to firms of remedies and penalties can be very large. For example, recent enforcement actions in EPA's Region 4 under the CAA have led to remedies and penalties ranging from the very small to over $130 million (www.epa.gov/region4/ead/general/recent).

[11]One might argue that environmental constituencies may pressure government agencies for more enforcement actions; my results suggest, in contrast, that government agencies recognize the salutary effects of environmentalism on facility performance and therefore may compensate for this added community pressure on facilities by exercising less regulatory oversight.

participation and associated pollution abatement, the EPA could have afforded participants a less adversarial treatment of potential infractions, with fewer costly inspections and enforcement actions – over and beyond reductions in enforcement rates due to reduced pollution. Second, the P2 program is far broader in scope than the 33/50; it seeks to prevent or reduce waste generation of some 650 chemicals in the TRI database while the 33/50 targeted seventeen high-use toxic chemicals with specific pollution reduction goals. Between 1991 and 1995, over half of all TRI facilities had adopted at least one P2 practice. In the same period, only 12% of eligible firms had joined the 33/50 program.

As in Decker (2005), I examine in model 2 whether the effects of P2 adoption vary by industry. In doing so, I find evidence in support of the "regulatory responsiveness" theory per *Hypothesis IV* of reduced enforcement actions for three industries which are: Fabricated metal products (SIC 34), Transportation equipment (SIC 37), and Measuring and analyzing instruments (SIC 38) perhaps because of supplemental environmental projects or because of enforcement rewards for P2 adoption. Table 6 displays the proportional marginal effects of P2 adoption on enforcement. P2 adoption-induced reductions in enforcement rates are large in both statistical and economic senses for these three industries, with annual reductions of 42% for SIC 34, 25% for SIC 37, and 49% for SIC 38. Decker (2005) reports similar mixed evidence of voluntary pollution abatement on the regulatory behavior. He finds that voluntary environmental investments by firms in the form of lower TRI releases resulted in fewer state inspection visits for plants in two industries (Chemical Manufacturing, Pulp and Paper) but had no statistically significant effect in two other industries (Iron and Steel, and Petroleum Refining). Finally, model 3 examines whether enforcement rewards are contingent on the functional attributes of the adopted practices. The results suggest that the adoption of practices that require procedural or equipment changes yield reduced enforcement rates while the adoption of practices that involve material changes do not. This is perhaps because the implementation of practices based on procedural and equipment changes involves a credible commitment by facilities to improve environmental performance: training their employees and/or undertaking significant investments in cleaner technologies. Maxwell and Decker's (2006) show the regulator will ease regulatory oversight on firms that make credible voluntary environmental investments.

VI. Conclusion

Voluntary pollution prevention has gained increased prominence among private firms following the passage of the 1990 Pollution Prevention Act which established a national policy that promotes source reductions instead of waste management. The main purpose of this paper is to test empirically the impact of P2 adoption on compliance and enforcement. In doing so, I use a sample of 1424 facilities whose parent companies are S&P500 firms over the period 1991-2004 for a total of 7681 facility-year observations. I find that P2 adoption spurs a decline in environmental violations for facilities in three industries (SICs 26, 33 36); the converse is observed for facilities in two other industries, namely SICs 28 and 37. Similarly, I find that only P2 adopters in three industries (SICs 34, 37 and 38) experienced statistically significant reductions of enforcement actions attributable to P2 adoption. Because P2 practices differ in their approach to prevent pollution, I disaggregate them into three broad categories and find that practices that involve changes in operating procedures spur fewer violations for all facilities while practices based on equipment or material substitutions do not. I also find a causal relationship between P2 practices based on improved procedures and cleaner manufacturing technology, and lower enforcement actions. Overall, this work indicates that (1) some, not all, P2 practices are effective at improving compliance; (2) the combination of procedures-based P2 practices and enforcement rewards for their adoption can significantly enhance environmental compliance. Finally, the results show that facilities in states with higher per capita environmental membership, that levy strict liability for environmental harm, and facilities that operate in counties that are out of attainment with environmental air quality laws are less likely to violate environmental laws.

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Figure 1: Average Violation Rates for Adopters vs. non-adopters of Pollution Prevention Practices over the Period 1991-2004 for Facilities in the Manufacturing Industry.

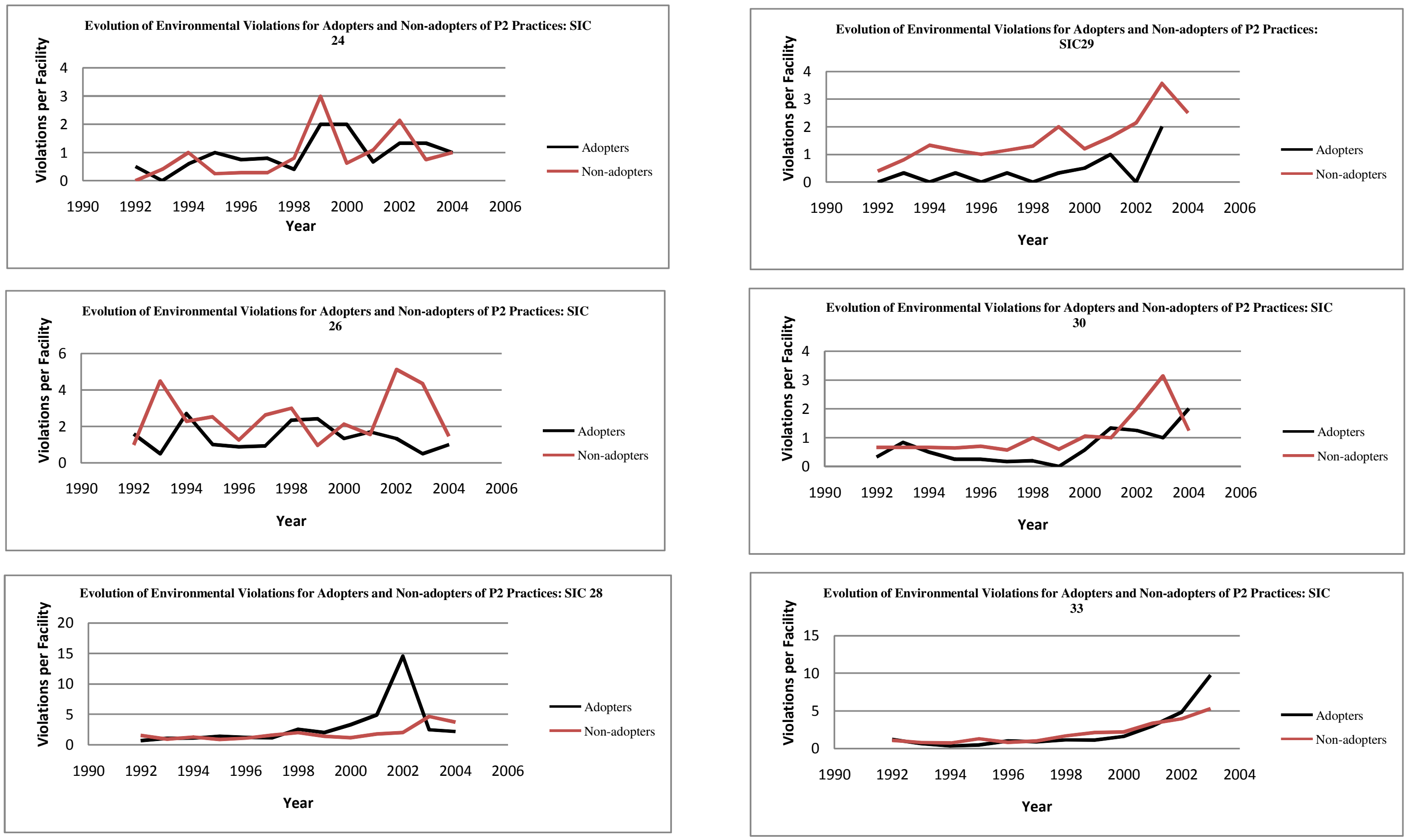
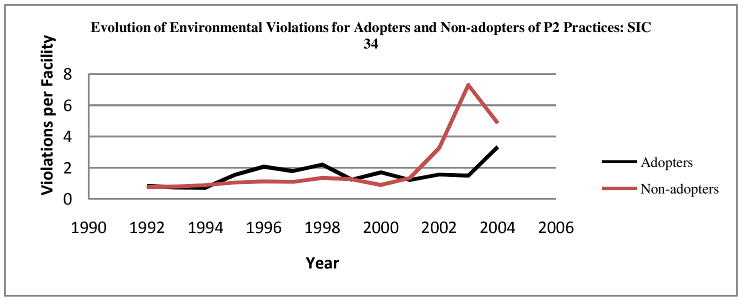
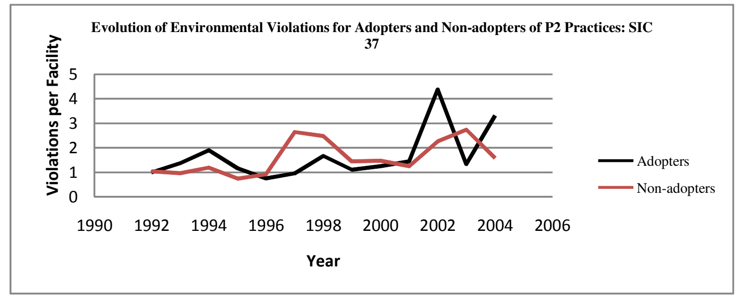
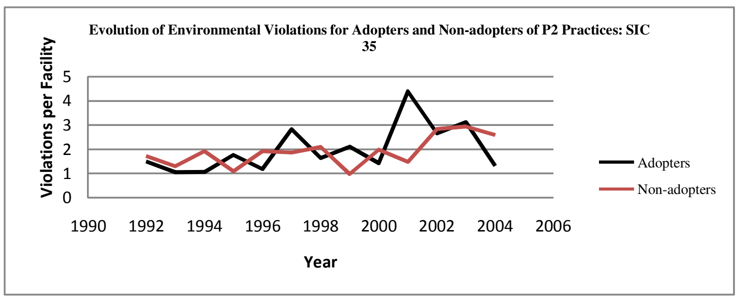
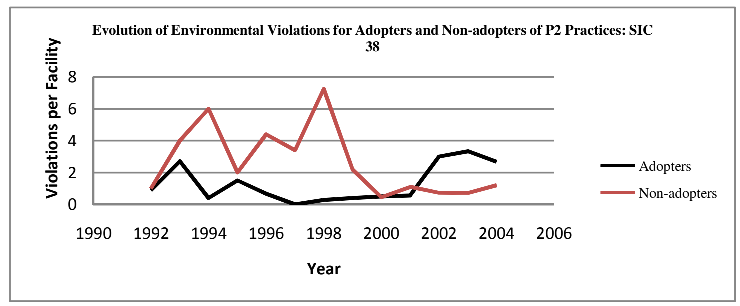


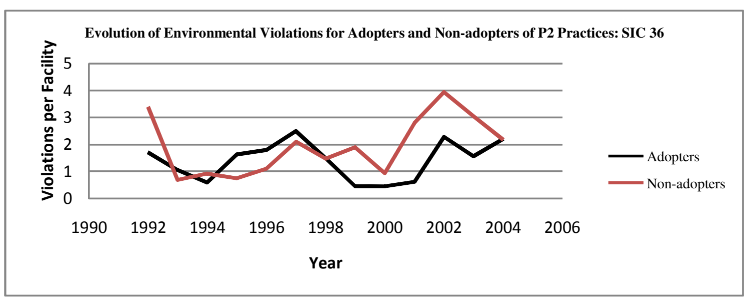
Figure 1: (*continued*)











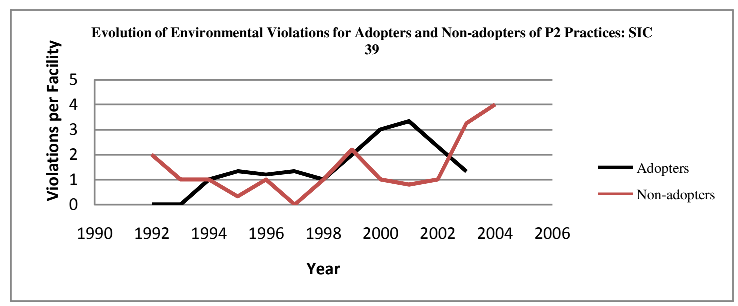


Table 1: List of EPA-Sponsored Pollution Prevention Practices

Good Operating Practices
W13 Improved maintenance scheduling, recordkeeping, or procedures
W14 Changed production schedule to minimize equipment and feedstock changeovers
W19 Other changes in operating practices
Inventory Control Activities
W21 Instituted procedures to ensure that materials do not stay in inventory beyond shelf-life
W22 Began to test outdated material — continue to use if still effective
W23 Eliminated shelf-life requirements for stable materials
W24 Instituted better labeling procedures
W25 Instituted clearinghouse to exchange materials that would otherwise be discarded
W29 Other changes in inventory control
Spill and Leak Prevention Activities
W31 Improved storage or stacking procedures
W32 Improved procedures for loading, unloading, and transfer operations
W33 Installed overflow alarms or automatic shutoff valves
W35 Installed vapor recovery systems
W36 Implemented inspection or monitoring program of potential spill or leak sources
W39 Other spill and leak prevention
Raw Material Modifications
W41 Increased purity of raw materials
W42 Substituted raw materials
W49 Other raw material modifications
Process Modifications
W51 Instituted recirculation within a process
W52 Modified equipment, layout, or piping
W53 Use of a different process catalyst
W54 Instituted better controls on operating bulk containers to minimize discarding of empty containers
W55 Changed from small volume containers to bulk containers to minimize discarding of empty containers
W58 Other process modifications
Cleaning and Degreasing Activities
W59 Modified stripping/cleaning equipment
W60 Changed to mechanical stripping/cleaning devices (from solvents or other materials)
W61 Changed to aqueous cleaners (from solvents or other materials)
W63 Modified containment procedures for cleaning
W64 Improved draining procedures
W65 Redesigned parts racks to reduce dragout
W66 Modified or installed rinse systems
W67 Improved rinse equipment design
W68 Improved rinse equipment operation

Table 1: List of EPA-Sponsored Pollution Prevention Practices (*Continued*)

W71 Other cleaning and degreasing modifications
Surface Preparation and Finishing Activities
W72 Modified spray systems or equipment
W73 Substituted coating materials used
W74 Improved application techniques
W75 Changed from spray to other system
W78 Other surface preparation and finishing modifications
Product Modifications
W81 Changed product specifications
W82 Modified design or composition of product
W83 Modified packaging
W89 Other product modifications

Source: http://www.epa.gov/fedrgstr/EPA-TRI/1996/August/Day-30/pr-57DIR/Support/section8.pdf

Table 2: List of US Manufacturing Industries

SIC code	Industry
20	Foods and kindred products
21	Tobacco manufacturing
22	Textile mill products
23	Apparel and other textile products
24	Lumber and wood products
25	Furniture and fixtures
26	Paper and allied products
27	Printing and publishing
28	Chemicals and allied products
29	Petroleum and coal products
30	Rubber and misc. plastic products
31	Leather and leather products
32	Stone, clay, glass, and concrete products
33	Primary metal industries
34	Fabricated metal products
35	Industrial machinery and computer equipment
36	Electrical equipment and components
37	Transportation equipment
38	Measuring and analyzing instruments
39	Misc. manufacturing industries

Source: www.siccode.com

Table 3: Descriptive Statistics for the Data

Variable	Mean	Standard Deviation
P2	0.2922	0.4548
ENFORCE	1.0743	3.6386
TRI	0.3917	3.5362
NONATTAIN	0.2108	0.4079
LIABILITY	0.7613	0.4263
SIERRA	1.6792	1.0970
TQEM	0.5483	0.4977
URATE	5.3196	1.4349
DENSITY	916.31	1413.01
SIC 24	0.0213	0.1445
SIC 26	0.0692	0.2538
SIC 28	0.1873	0.3902
SIC 29	0.0209	0.1432
SIC 30	0.0367	0.1880
SIC 33	0.0784	0.2689
SIC 34	0.1416	0.3487
SIC 35	0.1134	0.3171
SIC 36	0.0788	0.2695
SIC 37	0.1749	0.3799
SIC 38	0.0254	0.1572
SIC 39	0.0121	0.1093
Number of observations	7689	

Table 4: Fixed Effects Poisson Estimation of the Compliance Equation

Description	Variable	Model 1 estimate	Model 1 t-ratio		Model 2 estimate	Model 2 t-ratio		Model 3 estimate	Model 3 t-ratio	
P2 adoption indicator	P2	0.026	0.63							
	P2PROC							-0.157	-2.53	**
P2 adoption effects	P2EQUIP							0.016	0.75	
by attributes	P2MAT							0.039	0.24	
	P2*SIC 24				-0.018	-0.05				
	P2*SIC 26				-0.252	-2.14	**			
	P2*SIC 28				0.303	3.93	***			
P2 adoption effects by	P2*SIC 29				-0.093	-0.19				
industry	P2*SIC 30				0.130	0.53				
	P2*SIC 33				-0.209	-1.67	*			
	P2*SIC 34				-0.116	-0.99				
	P2*SIC 35				0.039	0.43				
	P2*SIC 36				-0.300	-2.13	**			
	P2*SIC 37				0.150	1.81	*			
	P2*SIC 38				-0.039	-0.15				
	P2*SIC 39				0.454	1.59				
	TRI	0.177	3.92	***	0.176	3.32	***	0.178	3.35	***
	TRI*TQEM	-0.196	-2.47	**	-0.194	-2.72	***	-0.192	-2.50	**
	ENFORCE1	0.004	4.79	***	0.005	5.33	***	0.004	4.36	***
Other control variables	ENFORCE2	-0.003	-2.59	**	-0.002	-2.18	**	-0.003	-2.26	**
	SIERRA	-0.538	-2.70	***	-0.520	-2.49	**	-0.550	-2.47	**
	SIERRA^2	0.089	3.02	***	0.088	2.70	***	0.090	2.48	**
	ATTAIN	0.167	2.66	**	0.159	3.00	***	0.168	2.76	***
	LIABILITY	0.165	1.75	*	0.145	1.47		0.166	1.67	*
	URATE	-0.014	-0.89		-0.012	-0.72		-0.012	-0.68	
	Y91	-0.893	-7.49	***	-0.875	-7.17	***	-0.913	-7.41	***
	Y92	-1.032	-9.62	***	-1.002	-10.34	***	-1.020	-9.01	***
	Y93	-1.136	-10.71	***	-1.116	-11.14	***	-1.123	-9.66	***
	Y94	-0.883	-8.01	***	-0.859	-8.92	***	-0.872	-8.05	***
Time fixed effects	Y95	-0.916	-8.88	***	-0.888	-10.00	***	-0.906	-9.31	***
	Y96	-0.878	-9.55	***	-0.851	-9.71	***	-0.858	-9.62	***
	Y97	-0.763	-8.03	***	-0.725	-7.71	***	-0.750	-7.42	***
	Y98	-0.506	-5.27	***	-0.466	-5.95	***	-0.492	-5.72	***
	Y99	-0.678	-7.99	***	-0.650	-7.43	***	-0.655	-7.10	***
	Y00	-0.611	-6.82	***	-0.597	-7.10	***	-0.588	-6.48	***
	Y01	-0.350	-4.54	***	-0.336	-4.54	***	-0.342	-3.97	***
	Y02	0.168	2.22	***	0.170	2.57	***	0.173	2.27	**
	Y03	0.315	4.44	***	0.322	4.28	***	0.322	4.15	***
	Number of obs		7689			7689			7689	
	Logl		-6950.64			-6923.66			-6943.53	

Table 5: Fixed Effects Poisson Estimation of the Enforcement Equation

Description	Variable	Model 1 estimate	Model 1 t-ratio		Model 2 estimate	Model 2 t-ratio		Model 3 estimate	Model 3 t-ratio	
P2 adoption indicator	P2	-0.016	-0.31							
	P2PROC							-0.133	-1.96	**
P2 adoption effects	P2EQUIP							-0.161	-2.05	**
by attributes	P2MAT							0.036	0.47	
	P2*SIC 24				0.422	1.07				
	P2*SIC 26				-0.095	-0.62				
	P2*SIC 28				0.230	2.01	**			
P2 adoption effects by	P2*SIC 29				-0.566	-1.22				
industry	P2*SIC 30				0.138	0.42				
	P2*SIC 33				0.065	0.32				
	P2*SIC 34				-0.419	-2.37	**			
	P2*SIC 35				0.019	0.12				
	P2*SIC 36				0.022	0.10				
	P2*SIC 37				-0.239	-1.75	*			
	P2*SIC 38				-0.570	-1.88	**			
	P2*SIC 39				0.283	0.71				
	TRI	0.001	0.15		0.002	0.14		0.001	0.05	
	TRI*TQEM	0.054	0.63		0.059	0.70		0.059	0.80	
	VIOL1	0.002	2.08	**	0.003	2.76	***	0.002	1.79	*
Other control variables	VIOL2	-0.003	-2.72	***	-0.002	-2.02	**	-0.003	-2.74	***
	SIERRA	-1.203	-3.52	***	-1.155	-3.35	***	-1.223	-3.64	***
	SIERRA^2	0.158	2.79	***	0.150	2.95	***	0.160	2.82	***
	ATTAIN	-0.002	-0.03		-0.005	-0.06		-0.009	-0.12	
	LIABILITY	0.641	3.67	***	0.584	3.10	***	0.649	3.42	***
	URATE	-0.001	-0.04		-0.006	-0.23		0.000	0.01	
	Y91	-1.953	-8.76	***	-1.995	-11.67	***	-1.972	-9.74	***
	Y92	-2.035	-11.14	***	-2.002	-13.70	***	-2.019	-13.58	***
	Y93	-2.002	-13.72	***	-1.968	-13.01	***	-1.982	-14.78	***
	Y94	-1.814	-11.76	***	-1.778	-14.11	***	-1.791	-13.46	***
Time fixed effects	Y95	-1.663	-10.86	***	-1.649	-13.24	***	-1.653	-12.93	***
	Y96	-1.781	-12.17	***	-1.774	-14.62	***	-1.769	-13.55	***
	Y97	-1.660	-12.21	***	-1.647	-13.35	***	-1.652	-13.57	***
	Y98	-1.582	-11.51	***	-1.555	-12.97	***	-1.576	-13.27	***
	Y99	-1.490	-10.03	***	-1.484	-12.94	***	-1.479	-10.85	***
	Y00	-1.385	-12.30	***	-1.390	-13.22	***	-1.373	-9.77	***
	Y01	-0.925	-8.01	***	-0.922	-9.92	***	-0.914	-8.52	***
	Y02	0.152	1.93	*	0.161	2.23	***	0.147	1.82	*
	Y03	0.244	3.07	***	0.254	3.13	***	0.245	3.11	***
	Number of obs		7689			7689			7689	
	Logl		-5410.12			-5389.99			-5402.20	

Table 6: Proportional Marginal Effects of P2 adoption on Compliance Rates

Industry	Compliance Equation: Proportional Marginal Effect (%) Based on Model 2	t-ratio		Enforcement Equation: Proportional Marginal Effect (%) Based on Model 2	t-ratio	
SIC 24	-2.99	-0.046		41.26	1.073	
SIC 26	-18.98	-2.137	**	-6.93	-0.625	
SIC 28	24.29	3.933	***	15.28	2.005	**
SIC 29	-12.79	-0.194		-49.84	-1.219	
SIC 30	22.71	0.535		16.71	0.424	
SIC 33	-17.05	-1.670	*	5.18	0.325	
SIC 34	-10.32	-0.989		-42.44	-2.368	**
SIC 35	3.60	0.430		2.06	0.118	
SIC 36	-27.71	-2.131	**	1.98	0.103	
SIC 37	15.65	1.811	*	-25.95	-1.750	*
SIC 38	-4.02	-0.151		-49.81	-1.881	*
SIC 39	51.74	1.590		24.53	0.705	