Corporate Environmental Behavior and the Effectiveness of Government Interventions

OPENING DAY
INTRODUCTORY REMARKS BY

MIKE STAHL
U.S. EPA, DIRECTOR FOR THE OFFICE OF COMPLIANCE

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Prepared by Alpha-Gamma Technologies, Inc.
4700 Falls of Neuse Road, Suite 350, Raleigh, NC 27609

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Introductory Remarks by Mike Stahl

U.S. EPA, Director for the Office of Compliance

at the

Corporate Environmental Behavior and the

Effectiveness of Government Interventions

Washington, D.C.

April 26, 2004

Thank you, Matt. I don't know whether it's a good thing to be given the credit for having the vision to have started all of this—I guess that remains to be seen. I had a management professor once who used to tell me that there's a fine line between a vision and a hallucination, so I'm hoping that we end up with this being more of a vision than a hallucination. I think, based on what I've read about the discussion to come today, this is going to be a very promising and useful discussion for us.

First, I want to say that I am actually here pinch-hitting for Phyllis Harris, who is our Deputy Assistant Administrator in the Office of Enforcement and Compliance Assurance, who had hoped to be here but her schedule didn't permit her to come. I am only too happy to sit in for her because my roots with this effort do go back a ways, and I'm happy to see so many papers and so much research coming to fruition now, a little while later. So, it's a pleasure for me to be here.

I wanted to start out by mentioning that I consider myself both a practitioner in the field of compliance and enforcement, and something of an academician in that I am on the adjunct faculty at George Mason University in their master's degree in public administration. Now, that doesn't qualify me as being able to say I have a scholarly career that I'm pursuing on the side here, but it *has* caused me to think and reflect from time to time about this connection between social science research and academia generally and people in government agencies who are trying to get certain kinds of results and make certain things happen. I guess my observation is that having a foot sort of in both camps, as a practitioner and as an academician, I think the connection between those two worlds is much too faint and not nearly as strong as it should be, and I think there is a great deal that the two groups can learn from one another. So, I'm very pleased to see this effort, where I think we are beginning to blend folks from the social sciences and from an interdisciplinary background with practitioners who are actually on the front lines trying to increase compliance, protect the environment, and generally deliver government services in a more effective way.

One of the things I wanted to lay out for you as you begin your discussions today is the notion of "smart enforcement," and this is something that our program now at EPA is beginning to use as an umbrella concept for several directions that we're trying to move in simultaneously. Let me explain a little bit about smart enforcement and what it means and what are the components of it, because I think it will bear directly on a number of the papers that you have here today.

Essentially, smart enforcement means "using the most appropriate enforcement or compliance tools to address the most significant problems to achieve the best outcomes as quickly and effectively as possible." So, in order to try to carry out that notion of smart enforcement, we have a number of components now that we have actively under way or that we have moved toward over the last couple of years.

The first of those [components] is finding and addressing significant problems. We're doing much more to use data to try to determine what are the non-compliance patterns that really matter to us and which ones should we be focusing federal attention on.

The second component is to *use* data to *make* strategic decisions. We've got a number of national databases that talk about the compliance records and compliance behavior of facilities under the major environmental statutes, but it's really only been over the last three of four years that we have begun to use that data in much more expansive ways and in ways that allow us to manage the program in a smarter fashion.

The next component is to use the most appropriate tool to achieve the best outcomes. When we talk about tools in this program, we generally refer to four: The first is what we would call "compliance assistance," which is essentially just giving information to the regulated community to help them understand how to comply. Environmental requirements tend to be rather complex, so I think EPA, especially over the last seven or eight years, has put much more emphasis on trying to provide information to regulated entities to help them understand how to get into compliance and stay there.

The second tool that we talk about in our program are incentives, and the primary example there is our audit and self-policing policy, which provides incentives to companies to do facility audits, find violations, disclose them to EPA, and correct them. That policy, having been in place now for about four or five years, has led to a number of facilities stepping forward to do their own audits and their own self-policing to try to, in effect, get ahead of the curve and discover violations and correct them.

The next tool that I would talk about in terms of our smart enforcement approach is what I would consider to be the more traditional compliance monitoring—this includes inspections and investigations. Over the last several years, these have become more sophisticated, as we have done more-in-depth investigations at particular facilities and gone beyond just the normal onsite compliance check that our inspectors had been doing over the many years that EPA has been in business.

The final tool is enforcement, both civil and criminal. This is when we have reached the point where we feel that *we* have to take an action to correct some violation that is of significance to us and we feel that none of the other tools can work to get the result as effectively or as quickly as enforcement.

So, those four tools—assistance, incentives, monitoring, and enforcement—are the tools that we like to talk about in this program as being the ones that we're now trying to mix in the right combinations and apply to particular non-compliance patterns.

Another component of the smart enforcement approach is *assessing* the effectiveness of our program. We have put a great deal of effort in the last two or three years into looking at the performance information that we've now been collecting about EPA's enforcement and compliance program and getting some benefit out of the analysis of that information, in terms of recommendations about different ways to operate, adjustments that need to be made to our strategies. . . I think this notion of assessing the effectiveness is something that you'll see EPA continuing to do in its enforcement and compliance program over the foreseeable future.

The final element of smart enforcement is effectively communicating the outcomes of our activities, and we have, over the last couple of years in particular, begun to talk more about the pounds of pollution that we're reducing and less about just the number of enforcement actions that we take in a given fiscal year. We have moved very much toward communicating with the public in terms that they will find, I think, more valuable and more understandable and that really speak to what it is we're trying to produce for the environment.

So, this notion of smart enforcement, I think, is something that can serve as a bit of a touchstone for you as you go through the day and talk about the various papers and studies that are going to be presented here. Just based on a rather cursory review of what you're going to be talking about today, I think *many* of the papers will bear *directly* on our efforts to move in the direction of smart enforcement. So, I would urge that we do more of this over time, that this link between the academic world and the world of the practitioner be strengthened over time, and that some of the questions that practitioners have be picked up by academia and analyzed so that we can learn more about the right ways to operate programs. For example, I would hope that over time we can get a better sense of what *forces* or what *incentives* motivate compliance or non-compliance in the regulated community—what government interventions seem to be most *effective* in maximizing compliance—and what tools or combination of tools are most effective against particular *patterns* of non-compliance.

This is the kind of approach that we hope to be taking in EPA's Enforcement and Compliance Assurance program over the years, and I think that the research being done by those of you out here today who are going to be presenting papers will be very helpful in moving us more in the direction of smart enforcement and moving us into a more effective program over time. Let me leave you with that—I promised that I was going to be mercifully brief so that you could get to your papers and get to the really important discussions, and that's what I intend to do. I appreciate your participation in the conference, and we will make use of the research that all of you have done. Thanks very much.

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PROCEEDINGS OF

SESSION I: ENFORCEMENT ISSUES

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Session I: Enforcement Issues

Factors Shaping Corporate Environmental Performance: Regulatory Pressure, Community Pressure, and Financial Status

Dietrich Earnhart *

Department of Economics
University of Kansas

May 10, 2004

Dietrich Earnhart
Department of Economics
213 Summerfield Hall
University of Kansas
Lawrence, KS 66045
785-864-2866 (phone)
Earnhart@ku.edu

Abstract: This paper analyzes the effects of external pressure – regulatory and community pressure – on the level of environmental performance at individual polluting facilities. It considers two dimensions of regulatory pressure: (1) specific deterrence, which is generated by actual government interventions – namely inspections and penalties – performed at particular facilities, and (2) general deterrence, which is generated by the threat of receiving an intervention. As important, it compares the effects of deterrence – specific and general – based on the source of the intervention. For inspections, it compares state and federal inspectors; for penalties, it compares EPA administrative courts and federal civil courts. Second, the study measures community pressure indirectly using key community characteristics (e.g., education) that proxy for actual pressure. Finally, it considers the effects of facility- and firm-level characteristics, especially corporate financial status, on environmental performance. For this empirical analysis, the study examines wastewater discharges by chemical manufacturing facilities in the US for the years 1995 to 2001.

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1. Introduction

Recently the Environmental Protection Agency (EPA) has been expressing a strong interest in understanding better the factors that shape corporate environmental performance at individual polluting facilities (hereafter "environmental performance"). In particular, the EPA wishes to assess the effectiveness of government interventions, such as inspections and enforcement actions, for inducing better environmental performance. This broad interest in environmental performance echos concerns about compliance with environmental protection laws and the adequacy of environmental enforcement previously expressed in government reports (GAO, 1983; GAO, 1995; EPA, 1994).

To understand better these concerns and inform the EPA's more general interests, this study analyzes two sets of external pressure factors – regulatory and community pressure – that shape the level of environmental performance at water polluting facilities. It also considers the effects of facility- and firm-level characteristics, especially corporate financial status, on environmental performance. The study primarily measures environmental performance by the ratio of absolute discharges to effluent limits – relative discharges (i.e., compliance level), which captures both noncompliance and overcompliance. For this calculation, the study must consider specific pollutants. To produce more generalizable results, the study focuses on two common pollutants: biological oxygen demand (BOD) and total suspended solids (TSS).[1] As a broader measure of compliance, the study also examines the monthly count of effluent limit exceedances across all permitted pollutants. While this latter measure is exhaustively broad, it cannot capture overcompliance.

As the primary broad objective, this study attempts to identify the effects of certain government interventions on environmental performance at individual facilities in the industrial sector of chemical and allied products. The analysis considers various government interventions: (1) state inspections, (2) EPA inspections, (3) EPA administrative penalties: fines, injunctive relief sanctions, and supplemental environmental projects (SEPs), and (4) federal civil penalties: fines, injunctive relief sanctions, and SEPs.[2,3] Moreover, it examines the effects of these government interventions in two dimensions. The first dimension considers specific deterrence, which captures corporate responses to specific government interventions against particular facilities at given

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[1] This study also measures environmental performance by the absolute level of BOD and TSS wastewater discharges. Analysis of these measures is available upon request.

[2] For the chosen sample of facilities over the chosen sample period, no cost-recovery penalties, which are related to remediation, are imposed by federal courts. Injunctive relief sanctions represent court-imposed orders to perform particular a beneficial act or to stop performing a particular harmful act that relates to a facility's operation, e.g., install a new treatment system. SEPs represent court-imposed orders to perform an environmentally beneficial act that is not related to a facility's operation, e.g., fund an Earth Day parade.

[3] Future analysis will also consider state penalties. Collection of state penalties for the entire US would be very time consuming since no single database contains these data; instead, each state maintains its own separate database and some states do not maintain an electronic database. The study has collected data on penalties from the four states with the largest concentration of chemical manufacturing facilities (e.g., New Jersey). This manuscript seeks to examine the broadest sample of facilities. Obviously, the inclusion of state penalties would dramatically reduce the scope of the analysis.

moments in time (Earnhart, 2004b). The second dimension considers general deterrence, which captures the underlying "threat" of receiving an intervention (Earnhart, 2004b). To measure this threat, this study uses indicators of interventions against other similar facilities for the relevant time period and location (e.g., average number of federal inspections against other major chemical facilities in each EPA region for a given year).

While the primary broad objective seeks to identify the overall effects of government interventions on environmental performance, this study further derives six specific objectives that either identify the main effects of government interventions or determine whether these effects differ based on three factors: source of intervention, type of facility, and type of firm. The first specific objective seeks to identify the effects of actual government interventions – specific deterrence – on environmental performance. The second specific objective seeks to identify the effects of intervention threats – general deterrence – on environmental performance. The third objective seeks to compare the effects of specific and general deterrence based on the source of the intervention. For inspections, the study compares state and federal inspectors; for penalties, it compares EPA administrative courts and federal civil courts. EPA inspections may more greatly affect corporate decisions than do state inspections since facilities may believe that federal involvement indicates greater regulatory pressure. Similarly, civil penalties may more greatly affect corporate decisions than do administrative penalties since facilities may believe that Department of Justice involvement, which is required for civil cases, indicates greater regulatory pressure.[4] The fourth objective seeks to identify the effects of facility-level characteristics, such as type of production (based on the four-digit SIC code) or size, on environmental performance. The fifth specific objective seeks to identify the effects of firm-level characteristics, such as ownership structure and financial status on environmental performance. This study examines two dimensions of financial status. The primary dimension concerns overall financial performance, as measured by the rate of return on assets. The secondary dimension concerns financial resources immediately available for investment in better environmental management, as measured by annual revenues. To capture the effect of financial status, the study must limit itself to facilities owned by publicly-held firms since financial data on privately-held firms are not available. The sixth specific objective involving government interventions seeks to identify the interactions between the effects of specific and general deterrence and both facility-level and firm-level characteristics. This objective seeks to learn whether different types of facilities or facilities facing different corporate conditions respond differently to government interventions.

[4] Future analysis will consider a related objective. It will seek to compare the effects of monetary penalties (i.e., fines) and non-monetary penalties (i.e., injunctive relief, SEPs) on environmental performance. Even though both monetary and non-monetary penalties drain corporate financial resources, they affect corporate welfare differently. While fines provide no benefits to the firm, injunctive relief provides benefits in the form of reduced future scrutiny, due to improved environmental management, and increased financial payoff, whenever better environmental management is profitable. Similarly, SEPs may benefit a facility by improving its reputation. The current manuscript does not consider this objective since few civil non-monetary penalties were imposed on the sample of chemical manufacturing facilities during the identified sample period, making a comparison of civil and administrative non-monetary penalties difficult to implement properly. Future analysis will compare monetary penalties and non-monetary penalties without any distinction between the penalties' source: administrative or civil court.

As the secondary broad objective, this study explores the influence of local community pressure on environmental performance. The analysis measures community pressure indirectly using key community characteristics. These characteristics serve as proxies for pressure since they are correlated with actual pressure (Earnhart, 2004c; Pargal and Wheeler, 1996). Specifically, this study analyzes the influences of the following key community characteristics: (1) local labor market condition, as measured by the unemployment rate; (2) political engagement, as measured by the voter turnout rate; (3) political proclivity, as measured by the percent of Democratic voters; (4) intellectual sophistication, as measured by educational attainment [proportion of residents with a bachelor's degree]; (5) community size, as measured by the population density level; (6) community attachment, as measured by the (6a) proportion of owner occupied households and (6b) median age; (7) health concerns, as measured by the (7a) proportion of family households, (7b) proportion of family households with children, and (7c) proportion of male residents; (8) wealth, as measured by per capita income; (9) dependency on chemical manufacturing, as measured by proportion of private earnings generated by chemical production; and (10) racial composition, as measured by proportion of non-white residents.[5] As an illustrative example, a more intellectually sophisticated (i.e., better educated) community may be expected to mobilize its citizens more easily against and exert pressure more effectively upon local polluters than a less sophisticated community. The study measures community characteristics using Census data at the locale level (e.g., city) and Commerce Department Regional Economic Information Service (REIS) data at the county level.

Since overcompliance is quite prevalent in the studied sample, the analysis is able to examine the effects of community pressure on facilities' motivations to comply as well as to overcomply with effluent limits. In general, <u>each</u> objective speaks equally to facilities' abilities and motivations to comply with effluent limits as well as their abilities and motivations to overcomply with these same limits. At a minimum, the objectives not related to community pressure speak to facilities' <u>abilities</u> to overcomply with effluent limits. This general capacity represents a strength of the analysis.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature and identifies the present study's contribution to this literature. Section 3 presents the empirical application based on inspection, enforcement, and compliance data for chemical manufacturing facilities in the US from 1995 to 2001. Section 4 presents the econometric model. Section 5 presents the estimation results. Section 6 concludes.

2. Previous Literature and Contributions of Present Study

Previous analysis on the factors shaping corporate environmental performance is limited. Mark Cohen, the Director of the Vanderbilt Center for Environmental Management Studies, reports that surprisingly few empirical studies of environmental enforcement have been conducted and that they focus on a few industries: oil transport, steel mills, and pulp and paper mills (Cohen, 1999). Jon Silberman, the Senior Attorney in the EPA Office of Enforcement and Compliance Assurance, reaffirms the need for more empirical research (Silberman, 2000). In particular, previous economic analysis on the effectiveness of government interventions on facility environmental performance is

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[5] The analysis purposively excludes the level of environmental organization membership as a community pressure factor since it is most likely endogenously determined, especially in the case of discharges. (Besides, local-level data are not available in any reasonably accessible form.) Instead, the analysis relies upon more general community characteristics that might affect facility performance (Brooks and Sethi, 1997).

limited (Cohen, 1999). In the economics literature, few articles examine the effectiveness of government interventions on facility environmental performance involving standard emissions (i.e., non-accidental discharges) and they focus exclusively on two industrial sectors – pulp/paperboard and steel (Gray and Deily, 1996; Magat and Viscusi, 1990; Nadeau, 1997; Laplante and Rilstone, 1996; Helland, 1998a; Helland, 1998b).[6] In the realm of wastewater management, previous studies of industrial facilities examine only the former sector and consider only the effects of government inspections. Additional studies of wastewater management examine publicly-owned wastewater treatment plants and their responses to both inspections and penalties (Earnhart, 2004a; Earnhart, 2004b; Earnhart, 2004c). The only previous studies of penalty imposition on industrial facilities exist in the realm of air emission management. No previous study of industrial facilities considers specific deterrence stemming from penalties. In addition to standard emissions, a few studies examine the effect of government interventions on oil spills (e.g., Epple and Visscher, 1984; Anderson and Talley, 1995). Finally, two previous studies examine other dimensions of environmental performance. Stafford (2002) examines the effect of a new EPA enforcement protocol on facility compliance with hazardous waste regulations. May and Winter (1999) examine compliance with agro-environmental regulations.[7]

This study's examination of government interventions captures deterrence in two forms: specific and general. Previous studies on the effects of government interventions on facility performance address the two forms of deterrence in various combinations. Some studies analyze only specific deterrence, which stems from actual interventions at specific facilities (Magat and Viscusi, 1990; Helland, 1998a; Helland, 1998b; Smith, 1979; Gray and Jones, 1991a; Gray and Jones, 1991b). Some studies analyze only general deterrence, which stems from intervention threats. Consistent with economic theory of expected utility, this threat divides into two components: (1) the likelihood of an intervention and (2) the size (or burden) of the intervention, conditional on its occurrence. To capture the likelihood of an intervention, some studies use aggregate measures of government interventions within specified locations and/or time periods (Cohen, 1987; Anderson and Talley, 1995; Epple and Visscher, 1984; Viscusi, 1979; Bartel and Thomas, 1985). Other studies use the predicted probability of an intervention (e.g., Gray and Shadbegian, 2000). One study uses both likelihood measures simultaneously (Nadeau, 1997).[8] No previous study directly examines the expected conditional burden of an intervention. However, some previous studies examine indirectly variation in the conditional burden of an intervention (e.g., Gray and Jones, 1991a). Some studies separately examine both deterrence forms by considering first actual interventions and second predicted interventions (Laplante and Rilstone, 1996; Gray and Deily,

[6] Other similar studies focus exclusively on agency behavior regarding inspections and/or enforcement actions (e.g., Deily and Gray, 1991; Earnhart, 1997; Earnhart, 2000a; Earnhart, 2000b).

[7] In addition to environmental performance, other studies explore the effects of government interventions on performance related to worker or consumer safety regulations (e.g., Gray and Jones, 1991a; Gray and Jones, 1991b; Olson, 1999; Viscusi, 1979; Bartel and Thomas, 1985).

[8] Other studies do not focus on the likelihood of an intervention directly but instead focus on variation in the likelihood of an intervention based on identifiable factors (e.g., Stafford, 2002; Olson, 1999; Gray and Jones, 1991a;Viladrich-Grau and Grace, 1997).

1996). Three studies jointly analyze the two deterrence forms: Scholz and Gray (1990), Earnhart (2004a), and Earnhart (2004b). The first study does not consider environmental performance; the latter two studies consider environmental performance of publicly-owned wastewater treatment plants.

The present study is the first to examine jointly the two deterrence effects on industrial facilities. To analyze the effects of both deterrence forms on environmental performance, this particular empirical analysis examines a panel of data on wastewater discharges by large chemical manufacturing facilities across the US for the years 1995 to 2001.

Drawing upon the deterrence literature, this analysis uses the noted empirical studies as a point of departure to expand – in three other important directions – the analysis on the effects of government interventions on corporate environmental performance. In other words, the present study contributes to the literature in three other ways. First, it examines the distinction between federal and state inspections and compares their effects on industrial facility performance. Second, it examines the distinction between federal administrative and civil penalties and compares their effects on industrial facility performance.[9] Third, this study examines how different types of facilities and firms respond differently to government interventions.

Other economic studies examine the effects of non-regulatory factors on environmental performance and/or behavior. In particular, these studies explore the reasons for overcompliance, which need not be explained by regulatory pressure. McClelland and Horowitz (1999) explore the possibility of zero marginal abatement costs. Brännlund and Löfgren (1996) explore stochastic emission patterns. Arora and Cason (1996) explore firms' desire to present a "green" image to consumers. Downing and Kimball (1982) assess the possibility that management's concerns over corporate image induce overcompliance.[10]

Community pressure may also explain overcompliance. A few economic studies *explicitly* explore the effect of community pressure on environmental performance and/or behavior. Henriques and Sadorsky (1996) explore the effect of self-reported community pressure on Canadian firms' decisions to adopt an environmental plan. Dasgupta et al. (2000) explore the effect of self-reported community pressure (presence versus absence) on Mexican firms' decisions to adopt certain environmental management practices.

Other economic studies *implicitly* explore the effect of community pressure on environmental performance and/or behavior by examining polluters' responses to the potential for citizen action, which is measured by proxies for community pressure. In general, these studies rely upon community characteristics to serve as the proxies. Maxwell et al. (2000) explore firms' desire to

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[9] Earnhart (2004b) examines the differential effects of government interventions on facility performance by publicly-owned wastewater treatment plants, not industrial facilities; moreover, it does not examine the difference between administrative and civil penalties.

[10] Other studies explore the effects of non-regulatory factors on environmental performance and behavior without addressing overcompliance. Hammit and Reuter (1988) raise the possibility of "ignorant" compliance, while Brehm and Hamilton (1996) consider the possibility of ignorant non-compliance. Neither study addresses overcompliance. Hamilton (1995) and Khanna et al. (1998) explore the effect of stockholder pressure on Toxic Release Inventory (TRI) emissions. Since TRI emissions are mostly unregulated, these two analyses address neither compliance nor overcompliance.

preempt citizen political action for more stringent regulations at the state level; the expectation of citizen lobbying affects facilities' decisions to reduce emissions. Hamilton (1993) examines how hazardous waste facilities consider the potential for community action when deciding where to locate. Pargal and Wheeler (1996) explore the effects of community characteristics on facility-level industrial wastewater discharges in Indonesia and interpret these characteristics as capturing community-generated "informal regulation" against facilities. Wolverton (2002) examines the effects of community characteristics on the location decisions of Texas plants that report Toxic Release Inventory (TRI) emissions. Becker (2002) examines whether community characteristics help to explain the level of pollution abatement expenditures by manufacturing plants. Using a community characteristic more tightly linked to the potential for citizen action, Konar and Cohen (1997) explore the effect of community right-to-know laws on TRI emissions.[11] Lastly, Blackman and Bannister (1998) use a facility-specific feature — membership in a local political organization — as a proxy for community pressure when examining the adoption of propane use by traditional Mexican brickmakers. Similar to these previous studies, the present analysis indirectly explores the effect of community pressure on environmental performance using proxies for actual community pressure. In other words, while the analysis does not explicitly measure actual pressure, the effects of community characteristics on performance should be highly suggestive of actual pressure.

By drawing upon these previous analyses, the present study contributes to the literature that examines the effects of community pressure on corporate environmental performance in several ways. First, it examines the effects of community pressure on compliance as measured against an identifiable regulatory standard — permitted effluent limit — unlike all the previous studies of corporate environmental performance. Moreover, it examines the extent of overcompliance (and noncompliance).[12] This measure of performance may better capture the effects of community pressure since these effects may only serve to <u>complement</u> the effects of formal regulation, which

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[11] Other economic studies explore the connection between community characteristics and locally-aggregated emissions. For example, Brooks and Sethi (1997), the most sophisticated analysis of these studies, explore the relationship between zip code-level community characteristics and locally-aggregated Toxic Release Inventory (TRI) air emissions. Brooks and Sethi (1997) catalog and describe other studies that use simple correlations to link levels of or reductions in regionally aggregated air emissions and community characteristics. These studies, in addition to Brooks and Sethi (1997), fail to control for other factors that may influence emission reductions, especially regulatory factors.

[12] As a matter of fact, this contribution regarding compliance levels generalizes to most studies of environmental performance. Less than a handful of studies examine emissions relative to effluent limits (Laplante and Rilstone, 1996; Earnhart, 2004a; Earnhart, 2004b; Earnhart, 2004c). Some studies examine the simple distinction between compliance and noncompliance (e.g., Helland, 1998a; Nadeau, 1997; Gray and Deily, 1996), which is too limited since it ignores the fact that many facilities overcomply with effluent limits. [For example, McClelland and Horowitz (1999) report that aggregate emissions from pulp and paper plants in 1992 were roughly 50 % of the permitted emissions; as another example, several firms voluntarily reduce their emissions through participation in programs such as the EPA's 33/50 program (Arora and Cason, 1996).] Other studies analyze absolute emission levels without reference to permitted limits (Helland, 1998b; Magat and Viscusi, 1990), which is too limited since it ignores variation in effluent limits across facilities and across time for a given facility. All studies using TRI emissions do not address compliance levels since these emissions are mostly unregulated.

may sufficiently induce compliance but not overcompliance (i.e., community pressure may mostly affect the *degree* of compliance rather than the *status* of compliance).[13] Second, this study comprehensively incorporates government interventions and their threat. It examines separately federal and state inspections and federal enforcement, in the realm of both specific and general deterrence.[14] Similarly, it controls for other regulatory factors, namely general permit conditions.[15]

Finally, the present study contributes to the environmental literature by considering financial performance or status. In the economics literature, only one previous empirical study examines the link from firm-level financial status to facility-level environmental performance (Gray and Deily, 1996). Other studies explore the link from firm-level financial status to firm-level environmental performance (Konar and Cohen, 2001; Gottsman and Kessler, 1998; Earnhart and Lizal, 2002). The present study represents only the second study of firm-level financial status to facility-level environmental performance by linking corporate revenues and rates of return on assets to facilities' compliance levels (i.e., relative discharges) and degree of noncompliance (i.e., monthly frequency of effluent limit violations). In addition, this study contributes by examining how facilities facing different corporate financial conditions respond differently to government interventions.

The results of this study generate benefits beyond these noted contributions to the literature. First, the results should help federal and state environmental regulatory agencies to allocate effectively their resources to achieve environmental protection. The results can provide this help by explaining how different types of facilities or facilities in different corporate "environments" respond differently to various influences and combinations of influences, including government interventions and community pressure. Second, the results should help entities of the environmentally-regulated community, chemical sector in particular, to allocate its resources effectively to improve their compliance level and overall environmental performance in terms of wastewater discharges. In particular, the results should help to identify which corporate characteristics permit improvement. Since the chemical and allied products sector is a large source of manufacturing output and wastewater discharges, the results should be strongly generalizable to the economy as a whole and pollution control as an overall concern.

These contributions and benefits aside, this research certainly has its limitations. While the analysis includes many influential factors on corporate environmental performance, it does not consider several other noteworthy factors, such as criminal penalties, social norms, citizen suits, market forces, and third-party liability claims (Cohen, 1999). Also, this research cannot claim to identify causation, only statistically significant correlations, for the included factors. Thus, it must qualify any claims to identifying the motivations and/or abilities behind compliant or overcompliant

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[13] Formal regulation may induce overcompliance when emissions are stochastic, an issue explored by Brännlund and Löfgren (1996), as noted above.

[14] The comprehensiveness of the current study stands in stark contrast to previous studies of community pressure on corporate environmental behavior and/or performance, which do not control for regulatory factors. As the only exception, Dasgupta et al. (2000) control for self-reported formal regulatory presence (yes/no).

[15] Earnhart (2004c) makes similar contributions for environmental performance by publicly-owned wastewater treatment plants.

behavior and performance.

The remaining sections use the noted literature to guide and interpret the empirical analysis of facility-level environmental performance.

3. Empirical Application

3.1. Selection of Research Sample

To examine the effectiveness of government interventions, the influence of community pressure, and the effect of financial status, this paper examines a specific type of environmental performance: wastewater discharges by the 508 large ("major") chemical manufacturing facilities across the US during the years 1995 to 2001. This selection is quite appropriate for several reasons. First, unlike other media, regulators systematically record wastewater discharge limits, which are critical for calculating the level of compliance (or noncompliance), and actual discharges. Second, the EPA focuses its regulatory efforts on EPA-classified "major" facilities.[16] The 508 major facilities represented 21 % of the 2,481 chemical facilities in the National Pollutant Discharge Elimination System (NPDES) in 2001. Moreover, they represented the bulk of wastewater discharges from this sector. Therefore, the results from this sample of facilities are strongly representative of the chemical industry as far as pollution control is concerned.

As the most important criterion for this sample selection, the sector of chemical and allied products serves as an excellent vehicle for examining corporate environmental performance. [The two-digit Standard Industrial Classification (SIC) code for this sector is 28.] Several reasons exist. First, the EPA has demonstrated a strong interest in this sector as evidenced by its study (joint with the Chemical Manufacturing Association [CMA]) on the root causes of noncompliance in this sector (EPA, 1999) and its study on the compliance history for this sector [*Chemical Industry National Environmental Baseline Report 1990-1994* (EPA 305-R-96-002)]. Second, the CMA has demonstrated a strong interest in promoting pollution reduction and prevention with its Responsible Care initiative. Similarly, this sector is expected to display a wide variety of environmental performance, involving noncompliance and overcompliance. Analysis of all major chemical manufacturing facilities confirms this variety of compliance rates. For example, the mean level of biological oxygen demand (BOD) relative discharges is 0.28, while the standard deviation is 0.34 and the range is 0 to 10.52. Similar data for TSS relative discharges confirm this assertion. The mean level is 0.32, the standard deviation is 0.36, and the range is 0 to 9.87. Third, this sector permits the analysis to exploit similarities and differences across the four-digit SIC sub-sectors. In the sample used for this study, the mean level of BOD relative discharges varies dramatically across the sub-sectors from a low of 0.09 to a high of 0.70. For TSS relative discharges, the mean level varies from a low of 0.03 to a high of 0.57. Fourth, one of the sub-sectors, industrial organics (SIC-code 2869), is regarded by the EPA as a priority industrial sector. Fifth, this sector is a large source of manufacturing output and wastewater discharges. For this last reason, results should be strongly generalizable to the economy as a whole and pollution control as an overall concern.

To retain this strong generalizability, the study focuses on two pollutants common to most

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[16] Major industrial facilities meet one of two criteria: (1) possess a discharge flow of 1 million gallons per day, or (2) cause significant impact on the receiving waterbody. The EPA's Permit Compliance System (PCS) database only systematically records wastewater discharges and effluent limits for major facilities in the National Pollutant Discharge Elimination System (NPDES).

regulated facilities: biological oxygen demand (BOD) and total suspended solids (TSS).[17] Analysis of both BOD and TSS appears warranted since the two measures seem to capture different dimensions of performance based on the weak correlation – only 0.11 – between the two measures. As a broader measure of compliance, the study also examines the monthly count of effluent limit exceedances across all permitted pollutants.

3.2. Government Regulatory Influence

This chosen sample permits analysis of government regulatory pressure. Government efforts to control water pollution begin with the issuance of facility-specific permits. Although the EPA possesses the authority to issue permits, this authority has been delegated to states that meet federal criteria. Permits are issued generally on a five-year cycle. Within a five-year permit, agencies may impose initial or interim limits, which serve as a transition to the final limits, which are generally more stringent. In other cases, agencies may impose final limits immediately. To ensure compliance with the permits, the EPA and state agencies periodically inspect facilities and take enforcement actions as needed. While the EPA retains authority to monitor and sanction facilities, state agencies are primarily responsible for monitoring and enforcement. Inspections represent the backbone of environmental agencies' efforts to monitor compliance and collect evidence for enforcement (Wasserman, 1984); inspections also maintain a regulatory presence (EPA, 1990).[18] As for enforcement, agencies use a mixture of informal enforcement actions (e.g., warning letters) and formal enforcement actions (e.g., administrative orders), which include penalties.[19] In particular, EPA regional offices may initiate an administrative proceeding to impose an administrative penalty. Alternatively, the EPA regional offices may request the Department of Justice (DOJ) to initiate a civil court proceeding to impose a civil penalty. As likely, EPA regional offices may request the initiation of a civil court proceeding after the imposition an administrative penalty, especially when the administrative penalty fails to induce compliant behavior.

3.3. Data Collection

To examine the effects of regulatory pressure — inspections and enforcement, community

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[17] BOD and TSS are two of the five conventional pollutants (as classified by the EPA); conventional pollutants are the focus of EPA control efforts. The EPA considers BOD the most damaging of the conventional pollutants and the focus of their control efforts (Helland, 1998a; Magat and Viscusi, 1990). [Conversations with federal officials confirm this point.] TSS is also damaging. All previous wastewater studies focus exclusively on BOD. The one exception is Laplante and Rilstone (1996), who also consider TSS. In sum, a focus on BOD and TSS discharges need not be limiting.

[18] In general, federal and state inspection guidelines are minimal, according to EPA officials. As one example, the Enforcement Management System advocates that inspections follow a systematic plan that considers time since the last inspection and compliance history (EPA, 1990). (Further details on inspection guidelines are available upon request.)

[19] EPA policies provide only general enforcement guidelines; instead, much discretion is left to EPA regional offices and administrative and civil courts (Lear, 1998). According to EPA officials, certain factors, such as the economic benefit of noncompliance and compliance history, may explain the likelihood of enforcement actions. (Further details on EPA enforcement guidelines are available upon request.) Certain penalty types are not considered formal. The present study does not distinguish formal and non-formal penalties.

pressure, and financial status on the environmental performance of US chemical manufacturing facilities, this study gathers data from various databases. The EPA Permit Compliance System (PCS) database provides the following data elements for each chemical facility: (1) permit issuance dates, (2) type of discharge limit [initial, interim, or final], (3) indication of changes to a permit during the current five-year issuance period, (4) monthly wastewater flow [in millions of gallons/day], (5) BOD and TSS monthly discharge limits, (6) BOD and TSS monthly discharges, (7) indicator of effluent limit exceedance for each regulated pollutant, (8) four-digit SIC code, and (9) location.

Further discussion on discharge measurements, limits, and limit exceedances is needed. First, facilities monitor and facility-specific effluent limits restrict discharges according to two pollution measures: monthly average and monthly maximum. Conversations with government officials and the EPA's definition of significant noncompliance, however, suggest that regulators especially care about the average limit (GAO, 1996). Thus, this study focuses on the average discharge and limit. Second, facilities may monitor and facility-specific effluent limits may restrict only quantities (e.g., kilograms of BOD), only concentrations (e.g., milligrams of BOD per liter of water), or both. By focusing on compliance levels, the study is able to compare across all facilities regardless of the form of their discharge measurement and effluent limit. The analysis calculates relative discharges – the ratio of absolute discharges and effluent limits – regardless of the type of discharge and limit. If both quantity and concentration limits apply, the analysis calculates the mean level of compliance. Third, each facility may have several points of discharge and several sources of wastewater generation. For each combination of discharge point and generation source, the analysis identifies the relevant discharge level and effluent limit and then calculates the level of relative discharges. In order to generate a single observation for each specific facility at a particular moment in time, the analysis calculates the mean relative discharge level across all multiple combinations of points and sources. In this way, the data on environmental performance match with the facility-level data, especially the information on government interventions.[20] Fourth, the monthly count of effluent limit exceedances across all regulated pollutants is calculated in a similar fashion by summing across all multiple combinations of points and sources. Fifth, a given facility may not discharge any pollution in a specific month. If true, BOD and/or TSS discharges are recorded as zero.

The PCS database also provides data on inspections performed by federal and state regulators. Both the PCS database and the EPA Docket database provide data on federal penalties imposed by EPA administrative courts. However, only the EPA Docket database provides data on federal penalties imposed by civil courts. Penalties represent the sum of three penalty components: monetary fines, value of injunctive relief, and value of SEP. (For the chosen sample of facilities and study period, cost-recovery penalties, which are related to remediation, are not imposed.) Accordingly, the study integrates the two databases, while using the Docket database to identify civil penalties.

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[20] For facilities with multiple point/source combinations, the analysis also calculates the maximum level of compliance. Similarly, the analysis also calculates and examines the maximum level if both quantities and concentrations are measured and restricted in the same month for a particular facility. Preliminary estimation of these maximum compliance levels generates results similar to those reported for the average level of compliance.

The U.S. Census Bureau provides information on natural resource-related budgets for local and state agencies.[21] Since all EPA activities are related to natural resources, this study utilizes more specific budgetary information on the Enforcement and Compliance Assistance program within the EPA. However, this information is available only for the EPA regional offices.[22] For the central EPA office, this study uses simply the entire agency budget, as provided by the Office of Management and Budget. The National Council of State Governments provides data on the number of business establishments located in a given state.

Two sources provide data on community characteristics. The U.S. Census database provides data on certain community characteristics at the locale level for 1990 and 2000. The study translates these decennial data into annual data by interpolating between the two endpoints, except for the year 2001, which utilizes data for the year 2000. The Commerce Department Regional Economic Information Service (REIS) database provides data on certain community characteristics at the county level on an annual basis.[23] The specific community characteristics are as follows: (1) voter turnout rate and Democratic voting percentages in available presidential elections, (2) proportion of residents with a bachelor's degree, (3) income per capita, (4) proportion of owner occupied households, (5) unemployment rate, (6) population density, (7) median age, (8) proportion of family households, (9) conditional proportion of family households with children, (10) proportion of non-white residents, (11) proportion of private earnings generated by chemical manufacturing, and (12) proportion of male residents.

The EPA Toxic Release Inventory (TRI) database provides information on a facility's parent company. The Business and Company Resource Center database provides data on a parent company's ownership structure: privately-held or publicly-held. The Compustat / Research Insight database provides annual financial data on publicly-held firms.[24] (Future analysis will additionally

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[21] While consideration of all natural resources may be too wide, data on water pollution control expenditures is not readily available. While the National Council of State Governments provides information on water quality-related budgets for local and state agencies, it is available only for one year – 1996 – of the sample period. (Results generated using this alternative measure are available upon request.) Also, data on state and local natural resource-related budgets are available only for the years 1995 to 1999. The study extrapolates these data to cover the years 2000 and 2001.

[22] EPA regional data exist only for the years 1998 to 2002; the study backward extrapolates these data to cover the years 1995 to 1997.

[23] Thus, the analysis also considers the county as a relevant scale for identifying a "community". This scale arguably also captures an appropriate population whose utility is affected by local water quality that is influenced by a sampled facility's discharges. A smaller scale, such as locale, is certainly useful. However, it may omit people whose utility is affected by local water quality, especially since each facility is a major polluter. A larger scale, such as state regulatory district, would probably include water quality unaffected by the local facility.

[24] In certain cases, the TRI database does not provide data on a facility's parent company for a specific year. The study is still able to identify the parent company in most cases using additional data available in either the PCS or TRI database. As the most useful method, the study uses the parent company from the preceding and succeeding years if the name remains the same. If no parent company name is

consider quarterly financial data.)

All dollar-denominated values are deflated to 1995 levels using the Consumer Price Index.

This study considers different sub-samples when examining different measures of performance and different sets of explanatory factors. First, it considers three types of performance: BOD discharges, TSS discharges, and monthly frequency of effluent limit exceedances across all regulated pollutants. The sample for monthly effluent limit exceedances includes all major chemical facilities for all months across the entire sample period. This broad sample includes 508 facilities that were active at some point over the sample period: January, 1995, to June, 2001.[25] Of these 508 facilities, 456 were active throughout the entire sample period. In contrast, 25 facilities entered the sample at some point after January, 1995, while 27 facilities exited the sample at some point before June, 2001.[26] Although technically possible, no facility is ever temporarily inactive; instead, each exiting facility remains permanently inactive. By including all ever active facilities, the analysis greatly minimizes any survivor bias. Of course, the study cannot eliminate this bias since it must select some starting point. However, any survivor bias is expected to be small since very few facilities exit the sample: attrition represents only 5 % of the overall sample over a relatively long 6.5-year period.

The sub-samples for BOD and TSS discharges are smaller. Even though most major

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reported within the TRI database, the study uses the facility name to match with the Business and Company Resource Center database and Compustat / Research Insight database. The study assumes that a facility name is sufficient to identify a publicly-held firm. Thus, if neither of the databases indicates publicly-held ownership structure, the facility is assumed to be owned by a privately-held firm. In certain cases, the Business and Company Resource Center database does not provide data on ownership structure. For these cases, the study uses the Compustat database to identify ownership structure. By default, the company is publicly-held if found in the Compustat database, and privately-held if not found. Finally, while the TRI and Compustat databases provide annual data for the entire sample period, the Business and Company Resource Center database provides data only starting in 2001. Nevertheless, the study is able to identify changes in ownership structure based on the Compustat database, given the assumption that the Compustat database contains all publicly-held firms. Fortunately, the Business and Company Resource Center database generally indicates changes in ownership during the sample period (1995 to 2001). This history permits the study to search for changes in ownership structure using the annual data reported within the Compustat database. Without this historical information, the study would need to search the Compustat database for each firm and for all years prior to 2001.

[25] The study does apply a few other criteria for inclusion in the sample. Specifically, the study excludes particular types of discharge and certain types of facilities. First, it excludes discharges reported on a non-monthly basis. Without this restriction, it would be very difficult to compare across facilities. This restriction eliminates few relevant observations since practically all major facilities facing effluent limits report their discharges monthly. Second, the study excludes bio-solid (i.e., sludge) discharges. Third, the study excludes industrial users, i.e., facilities that discharge into pre-treatment programs run by publicly-owned treatment works. This restriction eliminates only three major facilities. Together, the latter two restrictions indicate the study's focus on direct discharges into surface water bodies.

[26] The PCS database does not indicate the date of activation. Instead, it indicates only the date of inactivation. Nevertheless, the study identifies the apparent activation date based on the presence of DMR records. Details on this identification are available upon request.

chemical facilities discharge both BOD and TSS, several discharge only one or neither. Therefore, this study considers two separate sub-samples: one for BOD and one for TSS. To remain in each sub-sample, a given facility must discharge the particular pollutant at least once during the seven-year sample period. Based on this restriction, the BOD sub-sample contains 380 facilities and the TSS sub-sample contains 461 facilities.[27] Moreover, not all facilities discharging either BOD or TSS (or both) possess a permit that imposes effluent limits on these specific pollutants. Given the focus on compliance level as a measure of environmental performance, to remain in each sub-sample, a given facility must face an effluent limit for the relevant pollutant in the particular month of discharge. This restriction eliminates 1,832 observations from the BOD sample, dropping its size from 26,172 to 24,340. The same restriction eliminates 3,152 observations from the TSS sample, dropping its size from 32,378 to 29,226.[28]

This study also considers different sub-samples when examining different sets of explanatory factors. It considers all major facilities, when excluding financial status as an explanatory factor, and only major facilities owned by publicly-held firms, when including financial status as an explanatory factor. The second set of facilities represents 63 % of the overall sample.

Section 4 structures the econometric analysis of these collected data, including the creation of measures to capture deterrence. It also interprets the statistical summary of the collected and formatted data. Section 5 displays the analytical results.

4. Econometric Approach

4.1. Regression Framework

This paper analyzes the effectiveness of government interventions and community pressure for inducing better environmental performance. To analyze these effects, consider the following notation. Let Y_{it}^{j} represent the level of environmental performance type *j* for facility *i* in time period *t*, where $j \in \{BOD, TSS, ALL\}$, BOD represents BOD relative discharges, TSS represents TSS relative discharges, and ALL represents the monthly frequency of effluent limit exceedances across all regulated pollutants.[29] This performance level depends on several explanatory variables. With only a few exceptions, which are noted where relevant, this set does not vary across the three types of performance: $j \in \{BOD,TSS,ALL\}$. Therefore, the notation for the explanatory variables does not include the superscript *j*.

To estimate the effects of government interventions on environmental performance, the

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[27] Most facilities discharge both BOD and TSS (N=389). Some discharge only TSS (N=86). Very few discharge only BOD (N=5). And few discharge neither (N=42). Further examination of these various sub-samples is available upon request. Results of a comparison between facilities that rarely discharge a specific pollutant and facilities that almost always discharge is also available upon request.

[28] The PCS database does not provide a record for each month of a facility's existence. The analysis assumes that no missing record includes an operative effluent limit. This assumption is unlikely to generate a selection bias since the absence of a record is driven by poor recordkeeping according to EPA officials.

[29] For BOD and TSS discharges, preliminary analysis also estimates absolute discharge levels and the qualitative state of noncompliance versus compliance using a Probit model (Maddala, 1983). These results are available upon request. The study focuses on the compliance level (i.e., relative discharges) as the primary measure of environmental performance since it is the most comprehensive indicator and captures overcompliance, which is very prevalent in the sample.

analysis must first sort out deterrence. One form of deterrence – specific deterrence – stems from actual interventions at specific facilities. Facilities may be able to respond to actual interventions within the same month of the intervention. In this case, performance and interventions would be simultaneously determined. However, facilities most likely need at least a few weeks, if not several months, to respond to interventions (Magat and Viscusi, 1990; Earnhart, 2004b). Accordingly, the analysis uses lagged, not current, values of interventions as regressors. In the case of inspections, the analysis generates the cumulative count of inspections performed by the state at a specific facility in the preceding 12-month period, denoted as I_{it-12}^{ST}, and generates the similar cumulative count of inspections performed by the EPA, denoted as I_{it-12}^{EPA}. In the case of enforcement, the analysis generates the cumulative count of EPA administrative penalties and conditional mean administrative penalty magnitude imposed against a specific facility in the preceding 12-month period, collectively denoted as P_{it-12}^{ADM}, and generates the cumulative count of federal civil penalties and conditional mean civil penalty magnitude, collectively denoted as P_{it-12}^{CIV}.[30]

By using lagged, not current interventions as regressors, the analysis implicitly claims that performance and interventions are not simultaneously determined.[31] To buttress this claim, the study considers the determination of interventions. While current interventions may depend on current performance, it is highly doubtful that agencies are cognizant of a facility's performance in the very month chosen for an actual intervention. Agencies more likely base their intervention decisions on

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[30] This construction needs elaboration. First, the study chose a period of 12 months for various reasons: (1) major polluters should be inspected once per year, (2) previous studies, such as Laplante and Rilstone (1996) and Earnhart (2004a,b), examine a 12-month period of lagged interventions, and (3) preliminary analysis indicates that other time periods [e.g., 6 and 24 months] generate less significant results. Second, the chosen approach of accumulating interventions is more consistent with reality than the alternative approach of including multiple monthly indicators of lagged interventions (e.g., Magat and Viscusi, 1990). According to EPA officials, regulatory agencies generally induce better performance by repeatedly inspecting polluters. As for enforcement, penalties are sufficiently uncommon as not to warrant multiple indicators. Nevertheless, it seems helpful to accumulate administrative penalties over a 12-month period since administrative penalties appear to be imposed over the course of a time period longer than a month. On average, the number of penalties over a 12-month period is 10 times greater than the number in a single month. In contrast, civil penalties do not accumulate over a 12-month period. At the most, only a single civil penalty is imposed over a 12-month period. Thus, the civil penalty specific deterrence variable serves more as an indicator variable. Moreover, the conditional mean civil penalty magnitude equals the sum of civil penalties for the same period. In this way, the analysis can explicitly interpret the mean magnitude as an interaction between the penalty indicator and penalty sum. The chosen approach of cumulative interventions also retains the explanatory power of potentially multiple inspections within one regressor rather than dissipating the explanatory power across several regressors. The same dissipation of explanatory power may apply to penalties. Nevertheless, future analysis should explore the use of multiple monthly indicators since this approach permits the testing of whether the effects of specific deterrence are persistent (Laplante and Rilstone, 1996).

[31] Within an instrumental variables approach for resolving any potential simultaneity between performance and interventions, lagged interventions serve as highly proper instrumental variables for current interventions since lagged interventions are certainly exogenous with respect to current performance (Laplante and Rilstone, 1996; Magat and Viscusi, 1990). Thus, the assumed connection between lagged interventions and current performance need not be troubling.

past performance since they need time to evaluate performance before responding to it (Magat and Viscusi, 1990). In this case, again, performance and actual interventions are not simultaneously determined. Instead, lagged performance is pre-determined relative to current interventions.

The other form of deterrence – general deterrence – stems from the threat of an intervention. As noted above, the threat divides into its two constituent components: likelihood and conditional burden. Similar to most previous studies of inspections, the analysis assumes that the burden of each inspection does not vary across the facilities (e.g., Earnhart, 2004b; Laplante and Rilstone, 1996; Gray and Deily, 1996; Nadeau, 1997). [Only Helland (1998b) differentiates according to the type of inspection (e.g., performance audit versus compliance evaluation).] Instead, the analysis focuses exclusively on the likelihood of an inspection. The analysis denotes the likelihood of an EPA inspection and a state inspection as IL_{it}^{EPA} and IL_{it}^{ST}, respectively. Unlike similar studies, the analysis allows the conditional burden of each penalty to vary across the facilities (e.g., Earnhart, 2004b; Gray and Deily, 1996; Nadeau, 1997). Thus, the present study considers both components of enforcement-based general deterrence: likelihood and conditional burden. The analysis denotes the likelihood of an EPA administrative penalty as PL_{it}^{ADM} and federal civil penalty as PL_{it}^{CIV}. To capture inspection and penalty likelihoods, the analysis employs a pair of proxies based on the annual aggregate measure of interventions against other similar facilities – major chemical facilities – in the same relevant location (e.g., state) and same time period (Earnhart, 2004b; Nadeau, 1997).[32] One proxy captures the inspection likelihood; the other captures the penalty likelihood. This approach of considering other facilities keeps separate the two deterrence forms. To adjust for differences in the number of major chemical facilities across states or EPA regions and across time, the analysis divides each aggregate count of interventions by the number of other major chemical facilities in each state or EPA region of the given year. When examining the threat of enforcement, the analysis captures the conditional burden component of general deterrence using the conditional mean penalty magnitude imposed against other major chemical facilities in the same EPA region. These conditional mean magnitudes are denoted as PM_{it}^{ADM} and PM_{it}^{CIV} for EPA administrative and federal civil penalties, respectively. Since the mean penalty magnitude is conditional on the imposition of a penalty, no adjustment for the number of major chemical facilities is needed.

These constructed general deterrence measures imply a particular way of understanding a facility's expectations about future regulatory pressure. As constructed, each facility gauges its expectation of monitoring and enforcement based on the observed experience of other similar facilities. By considering annual aggregate measures, the analysis assumes that each facility has fully rational, forward-looking expectations: it perfectly estimates the amount of regulatory pressure over an entire year at the beginning of each year and retains this expectation throughout the year.

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[32] Conversations with EPA officials confirm that aggregate measures of interventions properly proxy the likelihood of an intervention. (They also confirm the expectation that increased likelihoods prompt better facility performance.) Nevertheless, this approach assumes that the likelihood is generic to all similar facilities. Future analysis will attempt to refine the determination of "similar facilities" by expanding the dimensions used to define "similar". Currently, the analysis considers only two-digit SIC code, EPA classification ("major"), location (e.g., state), and time period (i.e., current year). In the case of inspections, the dimension of EPA classification is quite important since the frequency of inspections is dramatically greater at major facilities than at minor facilities, due to a federal guideline to inspect major facilities at least once annually (EPA, 1990).

Certainly, other perspectives on general deterrence expectations exist. Preliminary analysis indicates that use of backward-looking expectations that are updated annually generate similar or worse estimation results. Use of monthly-updated measures are probably overly sensitive to monthly variations in monitoring and enforcement events. Future analysis will consider a 12-month moving window of historical and/or future interventions against other similar facilities (e.g., 6 historical months and 6 future months).

These general deterrence measures should not depend on the particular facility's performance since the interventions are imposed against other facilities. Instead, these interventions should depend on other facilities' performance levels. In addition, it is highly doubtful that one facility's performance depends on other facilities' performance. (Of course, all facilities' performance may depend upon common factors, such as seasons (e.g., treatment may be more difficult in cold weather). As a matter of fact, the general deterrence proxies rely upon factors that are common to all similar facilities. These common factors capture exogenous elements of regulatory pressure: exogenous variation in regulatory pressure across regions / states and time.

In addition to these deterrence measures, other regulatory factors may affect the level of environmental performance. First, the analysis captures variation in regulatory pressure not reflected in the specific and general deterrence measures by including three regressors that separately measure annual budgetary resources expended by state and local agencies (by state), EPA regional offices (by region), and the EPA federal office (for the entire US). Each budgetary measure is adjusted by the number of establishments in each state, region, and country, respectively, for the relevant year (Helland, 1998a). The analysis also includes EPA regional indicators. Second, the analysis includes facility-specific NPDES permit conditions as regressors, which collectively capture certain dimensions of regulatory stringency:

(1) permitted effluent limit level (in pounds/day);
(2) limit type: interim versus final;
(3) magnitude of expiration (in days);
(4) indicator for any modification(s) to NPDES permit after issuance.

For comparability, the analysis converts each concentration limit to a quantity limit using the facility's reported flow of wastewater for the specific month.[33] Limits vary across facilities and time due to variation in effluent guidelines across sub-sectors, seasonal variation for facilities located on certain waterways, and use of water-quality-based standards. To control for seasonal variation, the analysis also includes a set of season indicators. Let G_{it} collectively denote these additional regulatory conditions.

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[33] Generation of this regressor demands elaboration. First, some facilities have multiple points of discharge and/or sources of wastewater generation. For each combination of discharge point and generation source, the analysis identifies the relevant effluent limit and wastewater flow level, converts any concentration limit to a quantity limit using the relevant flow rate, and finally calculates the mean effluent limit across all multiple combinations of points and sources. This approach generates a single observation for each specific facility at a particular moment in time. Second, in certain cases, no monthly measurement of wastewater flow is available. Rather than dropping these observations, the analysis imputes a replacement value based on the following hierarchy depending on data availability: (1) facility-specific annual average flow, (2) facility-specific sample average flow, and (3) sample-wide average flow. This imputation affects only 0.04 % of the TSS sample and 0.9 % of the BOD sample.

In addition to regulatory pressure, community pressure may also affect corporate environmental performance. The analysis measures community pressure indirectly using the following key community characteristics:

(1) local labor market condition, as measured by the unemployment rate,

(2) political engagement, as measured by the voter turnout rate;

(3) political proclivity, as measured by the percent of Democratic voters in Presidential elections;

(4) intellectual sophistication (or educational attainment), as measured by the proportion of residents with at least a bachelor's degree;

(5) community size, as measured by the population density level;

(6) community attachment, as measured by these two characteristics:

 (a) the proportion of owner occupied households, and

 (b) median age;

(7) health concerns, as measured by these three characteristics:

 (a) proportion of family households,

 (b) proportion of family households with children, and

 (c) proportion of male residents;

(8) wealth, as measured by per capita income;

(9) dependency on chemical manufacturing, as measured by proportion of private earnings generated by chemical production;[34] and

(10) racial composition, as measured by proportion of non-white residents.

Let C_{it} collectively denote these community characteristics.

Exploration of the connection between community characteristics and wastewater discharges may not capture properly the effect of community pressure because both facility and household location decisions potentially generate endogeneity problems. First, a firm that wants to build a new facility is more likely to choose a location that is more receptive to high pollution facilities (i.e., lower expected community pressure); this receptivity may be correlated with identifiable socioeconomic factors. Second, people who choose to live in a neighborhood near an existing polluter are more likely to have a higher tolerance for pollution. Similarly, once a polluter has located at a specific site, lowered property values may prompt individual households to leave or enter the affected community. Again, this tolerance and the re-location choices may be correlated with identifiable socioeconomic factors. In general, it is difficult to avoid these endogeneity

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[34] The REIS database does not provide data on private earnings generated by chemical manufacturing when these data would permit the identification of individual facilities. Rather than omitting these observations lacking data, thus introducing a potentially strong bias, the analysis imputes replacement values according to the following hierarchy based on availability: (1) facility-specific mean over the entire sample period, (2) state-wide mean for the relevant year, i.e., state within which the facility resides, and (3) sample-wide mean for the relevant year. This imputation affects roughly 20 % of the sample. However, the imputation rarely draws upon the sample-wide mean (<0.1 % of the sample). Instead, 7 % of the sample uses imputed values based on facility-specific means and 14 % of the sample uses imputed values based on state-year specific means. The former imputation serves as a good proxy if chemical production for a given locale varies little over time. The latter imputation serves as good proxy if chemical production varies little across space within a given state.

concerns. Nevertheless, the econometric analysis attempts to mute these concerns by employing a fixed effects model when estimating the panel data of environmental performance. In this way, the analysis controls for inherently "dirty" or "clean" facilities, reducing any potential omitted variable biases associated with the effects of community characteristics.[35]

The level of environmental performance also depends on factors besides external pressure. In particular, it depends on firm-level characteristics: (1) financial status, as measured by annual revenues and the rate of return on assets, which represents the ratio of net income to total assets; and (2) ownership structure indicators: privately-held and publicly-held. When examining the link from financial status to environmental performance, the analysis avoids using current financial status, since contemporaneous financial status and environmental performance are most likely jointly determined. Instead, the analysis uses lagged financial status, which is considered as predetermined (Lizal and Svejnar, 2002a,b; Earnhart and Lizal, 2003). Thus, lagging financial status avoids any endogeneity problem (Austin et al., 1999). Moreover, one would expect a lag between the generation of financial resources and the ability to invest in ways of reducing wastewater discharges.

Similar to firm-level characteristics, environmental performance most likely depends on facility-level characteristics:

(1) flow capacity, as measured by the average flow of wastewater over the preceding 12-month period (millions of gallons / day);[36]
(2) marginal compliance costs, as proxied by the ratio of actual wastewater flow to flow capacity (Helland, 1998a);
(3) stochasticity of wastewater discharges, as measured by the standard deviation of BOD or TSS relative emissions over a current calendar year;[37] and
(4) industrial sub-sector indicators (Table 1.b provides a full listing).

According to Brännland and Löfgren (1996), as discharge variability rises, facilities may choose to increase their compliance level (i.e., decrease level of relative emissions). Let F_{it} collectively denote

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[35] Future analysis will attempt to avoid this endogeneity concern by estimating the effects of current community characteristic levels on subsequent changes in performance levels, e.g., the effect of 1995 community characteristic levels on the change in performance levels between 1995 and 1996 (Brooks and Sethi, 1997). This future analysis will consider several starting points (e.g., 1995, 1996, 1997) and several time frames for calculating performance changes (e.g., one-year change between 1995 and 1996, two-year change between 1995 and 1997).

[36] In certain cases, no monthly measurement of wastewater flow is available. Rather than dropping these observations, the analysis imputes a replacement value based on the following hierarchy depending on data availability: (1) facility-specific annual average flow, (2) facility-specific sample average flow, and (3) sample-wide average flow. This imputation affects less than 3 % of the sample. As a check for robustness, analysis estimates only those observations with available data on wastewater flow. The estimation results are highly similar to the reported results.

[37] Preliminary analysis also uses standard deviations of absolute discharge levels to measure stochasticity. The estimation results are roughly similar to those reported.

these firm- and facility-level characteristics.[38]

Lastly, the analysis interacts the various measures of specific and general deterrence with the firm- and facility-specific regressors. These interactions help to indicate whether different types of facilities or facilities facing different corporate conditions respond differently to government interventions. Let X_{it} collectively denote these interactions.

The following regression equation captures the functional relationship between environmental performance and the noted explanatory variables, especially regulatory and community pressure:

$$f(Y_{it}^{j})=\beta^{EPA} I_{it-12}^{EPA} + \beta^{ST} I_{it-12}^{ST} + \beta^{ADM} P_{it-12}^{ADM} + \beta^{CIV} P_{it-12}^{CIV} + \Omega^{EPA} IL_{it}^{EPA} + \Omega^{ST} IL_{it}^{ST} + \psi^{ADM}PL_{it}^{ADM} + \psi^{CIV}PL_{it}^{CIV} + \psi^{ADM}PM_{it}^{ADM} + \psi^{CIV}PM_{it}^{CIV} + \eta^{G}G_{it} + \eta^{C}C_{it} + \eta^{F}F_{it} + \eta^{X}X_{it} + \sigma \lambda_{it} + \varepsilon_{Yitj} , \quad (1)$$

where ε_{Yitj} represents the error term and λ_{it}^{j} represents the inverse Mills ratio associated with BOD and TSS relative emissions [$j\in\{BOD,TSS\}$], which is defined in the immediately following paragraph. When estimating BOD and TSS relative emissions (i.e., *j*=BOD,TSS), the analysis employs a semilog specification: $f(Y_{it}^{j})=\ln(Y_{it}^{j})$[39]. When estimating the monthly frequency of effluent limit exceedances (i.e., *j*=ALL), the analysis employs a linear specification: $f(Y_{it}^{j})=Y_{it}^{j}$.

Before estimating environmental performance, the econometric analysis must first address the fact that facilities do not always submit discharge monitoring reports with measured discharges, even though federal regulations require their monthly submission. This concern does not apply to effluent limit exceedances since only a handful of observations indicate the failure to submit a discharge monitoring report with information on limit exceedances. From the BOD sample, 225 of the 24,340 observations lack data on measured discharges; from the TSS sample, 252 of the 29,226 observations lack data on measured discharges. Thus, any bias introduced by the failure to report

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[38] Previous studies of environmental performance explore two other characteristics. First, some previous studies using panel data include the lagged dependent variable as a regressor (e.g., Earnhart, 2004b). This regressor may capture potential inertia in the treatment process. This inertia most likely stems from the use of fixed control equipment, whose installation generally requires time (Laplante and Rilstone, 1996). Consequently, the regressor may provide information on the facility's stock of pollution control capital and the general character of its abatement technology (Magat and Viscusi, 1990). However, inclusion of the lagged dependent variable as a regressor greatly complicates the use of panel data models. Fortunately, inclusion of facility-specific constants in the fixed effects model may more adequately control for the general character of a facility's abatement technology if it varies little over time. Second, some previous studies include the production price index for the identified sector, chemical manufacturing in this case, as a regressor that attempts to control for variation in the opportunity cost of any production reductions prompted by efforts to improve environmental performance (Shimshack and Ward, 2003; Helland, 1998a). The study has obtained this information and generated this regressor. Future analysis will include this regressor.

[39] This paper also estimates a linear specification for BOD and TSS relative discharges. Based on a goodness-of-fit measure – adjusted R^2 – and the prevalence of significant coefficients, the analysis focuses on the semilog specification as the better model. The use of log values for the dependent variable also minimizes the effect of outliers (Gray and Deily, 1996; Earnhart, 2004b).

discharge measurements may be quite small.[40] To address the non-reporting of discharges data, the study uses a Heckman correction procedure to adjust for any potential sample selection bias (Heckman, 1979; Earnhart, 2004b). As the first step in this procedure, the analysis estimates a probit model of the facility's decisions to report monthly discharges. Let R_{it} indicate the decision of facility *i* to report discharges in time period *t*. Let K_{it} indicate the set of explanatory variables. Equation (2) captures this reporting relationship:

$$R_{it} = \theta K_{it} + \varepsilon_{Rit} , \qquad (2)$$

where ε_{Rit} represents the error term for equation (2). This estimation generates useful results. For BOD reporting, roughly two-thirds of the slope coefficients are statistically significant at the 10 % level; in particular, flow capacity and general deterrence strongly affect the BOD reporting decision. For TSS reporting, roughly three-fourths of the slope coefficients are statistically significant at the 10 % level; in particular, industrial sector classification and state inspection-related specific deterrence strongly affect the TSS reporting decision. [Further details on this estimation are available upon request.[41]] As the second step of this procedure, the analysis uses the estimated probit coefficients and associated variables to generate an inverse Mills ratio, λ_{it}, for each observation with reported emissions. This ratio serves as the correction term for sample selection in the third step of the procedure, which involves estimation of reported relative discharges, shown in equation (1). The inverse Mills ratios are computed for BOD and TSS discharges and included as regressors in the environmental performance equations for BOD and TSS relative discharges.

The study estimates the three performance equations using the following three econometric regression models: pooled ordinary least squares (OLS), fixed effects, and random effects (Hsiao, 1986). The latter two models are standard panel data models. Each specific panel data model stems from a more general model that captures differences across the various polluters by incorporating an individual term for each facility. If this facility-specific term is uncorrelated with the other regressors in equation (1), then the random effects model is appropriate. The random effects model captures differences across the various polluters by including a random disturbance term that remains constant through time and captures the effects of excluded factors specific to each facility. If the facility-specific term is correlated with the other regressors in equation (1), then the fixed effects model is appropriate. The fixed effects model captures differences across the various polluters by estimating an individual constant term for each polluter. (Note that use of this model eliminates the ability to estimate a coefficient for any time-invariant regressor; the analysis considers two time-invariant regressors, EPA region and industrial sub-sector; nevertheless, the fixed effects

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[40] Self-monitoring is the most important source of information utilized by state and federal regulators to assess environmental performance (EPA, 1990). Although facilities may have incentives to under-report emissions, stiff sanctions for false reports, including incarceration (Shimshack and Ward, 2003) and periodic inspections provide countervailing incentives to report honestly (Magat and Viscusi, 1990).

[41] The analysis uses a two-stage estimation process for estimating the reporting decision and performance levels. The nonlinearity of the probit model is sufficient for identifying the two related equations (Greene, 1997). Nevertheless, to help identify these two related equations, the probit equation for the reporting decision excludes certain variables that relate to performance and includes certain variables not related to performance (e.g., preceding 12-month average of BOD mass loadings). A likelihood ratio test statistic confirms that the excluded variables are jointly significant only at levels greater than 10 %.

model indirectly captures the effect of industrial sub-sector when it is interacted with deterrence measures.) The analysis uses an F-test of fixed effects to discern whether the fixed effects model dominates the pooled OLS model, i.e, the F-test rejects the null hypothesis of no fixed effects. The analysis uses the Hausman test of random effects to evaluate whether the estimation can use the more efficient random estimates or whether these estimates are inconsistent when compared to the fixed effects. When the Hausman test signals that the random effects estimator is consistent with the fixed effects estimator, the random effects estimator is preferable since it is more efficient by construction.[42] Unlike the BOD- and TSS-related performance measures, the monthly frequency of effluent limit exceedances need not represent a continuous variable; instead, this measure represents integer or count data. Accordingly, the study also estimates this third performance equation using a count data model, namely the Poisson model (Greene, 1997).[43] Since least squares regression generates consistent results from count data (Greene, 1997) and the use of a Poisson model generates estimation results sufficiently similar to the reported results, the current paper does not provide the Poisson results. Moreover, attempts to adjust for the panel data structure by incorporating fixed effects into the Poisson model did not generate convergence. Future analysis will more strongly focus on the estimation of these count data. Lastly, estimation of this third performance measure omits certain regressors since they are not available or relevant for effluent limit exceedances: (1) permitted effluent limit level and (2) stochasticity of relative wastewater discharge level. Besides effluent limit, other permit conditions – limit type, expiration, and modifications – apply equally to all regulated pollutants with minor exceptions.

4.2. Statistical Summary of Regression Variables

Table 1 provides statistical summaries of the formulated dependent variables and regressors. These summaries draw upon the samples used for the regression analysis. First, Table 1.a summarizes the environmental performance measures. Facilities on average exceed 0.31 of their limits in a given month. Consistent with this small average, facilities do not exceed a single limit in 79 % of the months (not shown in Table 1.a). Facilities on average generate BOD discharges that are 82 % below their BOD monthly limit. This figure indicates a need to analyze the degree of compliance rather than the status of compliance. At the other end, BOD discharges surge as high as 952 % above the permitted limits. This figure indicates a need to analyze the degree of <u>non</u>compliance rather than the status of noncompliance. The comparable figures lead to the same two conclusions: on average, TSS discharges are 78 % below permitted limits, yet they surge as high

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[42] Future analysis will jointly estimate BOD- and TSS-related environmental performance using a seemingly unrelated regression (SUR) approach, which improves the efficiency of the coefficient estimates and permits proper testing of differences between BOD- and TSS-related coefficients (Greene, 1997). The current paper does not provide this SUR estimation since implementation requires a sub-sample restricted to observations with <u>both</u> BOD and TSS relative discharges. The current paper seeks to examine the broadest set of facilities.

[43] Preliminary analysis also attempts to use a negative binomial model with limited success. Future analysis will refine the use of this alternative model.

as 887 % above the permitted limits.[44]

Second, Table 1.b summarizes the regressors common to all measures of environmental performance, while excluding financial-related regressors. This summary includes information on inspections and penalties.[45] It also includes information on community characteristics. The average community contains about 685 people per square mile, provides at least a bachelor' degree to about 18 % of its residents, voted for the democratic presidential candidate at a 47 % rate, enjoys nearly $ 22,600 in income per person, and endures a 5.3 % unemployment rate.

Third, Table 1.c summarizes the financial-related regressors.

Fourth, Tables 1.d and 1.e summarize the regressors unique to BOD and TSS, respectively. These regressors mostly relate to permit conditions. Facilities face interim limits about 2 % of the time. Facilities possess expired permits for 197 days on average. The mean BOD discharge limit is roughly 800 pounds per day. The mean TSS discharge limit is roughly 1,280 pounds per day. Both BOD and TSS discharge limits vary across facilities, across years, and within years.[46] This variation confirms the need to examine relative discharges, rather than simply absolute discharges.

5. Estimation Results

5.1. Organization of Results

Finally, the analysis estimates the three environmental performance equations, one for each type of performance. Initially, the analysis omits financial status as a regressor, in order to examine all relevant facilities. In the second-to-last sub-section of this section, the analysis includes financial status as a regressor, with and without its interaction with deterrence measures, while examining the sub-sample of facilities owned by publicly-held firms. Since the regressor list includes various measures based on a preceding 12-month period, e.g., cumulative EPA inspections, or preceding calendar year, e.g., annual revenues, the regression sample period starts on January, 1996. Consequently, the sample sizes drop to 20,398 for BOD discharges, to 23,228 for TSS discharges, and to 32,109 for limit exceedances. To test the differences between pairs of intervention types (e.g., administrative penalties vs civil penalties), the analysis considers an econometric specification that omits the interactions between deterrence measures and facility/firm characteristics. Inclusion of these interactions complicates this testing of differences because the effect of each intervention type depends on facility/firm characteristics. (Future analysis will transform the facility/firm characteristics in order to facilitate the comparison of intervention types based on a specification that includes the noted interactions.) To test differences across facilities' responsiveness to deterrence,

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[44] When estimating relative discharges, the analysis deletes a handful of observations that indicate BOD or TSS relative discharge levels greater than 10, i.e., discharges exceed the permitted limit by more than 900 %, since the regression analysis is sensitive to outliers.

[45] A few penalties do not impose a positively-valued sanction. These zero values are incorporated into the conditional mean associated with penalty magnitudes. Preliminary analysis attempted to discern zero-value penalties from positive-value penalties. This effort did not seem to improve the analytical ability to understand facilities' responses to the imposition of penalties. Future analysis will hope to refine this effort.

[46] According to government officials, BOD limits are sometimes lowered to address ambient surface water quality concerns associated with dissolved oxygen. A similar logic applies to TSS limits.

the analysis considers a second specification that includes the interactions between deterrence measures and facility/firm characteristics.

As noted above, the analysis uses three econometric models – pooled OLS, random effects, and fixed effects – and uses standard tests to assess these models. When an F-test indicates significant facility-specific effects, the fixed effects estimator dominates pooled OLS. Since this dominance always holds, the study only reports the pooled OLS estimates for the sake of comparison. When the Hausman test signals that the random effects estimator is consistent with the fixed effects estimator, the random effects estimator is preferable to the fixed effects estimator since it is more efficient by construction.

5.2. Omit Financial Variables and Deterrence Interactions: Interpret Effects of Deterrence

Initially, the estimation omits both the financial variables and the deterrence interactions. Estimation results for BOD relative discharges, TSS relative discharges, and monthly limit exceedances are shown in Tables 2,3 and 4, respectively. As the first performance measure, this section interprets the results for BOD relative discharges. Based on the F-test of facility-specific fixed effects, the fixed effects estimator dominates the pooled OLS estimator, and based on the Hausman test of fixed effects, the fixed effects estimator dominates the random effects estimator, as shown in Table 2. Thus, this study focuses on the results of the fixed effects model. Also, the insignificant coefficient associated with the inverse Mills ratio indicates that the Heckman two-step method is not needed to correct a selection bias associated with the reporting of BOD discharges, as shown in Table 2.

More important, the results shown in Table 2 indicate that both specific and general deterrence affect BOD relative discharges. Consider inspection-related deterrence. The significantly negative effect of preceding 12-month cumulative EPA inspections indicates that greater federal presence on site at specific facilities improves performance. The effect of specific deterrence from state inspections is insignificant. While the effect of state aggregate inspections is significantly positive, the effect of EPA aggregate inspections is insignificant. Thus, the threat of neither federal nor state inspections prompts better environmental performance.[47] Consider also penalty-related deterrence. While the significantly positive effect of preceding 12-month cumulative administrative penalties indicates that an increase in the number of administrative penalties against specific facilities undermines performance, the significantly negative effect of the preceding 12-month average administrative penalty magnitude indicates that a larger administrative penalty improves performance. The estimated effects for civil penalties indicate the opposite conclusion: more civil penalties improve performance, while a larger civil penalty undermines performance. The opposite results for the count of administrative penalties and civil penalties may be explained by the much lesser prevalence of civil penalties. Accordingly, facilities might respond more strongly to an increase in a less frequently-imposed sanction. As for penalty-related general deterrence, the effect of average number of administrative penalties against other similar facilities is significantly positive, while the effect of the average administrative penalty magnitude against

[47] The economic theory of regulation may help to explain this unexpected result for KDHE aggregate inspections. Kambhu (1989) and Kadambe and Segerson (1998) argue that increased regulatory scrutiny may generate an indirect effect on polluters' performance by prompting them to evade scrutiny more strongly. This indirect effect mitigates the direct effect of increased scrutiny on polluters' performance. Thus, the overall effect of an increased inspection threat on facility performance may be negative.

other similar facilities is insignificant. In contrast, the effect of average number of civil penalties against other facilities is insignificant, while the effect of the average civil penalty against other facilities is significantly negative. These last four results indicate that the threat of more administrative penalties undermines performance, while the threat of larger civil penalties improves performance. In sum, these results indicate a mixed degree of effectiveness for interventions and intervention threats in terms of both inspections and penalties.

As the second performance measure, this section interprets the deterrence-related results for TSS relative discharges, as shown in Table 3. Based on the F-test of facility-specific fixed effects, the fixed effects estimator dominates the pooled OLS estimator, and based on the Hausman test of fixed effects, the random effects estimator dominates the fixed effects estimator, however, this dominance is only marginal (i.e., the Hausman test only marginally rejects the null hypothesis of consistent estimates). Consistent with this marginal dominance, the random effects and fixed effects estimation results are quite similar. Thus, this study considers the results of both the random and fixed effects models even though the conclusions are identical. Also, the significant coefficient associated with the inverse Mills ratio indicates that the Heckman two-step method is needed to correct a selection bias associated with the reporting of TSS discharges, as shown in Table 3.

Similar to the BOD results, the TSS estimation results indicate that deterrence affects performance. First, both specific and general deterrence stemming from state inspections significantly improves performance. Specific deterrence stemming from neither administrative nor civil penalties affects performance. General deterrence stemming from the number of administrative penalties undermines performance, while general stemming from the average administrative penalty magnitude improves performance. Lastly, general deterrence stemming from the average civil penalty magnitude improves performance. Again, in sum, these results indicate a mixed degree of effectiveness for specific and general deterrence stemming from both inspections and penalties.

As the third performance measures, this section interprets the deterrence-related results for limit exceedances. Based on the F-test of facility-specific fixed effects, the fixed effects estimator dominates the pooled OLS estimator, and based on the Hausman test of fixed effects, the random effects estimator dominates the fixed effects estimator, however, this dominance is only marginal (i.e., the Hausman test only marginally rejects the null hypothesis of consistent estimates). Consistent with this marginal dominance, the random effects and fixed effects estimation results are similar in general. Thus, this study considers the results of both the random and fixed effects models even though the conclusions are nearly identical. Of the inspection-related effects, only general deterrence stemming from state inspections significantly affects performance, oddly enough, it undermines performance. Of the penalty-related effects, only two are significant. Specific deterrence stemming the number of administrative penalties undermines performance, yet specific deterrence stemming the average administrative penalty magnitude improves performance. Again, in sum, the results are mixed.

The interpretation of these results fulfills the first two specific objectives of the primary broad objective: (1) to identify the effects of actual government interventions – specific deterrence – on environmental performance, and (2) to identify the effects of intervention threats – general deterrence – on environmental performance.

5.3. Comparison of Interventions based on their Source

The third objective seeks to compare the effects of specific and general deterrence based on the source of the intervention. For inspections, the study compares state and federal inspectors; for penalties, it compares EPA administrative courts and federal civil courts. Put differently, the analysis tests the difference between the effect of federal inspections and the effect of state inspections on facility performance (i.e., difference between federal and state coefficients). It also tests the difference between the effects of EPA administrative penalties and the effects of federal civil penalties. The analysis tests these differences using F-tests, which pose a null hypothesis of equal effects, as shown in Table 5. The testing uses the estimation results of the fixed effects model for BOD discharges and the random effects model for TSS discharges and limit exceedances. As noted above, these estimation results stem from a regression model that omits the interactions between deterrence measures and facility/firm characteristics, omits the financial regressors, and uses the sample of all relevant facilities regardless of ownership structure. Examine first the difference between federal inspections and state inspections. And consider first the specific deterrence measures. Based on BOD results, the effect of actual federal inspections at a specific facility is negative, while the effect of actual state inspections is insignificant; moreover, the difference between the two effects is significant, as shown in Table 5. Thus, specific deterrence stemming from EPA inspections is more effective at improving performance than specific deterrence stemming from state inspections. However, TSS results generate the opposite conclusion: actual state inspections against specific facilities more effectively improve performance than do EPA inspections. Results for limit exceedances indicate no significant difference between the two inspection-related specific deterrence effects. Consider second the general deterrence measures. The results of all three performance measures indicate the same conclusion: no significant difference exists between EPA inspection-related general deterrence and state inspection-related general deterrence. These results are consistent with the expectation that actual federal inspections against specific facilities improve facility performance more strongly than do actual state inspections. However, these results do not support the same expectation for the threat of inspections.

Examine second the difference between EPA administrative and federal civil penalties. Consider first specific deterrence measures. The BOD results indicate that an increase in the number of civil penalties improves performance more greatly than does an increase in the number of administrative penalties, while an increase in the average administrative penalty magnitude improves performance more greatly than does an increase in the average civil penalty magnitude. The TSS results and exceedances results indicate no significant differences. The same conclusions apply for general deterrence measures. These results, at least the BOD results, are consistent with the expectation that specific and general deterrence stemming from civil penalties, at least their frequency, improves facility performance more strongly than does deterrence stemming from administrative penalties. This difference may support the conjecture that involvement on the part of the Department of Justice implies greater scrutiny. However, the same BOD results indicate the completely opposite conclusion in terms of the average penalty magnitude. This study must analyze more fully this apparent contradiction.

5.4. Effects of Facility and Firm Characteristics

The fourth and fifth specific objectives of the primary broad objective seeks to identify the effects of facility- and firm-level characteristics on environmental performance. To capture the effect of firm-level financial status, the study must limit itself to facilities owned by publicly-held firms. As noted above, the final sub-section of this section estimates that effect.

This sub-section interprets the results for the other characteristics. First, facilities owned by publicly-held firms significantly outperform facilities owned by privately-held firms, according to

BOD results. No significant effect is indicated by the TSS or limit exceedances results. Second, environmental performance in general does not depend on the type of production as captured by the industrial sub-sector. Within the TSS results, only one individual sub-sector generates a statistically significant coefficient. Within the limit exceedances results, no relevant coefficients are significant. The BOD results cannot generate these coefficients since the industrial sub-sector indicator is time-invariant and the fixed effects model is the dominant model, i.e., neither pooled OLS nor the random effects model generates consistent estimates. Third, the highly positive effect of flow capacity indicates that larger facilities underperform smaller facilities; i.e., pollution treatment involves diseconomies of scale. (The effects on BOD and TSS relative discharges are highly significant; the effect on limit exceedances is not significant.) Regulators should evaluate the monitoring and enforcement pressure placed on larger facilities given these highly significant results. Fourth, the significantly positive effect of the flow to flow capacity ratio on TSS relative discharges indicates that facilities facing higher marginal compliance costs increase their relative discharges, given the interpretation that the flow to flow capacity ratio proxies for marginal compliance costs. The effects of this proxy on BOD relative discharges and limit exceedances are insignificant. Fifth, an increase in the stochasticity of wastewater discharges significantly undermines performance in terms of BOD and TSS discharges. According to Brännland and Löfgren (1996), as discharge variability rises, facilities may choose to increase their mean compliance level (i.e., decrease their average level of relative discharges). However, these results indicate that a facility may not be able to separate its mean level of discharges and the deviation about this mean level.

5.5. Interactions between Deterrence Measures and Facility/Firm Characteristics

The sixth specific objective of the primary objective seeks to identify the interactions between both facility-level and firm-level characteristics and the effects of both specific and general deterrence. This objective seeks to learn whether different types of facilities or facilities facing different corporate conditions respond differently to government interventions. In other words, the analysis tests whether the effects of deterrence differ according to facility- or firm-level characteristics. To test for these differences, the analysis interprets the results of the second specification, which includes the interactions between deterrence measures and facility- and firm-level characteristics. In particular, the analysis assesses whether the coefficients on interactive terms are significantly different from zero.

As noted above, civil penalties are imposed much less frequently than are administrative penalties. As a matter of fact, the imposition of civil penalties is not sufficiently frequent to permit the interaction between civil penalty-related deterrence and facility/firm characteristics. Consequently, the analysis is only able to estimate the interactive terms between (1) inspection-related deterrence and administrative penalty-related deterrence and (2) facility- and firm-level characteristics.

For each performance measure, based on the F-test of facility-specific fixed effects, the fixed effects estimator dominates the pooled OLS estimator, and based on the Hausman test of fixed effects, the random effects estimator dominates the fixed effects estimator. (These F-test and Hausman test results are available upon request.) Accordingly, the analysis focus its interpretation on estimation results from the random effects model for each performance measure. Rather than reporting the estimation results from the numerous individual interactive terms, Table 6 reports the results from F-tests that discern whether a particular set of interactive terms collectively differ from zero. (Needless to say, complete regression results are available upon request.) The analysis considers the following sets of interactive terms:

(1) ownership structure;
(2) industrial sub-sectors; and
(3) flow capacity, flow to flow capacity ratio, and stochasticity of discharges.

Moreover, these sets are divided into four sub-sets:

(1) inspection-related specific deterrence,
(2) inspection-related general deterrence,
(3) administrative penalty-related specific deterrence, and
(4) administrative penalty-related general deterrence.

Thus, Table 6 reports twelve F-test results for each performance measure.

These F-test results generate the following conclusions. First, both specific and general deterrence stemming from both inspections and administrative penalties depend on the ownership structure of the firm owning the relevant facility. This conclusion applies to all three performance measures. For example, in terms of BOD relative discharges, facilities owned by publicly-held firms respond more strongly to specific deterrence stemming from state inspections than do facilities owned by privately-held firms. In contrast, facilities owned by publicly-held firms respond less strongly to specific deterrence stemming from the number of administrative penalties than do facilities owned by privately-held firms, in terms of BOD relative discharges. Second, both specific and general deterrence stemming from both inspections and administrative penalties depend on the facility's industrial sub-sector. This conclusion applies to all three performance measures. For example, in terms of BOD relative discharges, facilities producing industrial organic chemicals respond less strongly to general deterrence stemming from federal inspections than do facilities producing "other types of chemicals". In contrast, facilities producing industrial organic chemicals respond more strongly to specific deterrence stemming from the number of administrative penalties than do facilities producing "other types of chemicals", in terms of BOD relative discharges. Third, both specific and general deterrence stemming from both inspections and administrative penalties depend on the facility's characteristics other than industrial sub-sector, such as flow capacity. This conclusion applies to all three performance measures. For example, in terms of BOD relative discharges, larger facilities, as measured by their flow capacity, respond less strongly to specific deterrence stemming from federal inspections than do smaller facilities. In contrast, larger facilities respond more strongly to general deterrence stemming from the average administrative penalty magnitude than do smaller facilities, in terms of BOD relative discharges.

5.6. Sample of Facilities Owned by Publicly-Held Firms

The two preceding sub-sections examine all of the facility- and firm-level characteristics except firm-level financial status. This sub-section examine financial status by considering the sub-sample of facilities owned by publicly-held firms, while incorporating financial status as a regressor in the estimation process. This sub-section considers the two noted specifications: (1) excluding and (2) including interactions between deterrence measures and facility/firm characteristics. First, the analysis examines the effect of financial status on the three performance types. Second, it examines the interaction between financial status and deterrence measures based on the second specification.

Table 7 reports the estimation results from the first specification. It reports the results of the F-test for Fixed Effects and Hausman Test for Random Effects, along with adjusted R-squared values. Based on the results for the two aforementioned tests, the fixed effects model dominates for BOD relative discharges, while the random effects model dominates for both TSS relative discharges and monthly limit exceedances. Rather than reporting the coefficient estimates for each model, Table 7 reports only the coefficients from the dominant model. Moreover, Table 7 reports only the coefficients related to financial status: annual revenues and return on assets. First, regardless of performance measure, the effect of lagged annual revenues is negative. While this negative effect is never significant, it is almost marginally significant for TSS relative discharges and limit exceedances. If truly significant, the estimated effects would indicate that a greater flow of cash may help to improve subsequent environmental performance, perhaps by helping to alleviate any liquidity constraint facing firms who wish to invest in better environmental management techniques. Second, increases in the (lagged) return on assets significantly undermine subsequent environmental performance in terms of BOD and TSS relative discharges. (The effect on all limit exceedances is insignificant.) This effect indicates that current financial success, as measured by a more healthy profit stream relative to total assets, actually impedes future environmental success.

Next, the analysis examines the interaction between financial status and deterrence measures based on the second specification noted above. Again, the imposition of civil penalties is not sufficiently frequent to permit the interaction between civil penalty-related deterrence and firm-level characteristics. Consequently, the analysis is only able to estimate the interactive terms between (1) inspection-related deterrence and administrative penalty-related deterrence and (2) firm-level financial status. Rather than reporting the estimation results from the several individual interactive terms related to the two dimensions of financial status, Table 6 reports the results from F-tests that discern whether a particular set of interactive terms collectively differ from zero. (Complete regression results are available upon request.) The analysis considers the following sets:

(1) inspection-related specific deterrence,
(2) inspection-related general deterrence,
(3) administrative penalty-related specific deterrence, and
(4) administrative penalty-related general deterrence.

As shown in Table 6, both specific and general deterrence stemming from both inspections and administrative penalties depend on the financial status of the firm owning the relevant facility. This conclusion applies mostly to BOD and TSS relative discharges. Based on BOD discharges, all four types of deterrence depend on financial status. For TSS discharges, only general deterrence stemming from inspections does <u>not</u> depend on financial status. For all limit exceedances, only specific deterrence stemming from inspections depend on financial status. Although not shown in Table 6, the estimated sign and statistical significance of individual interactive coefficients reveal the following examples. In terms of BOD relative discharges, facilities owned by firms enjoying a larger revenue flow respond more strongly to specific deterrence stemming from federal inspections than do facilities owned by firms suffering a smaller revenue flow. In contrast, based on TSS relative discharges, facilities owned by firms enjoying a greater return on assets respond less strongly to general deterrence stemming from the number of administrative penalties than do facilities owned by firms suffering a lesser return on assets.

5.7. Effects of Community Characteristics

Finally, the analysis examines the effects of community pressure on environmental performance by interpreting the estimated effects of key community characteristics. The study draws upon the regression results generated without interactions between deterrence measures and facility/firm characteristics and based on the sample of all relevant facilities regardless of ownership structure. Moreover, as noted above, use of a fixed effects model helps to avoid endogeneity concerns between facility and household location decisions. Thus, the analysis interprets only the fixed effects estimates regardless of the identified dominant model. These estimates are shown in Tables 2, 3 and 4.

These conclusions follow. First, communities suffering higher unemployment rates fortunately enjoy better environmental performance. This estimate effect runs counter to an expectation that communities distracted by unemployment would not be motivated to pressure local facilities for better environmental performance. Second, communities that vote more often suffer worse BOD-related performance, while enjoying better TSS-related performance (the latter effect is only marginally significant with a p-value of 0.11). The latter effect is consistent with the expectation that more politically engaged communities will more effectively pressure facilities for better performance. Third, communities that vote more greatly for Democratic presidential candidates enjoy better environmental performance. This result is consistent with a potential expectation that Democratic voters care more about environmental protection. Fourth, more sophisticated communities, as measured by their educational attainment, suffer worse BOD-related and exceedance-related performance. This result runs contrary to an expectation that better educated communities would more effectively pressure facilities for better performance. Fifth, more rural communities, as measured by population density, enjoy better BOD-related performance, while urban communities enjoy better TSS-related performance. The latter effect is consistent with a potential expectation that more densely populated communities might be better to mobilize pressure against local facilities. Sixth, communities consisting of more homeowners suffer worse BOD-related performance, while enjoying better TSS-related performance. The latter effect is consistent with the expectation that homeowners are more attached to their communities, thus, more willing to pressure facilities for better performance. Median age also proxies for community attachment. Older communities enjoy both better BOD- and TSS-related performance. The latter effect is consistent with the similar effect of homeownership. However, older communities suffer worse exceedance-related performance. Seventh, communities with more families suffer worse TSS-related performance. This results runs counter to the expectation that families care more about the health concerns associated with water pollution. Consistent with this contrary result, communities with more families containing children suffer worse BOD- and exceedance-related performance. In contrast, communities with more families containing children enjoy better TSS-related performance. Thus, an increase in the proportion of families increases TSS relative discharges, but a shift in this proportion towards families with children actually decreases TSS relative discharges. The proportion of male residents has no effect on any performance measures. Eighth, more wealthy communities enjoy better BOD- and TSS-related performance, while suffering worse exceedance-related performance. The former two effects are consistent with the expectation that environmental quality is a normal good; as income rises, residents demand better environmental performance from their local facilities. Ninth, communities more dependent on chemical manufacturing for their private earnings enjoy better TSS-related performance. This result runs counter to the expectation that communities more beholden to local facilities would be less likely to pressure these facilities for better performance. Tenth, less white communities suffer worse TSS-related performance, while enjoying better exceedance-related performance. (The positive effect of non-white residents on BOD relative discharges is insignificant with a p-value of 0.15.) Thus, concerns of environmental justice are possibly evident only for TSS relative discharges.

6. Conclusion

This paper analyzes the effects of external pressure – regulatory and community pressure – on the level of environmental performance at individual polluting facilities. It considers two dimensions of regulatory pressure: (1) specific deterrence, which is generated by actual government interventions – namely inspections and penalties – performed at particular facilities, and (2) general deterrence, which is generated by the threat of receiving an intervention. As important, it compares the effects of deterrence – specific and general – based on the source of the intervention. For inspections, it compares state and federal inspectors; for penalties, it compares EPA administrative courts and federal civil courts. Second, the study measures community pressure indirectly using key community characteristics (e.g., education) that proxy for actual pressure. Finally, it considers the effects of facility- and firm-level characteristics, especially corporate financial status, on environmental performance. As the primary broad objective, this study attempts to identify the effects of certain government interventions on environmental performance at individual facilities in the industrial sector of chemical and allied products. Within this primary objective, this study derives certain specific objectives that either identify the main effects of government interventions or determine whether these effects differ based on three factors: source of intervention, type of facility, and type of firm. All but one specific objective is described above. The remaining specific objective seeks to identify the interactions between the effects of specific and general deterrence and both facility-level and firm-level characteristics. This objective seeks to learn whether different types of facilities or facilities facing different corporate conditions respond differently to government interventions. As the secondary broad objective, this study explores the influence of local community pressure on environmental performance. The analysis measures community pressure indirectly using key community characteristics, such as per capita income, which serve as proxies for actual pressure. For this empirical analysis, the study examines wastewater discharges by chemical manufacturing facilities in the US for the years 1995 to 2001.

This concluding section neither summarizes nor re-interprets the estimation results reported above.

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Table 1

Summary Statistics

Table 1.a. Environmental Performance Measures

Variable	N	Mean	Standard Deviation	Min	Max
Monthly Frequency of Limit Exceedances	32,019	0.31825	0.9036791	0	41.00
BOD Relative Discharges	20,398	0.316	0.355	0	9.871
BOD Relative Discharges (logs)	20,398	-1.91297	1.2300820	-10.61684	2.2533948
TSS Relative Discharges	23,228	0.282	0.341	0	10.521
TSS Relative Discharges (logs)	23,228	-1.59803	1.1030648	-11.36389	2.2060348

1.b. Regressors Common to All Dependent Variables (Except Financial-related Regressors)

Variable	**N**	**Mean**	**Std Dev**	**Min**	**Max**
Preceding 12-month Cumulative EPA Inspections	32019	0.0876355	0.3342007	0	4
Preceding 12-month Cumulative State Inspections	32019	1.3554452	1.8052616	0	27
Annual EPA Inspections of Others / # of Others	32019	0.0802682	0.0763154	0	0.7272727
Annual State Inspections of Others / # of Others	32019	1.2807481	1.2581372	0	9.625
Preceding 12-month Cumulative Admin Penalties	32019	0.0447859	0.2737716	0	4
Preceding 12-month Avg Admin Penalty ($/action)	32019	3227.74	111289.73	0	8225931
Preceding 12-month Cumulative Civil Penalties	32019	0.0013742	0.0460643	0	2
Preceding 12-month Avg Civil Penalty ($/action)	32019	235.559168	10187.3	0	556881
Annual Admin Penalties on Others / # of Others	32019	0.0410064	0.0530531	0	0.15
Annual Average Admin Penalty on Others ($/action)	32019	59995.07	128615.55	0	587827.64
Annual Civil Penalties on Others / # of Others	32019	0.0020406	0.0058374	0	0.037037
Annual Average Civil Penalty on Others ($/action)	32019	64255.97	202684.31	0	1266976
State and Local Budget / # of businesses ($ per)	32019	43308.0566	33.2059753	9.1575639	566.9949875
EPA Regional Budget / # of businesses ($ per)	32019	677.5628346	154.43205	473.7963493	1229.3
EPA Overall Budget / # of businesses ($ per)	32019	17489.4022	1.5932892	15.7866106	20.6166986
Region 2 (1,0)	32019	0.0800775	0.2714173	0	1
Region 3 (1,0)	32019	0.1244886	0.3301433	0	1
Region 4 (1,0)	32019	0.2600019	0.4386421	0	1
Region 5 (1,0)	32019	0.1220838	0.3273876	0	1
Region 6 (1,0)	32019	0.3265873	0.4689722	0	1
Publicly-Held Ownership (1,0)	32019	0.6299697	0.48282	0	1
SICO1:alkalies/chlorine, gases, inorganic pigments [a]	32019	0.0761423	0.2652298	0	1
SICO2: organic fibers, surface agents, adhesives [a]	32019	0.0534995	0.2250308	0	1

SICO3: toilet preparations, pharmaceuticals [a]	32019	0.0608389	0.2390383	0	1
SIC19: industrial inorganics [a]	32019	0.1271433	0.3331386	0	1
SIC21: plastic materials and resins [a]	32019	0.1961648	0.3971008	0	1
SIC65: cyclic crudes and intermediates [a]	32019	0.0518442	0.2217159	0	1
SIC69: industrial organics [a]	32019	0.2427309	0.4287404	0	1
Flow Capacity (million gallons / day)	32019	2.417954	4.3171077	0.000695	65.0416667
Flow to Flow Capacity (ratio)	32019	1.077509	2.1378475	0	203.5253933
Winter Season (1,0)	32019	0.2575346	0.4372831	0	1
Spring Season (1,0)	32019	0.2729317	0.445473	0	1
Summer Season (1,0)	32019	0.2426372	0.4286842	0	1
Unemployment (rate)	32019	0.0531925	0.0198478	0.009	0.158
Voter Turnout (rate)	32019	0.3749613	0.0560933	0.2234865	0.532039
Democratic Vote (proportion)	32019	0.4702322	0.0900864	0.218163	0.8251648
Bachelor’s Degree or more (proportion)	32019	0.1827148	0.0896708	0.025	0.703
Population Density (person/sq mile)	32019	684.8055623	1245.4	14.8	11412.3
Owner Occupied Housing (proportion)	32019	0.6550819	0.1182281	0.297	0.942
Median Age (years)	32019	35.4350948	3.9474492	22	49
Family Households w/ Children (proportion)	32019	0.4812143	0.0542532	0.2584856	0.6835023
Family Households (proportion)	32019	0.6842599	0.0765644	0.388	0.8778
Male Residents (per 100 females)	32019	89.5252016	10.7172648	69.7	194.78
Per Capita Income ($/person)	32019	22600.82	4841.08	12955	50002
Chemical-Related Private Earnings (proportion)	32019	0.09928	0.1112577	0	0.6067182
Non-White Residents (proportion)	32019	0.2534437	0.1987409	0	0.9109927

[a] The omitted category for industrial sub-sector is “other”, which contains these sub-sectors: 2822 (synthetic rubber), 2841 (soaps), 2842 (polishes), 2861 (sanitation goods), 2879 (gum/wood chemicals), and 2892 (explosives).

1.c. Financial-Related Regressors, which are Common to All Performance Measures

Variable	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
Total Revenues [lagged] ($)	18073	18,014,833,701	24,348,745,654	18,359,000	147,045,823,484
Return on Assets [lagged] (ratio)	18073	0.0690892	0.0811904	-0.2896256	0.436318

1.d. Regressors Unique to BOD Relative Emissions

Variable	**N**	**Mean**	**Std Dev**	**Min**	**Maximum**
Monthly Effluent Limit (lbs/day)	20398	800.8735078	2437.18	0	31686.83
Interim Limit Type (1,0)	20398	0.0205903	0.1420116	0	1
Modification to Permit (1,0)	20398	0.1016766	0.30223	0	1
Permit Expiration (days)	20398	197.1533	544.27407	0	5145
Standard Deviation of Relative Discharges	20389	0.1813026	0.9624849	0	38.466098

1.e. Regressors Unique to TSS Relative Emissions

Variable	N	Mean	Std Dev	Min	Max
Monthly Effluent Limit (lbs/day)	23228	1283.31	4038.01	0	50000
Interim Limit Type (1,0)	23228	0.0162304	0.1263633	0	1
Modification to Permit (1,0)	23228	0.0867488	0.2814726	0	1
Permit Expiration (days)	23228	210.33507	580.15835	0	5693
Standard Deviation of Relative Discharges	23228	0.1737951	0.3744842	0	17.0494

Table 2

Estimation of BOD Relative Emissions

Variable	Pooled OLS		Random Effects		Fixed Effects	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Preceding 12-month Cumulative EPA Inspections	-0.0285	0.2278	-0.03446	0.0562	-0.03553	0.0501
Preceding 12-month Cumulative State Inspections	0.00055411	0.9205	0.007303	0.1923	0.006263	0.2672
Annual EPA Inspections of Others / # of Others	-0.05603	0.757	0.071251	0.5817	0.067272	0.6059
Annual State Inspections of Others / # of Others	0.03395	0.0003	0.06393	<.0001	0.061703	<.0001
Preceding 12-month Cumulative Admin Penalties	0.20817	<.0001	0.042691	0.0878	0.044217	0.0784
Preceding 12-month Avg Admin Penalty	-1.21e-07	0.0435	-1.18e-07	0.0073	-1.18e-07	0.0075
Preceding 12-month Cumulative Civil Penalties	0.17198	0.4437	-0.52146	0.0021	-0.53663	0.0016
Preceding 12-month Avg Civil Penalty	-0.00000346	0.0002	1.33e-06	0.054	1.37e-06	0.0474
Annual Admin Penalties on Others / # of Others	-0.30756	0.3303	1.001932	<.0001	0.988102	<.0001
Annual Average Admin Penalty on Others	5.38e-08	0.6126	2.48e-08	0.7608	2.37e-08	0.7733
Annual Civil Penalties on Others / # of Others	-12.31464	<.0001	-8.15503	<.0001	-7.92676	<.0001
Annual Average Civil Penalty on Others	3.27e-07	<.0001	2.63e-07	<.0001	2.57e-07	<.0001
State and Local Budget / # of businesses	0.00146	0.0025	0.000523	0.5452	0.000754	0.4008
EPA Regional Budget / # of businesses	0.00082242	<.0001	0.001134	<.0001	0.00116	<.0001
EPA Overall Budget / # of businesses	-0.089	<.0001	-0.07673	<.0001	-0.07618	<.0001
Region 2	-0.33199	<.0001	-0.80376	0.1012	N/A	
Region 3	0.12458	0.038	-0.28801	0.5214	N/A	
Region 4	0.53165	<.0001	0.211143	0.621	N/A	
Region 5	0.72466	<.0001	-0.14162	0.7638	N/A	
Region 6	0.23757	0.0005	-0.32289	0.4499	N/A	
Monthly Effluent Limit	-0.00004459	<.0001	-0.00026	<.0001	-0.00042	<.0001
Interim Limit Type	0.49856	<.0001	-0.19814	<.0001	-0.204	<.0001
Modification to Permit	0.03449	0.2214	-0.11758	0.0012	-0.12326	0.0008

Permit Expiration	-5.39e-08	0.0009	3.75e-09	0.8567	1.38e-08	0.5122
Publicly-Held Ownership	-0.03928	0.034	-0.06807	0.0023	-0.06709	0.0031
SICO1	-0.0409	0.4354	0.176095	0.7412	N/A	
SICO2	-0.06409	0.1221	-0.00632	0.9885	N/A	
SICO3	-0.30997	<.0001	0.287759	0.5033	N/A	
SIC19	-0.18737	<.0001	-0.23919	0.5034	N/A	
SIC21	0.22934	<.0001	0.260544	0.3694	N/A	
SIC65	-0.59664	<.0001	-0.59721	0.1375	N/A	
SIC69	0.19939	<.0001	0.357438	0.2034	N/A	
Flow Capacity	0.02667	<.0001	0.072786	<.0001	0.072752	<.0001
Flow to Flow Capacity Ratio	-0.02942	<.0001	0.002972	0.5159	0.003415	0.4571
Std Deviation of Relative Discharges	0.0944	<.0001	0.034071	<.0001	0.033154	<.0001
Winter Season	0.18732	<.0001	0.191222	<.0001	0.191235	<.0001
Spring Season	0.12959	<.0001	0.120142	<.0001	0.119394	<.0001
Summer Season	0.0571	0.0154	0.028412	0.0798	0.026611	0.1021
Unemployment	-4.54041	<.0001	-3.52847	<.0001	-4.09001	<.0001
Voter Turnout	-0.19833	0.3959	2.963887	<.0001	3.527721	<.0001
Democratic Vote	0.63181	<.0001	-0.98449	0.0327	-0.93586	0.0602
Bachelor’s Degree or more	0.43304	0.0004	1.774633	0.1138	0.43304	0.0004
Population Density	-0.00014036	<.0001	0.000139	0.1347	0.001107	0.0001
Owner Occupied Housing	0.9763	<.0001	1.667313	0.0501	2.59903	0.0148
Median Age	-0.02989	<.0001	-0.0083	0.7647	-0.02989	<.0001
Family Households w/ Children	0.80605	0.0047	6.736635	<.0001	7.855912	<.0001
Family Households	0.16969	0.5484	-0.75455	0.5872	-2.01927	0.2422
Male Residents	-0.00038563	0.6836	-0.00069	0.874	-0.00127	0.8013
Per Capita Income	-0.00000748	0.0091	-0.00007	<.0001	-0.0001	<.0001
Chemical-Related Private Earnings	-0.28285	0.0048	-0.46379	0.3153	-0.3215	0.5599
Non-White Residents	0.3875	<.0001	0.730073	0.0815	0.876621	0.1543
Inverse Mills Ratio	-2.68841	<.0001	0.329728	0.244	0.364889	0.201
Adjusted R-squared		0.1326		0.0421		0.5991
Number of Observations		20388		20388		20388

Regression also includes an intercept term.
Hausman Test for Random Effects: statistic = 83.74, degrees of freedom = 39, p-value = 0.001
F-Test for Fixed Effects: statistic = 74.57, degrees of freedom = 341, p-value = 0.0001
The sample includes only those observations where a legal limit applies and emissions are reported.
The analysis uses a two-stage estimation process when estimating the reporting and performance equations. To help identify these two equations, the analysis excludes two variables. An LR test confirms these variables are insignificantly different from zero when tested collectively.

Table 3

Estimation of TSS Relative Emissions

Variable	Pooled OLS		Random Effects		Fixed Effects	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Preceding 12-month Cumulative EPA Inspections	0.04059	0.0428	-0.01271	0.4003	-0.01163	0.4439
Preceding 12-month Cumulative State Inspections	-0.079	<.0001	-0.0411	<.0001	-0.04116	<.0001
Annual EPA Inspections of Others / # of Others	-0.1444	0.3391	-0.10332	0.3365	-0.08472	0.4344
Annual State Inspections of Others / # of Others	0.01008	0.1964	-0.02468	0.0124	-0.02353	0.02
Preceding 12-month Cumulative Admin Penalties	0.06517	0.0088	0.029165	0.1471	0.027687	0.1713
Preceding 12-month Avg Admin Penalty	1.02e-07	0.0546	-3.00e-08	0.4437	-3.19e-08	0.4171
Preceding 12-month Cumulative Civil Penalties	0.41178	0.0147	0.041392	0.7436	0.042133	0.7404
Preceding 12-month Avg Civil Penalty	-0.00000221	0.0039	6.44e-07	0.2527	6.36e-07	0.2603
Annual Admin Penalties on Others / # of Others	0.44785	0.0885	0.300147	0.1121	0.332448	0.0808
Annual Average Admin Penalty on Others	-1.89e-07	0.0348	-2.09e-07	0.0023	-2.09e-07	0.0025
Annual Civil Penalties on Others / # of Others	-2.65808	0.2595	1.666018	0.3187	2.003711	0.2354
Annual Average Civil Penalty on Others	-1.19e-07	0.0606	-2.36e-07	<.0001	-2.47e-07	<.0001
State and Local Budget / # of businesses	0.00087426	0.029	-0.00027	0.7283	-0.00099	0.2192
EPA Regional Budget / # of businesses	0.00073485	<.0001	0.000494	0.0012	0.000401	0.0099
EPA Overall Budget / # of businesses	0.03943	<.0001	0.026177	0.0016	0.037358	<.0001
Region 2	-0.17616	0.0003	-0.02394	0.9446	N/A	
Region 3	-0.03855	0.46	0.154999	0.6333	N/A	
Region 4	0.21292	0.0023	-0.14322	0.6366	N/A	
Region 5	0.79363	<.0001	0.664953	0.0456	N/A	
Region 6	-0.18558	0.0042	-0.31789	0.3077	N/A	
Monthly Effluent Limit	-0.00001979	<.0001	-0.00001	0.0093	-8.50e-06	0.0578
Interim Limit Type	-0.10605	0.0515	0.003581	0.9375	-0.00244	0.9578
Modification to Permit	-0.0441	0.0984	-0.13013	0.0002	-0.13216	0.0002

Permit Expiration	-1.75e-08	0.17	-4.47e-08	0.0043	-4.95e-08	0.0019
Publicly-Held Ownership	-0.0095	0.5306	0.003638	0.8478	0.007132	0.7108
SICO1	-0.54621	<.0001	-0.3946	0.1669	N/A	
SICO2	-0.57503	<.0001	-0.40152	0.2034	N/A	
SICO3	-1.08986	<.0001	-0.89429	0.0081	N/A	
SIC19	-0.40261	<.0001	-0.21289	0.392	N/A	
SIC21	-0.18738	<.0001	-0.04482	0.8416	N/A	
SIC65	-0.32694	<.0001	-0.28793	0.3682	N/A	
SIC69	-0.32979	<.0001	-0.15917	0.4636	N/A	
Flow Capacity	-0.00617	0.0191	0.054325	<.0001	0.060198	<.0001
Flow to Flow Capacity Ratio	0.01836	<.0001	0.019456	<.0001	0.019755	<.0001
Std Deviation of Relative Discharges	0.48727	<.0001	0.214487	<.0001	0.209525	<.0001
Winter Season	0.06417	0.0012	0.081536	<.0001	0.080849	<.0001
Spring Season	0.04973	0.011	0.065256	<.0001	0.064532	<.0001
Summer Season	0.01952	0.3227	0.0269	0.0463	0.026284	0.0526
Unemployment	-5.6557	<.0001	-4.00766	<.0001	-3.85062	<.0001
Voter Turnout	0.41705	0.0306	-0.54908	0.3219	-0.9713	0.1106
Democratic Vote	0.10637	0.3553	-1.1986	0.0013	-1.44499	0.0004
Bachelor’s Degree or more	0.05844	0.5472	0.790687	0.3247	0.05844	0.5472
Population Density	0.00002487	0.0105	-0.00006	0.3622	-0.00081	0.0002
Owner Occupied Housing	0.03115	0.8185	-1.55116	0.0188	-3.09663	0.0003
Median Age	-0.01105	0.0006	-0.00397	0.8517	-0.01105	0.0006
Family Households w/ Children	0.65589	0.0073	-0.98229	0.2064	-2.00544	0.0209
Family Households	0.94729	<.0001	5.248145	<.0001	9.451691	<.0001
Male Residents	-0.00298	0.0001	-0.00132	0.6979	-0.00629	0.1217
Per Capita Income	-0.00002447	<.0001	-0.00004	<.0001	-0.00002	0.0098
Chemical-Related Private Earnings	-0.0217	0.7907	-0.51673	0.1727	-1.06125	0.0238
Non-White Residents	-0.04976	0.3583	1.11386	0.0006	2.12361	<.0001
Inverse Mills Ratio	-4.21054	<.0001	-2.6524	<.0001	-2.68021	<.0001
Adjusted R-squared		0.1323		0.0361		0.6024
Number of Observations		23201		23201		23201

Regression also includes an intercept term.
Hausman Test for Random Effects: statistic = 53.62, degrees of freedom = 39, p-value = 0.0596
F-Test for Fixed Effects: statistic = 71.36, degrees of freedom = 405, p-value = 0.0001
The sample includes only those observations where a legal limit applies and emissions are reported.
The analysis uses a two-stage estimation process when estimating the reporting and performance equations.
To help identify these two equations, the analysis excludes two variables. An LR test confirms these variables are insignificantly different from zero when tested collectively.

Table 4

Estimation of Monthly Effluent Limit Exceedances

Variable	Pooled OLS		Random Effects		Fixed Effects	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Preceding 12-month Cumulative EPA Inspections	0.06379	<.0001	0.016833	0.256	0.015684	0.2932
Preceding 12-month Cumulative State Inspections	0.03748	<.0001	0.004338	0.3201	0.003205	0.4698
Annual EPA Inspections of Others / # of Others	0.29109	0.0054	-0.03774	0.6991	-0.07453	0.4508
Annual State Inspections of Others / # of Others	-0.02889	<.0001	0.02654	0.0035	0.032722	0.0006
Preceding 12-month Cumulative Admin Penalties	0.1943	<.0001	0.037241	0.0599	0.031489	0.1146
Preceding 12-month Avg Admin Penalty	5.25e-09	0.9088	-7.17e-08	0.1047	-7.48e-08	0.0921
Preceding 12-month Cumulative Civil Penalties	0.16871	0.2486	-0.02975	0.8354	-0.05748	0.69
Preceding 12-month Avg Civil Penalty	-5.89e-07	0.3747	-6.93e-09	0.9913	6.91e-08	0.9143
Annual Admin Penalties on Others / # of Others	0.49641	0.0105	0.199677	0.2765	0.20588	0.2671
Annual Average Admin Penalty on Others	-5.78e-08	0.3699	2.23e-08	0.7311	1.60e-08	0.8096
Annual Civil Penalties on Others / # of Others	-0.48975	0.7682	-0.55276	0.716	-0.57523	0.7093
Annual Average Civil Penalty on Others	1.93e-09	0.9661	7.69e-09	0.8561	2.06e-08	0.6379
State and Local Budget / # of businesses	0.00011234	0.5757	-0.00096	0.1223	-0.00099	0.1899
EPA Regional Budget / # of businesses	0.00017339	0.076	0.000071	0.6044	0.000123	0.3936
EPA Overall Budget / # of businesses	-0.02097	<.0001	-0.01783	0.0038	-0.01723	0.0212
Region 2	-0.18581	<.0001	-0.27123	0.0714	N/A	
Region 3	0.12528	<.0001	0.06876	0.6357	N/A	
Region 4	-0.0444	0.2911	-0.00963	0.9456	N/A	
Region 5	0.04883	0.2937	-0.10296	0.4841	N/A	
Region 6	-0.18752	<.0001	-0.12647	0.3559	N/A	
Interim Limit Type	0.01998	0.6008	0.013823	0.7415	0.011358	0.7892
Modification to Permit	-0.00185	0.9276	0.06593	0.0394	0.07751	0.0191
Permit Expiration	-4.54e-09	0.6769	-7.10e-08	<.0001	-7.52e-08	<.0001

Publicly-Held Ownership	-0.05301	<.0001	-0.01823	0.2972	-0.01552	0.3947
SICO1	0.17581	<.0001	0.143367	0.2648	N/A	
SICO2	-0.04662	0.0662	-0.10345	0.4742	N/A	
SICO3	-0.147	<.0001	-0.1957	0.1802	N/A	
SIC19	0.03561	0.0603	-0.0321	0.7643	N/A	
SIC21	-0.02501	0.1416	-0.03111	0.7521	N/A	
SIC65	0.00594	0.8177	-0.02882	0.8461	N/A	
SIC69	0.07255	<.0001	0.017905	0.8489	N/A	
Flow Capacity	0.00791	<.0001	0.002906	0.4311	0.000198	0.9633
Flow to Flow Capacity Ratio	-0.00193	0.4082	-0.00014	0.9493	-0.00026	0.9044
Winter Season	0.04459	0.002	0.04847	0.0002	0.048383	0.0002
Spring Season	-0.00228	0.8733	0.002323	0.8561	0.002121	0.869
Summer Season	0.01955	0.1793	0.019956	0.1248	0.019657	0.1318
Unemployment	-1.46681	<.0001	-1.15431	0.0837	-0.90661	0.2025
Voter Turnout	0.10322	0.4506	0.055088	0.9023	-0.5354	0.3504
Democratic Vote	-0.44481	<.0001	-0.31722	0.2835	-0.52036	0.1932
Bachelor’s Degree or more	0.386	<.0001	0.496075	0.214	0.386	<.0001
Population Density	5.87e-07	0.9231	1.87e-06	0.9507	-0.00016	0.4037
Owner Occupied Housing	-0.30829	0.0021	-0.13524	0.7628	0.383716	0.6539
Median Age	0.00781	0.0014	0.001151	0.9194	0.00781	0.0014
Family Households w/ Children	-0.19432	0.2809	0.20037	0.752	1.44521	0.0916
Family Households	1.26454	<.0001	0.976237	0.185	0.594767	0.6615
Male Residents	-0.00063886	0.252	-0.0044	0.0713	-0.00137	0.7329
Per Capita Income	-0.00000785	<.0001	4.16e-06	0.4752	0.00002	0.0211
Chemical-Related Private Earnings	-0.14771	0.0165	0.267834	0.3157	0.500985	0.2731
Non-White Residents	0.26043	<.0001	-0.17528	0.3724	-2.2445	<.0001
Adjusted R-squared		0.0286		0.0047		0.2346
Number of Observations		32019		32019		32019

Regression also includes an intercept term.
Hausman Test for Random Effects: statistic = 47.58, degrees of freedom = 35, p-value = 0.0762
F-Test for Fixed Effects: statistic = 17.49, degrees of freedom = 504, p-value = 0.0001

Table 5

Differences between Effects of Paired Interventions on Corporate Environmental Performance: Results of F-Tests [a]

Table 5.1. Comparison of Federal and State Inspections

Comparison	BOD		TSS		All Exceedances	
	F-value	P-value	F-value	P-value	F-value	P-value
Specific Deterrence	4.76	0.029	3.02	0.082	0.64	0.422
General Deterrence	0.10	0.966	0.53	0.465	0.43	0.511

Table 5.2. Comparison of EPA Administrative and Federal Civil Penalties

Comparison	BOD		TSS		All Exceedances	
	F-value	P-value	F-value	P-value	F-value	P-value
Specific Deterrence						
Number of Penalties	11.7	0.001	0.01	0.923	0.22	0.640
Average Magnitude	4.62	0.032	1.43	0.232	0.01	0.919
General Deterrence						
Number of Penalties	19.73	0.000	0.67	0.415	0.24	0.621
Average Magnitude	7.64	0.006	0.15	0.701	0.05	0.828

[a] Based on the fixed effects model for BOD discharges and the random effects model for TSS discharges and all limit exceedances. Both models exclude interactions between deterrence measures and facility/firm characteristics, exclude financial-related regressors, and use the sample of all facilities regardless of ownership structure.

Table 6

Collective Significance of Interactive Terms involving Deterrence Measures and Facility / Firm Characteristics: Results of F-Tests [a]

Table 6.1. Federal and State Inspections

Set of Regressors	BOD		TSS		All Exceedances	
	F-value	P-value	F-value	P-value	F-value	P-value
Specific Deterrence						
Ownership Structure	8.75	0.000	3.73	0.024	15.15	0.000
Industrial Sub-sector	4.45	0.000	5.24	0.000	3.01	0.000
Capacity, Flow ratio, Stochasticity	31.14	0.000	20.50	0.000	0.81	0.516
Financial Status [b]	9.84	0.000	6.08	0.000	2.22	0.065
General Deterrence						
Ownership Structure	8.21	0.000	7.88	0.000	12.55	0.000
Industrial Sub-sector	4.79	0.000	4.66	0.000	1.76	0.038
Capacity, Flow ratio, Stochasticity	2.03	0.058	11.12	0.000	3.61	0.006
Financial Status [b]	7.31	0.000	0.73	0.571	0.58	0.065

[a] Unless otherwise noted, based on the random effects model that includes interactions between deterrence measures and facility/firm characteristics, yet excludes financial-related regressors, and uses the sample of all facilities regardless of ownership structure.
[b] Based on the random effects model that includes interactions between deterrence measures and facility/firm characteristics, including financial-related regressors, and uses the sample of only facilities owned by publicly-held firms.

Table 6.2. EPA Administrative Penalties

Set of Regressors	BOD		TSS		All Exceedances	
	F-value	P-value	F-value	P-value	F-value	P-value
Specific Deterrence						
Ownership Structure	1.33	0.265	0.57	0.564	7.35	0.001
Industrial Sub-sector	6.89	0.000	4.99	0.000	4.60	0.000
Capacity, Flow ratio, Stochasticity	2.23	0.037	6.04	0.000	7.84	0.000
Financial Status [b]	6.69	0.000	3.23	0.012	0.81	0.520
General Deterrence						
Ownership Structure	3.81	0.022	18.28	0.000	0.94	0.391
Industrial Sub-sector	5.25	0.000	4.44	0.000	0.99	0.461
Capacity, Flow ratio, Stochasticity	5.25	0.000	6.38	0.000	6.32	0.000
Financial Status [b]	1.99	0.093	6.66	0.000	0.27	0.900

[a] Unless otherwise noted, based on the random effects model that includes interactions between deterrence measures and facility/firm characteristics, yet excludes financial-related regressors, and uses the sample of all facilities regardless of ownership structure.
[b] Based on the random effects model that includes interactions between deterrence measures and facility/firm characteristics, including financial-related regressors, and uses the sample of only facilities owned by publicly-held firms.

Table 7

**Estimation of Environmental Performance Measures:
Inclusion of Financial Status as Regressor
Based on Sample of Facilities Owned by Publicly-Held Firms**

Variable / Statistic	BOD [a]		TSS [b]		All Exceedances [b]	
	Coeff / Statistic	P-value	Coeff / Statistic	P-value	Coeff / Statistic	P-value
Annual Revenues	-709E-15	0.544	-14E-13	0.155	-122E-14	0.165
Return on Assets	0.7724	0.0001	0.3653	0.003	-0.0682	0.591
F-test for Fixed Effects	58.27	0.0001	64.16	0.0001	12.51	0.0001
Adjusted R^2: Fixed Effects	0.6285		0.6242		0.2162	
Hausman Test for Random Effects	59.72	0.006	24.43	0.944	33.06	0.562
Adjusted R^2: Random Effects	0.0848		0.0320		0.0079	

The regression for BOD, TSS, and All Exceedances includes all of the regressors listed in Tables 2, 3, and 4, respectively, with the exception of Public Ownership Structure.

[a] Based on a fixed effects model.
[b] Based on a random effects model.

Deterrence and Corporate Environmental Behavior

Dorothy Thornton (University of California, Berkeley)

Neil A. Gunningham (Australian National University)

Robert A. Kagan ((University of California, Berkeley)

This research addresses the assumption that "general deterrence" is an important key to enhanced compliance with regulatory laws. Through a survey of 233 firms in 8 industries in the U. S., and in-depth interviews with 34 firms in the chemical and electroplating industries, asked (1) When severe legal penalties are imposed against a violator of environmental laws, do other companies in the same industry actually learn about such "signal cases"? (2) Does knowing about "signal cases" or other "general deterrence messages" change firms' compliance-related behavior? (3) How important is the threat raised by general deterrence compared with other factors in inducing legal compliance? We found that only 42% of respondents could identify the "signal case. But 89% could identify some enforcement actions against other firms, and 63% of firms reporting having taken some compliance-related actions in response to learning about such cases. Overall, we conclude that because most firms already are in compliance (for a variety of other reasons), this form of "explicit general deterrence" knowledge usually serves not to enhance the threat of legal punishment but as *reassurance* that compliance is not foolish and as a *reminder* to check on the reliability of existing compliance routines.

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Deterrence and Corporate Environmental Behavior[1]

In most regulatory programs, officials formally prosecute and obtain legal sanctions against violators in only a small percentage of infractions. They deal with most detected violations at the bottom of the "pyramid of sanctions" (Ayres & Braithwaite, 1992) – that is, by means of warnings, demands for remedial action, repeated re-inspection, and other informal pressures. At the same time, most regulatory officials, scholars, and environmental advocacy groups believe that governmental capacity to impose severe legal penalties, together with relatively frequent use of that capacity, is crucial to the implementation of regulatory norms. Underlying this belief is the theory of *general deterrence*, which holds that each tough legal penalty sends a "threat message" that reverberates through the community of regulated businesses. That threat presumably raises the perceived risk and cost of violations, and business executives increase their investment in compliance commensurately. Yet there is surprisingly little research that examines the extent to which general deterrence actually is important in motivating business firms' environmental behavior. This paper summarizes the results of a research project designed to explore that issue.

I. Explaining Regulatory Compliance: Alternative Hypotheses

A good deal of sociolegal scholarship questions the relationship between general deterrence and corporate regulatory compliance. First, in the cacophony of news, information, and demands of all kinds received by business firms in contemporary society, it is not clear how often business enterprises learn about legal penalties imposed on other firms in other places. Even if they do, business executives may not think that *their* firm (which may differ in many ways from the sanctioned firm) faces an enhanced risk of being found in violation and punished (see Braithwaite & Makkai, 1991). Thus against the general deterrence thesis, which assumes widespread dissemination and attention to clear deterrence messages, one might counterpose a "weak signal, weak threat" hypothesis -- that is, that the message often doesn't get through or send a meaningful threat.

Second, some research indicates that it is not general deterrence (hearing about legal sanctions against others) but "specific deterrence" -- the fear triggered by a firm's experience of

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being inspected, warned, or penalized *itself* – that is the chief driver of enhanced compliance efforts (Gray & Scholz, 1991; Gray & Shadbegian, 2004; Mendeloff & Gray, 2004).

Third, in economically advanced democracies, many corporate officials regard the threat of *informal social sanctions* – such as the damage to corporate reputation that can flow from negative publicity about a firm's environmental pollution – as far more salient and economically costly than the risk of legal penalties (Gunningham et al, 2003; Mehta & Hawkins, 1998; Prakash, 2000). In consequence, most general deterrence messages may be *redundant*, exerting little impact on corporate compliance behavior.

Fourth, high levels of compliance often are observed in contexts in which the threat of legal enforcement is relatively remote. Hence some scholars argue that for most firms, compliance stems not from fear of legal sanctions but from a sense of social duty or legal obligation. In democratic societies with a strong rule of law tradition, the theory suggests, most business managers have "internalized" (or simply agree with) the norms that underlie most regulatory rules. Or they are generally committed, as a matter of socialization and citizenship, to complying with duly enacted laws and regulations. For these firms, too, one might hypothesize that general deterrence signals are redundant, adding little if anything to compliance efforts.

Together, the alternative theories of corporate compliance suggest that corporate motives vary, and hence deterrence messages have variable effects. Some firms – the "amoral calculators" or "bad apples" (Bardach & Kagan, 1982:64-66) are responsive only to the threat of imminent legal sanctions (general and specific deterrence), while "good apples" respond primarily to social pressures and felt normative obligations (Malloy, 2003). For others, a combination of "fear" and "duty" may be operative;[2] they regard it as both prudent and right to commit to a policy of full compliance with governmental regulations. The legally binding character of regulations alone implies both a threat and an obligation. For firms responsive to this "implicit general deterrence," learning about legal sanctions against other firms does not *motivate* them to comply, but *reminds* them of preexisting commitments to comply, perhaps impelling them to intensify audits of their established compliance routines.

[2] Research on individual taxpayers has indicated that "fear" and "duty" tend to interact in producing compliance with income tax law (Schwartz & Orleans, 1967; (Scholz & Pinney, 1995). However, another study found that among taxpayers with a similar sense of duty, those who had lower fear of being caught (greater opportunity to cheat) had lower levels of self-reported compliance – indicating that "fear' has independent effects (Scholz & Lubell, 1998).

There is still one more way in which general deterrence messages may matter. Chester Bowles (1971:25), reflecting on his job as head of the U.S. Office of Price Administration during World War II, opined that 20 percent of the population would comply with any regulation, 5 percent would attempt to evade it, and the remaining 75 percent would go along with it as long as the 5 percent were caught and punished. Officials in other regulatory agencies often echo that theory, arguing that penalizing the "bad apples' helps keep the "contingently good apples" good (Bardach & Kagan, 1982). This suggests that explicit general deterrence messages often matter not because of the threat they signal but because they *reassure* companies that make costly compliance-related investments that they will not be at a competitive disadvantage vis-a-vis firms who violate the law.

II. The Research Project

In light of the complex and varied behavioral pathways suggested by the sociolegal research, a basic empirical puzzle remains: to what extent is "explicit general deterrence" salient and important in shaping corporate environmental behavior? Motivated by that question, this research project was designed to seek preliminary answers to these more specific questions:

1. When a tough legal penalty is imposed against a particular violator, how loud is the "deterrence signal" it sends? That is, how widely is it publicized, and to what extent do other companies in the same industry actually learn about it and remember it (or other penalty cases)?

2. To what extent does hearing about the "signal case" (or other penalty cases) change the compliance-related behavior of other firms?

3. In stimulating compliance, how salient are the "explicit general deterrence" messages sent by formal legal sanctions against other firms, compared to (a) the "specific deterrence" engendered by inspections of and legal sanctions against the firm itself, and (b) the "implicit deterrence" message sent simply by the dissemination of governmental regulations?

4. Compared to legal deterrence, how salient are other factors – such as the threat of informal economic and social sanctions, or normative commitments to compliance with laws and regulations -- as stimuli for compliance efforts?

5. To what extent do motivations vary across firms – depending, for example, on the type and size of organization, or the characteristics of particular industry sectors?

To begin to answer those questions, we proceeded in several steps. First, we identified a population of "penalty cases", based on press releases (n =112) issued by the US EPA between January 2000 and June 2001.[3] Second, after selecting a stratified random sample of 40 such press releases,[4] we searched a variety of news media databases to determine the breadth of coverage the media accorded the cases and penalties described in the EPA press releases.[5]

Third, we sought to assess to what extent other firms had "heard" the deterrence signals presumably sent by those (or other) penalty cases, and whether other firms changed their environmentally-relevant behavior in response. To that end, we conducted an 8-industry survey, organized by selecting 8 of the 40 "signal cases" whose media dissemination we had tracked. The 8 cases were chosen non-randomly to include a range of industries, localities, and penalties – such as a southern state aluminum fabricator in that repeatedly had discharged pollutants in excess of its permit limits (and was fined $1.1 million) and a California wastewater treatment plant official who had tampered with monitoring equipment to shield discharges that bypassed the treatment system (and was sentenced to 5 months in prison). The 8 cases are listed on Table 1, Appendix A). For each signal case, we identified business firms in the same industry and state.[6] After selecting a random sample of such facilities, we telephoned the "person responsible for environmental compliance" at each. Officials in 233 facilities agreed to be interviewed, a response rate of 80%.[7] Approximately 70% of the facilities whose officials we interviewed had

[3] We included only press releases of completed enforcement actions (for example, we did not include those simply announcing a prosecution) and excluded those involving "wholly illegal enterprises,' such as firms that operated entirely outside the law (midnight dumpers, unlicensed businesses). In truncating the period, we sought to concentrate on actions that were relatively more recent, so that respondents might have a better chance of remembering them, but not so recent that news of them might not have had time to circulate in the industry

[4] The sample was stratified to ensure we would have a mix of criminal and civil cases, and those in which the assessed legal penalty was against individual corporate officers as well as the company

[5] We searched for media coverage via Lexis-Nexis, major newspapers, local newspapers, radio and television news transcripts, industry news outlets, newswires and regional newspaper files. Of course, industry officials can and often do get news of penalty case from other kinds of sources as well, such as newsletters and direct communications from legal counsel, suppliers, customers and competitors. For us, it was feasible to survey coverage of the penalty cases only in more public, on-line news dissemination sources

[6] We compiled a list of facilities by searching EPA's Envirofacts database for facilities in the same state and SIC code as the signal facility. In addition, Switchboard.com and Yellowpages.com were searched for additional facilities in the same industrial categories as the signal facility, as was Hoovers.com. Where available, state databases of the relevant facilities were obtained.

[7] Response rates were 100 percent for sanitary treatment facilities (n=40 in Florida, 39 in CA), 76% for aluminum fabricators (26/34), 75% for steel fabricators (30/40); 73% for chemical manufacturers and blenders (29/40), and 69% for Colorado Electroplaters (22/32), 75% for asbestos abatement companies in New York (24/32) and 70% for

fewer than 100 employees; and only those in the chemical industry had a significant (25%) proportion with more than 1000 employees.

After obtaining general information about respondents and their firm,[8] we explored respondents' *knowledge of the signal case and of other enforcement actions* against other firms.[9] Other questions sought to assess respondents' *perception of various legal risks* associated with regulatory enforcement. For example, based on a hypothetical situation modeled on the regulatory violation in the signal case, respondents asked for their estimate of the likelihood of detection, and if detected, the likelihood and severity of the resulting legal penalty.[10] Finally, respondents were asked if hearing about a fine or prison sentence at *another* company in their industry ever induced them to (1) review their environmental programs; (2) change their management plans or monitoring methods; (3) change their employee training; or (4) change their equipment or other aspects of their physical plant. We regarded a company as having "taken an environmental action" if they reported having taken *any* of the actions listed above. (For a fuller account of this phase three research, see Thornton, Gunningham & Kagan, 2004).

The fourth phase of the project entailed longer in-depth interviews with officials at 17 chemical manufacturing facilities and 17 electroplating facilities in the states of Washington and

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chemical manufacturers in Louisiana (23/33). Although these are unusually high response rates for survey research, the possibility remains that nonresponding firms are more likely, on average, to have responded to deterrent messages differently than those that did respond. At the time of the research, it was not possible to consistently compare compliance records of nonresponding and responding firms, and in any case, our dependent variable in this study is not change in compliance but whether hearing general deterrence messages impelled firms to take measures to improve their environmental performance.

[8] Data was gathered on company size and what percentage of his or her time the respondent spent on environmental work (degree of environmental professionalism)

[9] Awareness of the signal case was obtained by presenting a vignette based on the signal case and asking of respondent had heard of such a case. Respondents were also asked (a) how many instances they could recall in which, during the last year or two, a company or individual had been fined (or incarcerated) for environmental violation, and (b) to describe as many particular infractions and penalties a they could.

[10] For example, chemical manufacturers and blenders in Louisiana were asked: "Assume for a moment that there was a chemical manufacturing plant that released CFCs into the air, 35% in excess of their permit limits, and then repeatedly failed to locate or repair the leaks that led to this excess. On a scale of 0 to 100, what do you think the chances are that the plant would be found out by law enforcement? "If they were found out, on a scale of 0 to 100, what do you think the chances are that the plant would be fined? "Can you give me a ballpark estimate of how much they might be fined?" (The latter two questions were then asked with respect to individual fines against plant operators/owners, the likelihood of incarceration, and the likelihood that penalties might result in plant closure.

Ohio, exploring the role of general deterrence messages as compared with specific deterrence, social pressures, and normative beliefs in shaping facilities' environmental behavior. (For a fuller account, see Gunningham, Thornton, Kagan 2004). Of the eight industries surveyed in the third phase of our project, the chemical industry had a greater proportion of large firms, and electroplating a large proportion of small firms.

III. Findings

A. Media Coverage of the Signal Case

Despite their seriousness, the 40 "signal cases" we selected from EPA press releases did not generally get *widespread* publicity in the news media. Only 10 of the press releases received "wide" media coverage (16 to 145 stories) and 14 cases received "low' media coverage (0-6 stories).[11] The apparent threshold for obtaining wide media attention was an unusually large fine (in excess of $4 million) or an unusually long jail sentence (e.g., 17 years) which occurred in only one case.

B. How Loud the Deterrent Message? Knowledge of Legal Penalties against Other Firms

When a specific "signal case" --was described to representatives of other firms in the same industry, only 42% of 233 respondents recognized and remembered it. [12] That is, a majority of officials responsible for compliance either hadn't heard of a serious penalty for a serious offense against a similar firm in their own state, less than two years earlier, or else they had not regarded it as sufficiently relevant or important to remember. This lends support to a "weak signal/weak threat" hypothesis.

On the other hand, general deterrence seems to have a cumulative effect on the consciousness of regulated companies: 89% of our respondents remembered at least one instance of *some* company having been penalized for an environmental violation in the past year or two, and 71% could describe at least one *particular example* of a person or business being penalized

[11] We compared only the wide and low media coverage groups in our analysis to avoid classification errors. The remaining 16 cases had intermediate coverage" (7-15 stories).

[12] All other things being equal, electroplaters (71%) were significantly more likely to recognize the signal case than were respondents from any other industry. The more professionalized the environmental staff person, the more likely they were to remember the signal case (Logistic Regression: Recall spc. ex.= f(#employees, professionalization, industry). No other variables were significant)

for an environmental offense. Nevertheless, their knowledge was limited and vague. Respondents report having heard of far fewer fines than actually occur.[13] In terms of particular cases respondents described, they tended to remember only those with unusually large financial penalties and/or cases where someone was sentenced to jail.[14] At the same time, respondents overwhelmingly *underestimated* the actual penalties when the signal cases were presented as hypotheticals, and a significant minority of respondents could not recall any particular instance of a penalty against an individual. Clearly, then, while respondents generally were conscious of the possibility of a significant penalty, they do not make special efforts to obtain timely and accurate information.

C. Perception of Legal Risk

Most respondents thought that serious infractions, such as those described in the signal case, would be detected; the median perception of detection risk was 70%. However, respondents' risk-of-detection perceptions were highly variable, ranging from close to 0 to 100% in most industries. Respondents generally felt that if a serious infraction resembling the signal case were to be detected, the offending company would be penalized; 92% of respondents felt the odds of a company fine were greater than 50:50. But 7% of respondents believed there was no possibility that an individual owner or operator would be fined personally, while only 11% believed he would certainly be fined. The median risk-of-individual-fine perception was 40%. Respondents were even less certain that an individual would be incarcerated: 53% of respondents believed that the chance that an owner or operator would be incarcerated for a serious environmental infraction was 10% or less.[15]

Most respondents thought it unlikely that environmental penalties would result in the *closure* of an offending facility.[16] But expectations of the magnitude of company fines varied

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[13] For example, the median number of fines against other companies (anywhere in the United States, in the last year or two) that respondents could recall was only eight. Yet in Louisiana alone, in a 1-year period (July 2001 through June 2002), 31 companies were fined for environmental infractions. Five of the 31 exceeded $100,000.

[14] Of the 107 respondents who gave a magnitude estimate, 43% cited fines of $1 million or more, 67% cited fines of $100,000 or more, while 26% of respondents who could describe a specific enforcement action noted that someone at the other company had been incarcerated.

[15] Electroplaters perceived the risk of incarceration as higher than did all other industries (median probability is above 50%, while for all other industries it is at or below 20%).

[16] For 50% of respondents, there was *no chance* that environmental penalties would eventually lead to facility closure, and 85% believed the probability of such a closure was 10% or less. But for the remaining 15% of

widely (from $0 to $20 million) as did estimates for owner/ operator fines ($0 to $2 million).[17] Based on a hypothetical modeled on the signal case, many respondents (68/223) could offer no estimate of the magnitude of the likely company fine. For those that guessed, 68% of respondents *underestimated* the fine actually imposed by an order of magnitude, 28% gave an estimate of the same order of magnitude, and 4% overestimated the fines by an order of magnitude.[18] On the other hand, after being told the actual penalty in the signal case, 85% of respondents felt that the punishment in the case was reasonable. Of the respondents who felt that the penalty had been unreasonable, slightly fewer than half (40%) felt that the punishments given were unreasonably stringent while the remainder (60%) felt that the punishments were too lenient. This support for tough legal sanctions against firms that had committed serious violations is consistent with the notion that publicized penalties serve a "reassurance function" for firms that regard themselves as compliant "good apples."

D. The Effect of Knowledge on Perception of Legal Risk.

There was no strong association between (a) knowledge of enforcement actions against other firms and (b) our measures of respondents' perceptions of the risk of detection and punishment. Five linear regression analyses were performed, each modeling a risk perception variable (likelihood of facility closure, detection, company fine, jail, individual fine) as a function of company size,[19] degree of professionalization,[20] knowledge (general deterrence)[21] and industry. All models were statistically significant but did not, in general, explain a large portion of the variation (see adjusted R^2).[22]

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respondents, the risk of forced closure was real, and in a very few cases, substantial. Electroplaters and asbestos abatement companies were more likely to think that fines might lead to facility closure. In fact, none of these respondents felt that the probability of facility closure was zero. Conversely, the vast majority of sanitary treatment facility respondents in both California and Florida deemed closure impossible, which seems a reasonable assessment given the indispensability of their function. Some chemical manufacturing facilities viewed the probability of facility closure as reasonably high, while most aluminum fabricators and steel fabricators viewed it as highly unlikely.

[17] Fifty percent of respondents believed that if a company official were incarcerated, the length of the sentence served would be 6 months or less. The longest period of incarceration envisaged was ten years.

[18] Those respondents that had heard of the signal case also tended to underestimate the fine, but less often (59%) than those who had not heard of the signal case (74%).

[19] Company size is divided into "large" (100 or more employees) and "small" (less than 100 employees).

[20] Measured as a percent of their time the respondent spent on environmental work.

[21] Three different measures used. First, the quantum of fines recalled, categorized as: none, one or two, three to 9, 10 to 15, 16 to 30, more than 30. Second, the number of particular cases recalled and described (none, one or two), and third, whether or not the signal case was recalled.

[22] Reference industry=sanitary treatment facilities in Florida.

E. Compliance-Related Behavior

A majority of companies (65%) reported that they had increased their compliance-related activity in some way after hearing about a fine or prison sentence at another company. Thus it appears that general deterrence messages, at least cumulatively, do matter. Our questions did not distinguish whether or not it was knowledge of the *signal case* (as opposed to other penalty cases) that triggered responsive environmental action. But employing a series of assumptions, we can estimate that 10 to 20% did respond to the signal case.[23]

The most commonly-reported responsive action (57% of respondents) was to review existing environmental control programs. But 23% changed their employee training, and 32% reported having changed equipment, suggesting that that a substantial fraction of facilities respond in potentially expensive ways to environmental enforcement actions taken against other firms.

F. Knowledge, Perception of Legal Risk, and Behavior

What distinguishes firms that do and do not report environmental actions in response to deterrence messages? A logistic regression model of company environmental action as a function of demographic, knowledge, risk perception, and other variables was developed. Table 3 (see Appendix) presents descriptive statistics for the variables employed in the model. Table 4 presents the results of the logistic regression. Company size was significantly and positively associated with the likelihood of taking environmental action. The degree of professionalization variable was *not* significantly associated with taking environmental action. Interestingly, respondents who could *describe more particular examples of enforcement actions against other firms* were more likely to report having taken an environmental action in response to deterrence signals. On the other hand, remembering the signal case, or remembering a larger *number* of instances of enforcement actions, were *not* significantly associated with taking environmental

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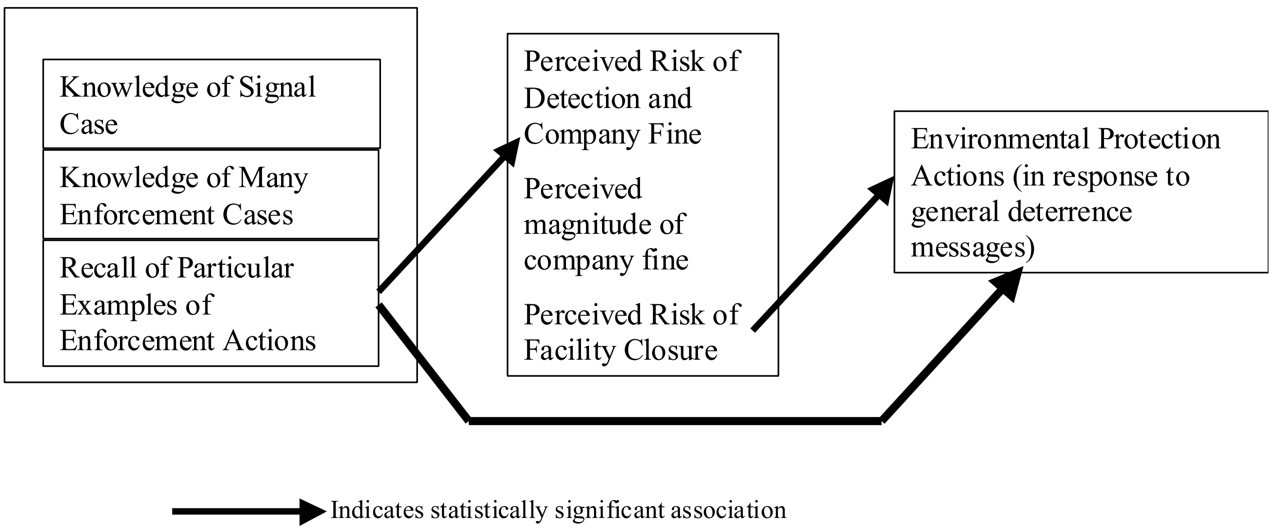
Facility Closure: df=190, F=10.168, p<.000, **Adj R^2=0.367**, Sig Vars: Asbes, Elec, Steel, Chem-KY (all +ve)
Detection: df=195, F=3.679, p<.000, **Adj R^2=.142**, Sig Vars: Chem-KY (+ve)
Company Fine: df=193, F=1.851, p=.043 **Adj R^2=.050**, Sig Vars: Particular Exs (+ve)
Individual Fine: df=185, F=2.390, p=.007, **Adj R^2=.083**, Sig Vars: Steel (-ve)
Jail: df=186, F=3.532, p<.000, **Adj R^2=.140** Sig Vars: Elec (+ve) SanTx-CA (+ve)

[23] About 65% of facilities reported they had taken an action in response to hearing about *some* legal penalty against *some* other company. About 40% had heard of the signal case. If we assume that the action-in-response rate (65%) is the same for that 40% of firms that were attentive to the signal case, then perhaps 24% of facilities took environmental action in response to the signal case. Since that may overestimate the signal case response, our guess is that 10-20% would be more realistic

actions. And firms that thought that the risk of detection and the magnitude of legal penalties were great were, on average, no more likely to take responsive environmental action than firms with lower estimates of legal risk.[24] Associations among variables are summarized in Figure 1.

Figure 1: Summary of Results



IV. Discussion

Classic deterrence theory predicts clear relationships between knowledge of "high profile" enforcement actions (fines and incarcerations) and improved compliance-related behavior. In most descriptions of the theory, (1) regulated entities are presumed to monitor their environment for information about enforcement activity and to have heard about high profile prosecutions and penalties; (2) knowledge of high profile cases is presumed to increase perceived risk of non-compliance; and (3) higher perceived risk of legal sanctions is presumed to improve overall compliance-related behavior.

Our results from the 8-industry, 223-firm survey provide only limited support for this theory. The majority of firms (65%) report having, at some point in the past, taken an environmental action in response to hearing about an enforcement action at another company. But we find only a weak association between increased information about other penalty cases

[24] Of the risk perception variables, only the perception that penalties might lead to facility closure was significantly associated with taking an environmental action. However, this result appears to be driven by the electroplating facilities in the sample, and is no longer significant (p=0.095) if electroplating cases are excluded from the dataset.

and increased perception of legal risk, and firms with higher risk perceptions of detection or fine were not significantly more likely to have taken an environmental action than those with lower risk perceptions. Moreover, contrary to the assumptions of general deterrence theory, firms did not obtain or retain accurate information about the frequency or magnitude of fines and other penalty information.

This seeming inconsistency[25] may reflect the previously-mentioned theory that general deterrence signals often serve not to enhance fear of sanctions per se but to remind reasonably 'good apples' – firms already committed to compliance as a general business strategy – that noncompliance can occur due to slippage in their company's own self-regulatory systems. This would explain the finding that the most common response to news of sanctions against other firms is to review one's own compliance program. And on occasion, a deterrence signal will inform a good apple of non-compliance (or risk of noncompliance) in their own facility (stemming, e.g., from employee error or deviance, or with respect to a regulation they were unaware of or had interpreted incorrectly); hence the signal will spur them into more than simple confirmation routines. In this way, information could affect behavior without changing risk perceptions.[26] Similarly, the examples of noncompliance cited by respondents were often couched in judgmental tones, critical of the behavior of the company punished. This supports the notion that explicit general deterrence messages serve a "reassurance function," informing already compliant firms that they are not foolish for doing so, since their competitors who "cheat' are getting caught and punished.

V. What The In-Depth Two-Industry Survey Adds

[25] The puzzle may reflect the possibility that the measures we constructed do not accurately reflect the underlying constructs. For example, we asked respondents, "If a company is violating in this manner, what do you perceive the risk of detection or punishment for that company to be?" However, we could not sensibly ask respondents how likely *they* were to commit the same violations, and their response may reflect their estimate of risk of detection for "bad apples" (not their own firm). Nor did we directly ask: Did hearing about an enforcement action at another company ever change your perception of risk? Furthermore, we obtained only a snap shot of *current* risk perceptions, but asked for an aggregate measure of behavior change, asking if companies had 'ever' taken environmental actions in response to deterrence signals. Our measure thus does not rule out the possibility that firms that acted in response to deterrence signals had higher risk perceptions at that prior time.

[26] Such a *reminder function* of deterrence comes through quite dramatically in our in-depth interviews in the electroplating and chemical industries. See Sec V, below

The two-industry survey -- longer, in-depth interviews of 34 firms in 2 of the 8 industries (chemicals and electroplating) -- sought a richer contextual understanding of what motivates management and how regulatees think about and respond to deterrence and to regulatory and social scrutiny more generally.[27]

Specific deterrence. Specific deterrence in its narrowest sense – a previous sanction against a company inclining it to make more strenuous efforts to avoid future penalties – had a significant impact on a substantial minority of companies in our sample, particularly smaller firms. Twenty-four per cent (4/17) of electroplaters and 11% (1/9) of chemical small-or-medium-sized enterprises (SMEs) said that a legal penalty against *their company* in the past had influenced its subsequent environmental actions. But the large chemical companies in our sample, who reported having had only minor violations over the last decade, had experienced no significant enforcement. For them, therefore, specific deterrence was not a salient driver of environmental actions.

Specific deterrence in its broader sense also includes the impact of *inspections* (with their implicit threat of sanctions). For electroplaters, inspections played an important role, prompting them to undertake whatever action was required of them in the belief that further enforcement action, with potentially profound consequences, would have followed from continuing non-compliance. Inspections also had an important "*reminder function"* for firms inclined to comply because they said it was the 'right thing to do.' Again, however, chemical companies said that inspections did not have a significant influence on them; only one identified inspection as an important reason for taking particular environmental actions. Most stated that they were already substantially beyond compliance, and so inspections held no fear for them.

Explicit General Deterrence. Knowledge about legal sanctions against other companies, according to our interviews, played only a very modest role in the case of electroplaters and an even smaller one for chemical companies. In the case of the former, only 12% (2/17) said a fine or prison sentence at another company had influenced specific environmental actions (less than the average of our 8 industry survey). Only 1/17 saw general deterrence as a powerful motivator for specific actions; 11/17 saw it as a relatively unimportant motivator. Among chemical SMEs,

[27] For a fuller account, see Gunningham, Thornton & Kagan, 2004

no one identified an environmental action that occurred against another company as having influenced *particular* environmental actions in their facilities. However, when prompted, many felt that hearing about another firm being penalized *might* influence them if the circumstances were sufficiently similar. Large chemical companies reported that they were not at all influenced by such considerations.

There seem to be three reasons why the impact of explicit general deterrence was small. First, companies had great difficulty comparing their own circumstances with those of the company that had been penalised, and most commonly dismissed the latter as being irrelevant (see also Braithwaite & Makkai, 1991). Second, the very large majority of our respondents claimed to be in compliance or even "beyond compliance." In these circumstances, hearing about punishments imposed on recalcitrants did not resonate with their own circumstances and triggered little fear in them. Third, some respondents suggested that it was only hearing about someone in similar circumstances going to prison, rather than merely being fined, that would influence them.

However, as in the 8-industry survey, explicit general deterrence did have a significant *reminder function* for both electroplaters and chemical companies - prompting them to review their own operations and think about environmental risks that otherwise might not have gained their immediate attention. Nevertheless, few reported making any *significant* changes as a result of such a reassessment.

Explicit general deterrence also fulfilled a *reassurance function.* Many respondents conceded that without effective enforcement, the overall performance of the industry would decline over time, as compliant firms would lose confidence that there was a 'level playing field' in terms of environmental standards. Many respondents placed considerable emphasis on this function, as complaints about enforcement commonly focused on the injustice of others *not* being punished, or not being punished heavily enough.

Implicit General Deterrence. For these respondents, what we have called "implicit general deterrence" – the threat of legal sanctions implied by the mere promulgation or history of enforcement of laws and regulations in the contemporary United States – was much more salient than either specific deterrence or explicit general deterrence. Although many of our respondents acted for instrumental reasons, they did not seem to engage in any careful weighing of the benefits of non-compliance versus the probability of being discovered and punished, as predicted by traditional deterrence theory. On the contrary, almost all our respondents gave the impression that there was no point even debating whether to comply or not. Compliance was regarded as mandatory. Electroplators and chemical SMEs saw legal punishment of serious violations as virtually inevitable.[28]

Our interviews indicate that "implicit general deterrence" arises from the general history of a particular regulatory regime (in this case targeted enforcement over the previous decade). In these industries inspection and enforcement activity have generated a 'culture of compliance', such that it becomes almost unthinkable to regulatees that they would calculatedly (as opposed to inadvertently) break the law. Most of our respondents took a similar view to EWs-7: "It's ludicrous to let things go and imagine you won't get into trouble…We are subject to inspection and to fines, huge fines, for not doing it. You can't fight that. You either comply or get out of the business." Thus it was *the regulations themselves* (rather than hearing about enforcement actions against other firms) that had the most direct impact on behavior. But that occurs against a backdrop where the common perception was that 'you go out of business if you don't comply.'[29]

For large chemical manufacturers, however, the mechanisms that led to compliance were rather different. Such firms commonly described regulation as only 'the baseline,' implying that it was a taken-for-granted minimum standard which they would usually substantially exceed for a variety of reasons discussed below. For them, regulation was taken for granted not because of the perceived inevitability of sanctions (that is, implicit general deterrence) but because they felt

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[28] Electroplaters voiced this sense most strongly, which may reflect enforcement actions these facilities had experienced in the past: 8/17 electroplating companies mentioned previous violations, fines, jail sentences, or threats of facility closure. Every electroplating facility was regularly inspected at least once a year: by the local sewer district if they had a discharge to the sewer, plus by the fire department, plus by state and federal environmental agencies. However, even smaller chemical companies (another industry subjected to substantial regulatory scrutiny and penalties in the past) commonly voiced a similar sense of "regulatory inevitability. "

This sense of regulatory inevitability was reinforced by the widespread perception among respondents that it was firms 'like theirs' who were most vulnerable to inspection and enforcement. Thus large firms believed that small firms were 'getting away with it' while they themselves were not, while the converse was the perception of small enterprises.

[29] Indeed, for many interviewees, the regulations had become so embedded in their culture that they exerted an almost unconscious influence on decision-making. Some respondents attributed legally required environmental steps at their facilities not to regulation but to the firms' environmental ethos, seemingly oblivious to the extent to which they operated in a thick regulatory soup which constrained many of their choices.

a failure to comply would send very undesirable signals to important stakeholders, triggering a variety of informal sanctions. Yet the law was seen as a salient standard in the minds of their investors, employees, customers, and local governments; hence they had to attend closely to legal compliance.

Such instrumental considerations, even in the more complex form of implicit general deterrence, were not the only ones that weighed upon our respondents. Almost half of our respondents also provided a range of normative explanations for why they complied. In essence, many of them perceived themselves as 'good guys', complying with environmental regulation because it was the right thing to do. However, they struggled to disentangle normative from instrumental motivations, and wrestled with the temptation to backslide when environmental improvements proved expensive. In the absence of regulation and implicit general deterrence, it is questionable whether their good intentions would have translated into practice.

In any event, deterrence in any form was of far greater concern to SMEs than it was to large ones. For major reputation-sensitive firms in the environmentally sensitive chemical industry, regulation and its enforcement played only a minor role ('as a baseline') and most chose to go substantially beyond compliance for reasons that related to risk management considerations and to the perceived need to protect their social license to operate. Crucial in this regard was maintaining the trust and support of local communities, of avoiding the attention of environmental groups and other potentially critical stakeholders, and of preserving the company's reputation as an environmentally responsible entity (see Gunningham et al, 2003).

Large companies appeared to differ from the smaller companies in terms of *how* they went about complying or over-complying. In their responses, they treated regulation and liability rules as sources of substantial additional costs, and hence as economic signals – to which they responded by seeking out solutions that substantially mitigated those costs and occasionally even saved them money overall. In this regard, they were proactive and innovative in a way that boundedly-rational small companies, particularly electroplaters, most certainly were not.

Thus there are various strands that must be taken into account in understanding what motivates corporate environmental behavior. There is a tight coupling for example, between normative and instrumental explanations for compliance. Even those who see themselves as 'good guys' and who comply because it is 'the right thing to do,' suggest they would be reticent to do so if they are not confident that the 'bad guys' are being effectively regulated and sanctioned. Similarly, there is a connection between informal social pressures and formal legal ones. Because the law is seen by many (including local communities) as a moral barometer, any company found in non-compliance risks not only legal sanctions but the informal stigma and reputation damage that the community and other stakeholders may inflict.

Finally, how these various strands play out depends very much on the size and sophistication of companies themselves and on the characteristics of the industry sector within which they are located. Electroplaters responded very differently to various external drivers than did chemical companies, and even within the latter, small and medium sized companies were influenced by substantially different considerations from large companies. Overall, there was little support for models of business firms as "amoral calculators," who carefully weigh the certainty and severity of sanctions and who can be manipulated through a judicious mix of specific and general deterrence.

VII. Conclusion

Our research provides only weak support, at best, for the classical "general deterrence' hypothesis (which we would now label 'explicit general deterrence"). Many EPA-imposed legal penalties, especially the less severe ones, do not get substantial coverage in the newsmedia. Fewer than half (42%) of 229 respondents in our 8-industry survey recognized and remembered the specific signal case. On the other hand, general deterrence seems to have a cumulative effect on the consciousness of regulated companies: most respondents thought the risk of detection of violations was high, and for many in our in-depth study, virtually inevitable. In the 8-industry survey, 89% of our respondents remembered at least one instance of *some* company having been penalized for an environmental violation in the past year or two. And some 63 percent reported having taken some environmental protection measures after learning about penalties against other companies. Most often, the reported reaction was to review their own compliance programs, but a substantial minority changed equipment, monitoring practices or employee training.

Yet many relationships predicted by the classical deterrence model did not appear in our data. Respondents who recognized the signal case or recalled a larger number of other cases were *not* more likely to report having taken environmental action in response. Officials who saw the risk of formal detection and punishment as high were not, on average, more likely to report taking environmental measures in response to general deterrence messages. Company managers were not closely attentive to the penalties assessed against violators, generally underestimating them. This suggests to us that penalties against other firms – at least in the United States near the beginning of the 21st Century -- play a somewhat different role from the one embedded in the classical general deterrence theory, which assumes that the imminent threat of legal punishment is the primary driver of compliance efforts.

Our survey as well as the in-depth interview evidence, rather, suggests that for most firms, general deterrence primarily serves a *reminder* and a *reassurance* function. For the "good apples" – firms that are generally committed to compliance for a variety of normative and reputational reasons – learning about penalties against other firms reinforces their perception of the need to continue compliance activities and of the potential disastrousness of non-compliance. Sometimes, a deterrence signal prods them to check and take further action. Deterrence signals both reassure 'good apples' that free-riders will be punished and remind them to make sure that they are responsible corporate citizens with no need to fear the social and economic costs that can be triggered by serious violations.

It must be remembered, however, that this research was conducted in the United States in the early 21st Century, more than a quarter century after American states and the federal government started serious enforcement of environmental laws. Hence the "implicit general deterrence" mechanism has matured, so that the enforcement and normative legitimacy of environmental regulations is taken for granted by many firms. And social and political support for environmental norms has given many companies a substantial economic stake in avoiding a reputation for being bad environmental citizen. Thus our research has little to say about the importance of explicit general deterrence messages at earlier stages in regulatory programs, when their value added may well be greater, or for firms (or industrial subsectors) that are deliberate evaders or chronically at the edge of or out of compliance.

Appendix A

Table 1. Signal Cases

Industry	Infraction	Penalty		
		Company Fine	Jail Sentence	Individual Fine
Electroplating, CO	The VP of a Denver plater, who, despite 56 warnings over 10 years allowed Zn, Cd, Cu, Cr, and Ni to be continually discharged into the Denver municipal sewers.	$250,000	12 months + 100hrs community service	
Waste Water Treatment, CA	The district manager of a Rodeo, California treatment plant who admitted to allowing wastewater to bypass a chlorine contact chamber and to tampering with monitoring methods on 473 days between 1995 and 1997.		5 months prison + 5 months home confinement + 1 year probation	$3000
Chemical Manufacturing or Blending, KY	In 1995, a plant in KY stored fuming sulfuric acid in a tank that had cast iron piping instead of steel piping. The iron corroded, and the company did not inspect the piping. This resulted in about 24,000 gallons of sulfuric acid solution being released into the air in a four-hour period, creating a chemical cloud. A thousand nearby residents had to be evacuated and several were treated for burns of their eyes, nasal passages and lungs.	$850,000 penalty + $650,000 on an emergency notification system		
Aluminum Fabrication – Southern States	An aluminum fabricator in Port Allen, LA, who discharged wastewater contaminated with hexanol and with a COD of 1,737 ppm (13X their permit limit) into an intercoastal waterway	$1.1 million 5 years probation	100 hours of community service	$2000 to $5000
Waste Water Treatment, FL	South Bay Utilities of Sarasota county, who discharged an estimated 290 gallons of inadequately treated wastewater, along with additional periodic discharges amounting to 1.5 tons of nitrogen in a two year period, into Dryman Bay.	$1.3 million		$445,000 (president of the company)
Steel Fabrication, IN	A corporation that settled allegations that it failed to control the pollution at eight steel minimills, resulting in thousands of tons of illegal air emissions of NOx, and mismanaged discharges of K061 dust in the soil and groundwater. The company contends that it had not violated any environmental law.	Civil penalty of $9 million $4 million on environmental projects $85 million on new control tech.		
Asbestos Abatement Services, NY	While carrying out an asbestos abatement project, between December 1997 and March 1998, the company failed to notify the EPA; knowingly sent workers into an asbestos "hot zone" for more than 12 weeks, without providing them with		41 months	$59,700 restitution

Industry	Infraction	Penalty		
		Company Fine	Jail Sentence	Individual Fine
	protective gear, or even informing them of the presence of asbestos; failed to have a certified contractor perform the work, to properly wet and bag the asbestos, to properly label the containers filled with asbestos, and to dispose of the asbestos at a landfill approved for that purpose.			
Chemical Manufacturing, LA	A chemical company in Westlake, LA was charged with releasing CFCs into the air in excess of the 35% limit and then repeatedly failing to locate and repair leaks.	$4.5 million penalty and Fund an "environmental justice" project in Westlake, LA		

Table 3: Responses to General Deterrence Messages: Descriptive Statistics

		Valid	Missing
Took environmental action in response to deterrence signal	63%	227	6
Company size		224	9
Large (>100 employees)	27%		
Percent time spent on environmental work		228	5
0 to 25%	33%		
26 to 75%	33%		
Greater than 75%	33%		
No of instances of company fines recalled		228	5
0	11%		
1	6%		
2-5	25%		
6-10	18%		
>10	39%		
Maximum	2,000		
Remember a particular example		232	1
0	29%		
1	45%		
2	26%		
Heard of the signal case	42%	229	4
Probability of Detection*		228	5
0-25%	23%		
26-75%	41%		
76-100%	36%		
Probability of Company Fine		226	7
0-25%	4%		
26-75%	12%		
76-100%	84%		
Risk**		225	8
0-2500	28%		
2501-7500	42%		
7501-10000	30%		
Magnitude of Company Fine (dollars)		196	37
0	1%		
Thousands	9%		
Tens of thousands	38%		
Hundreds of thousands	18%		
Millions or more	34%		
Probability of Facility Closure		219	14
0	50%		
1 to 10	35%		
11 to 25	11%		
26 to 75	3%		
76-100	1%		

*Probability of Detection= Response to the question: "on a scale of 0 to 100, what do you think the chances are that the plant (in hypothetical based on signal case) would be found out by law enforcement?" Estimated

Probability of Company Fine, Magnitude of Company Fine, and Probability of Facility Closure measures based on similar question about fate of company in hypothetical based on signal case.
**Risk= probability of detection x probability of company fine

Table 4. Logistic Regression Model of Corporate Environmental Action[30]

Dependent Variable: Taking environmental action in response to deterrence signals (binary).

	B	S.E.	Wald	Df	Sig.	Exp(B)
Demographic Variables						
Company size (large/small)	*1.254*	*.491*	*6.529*	*1*	*.011*	*3.504*
Degree of Professionalization	.008	.006	1.838	1	.175	1.008
Knowledge Variables						
Number of instances of company fines	.002	.002	.840	1	.359	1.002
Recall particular examples (0,1, or2)	*.980*	*.289*	*11.516*	*1*	*.001*	*2.665*
Recognize signal case	.386	.405	.908	1	.341	1.470
Risk Perception Variables						
Risk=prob of detection x prob co. fine	.000	.000	.887	1	.346	1.000
Magnitude of company fine (0,1,2,3,4)	-.013	.184	.005	1	.944	.987
Risk that penalties will lead to closure	*.072*	*.029*	*6.227*	*1*	*.013*	*1.074*
Constant	-1.775	.691	6.608	1	.010	.169

Shaded and italicized results show variables significant at or below a p=0.05 level.

[30] Number of cases included in the analysis=176 (=75.5% of all cases). The model chi-square is 50.706 which is significant at p=<.000. The –2 Log likelihood value is 175.150 and the Cox and Snell R Square is .250. A second model was also run including dummy variables for each industry. The addition of this block of variables was not significant at a 0.05 level and so these variables were not included in the model (Chi-square=9.812, df=7, p=0.199). A correlation matrix was calculated. No bivariate correlations exceeded .30.

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When and Why do Plants Comply? Paper Mills in the 1980s

Wayne B. Gray
Clark University and NBER

Ronald J. Shadbegian
University of Massachusetts at Dartmouth
U.S. EPA National Center for Environmental Economics

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Abstract

This paper examines differences in plant-level compliance with air pollution regulation for U.S. pulp and paper mills. We test a variety of plant- and firm-specific characteristics, to see which plants are more likely to comply with regulation. We also test how effective regulatory enforcement is in inducing compliance, and whether plants differ in their sensitivity to regulatory activity.

Our analysis is based on confidential, plant-level Census data from the Longitudinal Research Database for 116 pulp and paper mills, covering the 1979-1990 period. The LRD provides us with data on shipments, investment, productivity, age, and production technology. We also have plant-level pollution abatement expenditures from the Pollution Abatement Costs and Expenditures (PACE) survey. Using ownership data, we link in firm-level financial data taken from Compustat, identifying firm size and profitability. Finally, we use several regulatory data sets. From EPA, the Compliance Data System provides measures of air pollution enforcement activity and compliance status during the period, while the Permit Compliance System and the Toxic Release Inventory provide information on other pollution media. OSHA's Integrated Management Information System provides data on OSHA enforcement and compliance.

We find significant effects of some plant characteristics on compliance rates: plants which include a pulping process, plants which are older, and plants which are larger are all less likely to be in compliance. Compliance also seems to be correlated across media: plants violating water pollution or OSHA regulations are more likely to violate air pollution regulations. Firm-level characteristics are not significant determinants of compliance rates.

Once we control for the endogeneity of regulatory enforcement, we find the expected positive relationship between enforcement and compliance. We also find some differences across plants and firms in their responsiveness to enforcement. Pulp mills, already less likely to be in compliance, are also less sensitive to inspections. Some firm characteristics also matter here: plants owned by larger firms, whether measured in terms of their employment or by the number of other paper mills they own, are less sensitive to inspections and more sensitive to other enforcement actions, consistent with our expectations and with other researcher’s results.

1. Introduction

In most economic models of government regulation, a regulatory agency establishes standards with which regulated firms are required to comply. Compliance is usually accomplished by having inspectors visit plants to identify violations and to impose penalties on violators. Becker (1968) demonstrated that if both the probability of being caught and the penalty for violations are high (relative to the costs of compliance), we would expect profit-maximizing firms to optimally choose compliance. However, for many regulatory agencies, the number of inspectors is small relative to the regulated population and the penalties are limited, so there seems to be a limited incentive for compliance - yet most firms still seem to comply.

This puzzle of 'excessive' compliance has led to several strands of literature. Outside economics, researchers have emphasized the importance of social norms and a corporate culture that encourages compliance, and have conducted interviews to identify how corporate decisions are affected by pressures from both regulatory agencies and the general public. Within economics, a model by Harrington (1988) shows that in a repeated game, a regulator could substantially increase the expected long-run penalty for non-compliance by creating two classes of regulated firms - cooperative and non-cooperative. The cooperative firms are assumed to behave well and to be inspected only rarely. The non-cooperative firms would face much heavier enforcement. Since facing enforcement is costly, firms would be anxious to be placed in the cooperative group initially, and therefore would invest more in compliance at the start of the game, than would be predicted from the expected penalty in a one-period model.

On the empirical side, there have been several studies on the effectiveness of OSHA and

EPA enforcement, using a variety of estimation techniques. These include studies of environmental enforcement at steel mills for air pollution (Gray and Deily 1996); at paper mills for air pollution (Nadeau 1997) and water pollution [Magat and Viscusi (1990), Laplante and Rilstone (1996), and Helland (1998)]; and of OSHA regulation at manufacturing plants (Gray and Jones(1991), and Gray and Scholz(1993)). These studies generally find that enforcement has some effect on compliance, or the goals of compliance (reduced emissions or injuries). Since enforcement and compliance tend to be defined at the plant level, most of these studies do not incorporate firm-level variables. However, Helland finds that more profitable firms have fewer violations, and Gray and Deily find that compliance status is correlated across plants owned by the same firm, though they find insignificant effects of firm size and profitability on compliance. Gray (2000) finds little effect of corporate ownership change or restructuring on compliance and enforcement.

In this paper we use a sample of U.S. pulp and paper mills to examine differences in plant-level compliance with air pollution regulations. In particular, we test a variety of plant- and firm-specific characteristics, to see which plants are more likely to comply with regulation. We also compare the plant's air pollution compliance with its performance in other dimensions (water pollution, toxic chemicals, and worker health and safety). Finally, we test how effective regulatory enforcement is at inducing compliance, and whether plants differ in their sensitivity to enforcement activity.

We use confidential, plant-level Census data from the Longitudinal Research Database for 116 pulp and paper mills, covering the 1979-1990 period. The LRD provides us with data on each plant's shipments, investment, productivity, age, and production technology. We also have plant-level pollution abatement expenditures from the Pollution Abatement Costs and Expenditures (PACE) survey. We link in ownership information, based on the Lockwood Directory, which allows us to identify the number of paper mills owned by the firm, and also link in firm-level financial data taken from Compustat, identifying firm size and profitability. Finally, we add compliance and enforcement information from several regulatory data sets, although our focus is on the EPA's Compliance Data System, which provides measures of air pollution enforcement activity and compliance status during the period.

We use a logit model of compliance with air pollution regulation: compliance depends on regulatory activity directed towards the plant, as well as various plant and firm characteristics. Regulatory activity is endogenous - regulators target enforcement activity towards plants that are out of compliance – so a simple correlation between enforcement and compliance would be negative, indicating (naively) that enforcement decreases compliance. To address this targeting issue, we try two alternative ways of measuring enforcement. First, we try using lagged enforcement as an explanatory variable, in principle purging the equations of any contemporaneous endogeneity. Second, we try predicting enforcement from a tobit model on a set of variables which are clearly exogenous to the plant's compliance decision (state political support for environmental regulation and year and state dummies). We then use this predicted value in a second-stage compliance equation. Models using lagged regulatory activity continue to find a negative 'impact' of enforcement on compliance (which we attribute to remaining endogeneity), while models using predicted activity yield positive coefficients, with regulatory activity increasing compliance.

We find significant effects of plant characteristics on compliance rates: plants which include a pulping process, plants which are older, and plants which are larger are all less likely to be in compliance. In contrast, firm-level characteristics are not significant determinants of plant-level compliance rates. Plants violating other regulations (water pollution or OSHA regulations) are more likely to violate air pollution regulations.

We also find differences across plants in their responsiveness to enforcement. Pulp mills, already less likely to be in compliance, are also less sensitive to inspections. Finally, firm characteristics do seem to matter for a plant's inspection sensitivity (though they did not for the overall compliance rate). Plants owned by larger firms, whether measured in terms of firm employment or the number of paper mills owned by the firm, are less sensitive to inspections and more sensitive to other enforcement actions than plants owned by smaller firms.

Section 2 provides some background on environmental regulation and compliance issues in the paper industry. Section 3 describes a simple model of the compliance decision faced by a plant. Section 4 describes the data used in the analysis, Section 5 describes some econometric issues with the analysis, Section 6 presents the results, and Section 7 contains the concluding comments.

2. Paper Industry Background

Environmental regulations have grown substantially in stringency and enforcement activity over the past 30 years. In the late 1960s the rules were primarily written at the state level, and there was little enforcement. Since the early 1970s, the Environmental Protection Agency has taken the lead in developing stricter regulations, and encouraging greater enforcement (much of which is still done by state agencies, following federal guidelines). This expanded regulation has imposed sizable costs on traditional 'smokestack' industries, with the pulp and paper industry being one of the most affected, given its substantial generation of air and water pollution.

Plants within the pulp and paper industry can face very different impacts of regulation, depending in part on the technology being used, the plant's age, and the regulatory effort directed towards the plant. The biggest determinant of regulatory impact is whether or not the plant contains a pulping process. Pulp mills start with raw wood (chips or entire trees) and break them down into wood fiber, which are then used to make paper. A number of pulping techniques are currently in use in the U.S. The most common one is kraft pulping, which separates the wood into fibers using chemicals. Many plants also use mechanical pulping (giant grinders separating out the fibers), while others use a combination of heat, other chemicals, and mechanical methods. After the fibers are separated out, they may be bleached, and mixed with water to form a slurry. After pulping, a residue remains which was historically dumped into rivers (hence water pollution), but now must be treated. The process also takes a great deal of energy, so most pulp mills have their own power plant, and therefore are significant sources of air pollution. Pulping processes involve hazardous chemicals, raising issues of toxic releases.

The paper-making process is much less pollution intensive than pulping. Non-pulping mills either buy pulp from other mills, or recycle wastepaper. During paper-making, the slurry (more than 90% water at the start) is set on a rapidly-moving wire mesh which proceeds through a series of dryers in order to extract the water, thereby producing a continuous sheet of paper. Some energy is required, especially in the form of steam for the dryers, which can raise air pollution concerns if the mill generates its own power. There is also some residual water pollution as the paper fibers are dried. Still, these pollution problems are much smaller than those raised in the pulping process.

Over the past 30 years, pollution from the paper industry has been greatly reduced, with the installation of secondary wastewater treatment, electrostatic precipitators, and scrubbers. In addition to these end-of-pipe controls, some mills have changed their production process, more closely tracking material flows to reduce emissions. In general, these changes have been much easier to make at newer plants, which were designed at least in part with pollution controls in mind (some old pulp mills were deliberately built on top of the river, so that any spills or leaks could flow through holes in the floor for 'easy disposal'). These rigidities can be partially or completely offset by the tendency for regulations to include grandfather clauses, exempting existing plants from most stringent air pollution regulations.

3. Compliance and Enforcement Decisions

An individual paper mill faces costs and benefits from complying with environmental regulation, which may depend on characteristics of the plant itself, the firm which owns the plant, and the activity of environmental regulators. Given these constraints, the firm operating the mill is presumed to maximize its profits, choosing to comply if the benefits (lower penalties, better public image) outweigh the costs (investment in new pollution control equipment, managerial attention). Regulators, in turn, allocate their activity to maximize some objective function (political support, compliance levels, economic efficiency), taking into account the reactions of firms to that activity.

The objective function for mill i owned by firm j at time t includes the usual revenues and costs of production, but these are extended to include the penalties associated with being found in violation (Penalty), the probability of being found in violation (VProb), and the costs of coming into compliance (CompCost):

(1) $Profit_{ijt}(Comply) = P_{ijt}*Q_{ijt} – Cost_{ijt} – Penalty_{ijt}*VProb_{ijt}(Comply) – CompCost_{ijt}(Comply)$

Plants can vary their level of compliance (Comply) to maximize their profits (this assumes that the underlying compliance decision is in fact continuous, although we only observe a 0-1 compliance status in our data. Assuming that the benefits and costs of compliance are captured in the last two terms of equation (1), the plant will set its marginal cost of compliance equal to the marginal benefit from compliance, measured here in terms of reductions in expected penalties.

(2) $d(-Penalty_{ijt}*VProb_{ijt})/dComply = d(CompCost_{ijt})/dComply$

This implicitly determines an optimal level of compliance, Comply*.

The benefits to the firm from increasing compliance come in terms of reducing the probability of being found in violation of pollution regulations, thus reducing the expected penalties for violations. These penalties are usually associated with regulators in terms of legal sanctions and monetary fines, but could also be 'imposed' by customers boycotting the firm's products in the future. In some circumstances customers might also be willing to pay more for products that have been certified to have especially environmentally friendly production processes, although this is currently more common in Europe than in the U.S. If we make the usual assumption that the firm is risk-neutral, the expected benefits of compliance should be linear in the probability of being in non-compliance, so the marginal benefit to the plant from increasing its probability of compliance would be constant. Because of the difficulties associated with ensuring 100% compliance, we expect a rising marginal cost curve. Rising marginal costs along with constant marginal benefits should lead to an interior Comply* solution, equating the marginal costs and marginal benefits of compliance to the firm.

We focus on differences in compliance behavior across different mills, based on plant and firm characteristics. As mentioned earlier, there are likely to be substantial differences in pollution problems across different types of paper mills. We expect to see differences in compliance behavior being related to the production technology at the plant (especially the use of pulping) and related to the plant's age. There may also be economies of scale in complying with regulations, so larger plants might find it easier to comply with a given level of stringency. However, some of these plant characteristics on compliance could go either way: older plants might find it harder to comply with a given standard, but they could be subject to less strict standards due to grandfathering. Larger plants might enjoy economies of scale, but could also have more places that something could go wrong, raising their probability of non-compliance.

Compliance behavior may also depend on characteristics of the firm which owns the mill (e.g. the financial situation of the firm may matter). Pollution abatement can involve sizable capital expenditures, which may be easier for profitable firms to fund - either through retained earnings or through borrowing in capital markets. A firm in financial distress may not feel the full threat of potential fines in an expected value sense, if they would just go bankrupt if they happened to be caught. Firms with reputational investments in the product market may face an additional incentive not to be caught violating environmental rules, if their customers would react badly to the news.

Firms might also differ in the quality of the environmental support that they offer their plants. A large firm, or one specializing in the paper industry, is likely to have economies of scale in learning about what regulations require, and may be in a better position to lobby regulators on behalf of their plants. We cannot measure the strength of a company's environmental program, but may observe a correlation in compliance behavior across plants owned by the same firm. We may also see some effect of the firm size, either in absolute magnitude or in terms of the number of mills they operate.

The regulatory activity faced by a plant is also expected to affect its compliance behavior. A higher rate of inspections by regulators should increase VProb(Comply*) for any given Comply* value, increasing the benefits from compliance. This inspection effect could be described in terms of specific deterrence (plants who had been inspected in the past are more careful) or general deterrence (plants with a high probability of being inspected are more careful).[1] Other enforcement actions might encourage compliance by raising the costs of being found in violation (Penalty) without increasing the probability of being caught (VProb).

We test for differences across plants in their sensitivity to regulatory activity. Such differences could arise for a variety of reasons. Plants owned by larger firms that sell on a national market might be more concerned about bad publicity from environmental violations, raising their Penalty, and hence their benefits from compliance.[2] Larger plants may be used to having regular inspections so that inspections have less of a 'shock effect' (specific deterrence) than might be experienced by a smaller plant, reducing the benefits from compliance. Plants may also differ in the cost of increasing their compliance, giving them different impacts from the

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[1] Scholz and Gray (1990) examine the impact of OSHA inspections on injury rates and find significant evidence for both general and specific deterrence effects.

[2] Conversations with people in the paper industry suggested that most large firms had strong policies encouraging

same increase in regulatory activity.

Some of these different possibilities are shown in the three panels of Figure 1. These panels all assume upward-sloping marginal costs and unchanging marginal benefits from compliance. Each panel compares the impact on optimal compliance rates of an increase in the benefits from compliance (such as might be induced by increased regulatory activity) on two different plants. Figure 1a shows that even if the two plants differ in their initial level of compliance, they could have the same change in compliance for a given increase in regulation, if the slopes of their marginal cost curves are the same. Figure 1b shows that differences in the slopes of the marginal cost of compliance can result in very different impacts from the same increase in regulation – here the plant with high and steep compliance costs has both lower initial compliance and a smaller impact from the increased regulation. Finally, Figure 1c shows that plants with the same marginal cost of compliance can respond differently if the same increase in regulation has different marginal benefits for them, as might happen if the larger firm felt a greater desire to avoid adverse publicity (MB1').

In sum, a plant's compliance decision depends on its age and production technology, its firm size and profitability, and the regulatory activity directed towards it, with the possibility of some differences across plants in their sensitivity to that regulatory activity. We estimate a model of compliance behavior as follows:

(3) $Comply^*_{ijt} = f(REGS_{ijt}, X_i, X_j, X_{ijt}{*}REGS_{ijt}, OComply_{ijt}, YEAR_t)$.

COMPLY is the plant's observed compliance status with air pollution regulations. REGS is the regulatory activity faced by the plant, which could be either inspections or other enforcement

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100% compliance as much as possible, perhaps due to these concerns with adverse publicity.

actions. This activity could affect either the probability of being caught in violation or the negative consequences associated with being caught. The model includes characteristics of the plant (X_i) and firm (X_j), either of which could be interacted with enforcement activity to test for differences in the responsiveness of plants and firms to enforcement. The plant's compliance status with other regulatory areas is measured by OComply. Finally, year dummies ($YEAR_t$) allow for changes in enforcement, or its definition, over time.

Now consider the regulator's decision about how to allocate its regulatory activity. If enforcement were costless, regulators could use 'infinite' enforcement, catching all violators, in which case setting a fine equal to the environmental damages from pollution would be optimal. Becker (1968) notes that in a world with costly and uncertain enforcement, higher penalties might be substituted for some of the enforcement effort, to raise the expected penalty for violations. In fact, given limitations on the size of penalties under existing regulations, and the high costs of controlling some pollutants, it seems puzzling why any firms would comply with regulation. However, Harrington (1988) showed that a regulator could substantially raise the effectiveness of enforcement, by making future enforcement conditional on past compliance. In this model, non-compliance today not only raises expected penalties today, but the plant risks being treated much more severely for years to come (or forever, depending on the regulator's behavior).

If regulators are using the Harrington strategy, we would expect enforcement at a plant to be greater in plants which violated the standards in the past. On the other hand, if most of the differences in compliance behavior across plants are driven by fixed plant or firm characteristics, those plants which are out of compliance may be more resistant to enforcement pressures, because they face higher costs of compliance. Therefore regulators might have to balance the greater opportunity for compliance improvement against the greater enforcement effort needed to achieve that improvement.

Regulators may also respond to differences in the potential environmental harm caused by pollution, with plants in more rural areas facing less enforcement activity. In fact, Shadbegian, et. al. (2000) find evidence that plants with greater benefits per unit of pollution reduction wind up spending more on pollution abatement, suggesting that regulators are indeed being tougher on those plants.

Observed differences in enforcement across plants and over time may also be strongly influenced by the amount of resources allocated to regulatory enforcement in a particular state and a particular year. During the 1980s the budgets of most regulatory agencies tended to increase, so there were likely to be more inspections over time. There are also significant differences in the political support for regulation across different states due to the severity of pollution problems or to the political makeup of each state's population. On a more pragmatic note, states may differ in the extent to which they enter all of their enforcement activity into the regulatory databases we use.[3]

4. Data Description

Our research was carried out at the Census Bureau's Boston Research Data Center, using confidential Census databases developed by the Census's Center for Economic Studies. The primary Census data source is the Longitudinal Research Database (LRD), which contains

[3] Of course the latter difference would cause problems for our estimation of the model, since seeing one 'observed'

information on individual manufacturing plants from the Census of Manufactures and Annual Survey of Manufacturers over time (for a more detailed description of the LRD data, see McGuckin and Pascoe (1988)). From the LRD we extracted information for 116 pulp and paper milla with continuous data over the 1979-1990 period. We capture differences in technology across plants with a PULP dummy variable, indicating whether or not the plant incorporates a pulping process. Our control for plant age, OLD, is a dummy variable, indicating whether the plant was in operation before 1960[4]. We control for the plant's efficiency using TFP, an index of the total factor productivity level at the plant, which we calculated earlier when testing for the impact of regulation on productivity in Gray and Shadbegian (1995,2003). Possible economies of scale in compliance are captured by SIZE, the log of the plant's real value of shipments. Finally, we include IRATE, the ratio of the plant's total new capital investment over the past three years to its capital stock, to identify those plants with recent renovations.

In addition to these Census variables taken directly from the LRD, we use data from the Census Bureau's annual Pollution Abatement Costs and Expenditures (PACE) survey. The PACE survey provides us with the annual plant-level pollution abatement operating cost data from 1979 to 1990. We divide this by a measure of the plant's size (the average of its largest two years of real shipments over the period) to get a measure of the pollution abatement expenditure intensity at the plant, PAOC.

To the Census data we linked firm-level information taken from the Compustat database.

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enforcement action in a low-reporting state might mean the same thing as seeing several actions in a high-reporting state.

[4] We would like to thank John Haltiwanger for providing the plant age information. In our analysis we used a single dummy to measure plant age (OLD = open before 1960) for two reasons: our sample includes some very old plants, likely to heavily influence any linear (or non-linear) age specification, and concern with environmental issues was not prominent before the 1960s.

The ownership linkage was based on an annual industry directory (the Lockwood Directory), capturing changes in plant ownership over time, which allowed us to calculate FIRMPLANT, the log of the number of other paper mills owned by the firm. From the Compustat data we took FIRMEMP, the log of firm employment, and FIRMPROF, the firm's profit rate (net income divided by capital stock). We also include NONPAPER, a dummy variable indicating that the firm's primary activity as identified by Compustat was outside SIC 26 (paper products). Since some (not a large fraction) of our plants are privately owned and hence are excluded from Compustat, we also include a dummy variable, MISSFIRM, to control for those observations with missing Compustat data.

Our regulatory measures come from EPA's Compliance Data System (CDS). The CDS provides annual measures of enforcement and compliance directed towards each plant. Our compliance measure, COMPLY, is a dummy variable indicating whether the plant was in compliance throughout the year (based on the CDS quarterly compliance status field - if a plant was out of compliance in any quarter, COMPLY was zero). To measure air pollution enforcement, we use ACTION, the log of the total number of actions directed towards the plant during the year. We also split ACTION into INSPECT, the log of the total number of 'inspection-type' actions (e.g. inspections, emissions monitoring, stack tests), and OTHERACT, the log of all non-inspection actions (e.g. notices of violation, penalties, phone calls). These different types of actions may have different impacts on compliance, and may have different degrees of endogeneity with compliance.

To supplement the air pollution data, we also use information from three other regulatory data sets: the EPA's Permit Compliance System (PCS) and Toxic Release Inventory (TRI), and the Occupational Safety and Health Administration's (OSHA) Integrated Management Information System (IMIS). The EPA's PCS provides information on water pollution regulation. Unfortunately, this data set does not begin until the late 1980s, near the end of our period, so we cannot include its variation over time in the model. Instead, we create WATERVIOL, the fraction of years in which the plant had at least one reported water pollution emission that was in violation of its permit. The EPA's TRI data set provides information on the disposal of toxic substances from manufacturing plants. The TRI was first collected in 1987, so it also does not provide useful time series variation for our model. Thus, we calculate the average discharge intensity for the plant, TOXIC, as the annual pounds of environmental releases, averaged over the 1987-1990 period, divided by the average real shipments of the plant in the same time period. Finally, OSHA conducts inspections and imposes penalties to try to ensure safe working conditions. We use data from OSHA's IMIS to measure the fraction of inspections during each year that were in violation, OSHAVIOL, which is set to zero for those plants with no OSHA inspections during the year. The OSHA data spans our entire period, so we can include the annual values directly in our model.

5. Econometric Issues

Several econometric issues arise when we proceed to the estimation of equation (3). The key econometric issue that any study of enforcement and compliance must face is the endogeneity of enforcement: regulators are likely to direct more of their attention towards those plants which they expect to find in violation. The explanation of this targeting behavior could be as simple as a desire to avoid wasting limited regulatory resources by inspecting those plants which are almost certain to be in compliance (so probably no corrective action would result from an inspection). A more complicated explanation comes from the work of Harrington (1988), who showed that an optimal regulatory strategy could involve focusing long-run enforcement activity on a few non-complying plants to punish them for not cooperating with regulation. In any event, it is the case that past research has little trouble identifying a negative relationship between enforcement activity and compliance behavior: non-complying plants get more enforcement.

We tried two methods to overcome the endogeneity of enforcement: lagging the actual enforcement faced by the firm and generating a predicted value of enforcement (which we also lagged) to use in a second stage estimation (an instrumental variables method).[5] The possible problem with both of these methods is that some endogeneity may remain: for lagging, if there is serial correlation in both the enforcement and compliance decisions, and for predicting, if the explanatory variables used in the first stage are not completely exogenous. In addition, if the lags are long enough or the first stage equation performs weakly enough there will be little correlation between the instrument and the actual value of enforcement.

We use a relatively simple first-stage model to predict enforcement activity, focussing on variables that are clearly exogenous with respect to the plant's compliance decision: year dummies, state dummies, and VOTE. Year dummies account for changes in enforcement activity over time, while state dummies allow for cross-state differences in enforcement activity (or differences in reporting of that activity in the CDS). We also tested an alternative control for state-year differences in enforcement: the overall air pollution enforcement activity rate (looking

[5] Note that these two variables (lagged actual enforcement and predicted enforcement) could also be interpreted as

at manufacturing industries, and dividing overall actions in the year by the number of plants in the state's CDS database). The state enforcement rate was highly significant and had the expected positive sign, but proved less powerful than the state dummies and is not used in the final analyses shown here. Finally, we include a variable measuring the political support for environmental regulation within the state, VOTE, which is the percent of votes in favor of environmental legislation by the state's congressional delegation, as measured by the League of Conservation Voters. The lagged predicted value from this first-stage model is then used in the second-stage compliance models.

Another concern for the estimation of equation (1) is that the dependent variable in our compliance equations (COMPLY) is discrete: a plant is either in compliance or not in compliance. Thus we need to use an estimation method that is appropriate to a binary dependent variable. In this case, we choose the logit model. We also estimate the model using a (theoretically inappropriate) OLS regression model partly as a consistency check on the logit results, but mostly so that we can easily include fixed effects into the analysis.[6]

A final concern for the analysis is the limited time-series variation available for key variables. OLD and PULP never change in our data set, while other characteristics change only slightly over time. Going to a fixed-effects model would completely eliminate OLD and PULP and reduce the explanatory power of the other variables. If there is substantial measurement error over time, using fixed-effects estimators could also result in a sizable bias in the estimated

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corresponding to the specific and general deterrence effects mentioned earlier.

[6] The fixed-effects version of the logit analysis would require estimating a conditional logit model, which in our Census data set would probably raise disclosure concerns, making it unlikely that we could report the resulting coefficients.

coefficients (Griliches and Hausman (1986)). We briefly explore introducing fixed-effects into an OLS model of compliance, but do not otherwise use fixed-effects models.

6. Results

Now we turn to the empirical analysis. Table 1 presents summary statistics and variable definitions. Looking at the regulatory variables, compliance with air pollution regulations is common, with about three-quarters of the observations in compliance. Enforcement activity is also common, with plants averaging more than one enforcement action per year. Turning to other regulatory programs, few plants show violations of either water pollution (16 percent) or OSHA regulations (13 percent). Most of our plants (87 percent) were in operation in 1960 or before, with slightly less than half (46 percent) including pulping facilities. The last two columns (%CS and %TS) show the fraction of total variation in the variable accounted for by plant and year dummies respectively. Nearly all of the variables in our data set are primarily cross-sectional in nature, with only the productivity measure and firm profit rates showing significant time-series variation. In any event, all of our models include year dummies, to account for changes in overall compliance rates and definitions of compliance over the period.

In Table 2 we examine the correlations between key variables, using Spearman correlation coefficients because they tend to be more robust to outliers. Examining plant characteristics, we find that pulp mills are larger and spend more on pollution abatement, old mills are less productive and are less likely to incorporate pulping, and large mills are more productive and spend more on pollution abatement. Air pollution compliance is lower for plants that are large, old, incorporate pulping, and spend more on pollution abatement.[7] Air pollution enforcement activity is greater at plants which are large, incorporate pulping and spend more on pollution abatement. Performance on other regulatory measures tends to be worse for large plants, those incorporating pulping, and those that spend more on pollution abatement. Within the set of regulatory measures, there is weak evidence for similar compliance behavior across different regulatory programs: air compliance is negatively correlated with water pollution violations, OSHA violations, and TRI discharges. Finally, air enforcement is negatively correlated with compliance, evidence that the tendency to target enforcement towards non-complying plants may make it difficult to observe empirically the ability of enforcement to increase compliance.

Table 3 concentrates on the basic logit model of the compliance decision, based solely on plant and firm characteristics. Most of the relationships are similar to those seen in the earlier correlations. Compliance rates are significantly lower at old mills, pulp mills, and large mills, however there is little evidence for any impact of firm characteristics on compliance. Switching to an OLS model makes no noticeable difference in the results. However, a model incorporating plant-specific fixed effects does give substantially different results - not surprisingly, since Table 1 showed us that most of the variables are primarily determined by cross-sectional differences, and two of the key plant characteristics (pulping and old) are purely cross-sectional and therefore drop out of the fixed effects model. Interpreting the magnitude of the Table 3 effects is easiest from the OLS model (3D) -- a pulp mill is 17% less likely to be in compliance, while doubling a

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[7] Some dummy variables in our data set (OLD, NONPAPER, and MISSFIRM) are not 'disclosable' in our analyses. For these variables, we indicate the sign of the relationship, and double the sign (e.g. '--') for results significant at the 10% level or better.

plant's size reduces its compliance rate by 6% -- but the transformed logit effects are nearly identical.

Table 4 adds measures of the plant's performance on other regulatory measures. The different regulatory measures are included separately, and then combined into a single model. In all cases the results are similar: a plant's compliance behavior with regards to water pollution or OSHA regulation is similar to its compliance for air pollution. The TRI results are much weaker, and more sensitive to model specification. The weaker connection to TRI may be due to the different regulatory structure: the TRI provides an information-driven incentive to reduce discharges, while the other three regulatory programs follow the traditional command-and-control model, and might therefore be more affected by a plant having a "culture of compliance" for regulation in general. The magnitudes of the water and OSHA impacts could be substantial. In model 4D, for example, a plant with 100% water compliance has an expected air compliance rate 11 percentage points higher than one with 0% water compliance; a similar shift for OSHA compliance is associated with a 14 percentage point higher expected air compliance rate.[8]

Table 5 provides a first look at the relationship between a plant's compliance with air pollution regulations and a variety of measures of the enforcement effort it faces. We use both actual enforcement and predicted enforcement measures, each lagged two years in an attempt to reduce within-period endogeneity of enforcement.[9] Based on the correlations seen in Table 2, it is not surprising that we find evidence that plants which face greater enforcement activity, as

[8] These calculations are based on the logit model's derivative of the probability of compliance with respect to the explanatory variables equal to .1824, evaluated at COMP's mean value of .76.

[9] Predicted enforcement values come from a first stage tobit, explaining the log of each type of enforcement activity using state and year dummies, as well as the VOTE variable. The pseudo-r-square of the tobits is .143, so we are only explaining a relatively small part of the variation in enforcement.

measured by lagged actual enforcement, tend to have a higher probability of being out of compliance. We strongly believe that these results say more about the targeting of enforcement towards violators, and do not indicate completely counterproductive enforcement. In an earlier version of the paper, we examined the impact of enforcement on changes in compliance status. These results indicated that enforcement activity was most effective in moving plants from violation into compliance, rather than in preventing plants from falling out of compliance (results available from the authors).

Once we account for the endogeneity of enforcement by using lagged predicted enforcement we find the expected positive significant relationship between enforcement and compliance. In particular, in model 5C, we find that increasing inspections by one raises the probability of being in compliance by roughly 10%. However, once we include other actions along with inspections (model 5E), the coefficient on inspections becomes a bit smaller and is no longer significant, while the coefficient on other actions is positive and significant. The magnitude of the two coefficients implies that increasing regulatory actions, either by one inspection or one other action, leads to approximately a 10% increase in the probability of being in compliance -- although this increase is only statistically significant for other actions. This is a large impact, given that only 24% of our observations are out of compliance.

In Tables 6 and 7 we consider differences in the impact of enforcement, based on plant and firm characteristics. We focus our attention on those models which found the most positive impacts of enforcement activity on compliance -- models which use $P(INSPECT)_{-2}$ and $P(OTHERACT)_{-2}$. These models include all of the plant and firm characteristics found in Table 3, which have similar signs and magnitudes to those found earlier. Table 6 considers possible interactive effects using the three plant characteristics that were significantly related to compliance: plant age (OLD), plant size (SIZE), and having pulping operations (PULP). Recall all three of these characteristics are associated with lower compliance rates. When we interact these three variables with enforcement measures (separately), we see some differences in response to enforcement activity by plant type: pulp mills are less sensitive to enforcement activity. In particular, in model 6A, increasing inspections by one at a paper mill without pulping facilities increases the likelihood of compliance by approximately 20%, whereas if the paper mill does have a pulping facility the likelihood of compliance only rises by 5% -- although the interactive effect is not quite significant.

Table 7 presents similar results, using firm characteristics: profit rate, employment, and number of plants (the latter two measured in log form). Although firm characteristics seemed unrelated to compliance levels in Table 3, they appear to be strongly related to sensitivity to enforcement, with opposite effects seen for sensitivity to inspections and to other enforcement actions (such as notices of violation or enforcement orders). Plants owned by larger firms, whether measured by firm employment or by the number of other paper mills owned by the firm, are less sensitive to inspections, and more sensitive to other enforcement actions, than those owned by smaller firms. For example, in model 7D, increasing the log of firm employment from 2.5 (its mean value) to 3.0 -- only about 1/3 its standard deviation -- completely eliminates any positive effect that inspections have on the likelihood of compliance. In contrast, other actions have a positive impact on the likelihood of being in compliance for any firm with a log of employment greater than 1.5. Furthermore, for the same increase in log employment (2.5 to 3.0), an additional other action raises the likelihood of being in compliance by roughly 5%. Perhaps larger firms have better-developed regulatory support programs and are less likely to be 'surprised' by routine inspections, but are at the same time more able to focus compliance resources on plants with serious problems or plants in states with aggressive followup through other enforcement actions, raising the costs of non-compliance. Smaller firms might be more surprised by (and responsive to) routine inspections, but less able to put additional resources into plants with serious problems and less bothered by bad publicity associated with other enforcement actions.

7. Conclusions

We have examined plant-level data on enforcement and compliance with air pollution regulation to: 1) test whether enforcement is effective in inducing plants to comply; 2) test whether certain types of plants are more influenced by enforcement behavior; and 3) determine what other firm and plant characteristics are associated with compliance. We find significant effects of some plant characteristics on compliance: plants which include a pulping process, plants which are older, and plants which are larger are all less likely to be in compliance. Unlike Helland (1998), we find that firm-level characteristics are not significant determinants of compliance at the plant level. On the other hand, plants with violations of other regulatory requirements, either in water pollution or OSHA regulation, are significantly less likely to comply with air pollution regulations. We do not see the same sort of effect for 'voluntary compliance' as represented by TRI emissions. The magnitudes of the effects of plant-level characteristics on compliance are non-trivial, at least for large changes in plant characteristics and enforcement activity. In particular, doubling the size of a plant is associated with a 6%

reduction in compliance; a plant with pulping has 17% lower compliance than one without pulping; a plant in violation of water pollution regulations is 13% less likely to be in compliance with air pollution regulations.

Measuring the impact of regulatory enforcement on compliance is complicated by the targeting of enforcement towards plants that are out of compliance. This targeting effect generally results in a negative relationship between enforcement and compliance. However, when we account for the endogeneity of enforcement by using lagged predicted values of enforcement, based on variables that are clearly exogenous to the plant's compliance decision, we find the expected positive significant relationship between enforcement and compliance.

We also find some differences across plants in their responsiveness to enforcement, based on plant characteristics. Pulp mills, which have difficulties in complying with regulations, are also less likely to respond to regulatory enforcement (like Figure 1b). For example, increasing $P(INSPECT)_{-2}$ by one inspection at a paper mill without pulping facilities increases the likelihood of compliance by approximately 20%, whereas if the paper mill does have a pulping facility the likelihood of compliance only rises by 5%. Finally, even though firm characteristics are not found to be related to the level of compliance, we find them to be more strongly related to a plant's sensitivity to enforcement (like Figure 1c). Plants owned by larger firms, whether measured in terms of their employment or by the number of other paper mills they own, are less sensitive to inspections and more sensitive to other enforcement actions. For example, increasing the log of firm employment from 2.5 (its mean value) to 3.0 completely eliminates any positive effect $P(INSPECT)_{-2}$ have on the likelihood of compliance. On the other hand, for the same increase in log employment, one more $P(OTHERACT)_{-2}$ raises the likelihood of being in compliance by roughly 5%.

What lessons can be drawn by policy-makers from these results? First (and no surprise), there are observable characteristics of plants which are strongly associated with their compliance behavior. To the extent that regulators want to concentrate their enforcement activity on those plants which are likely to be in violation, knowing which characteristics are important for a particular industry could be useful. Second, firm characteristics seem much less important than plant characteristics in determining a plant's compliance rate. Third, a plant's behavior in one regulatory area appears to carry over into others, so that knowing a plant's compliance with water pollution regulations (or even OSHA regulations) provides an indication of whether it is likely to be in compliance with air pollution regulations. Fourth, enforcement is at least somewhat effective in encouraging compliance.

Finally, there is evidence that plants differ in their responsiveness to enforcement activity, and these differences are related to firm as well as to plant characteristics. In particular, plants owned by larger firms are less responsive to inspections, and more responsive to other enforcement actions (the effects of plant size are similar, though not statistically significant). This is consistent with other research on regulatory impacts: Gunningham, et. al. (2003) find a greater effect of EPA inspections for smaller firms, and Mendeloff and Gray (2003) find a greater impact of OSHA inspections on smaller workplaces.

We are planning to overcome some of the limitations of the current paper in future work. Most importantly, we anticipate extending the data set into the 1990s. This will enable us to include more years of data for other environmental regulatory measures, water compliance and toxic discharges. The expanded data set will allow us to look more closely at the interactions between the compliance decision for one pollution medium and compliance on other media. We also plan to expand our definition of compliance to allow us to distinguish among different levels of compliance, ranging from paperwork violations to excess emissions, and to distinguish between state-level enforcement activity and federal enforcement. Finally, we also plan to examine the impact of regulation on compliance for plants in other industries including steel and oil to see if regulatory effects differ across industries.

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Table 1

Summary Statistics
(N=1392)

Variable	Mean	Std Dev	%CS	%TS	Description
Plant Characteristics					
PULP	0.46	0.50	100	.	dummy, 1=pulping operations
OLD	0.87	0.34	100	.	dummy, 1=operating before 1960
TFP	0.89	0.22	33	33	total factor productivity (level)
SIZE	10.30	0.81	93	<10	real value of shipments (log)
IRATE	0.13	0.17	20	<10	real investment (last 3 years)/ real capital stock
PAOC	0.004	0.005	77	<10	pollution abatement operating expenses / value of shipments
Firm Characteristics					
FIRMEMP	2.49	1.43	70	<10	firm employment (log)
FIRMPROF	0.05	0.04	48	11	firm profit rate (net earnings/ capital stock
FIRMPLANT	2.29	0.85	80	<10	firm number of paper mills (log)
NONPAPER	0.20	0.40	.	.	firm's primary SIC not papermaking
MISSFIRM	0.19	0.39	.	.	plant not owned by Compustat firm
Air Pollution Regulation					
COMPLY	0.76	0.43	31	<10	dummy, 1=in compliance during year
ACTION	1.17	0.84	52	<10	total air enforcement actions (log) (mean # actions = 3.79)
INSPECT	0.72	0.50	34	<10	air inspections (log) (mean # inspections = 1.34)
OTHERACT	0.71	0.91	52	<10	other air enforcement actions (log) (mean # other actions = 2.45)
Other Regulatory Measures					
TOXIC	2.48	2.86	100	.	TRI air&water discharges/value of shipments (1987-90 avg pounds/$000)
WATERVIOL	0.16	0.29	100	.	% water violations (1985-90 avg)
OSHAVIOL	0.13	0.32	<10	18	% OSHA inspections w/ penalty (79-90)

%CS = percent of variation explained by plant dummies
%TS = percent of variation explained by year dummies

Table 2

Spearman Correlation Coefficients

(N=1392)

	PULP	OLD	TFP	SIZE	IRATE	PAOC
PULP	1.000					
OLD	(--)	1.000				
TFP	0.036	-0.130	1.000			
SIZE	0.538	-0.011	0.235	1.000		
IRATE	-0.048	0.065	0.015	0.042	1.000	
PAOC	0.515	0.012	0.006	0.396	-0.001	1.000
COMPLY	-0.230	(--)	-0.006	-0.179	-0.062	-0.178
ACTION	0.300	-0.071	0.050	0.372	0.006	0.324
TOXIC	0.310	-0.105	0.046	0.255	0.045	0.320
WATERVIOL	-0.025	0.149	-0.027	0.288	0.010	0.151
OSHAVIOL	0.039	0.013	-0.090	0.092	0.046	0.056

	COMPLY	ACTION	TOXIC	WATERVIOL	OSHAVIOL
COMPLY	1.000				
ACTION	-0.295	1.000			
TOXIC	-0.094	0.210	1.000		
WATERVIOL	-0.075	0.093	0.115	1.000	
OSHAVIOL	-0.116	0.099	0.034	0.143	1.000

Correlations exceeding about .08 are significant at the .05 level.
(--) indicates significant negative correlation.

Table 3

Basic Compliance Models

(Dep Var = COMP; N=1160)

model:	(3A) Logit	(3B) Logit	(3C) Logit	(3D) OLS	(3E) F.E.
			Plant Characteristics		
PAOC	1.064		0.427	0.072	0.879
	(0.07)		(0.03)	(0.02)	(0.18)
PULP	-0.919		-0.912	-0.170	
	(-5.07)		(-4.73)	(-4.94)	
OLD	(-)		(--)	(--)	
TFP	0.237		0.190	0.024	0.126
	(0.59)		(0.46)	(0.35)	(1.11)
IRATE	-0.328		-0.219	-0.039	0.019
	(-0.75)		(-0.50)	(-0.50)	(0.24)
SIZE	-0.303		-0.365	-0.055	0.011
	(-2.61)		(-2.81)	(-2.57)	(0.12)
			Firm Characteristics		
FIRMEMP		-0.042	0.120	0.018	-0.057
		(-0.38)	(1.01)	(0.88)	(-1.53)
FIRMPROF		2.970	2.468	0.451	-0.029
		(1.25)	(0.97)	(1.01)	(-0.06)
FIRMPLANT		0.127	0.052	0.011	-0.073
		(1.09)	(0.42)	(0.51)	(-2.09)
NONPAPER		(-)	(-)	(-)	(+)
LOG-L	-609.72	-645.96	-605.97		
pseudo-R^2	0.064	0.008	0.070	0.075	0.341

Regressions also include a constant term and year dummies.
Firm variables include MISSFIRM.

(-) indicates negative coefficient; (--) indicates significant negative.

Table 4

Compliance - Cross-Regulation Effects
Logit Models
(Dep Var = COMP; N=1160)

	(4A)	(4B)	(4C)	(4D)	(4E)	(4F)
			Cross-Regulation Effects			
TOXIC	-0.000			0.009	0.005	-0.031
	(-0.02)			(0.35)	(0.17)	(-1.33)
WATERVIOL		-0.713		-0.618	-0.670	-0.601
		(-2.73)		(-2.32)	(-2.54)	(-2.58)
OSHAVIOL			-0.836	-0.788	-0.765	-0.774
			(-4.14)	(-3.87)	(-3.76)	(-3.97)
			Plant characteristics			
PAOC	0.450	4.694	-1.793	1.429	2.184	
	(0.03)	(0.30)	(-0.12)	(0.09)	(0.14)	
PULP	-0.911	-1.070	-0.941	-1.086	-1.092	
	(-4.68)	(-5.30)	(-4.82)	(-5.26)	(-5.62)	
OLD	(--)	(-)	(--)	(-)	(-)	
TFP	0.190	0.118	-0.002	-0.054	-0.011	
	(0.46)	(0.28)	(-0.01)	(-0.13)	(-0.03)	
IRATE	-0.219	-0.321	-0.194	-0.292	-0.401	
	(-0.50)	(-0.72)	(-0.43)	(-0.65)	(-0.90)	
SIZE	-0.366	-0.245	-0.324	-0.220	-0.154	
	(-2.81)	(-1.78)	(-2.45)	(-1.58)	(-1.23)	
			Firm Characteristics			
FIRMEMP	0.120	0.099	0.108	0.095		-0.071
	(1.00)	(0.82)	(0.90)	(0.78)		(-0.63)
FIRMPROF	2.467	2.152	2.587	2.384		2.917
	(0.97)	(0.83)	(1.00)	(0.90)		(1.19)
FIRMPLANT	0.052	0.060	0.073	0.077		0.103
	(0.42)	(0.49)	(0.59)	(0.62)		(0.87)
NONPAPER	(-)	(-)	(-)	(-)		(-)
LOG-L	-605.97	-602.26	-597.68	-594.99	-598.54	-632.17
pseudo-R^2	0.070	0.075	0.082	0.086	0.081	0.029

Regressions also include year dummies, a constant term, and MISSFIRM.
(-) indicates negative coefficient; (--) indicates significant negative.

Table 5

Compliance - Enforcement Measures
Logit Models

(Dep Var = COMP; N=1160)

	(5A)	(5B)	(5C)	(5D)	(5E)	(5F)
			Enforcement Measures			
$P(ACTION)_{-2}$	-0.213 (-1.40)					
$ACTION_{-2}$		-0.291 (-3.14)				
$P(INSPECT)_{-2}$			0.551 (1.85)		0.429 (1.40)	
$INSPECT_{-2}$				-0.080 (-0.54)		0.045 (0.30)
$P(OTHERACT)_{-2}$					0.483 (2.20)	
$OTHERACT_{-2}$						-0.296 (-3.56)
LOG-L	-605.01	-601.03	-604.18	-605.82	-601.75	-599.52
pseudo-R^2	0.071	0.077	0.072	0.070	0.076	0.079

All models include the complete set of plant and firm characteristics from earlier models, along with year dummies and a constant term.

Table 6

Enforcement * Plant Characteristics
Logit Models

(Dep Var = COMP; N=1160)

	(6A)	(6B)	(6C)	(6D)	(6E)	(6F)
$P(INSPECT)_{-2}$	1.047	1.145	-0.065	-0.033	3.827	7.051
	(2.24)	(2.28)	(-0.14)	(-0.07)	(0.99)	(1.51)
$P(OTHERACT)_{-2}$		0.123		0.171		-1.314
		(0.33)		(0.41)		(-0.51)
$PULP*P(INSPECT)_{-2}$	-0.792	-1.124				
	(-1.46)	(-1.89)				
$PULP*P(OTHERACT)_{-2}$		0.490				
		(1.26)				
$OLD*P(INSPECT)_{-2}$			(++)	(+)		
$OLD*P(OTHERACT)_{-2}$				(+)		
$SIZE*P(INSPECT)_{-2}$					-0.309	-0.628
					(-0.85)	(-1.42)
$SIZE*P(OTHERACT)_{-2}$						0.175
						(0.72)
LOG-L	-603.08	-599.76	-602.89	-600.62	-603.82	-600.75
pseudo-R^2	0.074	0.079	0.074	0.078	0.073	0.078

All models include the complete set of plant and firm characteristics from earlier models, along with year dummies and a constant term.

Table 7

Enforcement * Firm Characteristics
Logit Models

(Dep Var = COMP; N=1160)

	(7A)	(7B)	(7C)	(7D)	(7E)	(7F)
$P(INSPECT)_{-2}$	0.458	0.458	0.685	1.311	0.829	1.604
	(1.18)	(1.67)	(1.47)	(2.55)	(1.32)	(2.35)
$P(OTHERACT)_{-2}$		0.402		-0.713		-0.862
		(1.00)		(-1.84)		(-1.65)
$PROF*P(INSPECT)_{-2}$	2.464	0.529				
	(0.38)	(0.07)				
$PROF*P(OTHERACT)_{-2}$		0.644				
		(0.14)				
$EMP*P(INSPECT)_{-2}$			-0.062	-0.445		
			(-0.37)	(-2.29)		
$EMP*P(OTHERACT)_{-2}$				0.488		
				(3.89)		
$PLANTS*P(INSPECT)_{-2}$					-0.142	-0.643
					(-0.50)	(-2.00)
$PLANTS*P(OTHERACT)_{-2}$						0.587
						(2.94)
LOG-L	-604.11	-601.73	-604.11	-593.39	-604.05	-596.80
pseudo-R^2	0.072	0.076	0.072	0.089	0.072	0.084

All models include the complete set of plant and firm characteristics from earlier models, along with year dummies and a constant term.

Figure 1

Impact of Shift in Regulation on Optimal Compliance

$$MB=MB(X_p,X_f,REGS,X*REGS)$$

$$MC=MC(X_p,X_f)$$

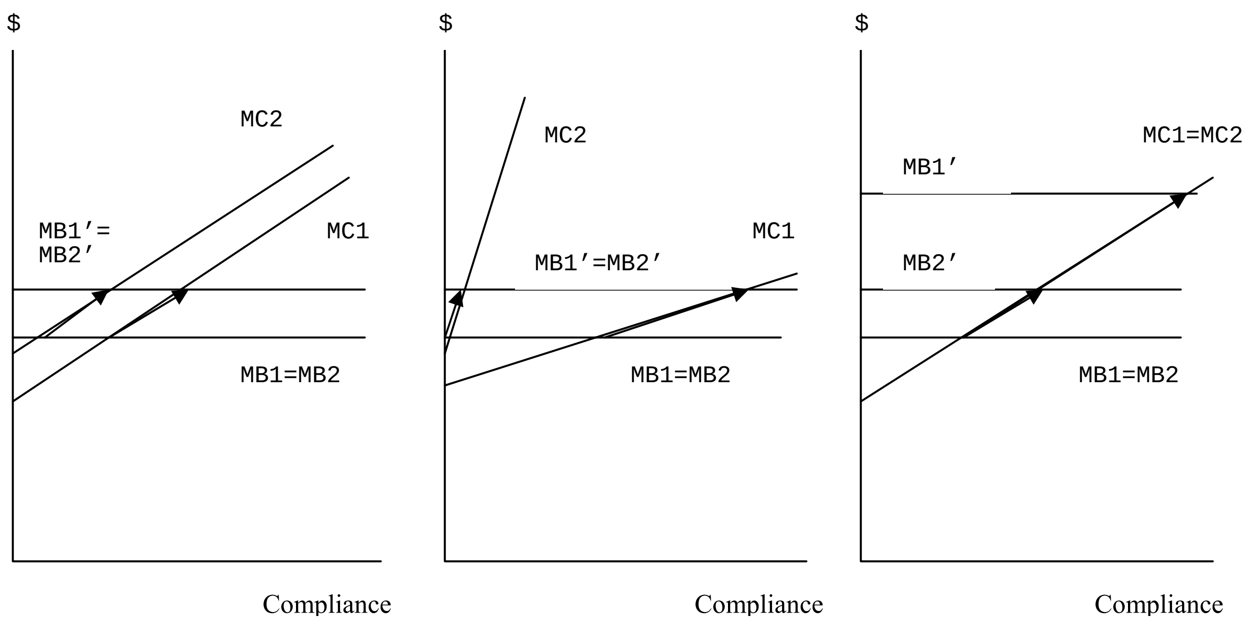

Figure 1a

Same MB shift,
Different MC levels,
Same MC slope

Figure 1b

Same MB shift,
Different MC levels,
Different MC slopes

Figure 1c

Different MB shifts
(MB1 more
sensitive),
Same MC

Session I: Enforcement Issues

Discussant No. 1: Nick Franco, OECA

COMMENTS ON:

Factors Shaping Corporate Environmental Behavior and Performance: Regulatory Pressure, Community Pressure, and Financial Status

Dietrich Earnhardt
University of Kansas

Observations

- The NPDES Permitting program has a unique regulatory structure, where regulated facilities are required to regularly self-report their performance; and compliance status is automatically determined in the PCS data system.
- Inspections are not the primary tool for identifying NPDES permit violations, but are a check to ensure accurate self-reporting. Thus, there may not be a strong correlation between inspections and specific and general deterrence. (For example, a compliance order could be issued without an inspection.)
- Supplemental Environmental Projects (SEPs) are not an EPA penalty, but a voluntary project undertaken by a regulated entity in conjunction with an enforcement action. Though this represents a financial obligation, it is unclear what impact this will have with respect to deterrence. SEPs are attractive to some regulated entities because they may be considered as a mitigating factor when determining penalty size, they often contain a component that may improve the regulated entities standing with the public, and so may lessen the overall negative impact and deterrent effect of enforcement activity.

Policy Implications

- From a policy perspective it is hard to account for the mixed results, and the inconsistency between the BOD and TSS results.
- It is doubtful that the results can be generalized to other media programs, given the unique regulatory structure of the NPDES program.
- Where the number or average size of penalties is shown to worsen performance, this may be accounted for the by the targeting effect, that is, penalties are given to those permitted facilities that are out of compliance (i.e., regulatory activity is endogenous).

Other Considerations

Given the mixed results, some other areas of research that may help to clarify the impacts of enforcement interventions, and provide clearer policy guidance are outlined below.

- What deterrent effect does the NPDES reporting system itself have on regulated entities, does this account for the lack of consistent impact found for state and federal penalties? How does this compare to other media programs where presence is established primarily through inspections, investigations, and enforcement?

- How can an analysis account for the enforcement policy of escalation? Escalation may account for some of the difference seen between administrative and civil penalties. Noncompliance with permitted effluent limits is normally first addressed with an informal enforcement action (e.g., phone calls) at the state level. Then if necessary a formal action (e.g., a compliance order, an administrative penalty order, or both). If these administrative enforcement actions were not successful at compelling compliance then a civil action would be initiated.
- Was the time period long enough to capture the results of injunctive relief? Capital-intensive injunctive relief projects often take longer to implement and show results than the time period of the study.

Session I: Enforcement Issues

Discussant No. 1: Nick Franco, OECA

COMMENTS ON:

Deterrence and Corporate Environmental Behavior

Dorothy Thornton, University of California, Berkeley
Neil Gunningham, Australian National University
Robert Kagan, University of California, Berkeley

<u>Observations</u>

- General Deterrence relies upon the "threat signal" being <u>received</u> and <u>understood</u>.
- The paper is important because it shows there is a real general deterrence effect (65% increased compliance activity base on enforcement activity against others); and the response to the threat signal varies across groups (e.g., drive into compliance, re-enforce compliance behavior, remind to pay attention to compliance requirements).

<u>Policy Implications</u>

- EPA has taken some steps to enhance and capitalize the general deterrence effect. Sought to enhance it by issuing more press releases about concluded enforcement cases (increased frequency of threat signal); and capitalize on it by using a signal case as an opportunity to educate others in the industry and encourage them to take advantage of the Audit Policy to self-disclose noncompliance by a certain time or face an inspection (increasing personal risk perception). Though more could be done

Paper identifies a number of opportunities for EPA to Enhance General Deterrence

- <u>Increasing Perceived Risk</u>: given that many who responded to the survey overwhelmingly underestimated <u>penalty size</u> suggests that EPA could enhance the general deterrence effect by doing more to ensure regulated entities better understand penalty policies, and penalties resulting from concluded cases.
- Likewise, EPA could take steps to ensure that regulated entities are better informed about the <u>number of penalties</u> given out, and the <u>broader applicability</u> of specific enforcement actions (e.g., helping to answer, does this apply to me?).
- More accurate knowledge about penalty size, frequency, and general applicability may enhance the general deterrence affect.

- <u>Reminder Function</u>: the reminder function suggests that EPA should, at the very least, use the occasion of a significant enforcement action to not only raise the perceived threat in the eyes of those inclined not to comply, but to prompt those inclined to comply to review their compliance status (e.g., an opportunity to provide self-assessment and compliance assistance materials).
- <u>Reassurance Function</u>: the paper also lends support to EPA's motivation to conduct inspections in order to maintain a presence in a particular sector in order: motivate compliance by increasing perceived risk; and to help ensure a level playing field, which

this paper suggests is a compliance motivator for some regulated entities (i.e., the reassurance function).

Other Considerations

- Would the results of the study differ in an industry where there is not widespread compliance? Would "explicit general deterrence" play more of a role?
- How can EPA foster "implicit general deterrence" (i.e., a culture of compliance) in an industry?
- There was a lag, 1.5-2 years between the signal case and the survey. This leads one to ask, does the general deterrence signal have a wasting impact; does it loose its affect over time?
- How often does a general deterrence signal need to be received to have the maximum impact in an industry? Is it more important that regulated entities remember the facts surrounding a specific case, or that their cumulative perception of risk is maximized?
- Are companies taking into account things other than penalties when deciding to act (e.g., injunctive relief, impact on public image)?
- Are there industry types or structures where the threat signal is better communicated, general deterrence has a greater impact (e.g., an industry with: a strong association, dominated by a few large players, homogeneous operations)?
- Similarly, are there characteristics of a particular company that would make it more inclined to head the general deterrence threat signal?

Session I: Enforcement Issues

Discussant No. 1: Nick Franco, OECA

COMMENTS ON:

When and Why do Plants Comply? Paper Mills in the 1980s

Wayne Gray, Clark University
Ron Shadbegian, University of Massachusetts

Observations

- It is not generally true that firms face a rising marginal costs with regard to achieving compliance. This seems to assume that compliance is a matter of capital outlays to implement end-of-pipe pollution control. This does not take into account other opportunities such process or input changes to reduce waste and pollution and simultaneously achieve compliance and costs savings, or avoid regulation all together, which may be available in other industries. This also seems to assume that companies can effectively externalize pollution costs, which is likely not true.
- It is unclear what the basis is for the statement that even with limited inspection presence and penalty size that "… most firms still seem to comply." EPA has calculated statistically valid compliance rates for only a handful of sectors, and these have not shown high levels of compliance.
- It appears that when populating dummy variable COMPLY, a plant was assumed to be in compliance unless found to be out of compliance. Depending on the inspection presence in the sector this assumption may skew the results.

Policy Implications

- The finding that where it is harder to comply, (i.e., cost of compliance is higher), plants are less likely to be in compliance, and less likely to respond to regulatory enforcement, seems intuitively obvious and suggests little in the way of policy prescriptions. The agency already accounts for these factors when developing compliance assurance strategies.
- The significance of plant-level characteristics on compliance, and the lack of significance of firm-level characteristics, could be helpful in terms of targeting enforcement and compliance resources. (Assuming the findings are generalizable). May be able use past inspection data to identify common characteristics of non-compliant plants.
- The finding that firm characteristics are strongly related to a plant's sensitivity to enforcement, but not to whether a plant is in compliance, raises a number of questions. Does this mean that firms in this sector do not pay attention to plant level compliance until a problem is identified? If this is the case it may suggest that compliance assistance and general deterrence messages should be delivered at the firm as well as the plant level.
- The finding that non-compliance in one regulatory area is indicative of non-compliance in other areas confirms the findings of other less formal analyses and anecdotal understanding of plant level compliance. What would make this finding more useful is a clear linkage between different types of non-compliance (e.g., if you are out of compliance with regulation A you are likely out of compliance with regulation B);

though this linkage is likely dependent on the industry and the mix of regulations that they are subject to. In particular, this type of finding could be leveraged if some source of readily available information could serve as an indicator of noncompliance that would otherwise be difficult or costly to determine.

Other Considerations

- Additional research to determine whether the plant characteristics associated with a higher likelihood of noncompliance in paper mills are generally applicable would facilitate applying the finding more broadly.

General Comments

- EPA would be better served by future studies if they did not focus exclusively on compliance, but also took into account other agency goals such as pollutant reductions. The Office of Enforcement and Compliance Assurance has two long-term outcome goals in the current Agency Strategic Plan, these are pounds of pollutants reduced, treated, or eliminated, and the number of regulated entities making improvements to environmental management practices.
- Research needs to view the suite of tools that EPA uses to ensure compliance (i.e., assistance, incentives, monitoring, and enforcement) in their proper context. All of these tools are used in conjunction with one another to ensure compliance, not individually. What would be a more fruitful line of research is looking at what combination of tools or strategies work best to ensure compliance.
- Many economic models define deterrence as a function of the probability of being caught in noncompliance and the cost of noncompliance. If this is the case, then inspections and investigations speak to the probability of non-compliance being detected, and penalties and other sanctions speaks to the cost of non-compliance. However, looking at just these two components does not address timing and follow-through issues. With respect to timing, is there an impact if there is a significant lag time between detection of noncompliance and the leveling of a penalty? Likewise, what is the impact of detection of noncompliance that results in no sanction? Is there a greater deterrent effect as the percentage of inspections that detect noncompliance lead to a penalty increases?

Session I: Enforcement Issues

Discussant No. 2: Randy Becker, U.S. Bureau of Census

COMMENTS ON:

Enforcement Issues:
EPA Conference on Corporate Environmental Behavior and the Effectiveness of Government Interventions

Randy A. Becker*
Center for Economic Studies
U.S. Bureau of the Census

April 26, 2004

Introduction

The U.S. Environmental Protection Agency (EPA) has been expressing a strong interest in understanding the factors that determine environmental performance at polluting facilities. The three papers presented here today all examine whether regulatory actions (i.e., inspection, penalties, etc.) result in better environmental performance at facilities.

These effects come in two basic forms: *Specific deterrence* measures the impact of past regulatory actions taken directly against one's facility, while *general deterrence* measures the impact of past regulatory actions taken against facilities like yours (e.g., other chemical plants in your state).

Comments on the paper by Dietrich Earnhart

The first paper presented here examines the effects of regulatory pressure on the monthly water pollution discharges of a panel of 508 "major" chemical (SIC 28) plants from 1995-2001. The water pollutants he examines are (mainly) biological oxygen demand (BOD) and total suspended solids (TSS).

* The opinions expressed here are my own and do not necessarily represent those of the U.S. Bureau of the Census.

The focus here is mainly on the effectiveness of the various regulatory levers that the government has at its disposal. Namely, this paper examines the effectiveness of inspections – which come from two sources: EPA and state – as well as the effectiveness of penalties – which also comes in two forms: EPA administrative penalties and federal civil penalties (administered by the Department of Justice). Then there is the question of whether – within each of these 4 types of regulatory actions – general deterrence is as effective as specific deterrence.

Results suggest (to use the authors words) “a mixed degree of effectiveness.” Indeed, it seems that, currently, there are at least as many *counter-intuitive* effects here as there are intuitive ones. But the paper makes clear that a lot of work is still pending, so these results should be viewed as preliminary. Many of the ‘next steps’ outlined in the paper are exactly the ones that I would suggest.

There is much to like about this paper, not the least of which is that it is a very carefully explained study. I like the *relative* measure of compliance that is used here – i.e., the ratio of absolute discharges to effluent limits – because (as the author also points out) it can capture not only non-compliance, compliance, and over-compliance, but also the *degree* of non-compliance or over-compliance. I like that the study is a joint examination of many factors: inspections vs. penalties, EPA vs. state intervention, specific vs. general deterrence, the role of firm characteristics and the interaction between firm characteristics and the different types of interventions, as well as the impact of community characteristics. This is a nice <u>broad</u> view of enforcement and compliance. Because there isn’t much time, let me focus most of my comments on some of the potential issues with this study.

First, I wonder whether we are studying the right facilities. (This may partly reveal my ignorance on this subject.) I’d like to see some more context provided here — e.g., a table of industrial water usage (or discharge) by 2-digit SIC manufacturing industry. I wonder whether there is a more "interesting" water-polluting industry to examine than chemicals, like pulp & paper, or food processing, or some such. And are BOD and TSS these chemicals facilities' main *water* concerns? Perhaps toxic releases, thermal pollution, etc. are as important, if not more so. And what are the *other* water pollutants in the "limit exceedances" measure? I don't believe that these are ever mentioned or discussed.

Also, it seems that air pollution is at least as problematic for chemical plants – if not more so – than water pollution, but there is no discussion here of cross-media issues. Do the inspection and penalty data used here also encompass air emission violations? If so, this might explain the weak and puzzling relationships seen here (at least in part). If they do not, perhaps there *should* be explanatory variables measuring how much regulatory pressure these facilities face on other fronts, since it may affect their compliance in the water dimension. That is, if you are constantly being inspected and fined for your air emissions, you may face some "spillover" scrutiny of your water discharges.

I was truly struck by the magnitude of "over-compliance" here: On average, month after month, these facilities are at 30% of their discharge limit. Since these plants are so far from being non-compliant, I wonder whether they're even all that interesting to examine. These large facilities have probably been regulated (and fined and inspected) for decades, which may be why they are so compliant. Perhaps the interesting cases – the facilities closer to the margin – are the small- and medium-sized plants that have only begun to experience more stringent regulation more recently.

The second paper, by Thornton *et al.*, suggests exactly this. In particular, they state that many of the plants that they talked to were "beyond compliance" and that "hearing about punishments imposed on recalcitrants did not resonate with their own circumstances and triggered little fear in them." (p.14) Furthermore, the large chemicals companies in particular suggested that "specific deterrence was not a salient driver of environmental actions" and that "inspections held no fear for them." (p.13) The authors go on to say that "in any event, deterrence in any form was of far greater concern to [small- and medium-sized enterprises] than it was to large ones." (p.16)

There is also this notion that larger firms have more political clout and may be able to negotiate more preferable emission limits. I am not sure there is strong evidence of that necessarily, but it would be yet another reason to incorporate small- to mid-sized plants into the analysis. I realize that this may not be possible however, because of a lack of data.

My overall concern here – which, again, may be born from my ignorance – is that we may be focusing on facilities that may not be all that sensitive to the instruments being explored — either because they are already super-compliant after decades of regulation and/or water pollution is only a secondary issue for them. Focusing on a more sensitive population – e.g., small- or medium-sized plants in an industry that really has serious issues with BOD and TSS – should really reveal the effectiveness of these regulatory instruments. Perhaps the author has a sensitive population here, in which case further evidence should be presented to make that case.

Also, it seems to me that *penalties* are really a special case – quite a bit different from *inspections* as a regulatory tool. In particular, unlike inspections, they are a tool that can only be used in certain circumstances – namely, when there has been some sort of violation. And their role is probably quite a bit different as well. It seems they would be used to *induce compliance*, but they cannot be used to improve environmental performance in general (i.e., generate more over-compliance) – which is really what we're talking about here in this sample of facilities!

Penalties also seem a bit difficult to analyze empirically. In particular, penalties may occur months after the actual violation, which would muddy any estimation of their "treatment" effect. Furthermore, it seems to me that there cannot be a penalty without an inspection. If the presence of a penalty always suggests the presence of an inspection, how does that affect the interpretation of the penalty estimates (if at all)? Finally, environmental performance may improve after an accidental discharge, with or without a penalty. Does this impact the interpretation of results?

These issues aside, what should regulators take away from the findings of this study? It seems to me that inspections are the only tool that they have at their disposal for any particular plant – or at least it's the first stop. Therefore, I'm not sure that penalties – particularly in the specific deterrence context – should receive equal and equivalent billing here in the analysis.

Finally, I would like to see more explanation of some of the counter-intuitive results. Also, why might we expect "asymmetric" results between these two pollutants (BOD and TSS)? And I think the author also needs to be a bit careful in interpreting his results: This study looks at facilities that are the largest of the large and therefore the results may not necessarily generalize. For example, at one point the claim is made that there are diseconomies of scale in water pollution abatement. Since small- and medium-sized plants are largely absent here, the results do not necessarily rule out a more U-shaped cost curve. Also, the compliance data here are self-reported. Could it be that inspections and penalties induce better *reporting*, but no actual change in behavior? That is, part of the inspection process may be the verification of emissions calculations. Is there any evidence for that here? For some intuition on this subject, the author may want to seek out the verification studies that have been done for the Toxics Release Inventory (TRI).

Comments on the paper by Dorothy Thornton, Neil Gunningham, and Robert Kagan

Like the first paper and the Gray & Shadbegian paper that follows, this paper explores whether general deterrence (in particular) is important in shaping corporate environmental behavior. The generally-held theory on general deterrence posits the following: First, firms continually gather information on environmental inspections and penalties against others. Second, evidence of a tough penalty against a firm reverberates throughout the community of regulated businesses and raises their perceived risk of getting caught and facing sanctions. Third, with this greater perceived risk, these businesses undertake measures to increase their compliance (after some cost-benefit analyses).

Rather than *infer* such deterrence from volumes of data on inspections, penalties, and plant-level pollution emissions, as do the other two studies, these authors simply *ask* firms whether they are influenced by the penalization of others like them. Their survey and interviews reveal little evidence of the sort of mechanism just outlined. I will now review some of the key findings presented in this paper and offer some commentary along the way.

The authors begin with 112 EPA press releases on "penalty cases" from January 2000 to June 2001 (i.e., recently but not *too* recent). From these, they sampled 40 cases. They then searched many news databases to determine the extent of the media coverage received by each of these cases. They find that most did not received "widespread" coverage. I think a bit too much emphasis is placed here on the importance of media coverage. That is just one channel for finding out such news. As important, if not more so, is the role of "informal" channels, such as from workers, supplier, customers, and indeed from the regulators themselves. The authors may have missed an important opportunity to ask firms: *How do you typically hear about other enforcement cases?* Perhaps they have some anecdotal evidence that they can present, from their in-depth interviews with businesses.

In any event, they chose 8 of the 40 “signal” cases and drew a random sample of firms operating in the same line-of-business and same state. Eighty percent (n=233) agreed to be interviewed/surveyed, which is a truly exceptional response rate! Of these, 42% recalled the signal case, which the authors think is rather low. I’m not so sure! (Is the glass 58% empty or 42% full?) In any event, it seems like some adjustment to this statistic is warranted, based on the “visibility” of the violating facility. That is, the responses should perhaps be “weighted” somehow — e.g., by the (inverse of the) number of such plants in that industry-state, by the size/prominence of the facility in question, and/or by the geographic proximity of the violator to the surveyed business.* In an interesting result, the more “professionalized” the respondent was (vis-à-vis the environment) the more likely the s/he recalled the signal case. I like this variable a great deal and think that it could perhaps play a useful role in other environment-related surveys, such as the Census Bureau’s Pollution Abatement Costs and Expenditures (PACE) survey.

In what might be deemed “good news” for general deterrence, 89% of respondents recalled at least one recent penalty cases (if not the signal case). When told of the signal case, however, respondents overwhelmingly under-estimated the actual penalties. The authors conclude that, overall, the first component of the theory of general deterrence – i.e., that firms actively seek out information on enforcement actions – is only weakly supported. Since these particular firms appear to be super-compliant, this may not be particularly surprising.

They also find no particularly strong association between knowledge of other cases and perceptions of the risk of detection or punishment (i.e., likelihood of being caught, of being

* Maybe we shouldn’t be surprised if a chemical plant in Louisiana did not hear of the signal case because there are in fact hundreds of chemical plants in Louisiana. Likewise, in a big state like California, it may not be surprising that a case in Oakland or Fresno isn’t known in San Diego. We *should* be surprised, however, if a steel mill in a small state did not hear about the other steel mill down the road.

fined, of being jailed, of plant being closed), implying a weak link between the first and second components of the theory. And they find that those with a greater perception of detection and punishment were *not* more likely to undertake compliance-related behavior, implying a weak link between the second and third components of the theory.

They do find, however, that 65% of respondents report that they increased compliance-related activity in response to hearing about another's fine or prison time, even if only meant reviewing their existing compliance programs. This effect was a function of company size as well as the number of other penalty cases the firm could describe.

Therefore, it seems as if general deterrence plays a role in most firms, even if it does not follow the mechanism commonly believed. The authors argue that it serves a "reminder" function (i.e., complying is a good thing) and a "reassurance" function (i.e., violators are punished and there truly is a level playing field). These conclusions were supported by their in-depth interviews.

I think it is quite right to suggest that we may be in a world that is "beyond general deterrence" (my terminology). After decades of environmental regulation (and the EPA itself!) there is now a "culture of compliance." Today, the very presence of regulations – rather than who got caught – is what spurs compliance. The chemical plants in this study report that regulations are just a "baseline" for them. Instead, protecting their reputations and avoiding informal sanctions (by customers, investors, employees, local residents, etc.) are their much bigger concern. The authors state that: "Overall, there was little support for models of business firms as 'amoral calculators' who carefully weigh the certainty and severity of sanctions and who can be manipulated through a judicious mix of specific and general deterrence." (p.17) This is a very optimistic conclusion – one I think we'd all like to believe.

However, I have a few notes of caution before we dismiss general deterrence altogether. First, there *are* "bad apples" out there (as evidenced by the signal cases). In particular, they may be among the 20% who refused to respond to the survey. The authors should acknowledge that there may be some selection bias in their statistics and (hence) their conclusions.

Second, the environmental personnel who responded to these surveys may not necessarily be their firms' final word. I have no doubt that *their* hearts are in the right place — in many ways, their career choice and livelihoods depend on regulation and environmental compliance. But they ultimately do not decide how much resources are devoted to environmental concerns. That decision is instead made at higher levels of the corporation and those decision-makers may not be as pro-environment as these folks. This is, I believe, a very compelling reason to look at *actions* (as in the other two papers), perhaps in addition to *words*.

Third, echoing my comments on the first paper, penalties are a rather special case. It is not hard to imagine that firms do not see themselves in these particular signal cases — just as I don't see myself in the millionaire who employs some bogus tax shelter and lands himself in a white-collar prison. But the message that middle-class audits by the IRS are on the rise may indeed resonate. What about *inspections* as general deterrence? The paper/survey is rather silent on this possibility.

Finally, I'd like to underscore the paper's final sentence: "Our research has little to say about the importance of explicit general deterrence messages at earlier states in regulatory programs, when their value added may well be greater, or for firms (or industrial subsectors) that are deliberate evaders or chronically at the edge of or out of compliance." (p.18) I think that's exactly right. It's very important to recognize the potential heterogeneity of firms – some will comply no matter what, some may only respond to specific deterrence, some to general deterrence, some only to customers/stockholders/communities, and some to a combination of these factors.

Comments on the paper by Wayne Gray & Ronald Shadbegian

Like the paper by Earnhart, this paper takes an empirical approach to examining specific and general deterrence. Because of certain econometric difficulties however, these authors (more or less) give up on estimating the former. They also focus on a different industry, different pollution problem, and earlier time period than does Earnhart. In particular, this paper examines the (annual) air pollution compliance of 116 pulp & paper mills from 1979-1990. This is modeled as a function of inspections and other enforcement actions (such as notices of violation, penalties, and phone calls), as well as plant and firm characteristics, and interactions between these characteristics and the different types of regulatory actions. In typical Gray & Shadbegian fashion, the paper offers a very nice discussion of the theoretical model, the previous literature, the regulatory environment faced by these plants, their hypotheses, and so forth. (This alone is worth the price of admission.) The paper's structure and exposition is tight.

The authors find that regulatory compliance was higher at facilities that had no pulping activity, were younger, and/or were smaller. *Firm*-level characteristics – namely, size and profitability – did not influence *plant*-level compliance however. "Cross-media" effects are apparent, in that air pollution compliance was worse among facilities with violations in other dimensions: water, toxic chemicals, and OSHA/safety.

On the key effect there is some mixed evidence. The authors find that 2-year lagged enforcement activity (a measure of specific deterrence) actually *reduced* current-year compliance, which is not what one would expect. (More on this in a bit.) On the other hand, 2-

year lagged *predicted* enforcement activity (a measure of general deterrence) did in fact *increase* current-year compliance, as might be expected. Here "other" enforcement actions (NOVs, penalties, etc.) had an impact rather than inspections. And there is some evidence of differences in sensitivities by plant- and firm-level characteristics. In particular, plants with pulping activity are found to have been *less* responsive to inspections than those that didn't pulp, and larger firms were less responsive to inspections but *more* responsive to other types of enforcement actions (NOVs, penalties, etc.). The authors point out that the latter seems to suggest that smaller firms might be more surprised by (and more responsive to) inspections and perhaps less bothered by bad publicity associated with violations. This story seems entirely plausible, though I am not sure that's the exact interpretation of this general deterrence measure.

In the limited time that I have, let me focus my comments on some of the potential issues I see with this research (while making no claim to have fully thought through the various issues I'm about to raise). First, and perhaps most importantly, I think the exclusion of plant-level fixed effects raises the specter of omitted variable bias. I appreciate that many of the plant- and firm-level variables included here are either time-invariant or change very little over time. However, without such fixed effects, one will always wonder whether the variables are in fact picking up the effects of other unobservable/unmeasured factors.

And I think there is evidence to be concerned about this: First, the Earnhart paper always rejects OLS in favor of the fixed effect model. Second, in Table 3 of the current paper, we see that the effect of plant size goes away with the introduction of (OLS) fixed effects. This suggests that there is something *correlated* with being small – but not smallness itself – that improves environmental performance. (At the very least, this possibility cannot be ruled out.) Third, the perverse effect of 2-year lagged enforcement (i.e., specific deterrence) may be due to this variable picking up a "bad apple" effect that would otherwise be soaked up with plant fixed effects.

The good news here is that the Chamberlain conditional logit, now available in commonly-used statistical software, is specifically built to handle a binary outcome variable in the context of panel data with fixed effects.[*] In this empirical specification, identification of "treatment" effects comes from plants that change compliance status at least once over these 12 years. Indeed, plants that are always out-of-compliance or always in compliance fall out of this analysis completely. Arguably, they are not the interesting population anyway (somewhat akin to the super-compliant plants discussed above).

Another question/concern I have is with the role of pollution abatement operating costs (PAOC) as an explanatory variable. This variable is not discussed much in the paper, perhaps because its impact is statistically insignificant (which may say something about the quality of these plants' PACE data). It occurred to me, however, that this variable could just as easily be the *dependent* variable. That is, regulatory actions should spur PACE expenditures (abatement activity) and then, in turn, compliance. What are we doing to our estimates by including this variable and what happens if one were to take it out?

I also think that the authors need to be more careful when interpreting their coefficients on the general deterrence measure. Their language suggests that they are talking about specific deterrence when they are not (e.g., in the above example of small firms being surprised by inspections and less bother by penalties). Finally, should the predicted probabilities used here perhaps vary by firm characteristics?

Conclusion

[*] I don't fully understand the confidentiality concerns alluded to in footnote 6 (page 17).

At this point, I think it is useful to briefly highlight a few important differences between the Gray & Shadbegian study and the previous two papers. First, this paper explores a much earlier time period than did the previous two. In light of the above discussion of the Thornton *et al.* paper, this is exactly when one might expect to see more pronounced specific and general deterrence effects – before compliance and over-compliance became quite commonplace (if indeed they have). And in such a world, Gray & Shadbegian's theoretical model of (to use the terminology of Thornton *et al.*) "amoral calculators" computing the optimal levels of (non)compliance seems entirely appropriate. Finally, to the extent that the results from the Gray & Shadbegian study differ from those of the other two, part of this may be due to the fact that they employ *EPA*-reported compliance rather than *self*-reported compliance. This again suggests the necessity of looking at *actions* rather than (or in addition to) *words*.

Summary of the Q&A Discussion Following Session I

Don Siegel (Rensselaer Polytechnic Institute)
Dr. Siegel directed his question to Dr. Wayne Gray "regarding the insignificance of the firm characteristics in the model." He wondered whether it would be possible to construct a "variable which would measure the percentage of the firm's revenue that's represented in this industry—where you link the plant-level data to the firm-level data." He said he thought of this because he believes there might be some diseconomies of scope in monitoring the environmental performance of plants, and he suggested that some sort of weighted least squares analysis might yield different results. Dr. Siegel closed by saying he thinks "the *theory* predicts that some of those firm characteristics would be important."

Dr. Wayne Gray (Clark University)
Dr. Gray responded, "Yes, we might well expect it to matter." He went on to state that in the Compustat database they did have the SIC codes to tell them whether or not a firm's industry affiliation was within "paper" (i.e, SIC 2600), but they "*didn't* find much of any effect of that." Furthermore, he said, "With the census data, in principle, we could identify all the establishments owned by that firm, but we'd only be able to do that very well for the manufacturing part of the firm's activities—so, again, if the firm has a substantial non-manufacturing component, I'm not sure we'd get so much out of it. It would seem that that would be more valuable if we had found more of that sort of general coding . . . ; it suggests that there may not be much there, but it is an interesting question as to whether that industry focus makes you better at being in compliance or more responsive."

Robert Kagan, (University of California at Berkeley)
Dr. Kagan commented that he was involved in a different study of the pulp and paper industry in which he and his colleagues "looked at environmental performance at particular facilities and at the firm level and corporate level—profitability and revenue—the size factor." He said, "We found *no correlation* when we looked at cross sections; however, we *did* find some relationship when we looked at corporate profitability at Time 1—say 7 or 8 years *before* the compliance/low-performance [problem] because the capital expenditure at Time 1 seems more likely to have an impact at Time 2."

Dr. Gray, (directing a return comment to Dr. Kagan)
Dr. Gray stated, "You were asking people in their surveys what they predicted the penalty would be for this sort of violation, but it seemed to me that you chose cases *initially* because they were sort of *big*, . . . therefore, they're getting *bigger* penalties than the *average* violation of that sort might be—you're sort of selecting on the size of the penalty." . . . When you select them off of being really big up front, then you may be picking ones that have an unusually high level of penalty, so maybe there are *lower* estimates of what the right fine would be or how likely they were to get jail time for that, . . .

Dr. Kagen: So they may be right on what the *average* penalty was and underestimating the *serious* violations—yes, I think you're right.

Pete Andrews, (UNC-Chapel Hill)
Dr. Andrews' first comment was directed to Wayne Gray. Dr. Andrews said he "was really struck by [Dr. Gray's] comment that one of the significant variables was the pulping facilities were just not responsive to inspections and so forth." He said he wonders whether Dr. Gray has ever thought about "digging more deeply and whether that was uniformly true across public facilities or whether even within that subcategory there are better and worse performers and, if so, whether that has to do with technology modernization and things like that . . ."

Directing his second question to Neil Gunningham, Dr. Andrews said, "You mentioned this culture of compliance in which people have this *belief* that they either comply or they get closed down, and I wonder if you've gone further to actually investigate whether that is, in fact, objectively accurate or not." Saying that it could just be a widespread assumption among small facilities, he noted that it shouldn't be hard to find out how aggressive enforcement agencies are in terms of whether they actually ever close anybody down or not.

Wayne Gray (responding to the first question)
Dr. Gray responded, "In terms of the details of the technology going on, we did do a paper a while back that looked at different kinds of pulping . . . sulfite pulping may be associated with more water pollution and some of the mechanical pulping might be associated with more air pollution and such, and we did see some sense in which, in terms of the location of these facilities, going to states where they had less stringent air or water pollution regulations, but that may not be exactly what you're looking at. What you were saying is that some plants may be more responsive within their [category]." He said any time you run a regression you get the average coefficient of the group, and it would require some sort of "observable characteristic" in terms of facilities' responses to regulations to "differentiate the sheep from the goats," so to speak, and split them into two groups. Dr. Gray continued, "Given that, I could then ask whether they seem to have different coefficients and such. . . . The other *problem* is that with the census data we're restricted to reporting the numerical coefficients based on the size of the number of plants we have in each category, so I wasn't able to talk about the *numbers* on the old ones because there weren't that many that were *new*." He closed by commenting that his "reluctance to split things down into too small a groups" is also related to his not wanting to reach the point where all that could be said is, "Yeah, they're different, but I can't tell you what the numbers are."

Pete Andrews (in response)
"But it might be a useful outcome, though, in terms of targeting and figuring out what it is in fact that's driving some businesses to do better than others, even in relatively similar categories."

Neil Gunningham (Australian National University), responding to Dr. Andrews' second question
Dr. Gunningham confirmed that they did not actually check on the level of enforcement activity and the number of closures following cited violations. He clarified that what was "really striking" to him and his colleagues was that it was the "*perceived* level [of enforcement activity that] had created this culture of ineligibility or compliance"—in other words, "something that is perceived to be real is real in its consequences."

Jon Silberman (U.S. EPA)
Mr. Silberman offered a "couple of quick observations" regarding the term "over-compliance," which many researchers were using in their discussions regarding Clean Water Act permits. He clarified, "that's an *economic* term, not a *regulatory* term," and he cited "engineering uncertainties and limitations, wet weather events and their outcomes, and also—*very important*—the impact of where you are in your renewal cycle" as factors that influence the compliance/over-compliance determination. To clarify, he stated, "We're behind now in most of the EPA Regions and some of our permits are being *administratively continued*, meaning that your permit numbers are not ratcheted down to their new levels for up to 10 years, and a firm that is approaching the end of that cycle is going to be desperately trying to predict where it's going to need to be in the future relative to a firm that just had its permit renewed. So, I would just like to suggest that when you combine that with the impact of the daily, weekly, and monthly limits in the typical permit, what looks like over-compliance is actually the minimum the firm really needs to do in order to avoid the types of spikes that will lead to non-compliance on an irregular basis."

Neil Gunningham
Responding from the basis of a previous study of the pulp and paper industry that he was involved with, Dr. Gunningham acknowledged that Mr. Silberman made a really interesting point, but "in that study certainly some of the over-compliance we found, or beyond-compliance activity, couldn't really be explained by this sort of permit cycle factor." He cited the example of companies spending "millions of dollars—*many* millions of dollars" to address the issue of smell, a local hot topic that's not regulated to any great extent. He concluded that these companies' beyond compliance efforts were obviously influenced by factors "other than just anticipating future permit laws."

Dietrich Earnhart (University of Kansas), adding to the discussion of beyond compliance behavior
Dr. Earnhart stated, "In our particular study we've controlled for the volatility of the discharges, which goes back to Mr. Silberman's point. It actually runs the *opposite* direction of what you just proposed, if I understood it correctly—that is, if a firm's discharges are more volatile, they should actually push their emissions or discharges down to a lower level in order to avoid those spike." He said their study showed a "*very strong* effect" of *higher* discharges associated with higher volatility. He added that they had also "attempted to control for where they are in the permit cycle," not exactly the way Mr. Silberman had captured that factor, but to the extent that they knew whether a

facility was "working with an expired permit or not, . . . whether they're working with final limits or interim or initial limits; we've controlled for the actual limit itself." Dr. Earnhart closed by acknowledging that while there's surely more they can do, they've at least attempted to capture a flavor of what he agrees are important dimensions.

Robert Kagan, asking "sort of a question back"
Dr. Kagan said that his comment "really relates to Wayne Gray's measure of compliance as a binary variable (compliant/non-compliant)." He commented that "the notion that we have violations that are spikes versus violations that are chronic" makes him wonder whether enforcement people really think that a measure of compliance/non-compliance tells them a lot. He explained, "It seems to me that it doesn't tell you much about the seriousness of the chronic nature of compliance, given the wide variety of violations that might be *found* at any moment, some of which are *one time* [events] and are easily correctable—*or* do you think that it *is* a good measure because it tells you something about . . . how much quality control a company is exercising [to achieve] compliance."

Nicholas Franco (U.S. EPA)
Mr. Franco responded, "Well certainly when we target we don't look at non-compliance as kind of a binary thing—we pay more attention to chronic non-compliers . . . , so it's the people that show chronic problems that indicate that it wasn't necessarily a one-time event or spill or something like that, so it does get more attention. Maybe that's something one could work into the analysis—the impacts of deterrence, specific or general, on chronic non-compliers—because I would assume that for those who are in chronic non-compliance it's going to require a much larger capital outlay for them to come back into compliance. So, that maybe explains some of the facts that you can kind of break those two groups out."

Magali Delmas, (UCSB)
Dr. Delmas brought a question related to the previous one about "How long does it take for people at the plant level to actually take action?" She wondered whether, in the efforts to determine the effectiveness of enforcement, anyone had explored "either in your regression or during your interviews and survey . . . how long it takes for people to take action, and does it change the result if you look at compliance 2-, 3-, 4 years after the enforcement action or after the inspection. Also, does this time depend on the type of enforcement?"

Wayne Gray
Dr. Gray clarified that they used a 2-year lag, and explained that the concern with trying to do "the contemporaneous thing" was that you run into the problem of discovering that a facility "had a really bad year—and had a lot of penalties." He explained, "You like to have at least a little bit of a lag because of the sense that it takes a little while for things to be corrected . . . In a sense, what you want is a multi-dimensional picture of how they're doing and the different dimension of: This problem happened because some piece broke

and they fixed it the next week; and This problem happened because they were just running the plant too hard and the treatment couldn't keep up with it; or something like that. I think we don't get that clear a picture from the sort of quantitative data as you might like to in terms of exactly what's going on."

Dietrich Earnhart, ("following up on Wayne's point")
Dr. Earnhart stated that working with monthly data is much easier because it helps you avoid the "contemporaneous quagmire." He added that, "It *could* be possible that with a minor amount of effort a facility could actually improve their performance even when given a month or two, . . . and it may not be some large capital outlay—it could just be a matter of a better way of tracking their waste stream." He stated that it could also take 2-3 years for a company to build up the necessary capital, financial or physical, to correct a problem and improve performance, and that's the issue—it varies on a case-by-case basis. Consequently, Dr. Earnhart said he would be "very reluctant to say that there's one particular lag period that would fit for all facilities." He cited the efforts of previous researchers to assign an effect factor to each preceding month. He also cited efforts, such as Wayne Gray's, to "slice the data various ways—1-year lag, 2-year lag, 3-year lag, and then hope that it will be discernible across regression analysis." Dr. Earnhart added that in his studies he has taken "3-month lags, 6-month lags, 12-month lags, 24-month lags, and frequently it's robust across all the timeframes." In conclusion, he stated, "So it's more to say: Something's happened reasonably recently—did that have an effect?" and he cautioned that this only would apply to specific deterrents; general deterrents present their own problems.

Corporate Environmental Behavior and the Effectiveness of Government Interventions

PROCEEDINGS OF

SESSION II: COMPLIANCE ISSUES

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Prepared by Alpha-Gamma Technologies, Inc.
4700 Falls of Neuse Road, Suite 350, Raleigh, NC 27609

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Session II: Compliance Issues

Corporate Self-Policing and the Environment: Factors Predicting

Self-Disclosure of Clean Air Act Violations under the

Environmental Protection Agency's Audit Policy*

Paul B. Stretesky

Department of Sociology

Colorado State University

Fort Collins, Colorado 80523

Telephone: 970.491.6825

Fax: 970.491.6825

E-mail: pstretes@lamar.colostate.edu.

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Abstract

The Environmental Protection Agency's self-policing or audit policy waives or reduces penalties when regulated entities voluntarily discover, disclose, and correct environmental violations. This study uses a case-control design to determine if specific deterrence, general deterrence and compliance assistance are associated with the odds of disclosing a Clean Air Act (CAA) violation under that policy. The event group consists of all 59 companies that disclosed a CAA violation under the Audit Policy between October 1, 1998 and September 30, 2000. The control group consists of a simple random sample of 59 companies that did not use the Audit Policy but were discovered to have violated the CAA during the same time period. The results of this research suggest that specific deterrence and compliance incentives are not related to Audit Policy use. However, companies with facilities operating in an industry where regional inspection rates are high are more likely to use the Audit Policy than companies with facilities operating in an industry where regional inspection rates are low. Also important is the finding that company size is a strong positive predictor of Audit Policy use.

Introduction

The Environmental Protection Agency (EPA) issued a policy entitled "Incentives for Self-Policing: Discovery, Disclosure, Correction, and Prevention of Violations" [Audit Policy] in 1995. The Audit Policy is a compliance incentive that waives or reduces penalties for regulated entities that voluntarily discover, promptly disclose, and correct violations of federal environmental requirements. There are several requirements for implementing the Audit Policy. First, a company must disclose the violation to the EPA within 21 days of the discovery of that violation. Second, the discovery cannot be the result of a legally required monitoring, sampling or auditing procedure. Third, the company must correct the discovered violation within 60 days of its discovery. Repeat violations (e.g., similar violations that have occurred at the same facility within the past 3 years or similar violations that have occurred as part of a pattern of violations at other facilities over the past 5 years) and violations that result in serious actual harm are not eligible.

Although the Audit Policy has been in existence for nearly nine years, researchers know little about what factors may actually predict whether a company will disclose a violation under the policy. The purpose of this study is to determine whether deterrence and compliance incentives by the EPA encourage companies to disclose violations of the Clean Air Act (CAA) under the Audit Policy.

Prior Research

Many regulatory personnel tend to view corporate offenders as rational actors who break the law to maximize profit (see Kagan and Scholz 1983). This view of corporate actors can be traced back to the materialist approaches of corporate behavior (see Edelman and Suchman 1997). Such a view has led to the popularity of corporate deterrence research in the social science literature (Braithwaite and Makkai 1991; Makkai and Braithwaite 1994; Russell and Gilbert 1999;

Stafford 2003). The basic idea behind deterrence is that behavior is influenced by negative consequences. Specific deterrence focuses on the future behavior of those actors that have already experienced negative consequences. General deterrence focuses on the future behavior of those actors that may or may not have experienced negative consequences, but believe that those consequences exist because they have seen others experience them (Gibbs 1974; Reiss 1984; Tittle and Paternoster 2000; Warr and Stafford 1993; Zimring and Hawkins 1973).

Research on specific deterrence is inconsistent (Doob and Webster 2003) and research on corporate deterrence is no exception. For instance, some corporate specific deterrence research shows strong positive effect while other research shows no (or even a negative) effect (May and Winter 1999). Simpson and Koper (1992:367) found that "among a group of prior offenders, formal-sanction severity is a strong inhibitor of re-offending." However, Block, Nold, and Sidak (1981) found that civil penalties were more likely to have a deterrent impact than more severe criminal penalties. Braithwaite and Makkai (1991) found evidence that sanction severity does not appear to have a deterrent effect in the regulation of nursing homes in Australia.

Sanctions against corporations may also have a general deterrent effect when they are administered to "make an example out of the violator and send the clear message to others who might violate laws and regulations" (see Cohen 1998). Research on corporate general deterrence has received much less attention in the literature than research on specific deterrence. However, unlike specific deterrence studies, some evidence suggests that general deterrence may have an effect on corporate behavior. For instance, Block, Nold, & Sidak (1981) studied the impact of antitrust enforcement on price markups in the white bread industry and found that bakers in neighboring areas reduced their prices after a price fixing case is brought in a nearby city.

Certainty of detection has also been shown to be a strong predictor of corporate behavior. In a study of the effectiveness of enforcement and compliance on agro-environmental policy in Denmark, May and Winter (1999) found that the frequency of inspections were viewed as highly effective at gaining corporate compliance of environmental regulations. May and Winter (1999:645) suggest that “smart enforcement consists of frequent inspections targeted toward important items.” Braithwaite and Makkai (1991) also found that certainty of detection was an important predictor of compliance in the nursing home industry. Other researchers studying detection certainty assert that inspections are likely to be related to corporate compliance (Sholz 1991; Scholz and Gray 1997).

The EPA’s Audit Policy is a compliance-oriented policy. Compliance-oriented policies are increasing in significance and focus on education, persuasion, and cooperation rather than detection and deterrence to improve corporate behavior (Parker 2000; Reiss 1984). According to Parker (2000:530) the shift toward compliance-oriented policy represents the “new regulatory state, which uses enforced self-regulation and incentives for voluntary compliance to steer corporate conduct toward public goals without interfering too greatly with corporate autonomy and profit” (see also Braithwaite 2000). Clarke (1987) suggests that compliance assistance efforts are more effective than deterrence efforts (see also Stone 1975). The EPA has initiated several special programs that provide compliance assistance to companies in order to encourage and facilitate disclosure of environmental violations (Office of Regulatory Enforcement, EPA 1999). Moreover, regulated entities that have received relief under the EPA’s Audit Policy suggest that compliance assistance, rather than deterrence itself, has increased their reporting of environmental violations (EPA 1999).

Friedrichs (1996) argues that regulatory agencies often confront the “choice between emphasizing compliance or deterrence.” However, it is also suggested that deterrent strategies combined with compliance strategies are likely to be more effective than deterrence or compliance alone (see May and Winter 1999; Simpson and Koper 1992). Thus, it may be argued that it is rational for regulated entities to take advantage of incentives provided in the compliance-oriented Audit Policy if there is a perceived or real likelihood that a regulatory agency would soon discover the violation and impose a sanction. While research on corporate compliance is pervasive, there is still a relative lack of information on corporate self-reporting. The purpose of this research, then, is to determine if specific deterrence, general deterrence, detection certainty, and compliance assistance efforts are associated with the odds of disclosing a violation under the EPA's Audit Policy. This is an important question since the Audit Policy is relatively unstudied policy and because it falls under the type of regulatory effort that Parker (2000) describes as part of the "new regulatory state."

Data and Methods

The unit of analysis in this study is company. The decision to study companies rather than facilities or geographic areas such as states or counties is largely based on theoretical and practical concerns. First, from a policy standpoint, the study of companies is desirable because they are the entities that make the decision to disclose environmental violations under the Audit Policy (Rebovich 1998). The Audit Policy implies a rationality that is typically associated with company-level decisions. As Simpson (1986:860) observed, companies are "economic entities that are rationally constructed, chartered, and owned by stockholders. Their overriding goals are economic, i.e., profitability and market share expansion." From this point of view, the self-disclosure of environmental violations may best be explained in terms of deterrence, incentives and factors that are both internal and external to the company (see Kramer 1982; Shover and Bryant 1993).

Second, many studies of organizational compliance are focused on the company. Several interesting covariates to be included in the proposed study are based upon the findings of previous company-level studies conducted in various industries (e.g., the nursing home industry, agricultural industry, chemical industry, liquor industry, auto industry, pharmaceutical industry, and securities industry). Third, many of the variables that are thought to be important in the study of corporate behavior are readily available for companies, but not available for geographic areas or facilities (e.g., corporate financial performance).

Sample

In order to assess whether sanction certainty, sanction severity and compliance incentives appear to influence the decision to self-disclose a violation of the Clean Air Act (CAA) under the Audit Policy it is necessary to compare companies that report CAA violations to companies that violate the CAA but do not report those violations. Unfortunately, it is not possible to identify every company that violates the CAA because some are never detected. However, investigations uncover over one-thousand violations of the CAA each year (Scalia 1999). Companies known by the Environmental Protection Agency to violate the CAA and not report that violation under the Policy can be compared to companies that violate the CAA and report it under the Audit Policy. In the proposed study, a case control design is used to make that comparison.

In general, case-control designs are used to identify factors that help differentiate cases that experience an event from cases that do not experience an event. In the proposed case-control study, the event group is composed of all companies that reported a CAA violation under the Audit Policy during the 1999 and 2000 Fiscal Years (October 1, 1998 – September 30, 2000). The event group in the proposed study is a complete enumeration and will consist of all 59 companies that were granted relief for violating the CAA under the Audit Policy. A list of those companies was made available to the researcher by the EPA's Office of Regulatory Enforcement. Companies that violated Section 211 of the CAA (mis-fueling violations) are excluded because those cases were handled by EPA Headquarters and because the nature of the cases was so different from most EPA regional CAA cases. The control group is the same size as the event group and also consists of 59 companies obtained by means of a simple random sample of all companies that were discovered by the EPA to have violated the CAA during the same time period as the event group. This study is mainly interested in making comparisons between companies that did use the Audit Policy to companies that could have used the Audit Policy had their violation not been discovered. Thus, companies charged with a criminal violation of the CAA are excluded from the control group sampling frame for the simple reason that these violations are ones that are likely to be judged by the EPA as resulting in "real harm" and would therefore are likely not be Audit Policy eligible (and not be reported under the Audit Policy even if discovered by the company).

The sampling frame needed to select the controls was easily constructed from the EPA's Integrated Data for Enforcement Analysis (IDEA) system. The IDEA system was developed by the EPA in response to a need for integrated data on facilities that were potentially involved in enforcement or compliance actions. The IDEA database has information on nearly all regulated facilities for the purposes of facilitating enforcement case screening, enforcement/inspection targeting, and management decision making. Because the IDEA system collects information at the facility level, and companies are the unit of study in the proposed investigation, it is important to make sure that facilities are linked to companies to ensure that companies with multiple facilities are not over-represented in the control group. This was accomplished by first linking facilities to companies and then taking the sample of companies.

Dependent Variable

The dependent variable is dummy coded and indicates whether a company self-disclosed or was discovered to have violated the CAA. If a company disclosed an environmental violation to the EPA under the Audit Policy at any facility between January 1999 and December 2000 it was given a score of "1." If a company was investigated and found to have violated an environmental law between January 1999 and December 2000 it is assigned the score of "0."

Variables measuring specific deterrence

Prior to discussing the creation of variables that measure specific deterrence it is important to point out a problem inherent in studying enforcement and inspection rates. It was not a problem when a company only had one facility as enforcement data could easily be collected for that company's facility. However, several of the companies in this dataset were linked to more than one facility. For those companies that operated more than ten facilities it was not possible—given limited resources—to collect enforcement data on all company facilities. Therefore, enforcement and inspection rates had to be estimated from a simple random sample of 10 facilities for 13 companies in this sample.

In order to measure specific deterrence related to past enforcement at the facility, IDEA is used to construct a variable that measures past enforcement as the average number of enforcement actions by the EPA across company facilities two years prior to the discovery or disclosure of a CAA violation. Two types of enforcement actions were counted: civil judicial and administrative (both formal and informal). There were no criminal enforcement actions initiated or settled against the companies in this sample during the time period under investigation. Since state regulatory agencies often take the lead in environmental enforcement matters, those enforcement actions were also counted as part of the total number of enforcement actions. One potential problem with calculating enforcement actions using IDEA is that some types of enforcement actions are linked to more than one company facility. For example, in one case a civil judicial enforcement action covered violations at ten facilities. In order to avoid counting one enforcement action several times for one company, an action that appears at more than one facility is only counted once.

As noted in the literature review, previous research on the sanction severity is mixed. For instance, Block, Nold, and Sidak (1981) found that civil penalties were more likely to have a deterrent impact than criminal penalties. Simpson and Koper (1992:367), however, found that "among a group of prior offenders, formal-sanction severity is a stronger inhibitor of future compliance than are measures of sanction certainty." Sanction severity is measured by variations in case outcomes on Audit Policy disclosure. Following Simpson and Koper's (1992:374) well known work on antitrust violations, an effort will be made to determine whether more serious cases are more likely to encourage self-disclosure. It should be noted, "what may be costly to one company may be relatively insignificant to another" (Simpson and Koper 1992:355). Nevertheless, it is reasonable to rank in order "how much of a problem particular outcomes appear to be" (Simpson and Koper 1992:355 see also Clinard 1983; Cullen and Dubeck 1985; Frank and Lombness 1988). IDEA is used to create two variables that indicate whether or not a civil or administrative penalty was imposed against a company two years prior to disclosing or being caught for an environmental violation. These variables are dummy coded (yes=1 and no=0) to indicate whether an environmental violation occurred and resulted in: (1) a civil penalty or (2) an administrative penalty. If sanction severity is related to the disclosure of environmental violations, companies that have experienced the most serious case initiations (e.g., civil penalties) should have greater odds of disclosing an environmental violation under the Audit Policy than companies with less serious outcomes (e.g., administrative penalties).

In the proposed study it is hypothesized that the effectiveness of the Audit Policy can be enhanced through targeted inspections. That is, the more certain it is that a violation will be discovered by a regulatory agency the more likely it is that a company will conduct an environmental audit and then disclose any environmental violations that are discovered as a result (see also Scholz 1991; Scholz and Gray 1997). One measure of detection certainty is the rate of CAA inspections at company facilities two years prior to the disclosure or discovery of a CAA violation. The rate of company inspections by state or federal regulatory agencies is derived from IDEA and calculated by dividing the number of inspections at company facilities by the number of company facilities that are eligible for inspection. This variable, then, represents the average number of inspection across company facilities 2 years prior to the discovery or disclosure of a CAA violation. It is hypothesized that a company with a high regulatory inspection rate should have greater odds of disclosure under the Audit Policy than a company with a low regulatory inspection rate.

Variables measuring general deterrence

In order to determine if general deterrence is related to reporting under the Audit Policy three different variables are created. To examine the hypothesis that the odds of disclosure under the Audit Policy are greater for companies with facilities situated in geographic areas where enforcement actions are more common than for companies situated in geographic areas where enforcement actions are less common, the rate (per 1000 facilities) of criminal cases, civil cases, and administrative cases that are initiated are computed (using IDEA) for the state or states in which the company's facilities operate. These rates of enforcement are calculated for two years prior to the disclosure or discovery of CAA violation. The rate of enforcement actions is calculated by dividing the number of environmental enforcement actions in that state by the number of facilities in that state. In cases where company facilities are located in multiple states, those rates of enforcement are averaged together to come up with an overall enforcement for all company facilities.

Certainty of detection and punishment is also likely to have a "within industry" effect since some industries are more likely to be targeted for inspections and enforcement by the EPA and state agencies. Thus, two variables are created that indicate percent of inspections and enforcement actions that occur within the same Standard Industrial Classification (SIC) in the EPA Region in which the company's facilities operate for two years prior to the company's disclosure or discovery of a CAA violation. For companies that have more than one facility operating in more than one region, these inspection and enforcement rates are averaged across regions. The percent of SIC regional enforcement actions can be estimated by taking the total number of SIC regional facilities where an enforcement action occurred divided by the total number of SIC regulated facilities in that region. The percent of SIC regional inspections can be estimated by taking the total number of SIC regional regulated facilities that have been inspected divided by the total number of regional SIC facilities operating in that SIC code. It is hypothesized that the odds of disclosure under the Audit Policy are greater for companies that operate within industries that have a high percentage of enforcement actions and/or inspections than for companies that operate in industries that have a low rate of enforcement actions and/or inspections.

Variables measuring compliance assistance

Regulatory agencies have run several special programs that provide compliance incentives to companies in order to facilitate disclosure of environmental violations under the Audit Policy (Office of Regulatory Enforcement 1999). Corporate feedback on compliance assistance is largely positive. Regulated entities that have received relief under the Policy suggest that compliance incentives have increased their self-reporting of environmental violations (EPA 1999). This assertion, however, has yet to be empirically examined. To examine the extent to which disclosure of environmental violations under the Audit Policy are related to regulatory assistance, one variable is created that indicates whether the company is likely to have received information concerning a compliance incentive (e.g., a letter providing the company with important incentives related to the Audit Policy including information that the EPA is about to target that industry for environmental violations). That variable is dummy coded with a score of "0" if the company is not likely to have received any Audit Policy assistance in the year prior to disclosure or discovery and "1" if the company is likely to have received assistance one year prior to disclosure or discovery. The list of industries targeted for compliance incentives is published in the EPA's Audit Policy Update.

Variables measuring corporate size

Size of corporations has also been identified as an important variable in corporate performance. It has been argued that the larger and more decentralized the company, the greater the likelihood of non-compliance (Coleman 1992; Shover and Bryant 1993). Other research has indicated, however, that larger corporate size may actually increase environmental compliance because large corporations have the ability and resources to minimize environmental harm (Florida 1996). To measure the size and decentralization of companies, three variables are created. The first variable represents the number of company facilities. The second variable represents the number of employees in the entire company. The third variable represents total company sales (in millions of dollars). These variables are constructed from information available in the Dun and Bradstreet database. Since data is not available in Dun and Bradstreet for all facilities, information is also taken from Standard and Poor's Corporate Descriptions. Bivariate correlations suggest that branches, sales, and employees are highly correlated. Moreover, these variables are theoretically similar in that they all, to some extent, measure some aspect of company size. Therefore, branches, sales and employees are combined together to create a company size factor, which is the principal component index of the three variables. This size component was highly consistent and all component loadings exceeded .8.

Analysis

Three questions are addressed in this analysis. First, do variables related to specific deterrence influence whether or not a company will disclose a CAA violation under the Audit Policy? Second, do variables related to general deterrence influence whether or not a company will disclose a CAA violation under the Audit Policy? Third, do variables that measure compliance incentives influence whether a company will disclose a CAA violation under the Audit Policy? Table 1 begins to address these questions.

[Table 1 about here]

Table 1 reports the mean values for the variables used in this analysis, broken down by Audit Policy use. All specific deterrence variables have higher means for companies that disclosed a CAA violation to the EPA than for companies that were discovered by the EPA to have violated the CAA. Only one of those differences is statistically significant however. In the case of administrative actions, only 1 in 20 companies discovered to have violated an environmental law used the audit policy while nearly 1 in 5 companies who reported a violation under the Audit policy had an administrative action against them two years prior to discovery or disclosure.

In the case of general deterrence, all means were higher for companies that disclosed a CAA violation to the EPA than companies that were discovered by the EPA to have violated the CAA. Except in the case of civil enforcement, companies that were located in states where civil enforcement rates were lower, on average, were more likely to disclose a violation of the CAA. Two general deterrence variables were statistically significant. Both SIC inspections and SIC enforcements within EPA region appear to be positively related to Audit Policy use. In the case of inspections, companies that had their violations discovered operated facilities in a region in which 23.1 percent of similar industrial operations were inspected. In contrast, companies that reported their violations to the EPA under the Audit Policy operated facilities in a region in which 34.6 percent of similar industrial operations were inspected. In the case of formal and informal enforcement patterns, companies that had their violations discovered operated facilities in a region in which 5.79 percent of similar industrial operations had an enforcement action. In contrast, companies that reported their violations to the EPA under the Audit Policy operated facilities in a region in which 8.90 percent of similar industrial operations had an enforcement action.

Again only in the case of compliance incentives, companies that used the Audit Policy, on average, are much more likely to have been targeted by a compliance initiative. Finally, according to the company size factor larger companies tend to use the Audit Policy.

Table 2 reports the odds ratios (OR) which are estimated from logistic regression predicting whether or not a company used the Audit Policy. Since EPA regional variations are not controlled for in this analysis, but may be important, fixed-effects logistic regression is also used to estimate odds ratios (StataCorp, 2001). Fixed-effects logistic regression enables the examination of the possibility that apparent effect of specific deterrence, general deterrence, and compliance incentive variables reflect the effects of a network of variables correlated with EPA region. Since regional enforcement patterns vary greatly it could be argued that what appear as effects of variables in the model could in fact be the effects of EPA regional enforcement patterns or practices (U.S. GAO 2000: 7). One drawback with using fixed-effects logistic regression is that the procedure relies on variation within the matched sets (i.e., variation on Audit Policy reporting within each EPA region). Regions with no variation on the dependent variable are then uninformative and are thus discarded. For this reason the sample sizes for the fixed effects analysis is 107 rather than 118 as it only represents the number of cases in informative regions, not the total number of cases.

[Table 2 about here]

As Table 2 demonstrates, when controlling for company size, none of the specific deterrence variables are related to Audit Policy use. This null finding is consistent with the corporate deterrence literature. The same null finding occurs for general deterrence variables, except in the case of the regional inspection rate within the industry. In that case the odds ratio is 1.03 ($p<.05$) and a one-standard deviation increase in the inspection rate for a particular industry within EPA region (e.g., an increase of 19.4 inspections per 100 SIC facilities in the region) increases the odds that a company will disclose a CAA violation under the Audit Policy by a factor of 2.2 (95% CI; 1.09, 4.14). While it must be pointed out that disclosing a CAA violation under the Audit Policy is a relatively rare event, it is also true that a modest one-standard deviation increase in the EPA inspection rate within region and industry more than doubles the odds of disclosure under the Audit Policy. In addition, the effect of SIC regional inspection rates on CAA disclosure is replicated in the fixed-effects logistic regression model (95% CI; 1.29, 7.00) suggesting that replication of the ordinary logistic regression results across EPA regions.

The compliance incentive variable is not statistically significant when controlling for company size suggesting that incentives by the EPA do not increase the odds of disclosing a CAA violation under the Audit Policy. What is clearly important in each of these models estimated is the relationship between Audit Policy use and company size. Larger companies are much more likely to report CAA violations under the Audit Policy than smaller companies. This provides evidence in support of the position that organizational size influences environmental compliance to the extent that larger companies are more likely to report a CAA violation under the Audit Policy. This finding is also consistent with the theoretical position that large organizations have more resources to take advantage of self-policing environmental policies. For example, Florida (1996) found that the number of employees in an organization was positively related to the number green practices adopted by that organization. Moreover, the literature on organizational size suggests that larger organizations have more resources to discover violations through self-audits and also have, on staff, personnel able to successfully negotiate and use the Audit Policy.

Conclusion

This study is the first to examine company predictors of Audit Policy use. Specifically, this research has examined the association between variables that measure specific deterrence, general deterrence, compliance incentives, and company size to determine if they are associated with the odds of disclosing a CAA violation under the Audit Policy.

The findings of this research add to the corporate behavior literature and are surprisingly consistent with other studies that find that specific deterrence does not appear to be related to levels of corporate compliance. Moreover, while not statistically significant, three of the four specific deterrence variables actually appear to suggest that specific deterrence could possibly decrease the odds that a company will disclose a violation under the Audit Policy when controlling for company size. Under this potential scenario Audit Policy use may reflect corporate actor estimates of sanction certainty in such a way that actors with more past environmental violations believe they are less likely to be caught and punished for a violation of the CAA in the future. This effect is referred to in the literature as the “positive punishment effect” (Pogarsky and Piquero 2003). While these results cannot be used to provide evidence of the positive punishment effect since results are not statistically significant, they also cannot be used to provide evidence that specific deterrence makes corporate actors more likely to use the Audit Policy. It may be that both the positive and negative effects of specific deterrence are occurring simultaneously in this sample of companies and that other corporate characteristics not accounted for in this study may help explain this finding though an interaction effect. At this point, however, such conjecture is merely speculative and more research needs to be focused on this finding.

Also consistent with previous research is the finding that industry inspection rates increase the odds of disclosure under the audit policy. Thus, efforts aimed at increasing the number of inspections among an industry may improve the odds that companies in that industry will disclose a violation of the CAA under the Audit Policy. This is an important policy finding since there is an increasing emphasis on environmental compliance though self-policing efforts.

Finally, this research suggests that company size is an important determinant of Audit Policy. Past research clearly suggests that size matters in the case of corporate environmental performance such that larger companies pollute at a greater rate than smaller companies (Grant, Jones and Bergesen 2002). This research builds on those previous findings and suggests that while corporate size may increase the rate of polluting, it may also increase the rate at which companies are willing to disclose violations under self-policing efforts. In short, larger companies have more resources than small companies that allow them to take advantage of the Audit Policy to mitigate potential negative consequence that may result from being caught for a CAA violation. This apparent large company advantage may be the result of compliance personnel who are actually on staff and work for the company and whose job it is to know how to mitigate company liability. Indeed, it is primarily large companies and industries that represent large companies who have responded to a request for comments by the EPA about the Audit Policy. Thus, it appears that company size may be a much more important predictor in determining why companies use the Audit Policy than variables measuring specific deterrence.

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Table 1 Means for Variables, by Discovery or Disclosure of CAA Violation

	Violation Discovered by EPA	Violation Disclosed to EPA
Specific Deterrence Variables		
Past Enforcement	.603	.700
Administrative Penalty	**.050**	**.200**
Civil Penalty	.002	.003
Past CAA Inspections	.899	1.23
General Deterrence Variables		
Criminal Enforcement	.500	.422
Civil Enforcement	.429	.423
Administrative Enforcement	10.2	14.0
SIC Regional Inspection Rate	**23.1**	**34.6**
SIC Regional Enforcement Rate	**5.79**	**8.90**
Compliance Incentive Variables		
SIC Incentive	**.080**	**.340**
Organization Variables		
Facility Size Factor	**–.590**	**.590**

Note: Bolded values indicate a statistically significant ($p<.05$) difference between discovery and disclosure. Results were derived from Difference of Means Tests and Mann-Whitney U Tests. In both instances results were nearly identical for all variables.

Table 2 Logistic Regression of Audit Policy Use

	OR (95% Confidence Interval) [Fixed Effects OR (95% Confidence Interval)]		
<u>Specific Deterrence Variables</u>			
Past Enforcement	.904 (.550, 1.49) [.873 (.528, 1.44)]		
Administrative Penalty	1.50 (.281, 8.04) [1.11 (.192, 6.41)]		
Civil Penalty	.495 (.030, 8.26) [.437 (.017, 10.7)]		
Past CAA Inspections	.793 (.539, 1.17) [.730 (.473, 1.13)]		
<u>General Deterrence Variables</u>			
Criminal Enforcement		.986 (.146, 6.67) [.295 (.015, 5.52)]	
Civil Enforcement		1.207 (.224, 6.50) [1.04 (.052, 21.1)]	
Administrative Enforcement		1.03 (.980, 1.07) [1.07 (.992, 1.17)]	
SIC Regional Inspection Rate		1.03 (1.01, 1.07)* [1.04 (1.00, 1.09)]*	
SIC Regional Enforcement Rate		.964 (.893, 1.04) [.931 (.836, 1.04)]	
<u>Compliance Incentive Variables</u>			
SIC Incentive			2.13 (.600, 7.57) 1.20 (.211, 6.86)
<u>Organization Variables</u>			
Facility Size Factor	5.35 (2.87, 9.96)* [4.22 (2.18, 8.18)]*	4.22 (2.42, 7.37)* [3.13 (1.69, 5.83)]*	4.01 (2.37. 6.81)* [2.99 (1.69, 5.27)]*
Constant	1.31	.184	–.154
-2 Log Likelihood	114 [81.0]	107 [78.2]	116 [85.5]
Sample Size	118 [107]	118 [107]	118 [107]

Note: OR = odds Ratios calculated from logistic regression and fixed effects logistic regression.

* p<.05

Regulation and Compliance Motivations:

Marine Facilities and Water Quality

Peter J. May
University of Washington

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Author Contact:

Professor Peter J. May
Center for American Politics and Public Policy
Department of Political Science
Campus Box 353530
University of Washington
Seattle, WA 98195-3530 USA
(206) 543 9842 fax (206) 685 2146
Email: pmay@u.washington.edu

Regulation and Compliance Motivations: Marine Facilities and Water Quality

ABSTRACT

This research examines how traditional regulatory and voluntary approaches affect motivations for addressing potential harms to water quality. The traditional approach consists of governmental enforcement of mandatory requirements. The voluntary approach consists of government calling attention to potential harms and facilitating actions to address them. These approaches are best thought of as endpoints for an array of regulatory forms, rather than as the sole choices in regulatory approach. Three sets of findings emerge from the research. One, not surprisingly, is that traditional regulation is more effective than is the voluntary approach alone in enhancing attention to water quality issues. A second shows that deterrent fears and sense of duty to comply are important motivations for action in addressing water quality. A third concerns factors that account for the variation in each motivation for which inspections, peer reputation, and attitudes toward government are shown to be important considerations.

These findings suggest a greater need for attention to regulatory arrangements and how those arrangements shape affirmative considerations for the attainment of regulatory goals. Traditional regulation establishes one set of arrangements that this research shows affect both deterrent fears and civic duty. Requiring permits is a powerful tool for gaining attention to potential problems and for setting forth expectations as to what constitutes the civic duty to comply. Yet, simply requiring permits is not sufficient to motivate action. Technical and financial assistance is often necessary for facilitating and directing actions to alleviate potential harms. These findings therefore confirm what is well known about the importance of building commitment and capacity to take action.

The willingness of facilities that are subject to voluntary regulation, as with marinas in this research, to take action rests largely on their good will and their civic intent. Threats of stronger regulation or regulatory actions loom in the background making such regulation "quasi-voluntary." Showcase actions are important in underscoring this backdrop. But, the central issue is how to enhance the commitment to protect water quality. The challenge is to create a stronger sense of civic duty in forming what might be considered a societal contract for protecting water quality. Actions to address water quality are stronger when facility operators view water quality harms as a shared problem that they have a civic duty to address. Social influences are a key to enhancing civic commitment and shared obligations to protect water quality. These can be enhanced by strengthening associational ties (i.e., among trade groups), by facilitating the emergence of strong industry leaders, and by providing credible evidence that action is appropriate.

Introduction

Despite bringing about substantial improvements in environmental quality since the early 1970s, environmental regulations have been criticized in many quarters for having unreasonable requirements and for engendering heavy-handed enforcement. These criticisms and the realization that the environmental problems of today are different than those of thirty years ago have spawned a search for viable alternatives to traditional forms of environmental regulation. Discussion of alternative regulatory approaches has occurred in a number of books and articles (e.g., Andrews 1999; Fiorino 1995, 2001; Gunningham and Grabosky 1998; Kettl 2002) as well as in various advisory reports (e.g., National Academy of Public Administration 1995). The search for alternatives has brought attention to two broad classes of regulatory approaches that have been labeled cooperative and voluntary regulation.

Cooperative regulatory approaches entail collaboration between regulatory authorities and regulated entities either in negotiating requirements (Marcus et al. 2002; Kerwin 1999) or shared agreements for monitoring performance and obtaining compliance (Harrison 1999; Sparrow 2000). The voluntary approach entails a governmental role in calling attention to a potential harm and in facilitating voluntary actions by relevant firms or industry associations to address the potential harms (Coglianese and Nash 2001; Lyon and Maxwell 2001; Potoski and Prakash 2002). While there are many variants for each of these approaches, a basic distinction between them and traditional regulation is the degree to which government compels actions to address environmental harms. Of particular interest for this research is the difference between mandatory regulation that involves a central role for government and voluntary approaches that entail a much more limited governmental role.

The notion that firms would voluntarily undertake actions to reduce pollution or go beyond minimum requirements is contrary to the image of profit-seeking firms that ignore the external impacts of their operations. However, experience with a diverse set of voluntary programs demonstrates that at least some firms are motivated to act out of a combination of a sense of civic duty, good public relations, market differentiation, and a fear of more stringent governmental regulation (Arora and Carson 1996; Prakash 2000; Segerson and Miceli 1998). At the same time, the limitations of these programs has been demonstrated by related research that shows participation by firms is uneven, the gains in pollution prevention are sometimes limited, and the programs are difficult to sustain and expand beyond a core group of committed entities (Andrews et al. 2001; King and Lenox 2000; Napier and Johnson 1998; Welch et al. 2000). Taken together, these diverse studies suggest that voluntary programs have promise but are not a panacea.

The promise is especially important to consider because in some circumstances voluntary programs may be the only realistic alternative. Mandatory regulation is more feasible when harms are visible and firms concentrated so as not to overwhelm enforcement capacity. Under such circumstances, pollution levels can be directly measured and monitored, the responsible parties are relatively easy to identify, and enforcement can be accomplished on a regular basis if there is sufficient number of enforcement staff. In contrast, voluntary approaches may be the only practical alternative when the sources of harms are widely dispersed and the cost of inspection, relative to the potential harm, is high. For example, many forms of nonpoint sources of water pollution involve widely distributed sources of harm for which it is often not practical to enforce regulations on a case-by-case basis other than by exception (i.e., when large spills occur). Given this, the relevant question is not whether voluntary programs are more effective than traditional regulation, but how can voluntary programs be improved?

Understanding the motivations of firms to address potential harms is important for gauging the promise and limitations of different regulatory approaches. If firms are motivated by a sense of duty and concerns about potential harms, the voluntary approach has promise. If these motivations are lacking, more coercive approaches may be necessary. As such, regulation and motivations go hand-in-hand. The form of regulation is predicated upon assumptions about willingness to act. And, the willingness to act is affected by the form of regulation. In getting at this interplay, the basic issues for this research are whether motivations and willingness to act are different under mandatory and voluntary approaches to regulation.

This research considers these by examining the influence of different regulatory approaches upon actions taken by marine facilities to address water quality as well as upon their motivations to take action. A natural experiment is provided by the fact that boatyards are typically subject to traditional regulation while marinas are typically subject to voluntary approaches. As explained in what follows, boatyards entail point sources of water pollution. Marinas are typically addressed as non-point sources of water pollution. By examining the role of alternative approaches and other factors in shaping actions and motivations to address potential harms to water quality by these facilities, this research provides insights about both the efficacy of alternative regulatory forms and potential steps to improve voluntary approaches.

Mandatory and voluntary approaches

Mandatory regulations constitute the traditional toolkit for motivating action to address potential harms and to protect public welfare (see May 2002). Compliance with regulatory requirements is compelled through enforcement actions and imposition of sanctions for those found to be out of compliance. The basic logic of this approach is a criminal law model of deterrence as examined in the seminal work of Becker (1968; also see Ehrlich 1972). From this perspective, individuals and firms comply because they fear the consequences of being found in violation of regulatory requirements. Inherent in this approach is the presumption that regulated entities are unwilling to take necessary actions to comply with regulations and therefore they must be compelled to do so. Obtaining greater compliance is brought about by reinforcing deterrent fears.

The voluntary approach involves a very different governmental role and different assumptions about the willingness of relevant entities to address potential harms. The governmental approach is non-coercive for which the key policy instruments are exhortation and various forms of assistance (Grabosky 1995; Harrison 1999; Wilms 1982). Rather than mandating action, government promulgates guidelines for best management practices and encourages adherence to them as a means of achieving desired outcomes.[1] Desired actions are encouraged through education, financial assistance, technical assistance, and other inducements. The assumption is that those entities that contribute to environmental harms are willing to address the harms but they fail to do so because of various complications (Brehm and Hamilton 1996; Coombs 1980; Kagan and Scholz 1984). Their failure to do so is either because they do not recognize the existence of a problem (requiring information), do not understand what can be done to address the problem (requiring education), or they do not have the capacity to take desired actions (requiring financial or technical assistance).

Mandatory and voluntary approaches are perhaps best thought of as endpoints for an array of regulatory forms, rather than as the sole choices in regulatory approach. Stated differently, variants of the mandatory approach can involve efforts to educate regulated entities about appropriate actions and can make available different forms of technical and financial assistance to facilitate compliance. There is always the possibility of legal action against those who contribute to specific harms under the voluntary approach. When pursued, these actions push the voluntary approach along the continuum toward that of traditional regulation. In the case of water pollution, for example, harmful acts can be pursued through the broader water-quality provisions of federal and state water quality acts. In addition, the voluntary approach at least implicitly holds the threat of switching to traditional forms of regulation if harms are not sufficiently addressed. For these reasons, it is perhaps better to think of this type of voluntary regulation as "quasi-voluntary." This form of regulation is labeled voluntary in the discussion that follows for ease of communication while keeping in mind the coercive backstop to such regulation.

> H1: The mandatory approach is more effective than the voluntary approach in gaining commitment to address potential harms by those entities that potentially contribute to those harms.

This hypothesis follows from the preceding discussion. Both mandatory and voluntary approaches are expected to positively influence the actions that are undertaken to address potential environmental harms. The mandatory approach is expected to be more effective in enhancing actions because it compels compliance. However, the effectiveness of the approach will be undermined if regulations are not taken seriously or if enforcement is lax. The voluntary approach is expected to engender actions by those firms that are predisposed to act by virtue of having a higher degree of concern about potential harms, stronger capabilities to act, or stronger fears of future regulation. However, the voluntary approach may fall short in failing to address recalcitrant entities. Commitment to address environmental harms can be gauged by the importance that relevant entities attach to their actions to address the harms.

Motivations to act

Consideration of the motivations of entities to take action in addressing potential harms is important for understanding the viability of different approaches. Most of the regulatory literature on the subject is concerned with the reasons why firms or individuals comply with regulations (see Winter and May 2001). Less attention has been paid to motivations in the absence of formal regulations, as with the voluntary approach, although the literature addressing the willingness of firms to voluntarily adhere to industry-developed guidelines is relevant (see Arora and Carson 1996; Prakash 2000; Segerson and Miceli 1998; Welch et al. 2000). Two sets of motivations that are involved are considered in what follows. One, deterrent fears, concerns the consequences of failing to address potential harms. A second, duty to comply, is a sense of obligation to address a potential harm.

Deterrent fears and regulatory approaches

A primary motivation for addressing potential harms is the deterrent fears associated with the negative consequences of failing to act. As discussed by Reiss (1984), such fears are potentially activated either through actions aimed at particular firms or individuals (specific deterrence) or through more general warnings (general deterrence). Specific deterrence is brought about by targeting individual entities for inspection, citations of violations of rules, and sanctions if firms fail to rectify those violations. A number of studies (Braithwaite and Makkai 1991; Burby and Paterson 1993; Gray and Scholz 1993; Helland 1998) reinforce the importance of inspections for compelling compliance, but vary in their findings with respect to the influence of sanctions once violations are detected. General deterrence, which serves to warn potential violators that negative consequences can follow from failing to act, is brought about by more diffuse actions that include showcase actions against violators and publicity about the consequences of failing to act. Potential shame or embarrassment of being caught violating rules has also been shown to be an important component of deterrence (Grasmick and Bursik 1990; Grasmick et al. 1991).

> H2: The mandatory approach activates a stronger sense of deterrent fears than does the voluntary approach.

This hypothesis follows from differences in the way that the two approaches potentially activate deterrent fears. As discussed above, the mandatory approach is based on compelling compliance by activating deterrent fears of the negative consequences of failing to comply. This is accomplished through specific deterrent actions involving enforcement and sanctions, and through general deterrent actions involving showcase enforcement actions.

Specific deterrence is not relevant to the voluntary approach because there are no mandatory rules or regulations to enforce. However, aspects of general deterrence do potentially apply. Embarrassment might be relevant if an entity is shown to be a laggard in addressing potential harms. This is the logic of posting “top 10 wanted lists” of environmental polluters that have been issued by environmental organizations. A second potential fear is that a firm may be found liable for harms that, although not specifically regulated, are subject to broader prohibitions. This fear is potentially activated by showcase lawsuits. A third potential fear that failure to act will result in stronger governmental regulation.

In sum, both approaches are expected to engender deterrent fears that serve as one key set of motivations for taking action to address potential harms. The mechanisms in fostering deterrent fears differ somewhat between the two approaches. The mandatory approach relies on both specific and general deterrence, while only general deterrence is relevant to the voluntary approach. Because of the greater arsenal of tools for engendering deterrent fears with specific deterrence, the mandatory approach is expected to be stronger in activating such fears. Evidence for stronger deterrent fears consists of the degree of concern that entities display of potential consequences for failing to act to address potential harms.

Duty to comply and regulatory approaches

An important foundation for any form of regulation is that citizens and firms acknowledge their responsibilities in preventing harms. Even when rules exist and are enforced, as with the mandatory regulatory approach, there is a strong presumption that the vast majority will obey their sense of duty to adhere to the rules. As noted by Tyler (1990), without such quasi-voluntary compliance there would be a need for a much stronger enforcement apparatus. This duty is based on a combined sense of moral obligation and agreement with the need and approach for addressing a given problem (McGraw and Scholz 1991; Scholz and Pinney 1995; Winter and May 2001). As verified with findings from this research, the sense of duty to comply can be thought of as independent of the deterrent fears discussed in the previous section.

The more basic aspects of duty to comply relate to the moral sense of obligation to obey laws and general ideological values. The more immediate aspects of this duty relate to the value of addressing a given problem and acceptance of the regulatory approach to it. Such acceptance has been shown to depend on the reasonableness of rules or guidelines, degree of trust in the agencies that promulgate them, and the extent to which other affected entities are believed to be doing their part in addressing the problem (Bardach and Kagan 1982; Kagan and Skolnick 1993, Levi 1988; Scholz and Lubell 1998; Tyler 1990).

> H3: The voluntary approach activates a stronger sense of duty to comply than does the mandatory approach.

This hypothesis follows from the preceding discussion. Both approaches are expected to invoke a sense of duty to comply. However, the mandatory approach is expected to be less effective in this regard because aspects of it potentially undermine the trust in regulatory authorities that is essential for instilling a sense of duty to comply. The voluntary approach potentially activates a sense of duty to comply through at least two means. One means is direct appeals to address potential harms through informational efforts telling how actions of affected entities potentially contribute to the harms. Implicit, if not explicit, is an appeal to the shared obligation to do one's part. A second means is more direct, one-on-one technical assistance to help educate affected entities about harms and steps to address them. This has the added potential benefit of gaining acceptance of the legitimacy of the recommended actions. Such acceptance has been shown by Winter and May (2002) to depend on the extent to which those providing advice are viewed as being competent and can be trusted. If these are lacking, the voluntary approach loses its effectiveness and the sense of obligation to comply is not enhanced.

Because the mandatory regulatory approach also typically entails provision of information and technical assistance, it also can be expected to activate a sense of duty to comply. Information and assistance is provided both as part of general publicity about regulations and when facilities are inspected. As with the voluntary approach, the trust that regulated entities place in regulatory agencies and the perceived competence of regulatory officials are important considerations. Yet, additional considerations also come into play. The style with which inspectors interact with regulated entities—whether inspectors are formal or facilitative—has been shown to affect motivations for compliance and the understanding of rules by regulated entities (Winter and May 2001). If enforcement of regulations is viewed as unreasonable, the essential trust in regulatory authorities and sense of duty to comply will be undermined.

Because of this potential, the mandatory approach is expected to at least partially undermine the sense of duty to comply.

In sum, both approaches are expected to engender a sense of duty to comply that serve as a second key set of motivations for taking action to address potential harms. The mechanisms for this are the same for both approaches. However, the mandatory approach has the potential for a backlash against what might be perceived as heavy-handed enforcement that in turn undermines trust in regulatory authorities and the sense of obligation to comply. Because of this potential, the mandatory path is hypothesized as being less effective in activating a sense of duty to comply.

The regulatory setting: Marine facilities and water quality

The setting for this research concerns marine facilities and their impacts on water quality. Marine facilities have been shown in several studies to be sources of water pollution for estuarine areas and bays for which there is little natural flushing (National Research Council 2000; U.S. EPA 1994, 1997). These impacts include point sources of water pollutants—toxic metals, oils, sediments—and potential releases of hazardous materials and toxic spills into water. Also relevant are non-point impacts from boats of raw or untreated sewage and fuel spills. A variety of consequences can follow that include increased toxicity, turbidity, and lower oxygen content of water. These in turn contribute to changes in the food chain in the marine environment, altered marine life, contaminated fish, increased algae growth, and generally unhealthy water quality.

The contamination of water is regulated by the federal government under several laws. Point sources are addressed under provisions regarding industrial discharge under provisions of the Clean Water Act (section 402(p)) that establish among other things the National Pollution Discharge Elimination System (NPDES) permit system. Non-point sources of pollution are addressed in the 1987 amendments to the Clean Water Act (section 319), and under coastal non-point sources of pollution provisions (section 6217) of the Coastal Zone Management Act Reauthorization Amendments of 1990. These federal laws assign key responsibilities to states for enforcement of discharge permit programs and for development of plans for management of pollution sources.

The data for this research address behaviors of operators of boatyards and of marinas in coastal and estuarine areas of California and Washington states. The contrast between the regulatory approaches for each set of facilities provides a natural experiment for examining the interplay of approaches and motivations to address harms. Boatyards are working marine facilities for repair and maintenance of pleasure and smaller commercial vessels. These are fixed point sources of pollution from boat haul-outs, hull pressure washing, sanding and painting, and repair operations. Boatyards are subject to mandatory regulations and permit requirements under the NPDES program as delegated to the states.

Marinas are basins with slips for boats, usually defined as having 10 or more slips, which may or may not provide fueling and other shore services. These have limited point sources (fueling and boat launching areas) and more extensive non-point sources of pollution relating to potential spills from boats of sewage, bilge, fuel, and cleaning materials. Marinas, with some exceptions, are not subject to regulatory requirements other than the broad prohibitions of federal and state water quality acts against impairing water quality.[2] Instead, marinas are subject to voluntary approaches for which states have encouraged, through education efforts and limited funding, adherence to best practices guidelines for marine facilities promulgated by the U.S. Environmental Protection Agency (1993, 2001). State efforts in this regard include information provision about best management practices, technical assistance, and small grant programs aimed at fostering voluntary action by marinas (see Washington State Department of Ecology 1999a).

Interviews with enforcement officials in each of the relevant regional offices of the states within which facilities for this study are located help set the context. Neither type of facility is high priority for enforcement actions. Because boatyards are required to have permits, they are monitored more extensively than are marinas. This typically consists of monitoring the filing of required, self-reported periodic analyses of water quality samples. In most regions, field inspections of boatyards are undertaken only every few years or less. Marinas generally fall "under the radar scope" of enforcement officials unless there is a complaint or a spill that draws attention to problems. It is difficult to assess compliance for either type of facility in that there is no systematic collection of reporting of field inspections other than inspection reports filed away in regional offices. Only more serious notices of violations or fines make it into centralized reporting. For the period January 2000 to July 2002, California state enforcement data indicate issuance of formal sanctions for 11 boatyards and two marinas, and Washington state enforcement data indicate formal sanctions being issued for 10 boatyards and two marinas. These numbers correspond to the self-reporting of facilities in the survey for this study of 9 percent of the facilities having actions taken against them for non-compliance with either reporting requirements or other provisions.

Several aspects of marine facilities are important to consider in setting the context for this research. Of particular concern are the comparability of the two types of facilities and the potential for systematic motivational differences between them. The rationale for mandatory regulation of boatyards are the greater potential harm to water quality posed by activities at boatyards and the greater ease with which point sources of harm can be regulated. The former might suggest that boatyard operators would be more motivated to take action but that is vitiated by the larger costs for boatyards to address potential harms. Capital expenditures for equipment addressing environmental issues by boatyards in this study were on average 30 percent higher than those expended by marinas. As such, it is unclear that boatyards are inherently more motivated to act than are marinas. This potential selection bias is controlled in the analyses that follow by introducing statistical controls concerning measures of the extent of water quality problems and constraints upon action.

A different potential bias is that one type of facility has greater capacity to act than another. There is no systematic evidence for this. Both types of marine businesses tend to be relatively small operations. Among the sample for this study, the median number of full-time employees is 14 for boatyards and 3 for marinas. Thirty percent of the marinas and 10 percent of boatyards have owners who operate more than one facility, which is indicative of a larger scale of operations. Most boatyards, comprising 92 percent in this sample, are privately owned while marinas have a wider mix of ownership, comprised of 30 percent that are publicly owned facilities. Potential selection biases stemming from differences in capacity are controlled in the analyses that follow by introducing statistical controls measuring the capacity of facilities to address potential harms to water quality.

Operators of marine facilities are as a group conflicted in their views about addressing harmful water quality impacts. Many are in the business because they enjoy boating and value clean water, but many also question the need for governmental regulation. Among the study sample, 31 percent of marina operators and 43 percent of boatyard operators moderately to strongly agree that government intrudes too much on business and that preserving property rights is more important than protecting water quality. Facility operators also share a perception that their efforts to address water quality pale in comparison to what they typically view as much more harmful impacts by such sources as municipal storm water outfalls and industrial discharges. In our interviews, boatyard operators in particular felt that their businesses were being singled out for attention when far greater sources of potential harm were being ignored.

Data and measures

The data were collected from a mail-out survey of marine facilities in California and Washington. Listings of 281 marinas and 140 boatyards in coastal and estuarine areas of the two states were identified from various publications and governmental permit listings. Questionnaires were mailed in late January 2002 with two rounds of follow-up lasting into March 2002. Valid responses were received from 144 marinas (51 percent response rate) and from 61 boatyards (44 percent response rate) for an overall response rate of 49 percent. Data collected from a preliminary phone contact with all facilities were used to gauge potential response biases. No statistically significant differences were found for marinas with respect to the number of slips or type of marina ownership, and none were found for boatyards with respect to number of employees or type of boatyard ownership. Although this non-response assessment is limited in scope, it suggests that the mail-out survey responses are representative of a range of marinas and boatyards in the two states. The unit of analysis is the individual marine facility. The data are weighted to take into account differences in response rates among the two types of facilities and among different geographic regions.[3]

The measures for this research relate to testing hypotheses concerning the role of regulatory approaches and other factors in influencing deterrent fears and sense of duty to comply among marine facility operators. All measures are drawn from the survey results. The key distinction is between the mandatory and voluntary approaches as reflected in the different treatment of boatyards (mandatory regulation) and marinas (voluntary approach). The differences in approach for the two sets of facilities are verified in analyses that follow.

The two sets of motivations are central considerations. Each is measured as a dichotomous variable for which a contrast is drawn between those facilities that score high on the motivation and the remaining facilities that score lower. This coding overcomes the statistical limitations of working with the ordinal measures for each set of motivations that were contained in the surveys of facilities. Deterrent fears are measured by respondents' rating of the fear of legal liability if harm occurred, fear of fines or other governmental action, concern that new requirements will be imposed if actions are not taken on their own, and avoidance of embarrassing media coverage.[4] The sense of duty to comply is measured by respondent agreement with two statements: "Regardless of the extent of the problem, marinas (boatyards) have a civic duty to address water quality issues," and "Marinas (boatyards) have a civic duty to report accidents or spills affecting water quality to relevant authorities."[5]

The commitment of marine facilities to address water quality problems is measured in three different ways. The first is the percentage of best management practices that are undertaken by each facility.[6] As detailed in the methodological appendix, these include installation of physical devices, use of appropriate equipment, restrictions on activities at the facility, and management practices that encourage appropriate actions by facility operators and boat owners. Standardizing this measure by computing the percentage of best practices makes it possible to compare marinas and boatyards with respect to actions undertaken. A second measure is respondent self-identification of the priority for their actions along a five-point scale that ranges from "not an issue that has really affected the facility" to "a top priority—a key consideration for facility upgrade." A third measure is the respondent's rating of efforts to address water quality in comparison to other facilities on a five-point scale from "less attention than most" to "we are a leader."

Several factors are potentially relevant for explaining variation in deterrent fears and sense of duty to comply. These include various attributes of each regulatory approach, attitudes toward governmental agencies and their handing of water quality issues, social influences, and the capacity to and constraints upon the ability to act. The regulatory attributes include specific deterrent enforcement practices (inspection within the past five years, whether or not sanctions were imposed, and awareness of showcase actions) and whether different types of assistance were provided (general information or education, technical assistance, and financial assistance).

Relevant attitudes about government include ideological perspectives, the perceived reasonableness of water quality regulations, and the perceived competence of governmental regulators. The ideological perspective about appropriate roles of government is measured as an index of mean agreement on a five-point scale with two statements: "In general, governmental agencies and regulations intrude too much on businesses," and "Preserving property rights is more important than protecting water quality."[7] The perceived reasonableness of governmental water quality regulations is gauged by agreement on a five-point scale with the statement: "The existing governmental rules concerning boatyards (marinas) and water quality are reasonable." Perceptions of the competence of government agencies are gauged by agreement on a five-point scale with the statement that facility managers "can rely on governmental agencies for advice about dealing with potential water quality impacts."

The perceived importance of peer reputation is the primary social influence for which information was obtained. This is measured as the mean score on a five-point scale of the extent to which respondents agree that their reputation with each of the other facilities, boaters, and governmental agencies is "an important consideration for how we do business."[8]

The final set of potentially relevant considerations are various aspects of the capacity of and constraints upon actions that facilities take to address water quality. The size of the facility, measured as the percentile of facility size relative to other facilities, serves as a proxy for both capacity to act and the costs of taking action. An index of perceived constraints is measured as the mean of respondent ratings on a five-point scale of the extent to which four factors "make it difficult to address water quality."[9] Two measures serve as proxies for the extent of water quality problems. One is respondent perceptions on a ten-point scale of water quality at their location five years ago. The second proxy is the amount of waterfront that is adjacent to the facility.

Findings

The findings are presented in several stages. The attributes of the mandatory regulatory and voluntary approaches are first discussed. The comparative impacts of the two approaches upon the willingness of marine operators to act in addressing potential harms to water quality are next considered. This leads to empirical examination of differences in deterrent fears and sense of duty to comply for the two approaches. Finally, multivariate analyses that explain variation in each set of motivations are reported.

Regulation of marine facilities

Table 1 shows systematic differences in provisions for marine facilities under the mandatory and voluntary approaches.[10] The greatest differences are the permit provisions and inspection of regulated facilities with a smaller difference in the application of sanctions. Permits are the central regulatory tools that specify the conditions for facility operation. Fines, warnings, or other actions are more infrequent with the typical action being a warning about boatyard practices or a fine for failure to submit a required report on time. More extreme sanctions include orders to remove contaminated soil and mandated upgrading of catch basins. Regulated facilities also receive information and education assistance as part of inspections and, to a lesser extent, technical assistance is sought from third parties. Very few regulated facilities received governmental financial assistance.

Various forms of assistance were provided marinas that are subject to the voluntary approach. A majority of marina operators report receiving information or educational assistance while fewer operators report receiving technical assistance or funding. Financial assistance was mainly in the form of grants for installation of sewage pump-out stations. A small percentage of marinas were also subject to sanctions that resulted from spills or other harms to water quality. The sanctions included small fines for spills of oil or fuel, a $13,000 fine for allowing vessel repair in the water, and warnings for leaking sewage and fuel systems.

Overall, the major difference between the mandatory and voluntary approaches as applied to these facilities is the use of coercive measures to compel compliance under the mandatory approach that are not present under the voluntary approach. Both approaches employ various forms of assistance. However, assistance is used in different ways for the two approaches. Under the mandatory approach, assistance is a mechanism for facilitating compliance. Under the voluntary approach, assistance is a mechanism for both gaining attention to potential problems and for facilitating action.

Table 1. Regulation of marine facilities

Characteristics	All Facilities	Mandatory	Voluntary	P-value [a]
	(Percentages [b])			
Regulatory Provisions				
NPDES permit [c]	38	100	0	<.01
Inspected in past 5 years	30	91	0	<.01
Fine, warning, other action	11	19	6	.02
Assistance Provided				
Information or educational assistance	68	76	63	.08
Technical assistance	32	43	25	.03
Financial assistance	20	2	31	<.01
Number of respondents [c]	157	53	104	--

Notes:
[a] P-value for t-test of differences for independent samples (two-tailed) for any given row between the percentages for regulated and non-regulated facilities. Facilities subject to mandatory regulation are those boatyards with required permits. Facilities subject to voluntary approaches are those marinas without permits.
[b] Cell entries are weighted percentage of respondents for each category.
[c] Un-weighted number of respondents for each category.

Actions to address water quality

Water quality programs seek to do two things whether they employ mandatory or voluntary approaches. They seek to gain attention to potential problems so that affected entities take action in addressing them. In addition, they seek to guide the actions that are undertaken by either mandating or recommending specific actions. Both of these are reflected by the adoption of best management practices as well as by the degree of effort that facilities put into addressing water quality. These issues are addressed in Table 2.

The mandatory approach is expected to be more effective than the voluntary approach in stimulating adoption of best practices (H1). As hypothesized, those facilities that are regulated report higher levels of action than those facilities subject to voluntary provisions. Yet, as evidenced by the results for the unregulated facilities, the voluntary approach appears to have had a notable impact in encouraging best practices and to a lesser extent in encouraging stronger efforts to address potential harms to water quality. Those facilities that are subject to the voluntary approach undertake on average 82 percent of actions undertaken by regulated facilities. As would be expected, the adoption of best practices is greater for marinas reporting receiving information and education than those that did not ($p < .05$). However, no statistical differences are detected between these groups for the other effort measures shown in Table 2.

Table 2. Actions to address water quality

	All Facilities	Mandatory	Voluntary	P-value [a]
	(Percentages [b])			
Actions / Effort				
Mean percentage of Best Management Practices undertaken [c]	69	78	64	<.01
Rate water quality as top priority [d]	23	31	18	.06
Leader in Efforts [e]	17	25	12	.05
Perceived Impact				
Substantial impact in reducing potential problems [f]	65	79	57	<.01
Number of respondents [g]	157	53	104	--

Notes:
[a] P-value for t-test of differences for independent samples (two-tailed) for any given row between the percentages for regulated and non-regulated facilities. Facilities subject to mandatory regulation are those boatyards with required permits. Facilities subject to voluntary approaches are those marinas without permits.
[b] Weighted percentage of respondents.
[c] Percentage of relevant practices for addressing water quality that are undertaken by a facility.
[d] Percentage of respondents that rate the priority for action as a "top priority – key consideration for upgrade."
[e] Percentage of respondents that rate efforts to address water quality, relative to other facilities, with the response that "we are a leader."
[f] Percentage of respondents providing a rating of 7 or greater on 10 point scale of "effect of actions in reducing potential harmful impacts on water quality."
[g] Un-weighted number of respondents for each category.

The lower part of Table 2 shows the perceptions of the impacts that marine facilities have had upon reducing harms to water quality. Consistent with the findings concerning levels of effort, a much greater percentage of regulated facility operators report substantial impacts in reducing potential harms than do unregulated facility operators. Taken together, these findings suggest that the mandatory approach has a greater influence on commitment to addressing harms than does the voluntary approach alone. These findings are expected and are not especially remarkable. The finding that the voluntary approach appears to have had an influence for a sizeable number of unregulated facilities is notable.

Other analyses of the data from this research provide insights concerning factors that explain variation in the extent of adoption of best practices by regulated and unregulated facilities (see May 2003).[11] Two aspects of the multivariate findings are of relevant for the present discussion. One relevant finding is that permits, and associated deterrent fears, are noteworthy influences on adoption of best practices. On average, when controlling for a variety other factors, facilities with permits have a 17 percentage point higher score in the actions that are undertaken than those that are not regulated. A second relevant finding is that civic duty is also shown to affect the adoption of best practices. The average effect upon best practices of increased amounts of civic duty is a 5.4 percentage point increase, when calculated as moving from the lowest quartile of civic duty to the highest quartile among the data. Note, however, that civic duty was found to have a stronger effect on best practices for regulated facilities than for unregulated facilities. This may seem counter intuitive. But, the finding suggests that regulations (and permits) play an important role in signaling what is desired and what constitutes civic duty. In the absence of regulations with which to comply, the understanding of what constitutes civic duty is more amorphous.

The findings reported in May (2003) also show that the willingness of marine facilities to address water quality is constrained by several factors. Regardless of the approach, facility operators complain about the complexity of rules governing water quality. As would be expected, this complexity is perceived as more constraining by those facilities that are subject to traditional regulation. The cost of devices to address water quality is also viewed as an impediment to taking action. An overarching consideration is the belief on the part of nearly a majority of facility operators that there is too much uncertainty about the impacts of marine facilities upon water quality to justify actions on their part. This belief when coupled with the fact that more than one-third of the facility operators are skeptical of governmental regulation constrains the acceptance of the need for actions to address water quality.

Motivations to act

One way of beginning to disentangle the effects of the mandatory and voluntary approaches is to consider their impacts upon motivations to act. Table 3 presents a comparison of various aspects of deterrent fears and sense of duty to comply. The findings show that deterrent fears and sense of duty to comply are relevant considerations for both types of facilities. The data further suggest that deterrent fears are more strongly activated by the mandatory approach, while the sense of duty to comply is comparable between the two approaches.[12]

The top part of the table addresses deterrent fears. The hypothesis (H2) is that the mandatory approach activates a stronger sense of deterrent fears than does the voluntary approach. Consistent with this hypothesis, these findings show that most aspects of deterrent fears are higher for regulated facilities than for those that are subject to the voluntary approach. The exception is the failure to statistically detect a difference between facilities in avoidance of embarrassing media coverage.

The more interesting aspect of these findings about deterrent fears is evidence of a notable percentage of unregulated facilities expressing deterrent fears. Nearly one-fifth of unregulated marinas express fears of legal liability and of fines or governmental actions. This reflects the fact that marinas are not truly unregulated, as they are subject to broader laws that prohibit harms to water quality. The lower percentage of marinas reporting concerns about future regulatory actions than boatyards likely reflects differences in the salience of water quality issues for the two types of facilities. The fear of embarrassing media attention evidenced by some operators reflects the importance of reputation to marine facility operators.

The bottom part of Table 3 addresses duty to comply. The hypothesis (H3) is that the voluntary approach activates a stronger sense of obligation than does the mandatory approach. This hypothesis is not supported by these data. The difference between the regulated and unregulated facilities with respect to each of the measures of duty to comply is not statistically significant. Nonetheless, with the exception of regulated facilities' sense of civic duty to report spills, majorities of marine facilities report various aspects of duty to comply as a strong motivation for their actions to address water quality. The larger percentage of unregulated marinas reporting a strong civic duty to report spills than that of boatyards, while not statistically significant, likely reflects the fact that educational efforts targeted at marinas have emphasized the importance of spill prevention and reporting to assist emergency clean up.

Table 3. Motivations to address water quality

Consideration	All Facilities	Mandatory	Voluntary	P-value [a]
	(Percent rating very strong consideration [b])			
Deterrent fears [c]	29	45	19	<.01
Fear of legal liability if harm occurred	33	54	21	<.01
Concern new requirements will be imposed if actions are not taken on own	32	46	23	<.01
Fear of fines or other governmental action	27	43	17	<.01
Avoidance of embarrassing media coverage	25	32	21	.15
Duty to Comply [d]	63	63	62	.88
Civic duty to address water quality	51	54	50	.66
Civic duty to report spills	55	49	58	.29
Number of respondents [e]	157	53	104	

Notes:
[a] P-value for t-test of differences for independent samples (two-tailed) for any given row between the percentages for regulated and non-regulated facilities. Facilities subject to mandatory regulation are those boatyards with required permits. Facilities subject to voluntary approaches are those marinas without permits.
[b] Weighted percentage of respondents rating each consideration as 4.5 or greater on a scale of 1 to 5.
[c] Score of 4.5 or greater for the mean of items that follow, each rated on a scale of 1 to 5.
[d] Score of 4.5 or greater for the mean of items that follow, each rated on a scale of 1 to 5.
[e] Un-weighted number of respondents for each category.

Explaining variation in motivations

Table 4 presents multivariate results for explaining variation in deterrent fears and sense of duty to comply. The dependent variables are whether or not a given facility scores high relative to other facilities for each motivation. Because each variable is dichotomous, logistic regression analyses were undertaken.[13] The t-tests of the coefficients provide an assessment of whether a given variable can statistically be detected as having an effect on motivations for these data. The sign of each coefficient can be used to tell whether a given factor has a positive or negative effect on the likelihood of a facility scoring high on each motivation. The magnitude of the effects of variables for logistic models is not linear and thus cannot be directly gauged from the size of the coefficients. Assessments of the magnitude of the impacts of relevant variables on the likelihood that facilities score high on each motivation are reported in what follows.

Table 4. Explaining differing motivations

	Logistic Analyses [a]	
	Deterrent Fears [b]	Duty to Comply [c]
Regulatory Approach		
Mandatory (versus voluntary) Approach [d]	1.68 ** (.80)	.67 (.77)
Deterrent Enforcement Practices		
Inspected within past 5 years	[1.58] [e] ** (.91)	[.61] [e] (.83)
Sanction imposed for water quality problems	.02 (1.10)	-2.10 *** (.90)
Awareness of showcase enforcement actions	.71 ** (.33)	-.24 (.27)
Assistance Provided		
General information or education	.50 (.64)	.52 (.66)
Technical assistance	-1.81 ** (.80)	.47 (.62)
Financial assistance	-.55 (.97)	-1.09 (.84)
Attitudes Concerning Government		
Conservative ideology	.54 * (.35)	-1.27 *** (.38)
Water quality standards are reasonable	-.46 ** (.26)	.27 (.25)
Perceived competence of government regulators	.32 (.27)	.17 (.27)
Social Influences		
Importance of reputation with others	-.23 (.59)	2.46 *** (.61)
Facility Capacity and Constraints		
Facility size relative to industry	-.01 (.01)	.01 (.01)
Implementation constraints	.59 ** (.36)	-.30 (.32)
Amount of water frontage (ln)	.17 * (.11)	.04 (.10)
Perceived water quality as of five years ago	.24 ** (.13)	-.09 (.14)
Constant	-8.42 (3.75)	-6.43 ** (3.35)
Model Statistics		
Number of observations	101	123
Pseudo-R^2 [f]	.26	.40
Chi-square GOF for model (p-value)	29.70 (<.01)	55.21 (<.01)
Percent correctly classified	84.8	82.6

Table 4 (con't)

Notes:
*** $p < .01$ ** $p < .05$ * $p < .10$ (one-tailed asymptotic t-tests).
[a] Cell entries are logit coefficients from binary logistic modeling with the standard error in parentheses.
[b] Contrast between those facilities that score high (scores of 4.5 or greater) and remaining facilities for items concerning deterrent fears shown in Table 3.
[c] Contrast between those facilities that score high (scores of 4.5 or greater) and remaining facilities for items concerning duty to comply shown in Table 3.
[d] Facilities subject to mandatory regulation are those boatyards with required permits. Facilities subject to voluntary approaches are those marinas without permits.
[e] Results from a separate logistic modeling for this variable when substituted for the regulatory approach variable. Because only regulated facilities were inspected, the form of regulation and inspection cannot be entered into the same model.
[f] Cox and Snell Pseudo R Square.

Regulatory approach. The first row of both models concerns the influence of regulatory approach upon the two sets of motivations. The coefficient for deterrent fears clearly shows that the mandatory regulation has a stronger influence on deterrent fears than does the voluntary approach. The multivariate findings show that regulated facilities, when other factors are taken into account, have a 36 percent greater likelihood of having high deterrent fears than do unregulated facilities.[14] This difference is as hypothesized and reaffirms the zero-order comparisons of Table 3.

The coefficient for sense of duty to comply is not statistically significant and thus fails to show the hypothesized greater effect of the voluntary approach upon that motivation. The lack of a difference in approach for duty to comply might be explained by the fact that the two approaches do not substantially differ in their levels of assistance as was shown in Table 1. In addition, inspections under the mandatory approach may not have the off-putting effect that was hypothesized as the reason why that approach would have a lesser effect on sense of duty to comply. The multivariate findings rules out the possibility that the lack of a difference in sense of duty to comply is an artifact of other differences among marine facilities.

Enforcement practices. The items of Table 4 concerning enforcement practices show that inspections and showcase actions contribute to deterrent fears. Inspections are central aspects of specific deterrence while showcase actions are important components of general deterrence. Inspected facilities, all of which are regulated boatyards, have a 35 percent greater likelihood of having high deterrent fears. Regulated boatyard operators with high awareness of showcase actions have a 17 percent greater likelihood of having high deterrent fears. The corresponding value for marina operators is 10 percent greater likelihood. The failure to find an effect of sanctions on deterrent fears is consistent with findings in the regulatory literature that inspections are a more important predictor of compliance than are sanctions (see Braithwaite and Makkai 1991; Burby and Paterson 1993; Gray and Scholz 1993; Helland 1998).

More surprising is the negative impact of sanctions on sense of duty to comply. Although the imposition of sanctions is relatively rare (see Table 1), these results suggest that sanctions undermine the sense of duty to comply. Indeed, regulated facilities subject to sanctions have 43 percent lower likelihood of having a high sense of duty to comply and unregulated facilities subject to sanctions have a corresponding 48 percent lower likelihood. This is perhaps because, as found by May and Winter (1999), imposition of sanctions are viewed by some entities as overly harsh responses.[15]

Assistance. The findings concerning the effects of various forms of assistance upon motivations, with the exception of technical assistance and deterrent fears, fail to show an effect on either set of motivations. The failure to detect more substantial impacts of assistance upon either set of motivations is puzzling. Information and technical assistance are important ingredients of the voluntary approach for which an effect on sense of duty to comply was expected. It may be that education efforts have been too general and technical assistance too specific to have an impact on more basic feelings of civic obligations. The negative effect of technical assistance upon deterrent fears can be explained by the observation that such assistance, involving consultation by third-parties about how to comply, facilitates compliance and thus eases fears of being deemed out of compliance. This facilitation is confirmed by the earlier analyses of variation in adoption of best practices (see May 2003). The multivariate results showed that provision of information and technical assistance had a substantial impact on the number of practices that were adopted by regulated facilities. (The fact that information and assistance did not have an effect on the number of practices adopted by unregulated facilities could reflect the generality of that information.) Those analyses also showed that financial assistance had a positive impact on adoption of best practices by both types of facilities.

Attitudes concerning government. The findings concerning the influence of different attitudes upon motivations to comply are dominated by the influence of ideology. Those facility operators with more conservative attitudes about government are more likely to have high deterrent fears and less likely to have a strong sense of duty to comply. More conservative boatyard facility operators are on average are 13 percent more likely to have high deterrent fears and 16 percent less likely to have a strong sense of duty to comply. The corresponding values for more conservative marina operators are 8 percent greater likelihood of deterrent fears and 23 percent lower likelihood of sense of duty to comply. The increased deterrent fears are likely related to the lower sense of trust in government associated with conservative ideology (Scholz and Lubell 1998) while the negative effect on sense of duty to comply is likely related to the lower sense of agreement of the value of regulations (Levi 1988; Tyler 1990).

Social influences. The presumption of social influence, addressed by Kagan and Skolnick (1993) and by Winter and May (2001), is that entities take action in order to earn the approval of others. This expectation is borne out by the findings concerning social influences and sense of duty to comply. In particular, those boatyard operators who are concerned about reputation have a 32 percent greater likelihood of having a strong sense of duty to comply while the corresponding value for marina operators is 44 percent. This influence may be especially relevant in industries like marine facilities for which trade associations are relatively strong and facility operators tend to know each other.

Conclusions

This research examines traditional regulatory and voluntary approaches for addressing potential harms to water quality. The traditional approach consists of governmental enforcement of mandatory requirements. The voluntary approach consists of government calling attention to potential harms and facilitating actions to address them. These approaches are perhaps best thought of as ends of a continuum, rather than as the sole choices in regulatory approach. In examining these, this research takes advantage of a natural experiment in contrasting actions undertaken by boatyards subject to traditional regulation with that of marinas subject to the voluntary approach. Hypotheses have been examined about the role of these approaches and other factors in shaping two key motivations—deterrent fears and sense of duty to comply—that are bases for actions to address potential harms.

Three sets of findings stand out from this research. One set concerns the impact of different approaches on the actions that have been taken to address potential harms. The findings clearly demonstrate that traditional regulation is more effective than is the voluntary approach alone. This is expected and in itself is not particularly noteworthy. More striking is that the voluntary approach does have substantial impacts for which the added gain in actions taken under mandatory regulation, when controlling for other factors, is on average 17 percent. As such, voluntary approaches of the type employed with marine facilities cannot be written off as wholly ineffective.

A second set of noteworthy findings concern the role of deterrent fears and sense of duty to comply as motivations for action. Both sets of motivations are evident for the facilities in this study. As expected, deterrent fears are stronger for those facilities that are subject to mandatory regulation than for those subject to voluntary approaches. The sense of duty to comply does not differ between the two types of facilities. Taken together, the findings about motivations are consistent with the stronger impacts of mandatory regulation upon actions to address potential harms.

A third set of findings concern factors that account for the variation in each set of motivations. The multivariate findings that explain variation in deterrent fears are consistent with prior findings about the importance of inspections in shaping specific deterrence (e.g. Burby and Paterson 1993; Gray and Scholz 1993; Helland 1998). But, deterrence is not limited to one-on-one enforcement. The findings that showcase actions add to increase deterrent fears, along with the fact that three quarters of marine facility operators report moderate to high awareness of large fines or other notable regulatory actions imposed on other facilities, underscore the value of general deterrence brought about through showcase actions. These put facilities on notice even when actions to address harms are not mandated.

Two other factors that differ from the traditional regulatory tools stand out as relevant considerations. One is the role of reputation among peers as a positive influence on a sense of duty to comply. A second factor is the role of attitudes toward government in shaping predispositions to take action. In particular, those facility operators with more conservative attitudes about government are shown to be more likely to have high deterrent fears and less likely to have a strong sense of duty to comply. These are important findings because they suggest that the willingness (and reluctance) to address harms is related to more basic predispositions.

Policy implications

Regulatory scholars have conducted fairly extensive research about regulatory instruments and, as with this research, increasing amounts of research about compliance motivations. These findings suggest a greater need for attention to regulatory arrangements and how those arrangements shape the relevance of normative and social considerations for the attainment of regulatory goals. The importance of context is reinforced by the various studies that I have conducted, often with others, regarding motivations. These studies address compliance motivations for Danish farmers (May and Winter 1999, Winter and May 2001), for homebuilders in western Washington (May and Wood 2003), and for marine facilities with this research. Concluding that the regulatory framework is important in explaining influences upon compliance motivations is unsatisfying to those who seek general prescriptions about regulatory enforcement and compliance. However, the findings across the various studies suggest that how regulatory situations are framed affects the role of different regulatory tools and the relevance of normative and social considerations.

The situation for boatyard operators in California and Washington mirror more typical regulatory arrangements in the United States that do not ferment shared norms or expectations. Regulators and regulated entities operate at arms-length with very limited interaction. As a consequence, there is little leeway or occasion for negotiation over the terms of compliance. Instead, the rules constitute fairly standardized conditions for permit adherence. Much of the enforcement rests on self-reporting of water-quality analyses and only occasional on-site inspections. Enforcement matters since fines are issued and sanctions for notable violations are publicized. However, this regulatory framework falls short of a social contract in that the relationship is one-sided with regulatory authorities dictating the terms of the permit. Given the lack of reciprocity for the relationship between regulators and boatyard operators, the arrangement is more coercive than contractual.

Regulations serve a variety of functions in this context. Requiring permits is a powerful tool for gaining attention to potential problems. Moreover, the conditions established with permits are important in setting forth expectations as to what specifically constitutes the civic duty to comply. Yet, simply requiring permits is not sufficient to motivate action. Technical and financial assistance is often necessary for facilitating and directing actions to alleviate potential harms. These findings therefore confirm what is well known about the importance of building commitment and capacity to take action.

Deterrent fears are reinforced through publicizing of showcase actions to provide a general deterrent effect, and through conducing inspections of facilities to provide a specific deterrent effect while also educating regulated entities about compliance steps.

The situation for marina operators in California and Washington presents a challenge in fostering actions to protect water quality when facilities such as boats within marinas are distributed sources of water pollution, the costs of facility-specific inspection are relatively high, and there is much uncertainty about the efficacy about different actions. The willingness to take action rests largely on the good will and civic intent of marina facility operators and their tenants. Threats of stronger regulation or regulatory actions loom in the background for which showcase actions are important in underscoring this backdrop. But, the central issue is how to enhance the commitment to protect water quality.

The challenge is to create a stronger sense of civic duty in forming what might be considered a societal contract for protecting water quality. Facility operators and boat owners, as with any source of nonpoint water pollution, need to recognize that individual actions matter in the stewardship of the environment. The findings of this study show that powerful drags on this civic commitment are distrust of government (i.e., conservative ideology) and concerns that actions will have minimal effects on water quality. Offsetting these somewhat is the belief among some facility operators that there is a serious problem with water quality. Actions to address water quality are stronger when facility operators view water quality harms as a shared problem that they have a civic duty to address.

Social influences are a key to enhancing civic commitment and shared obligations to protect water quality. The sense of civic duty of marina facility operators is enhanced by their concern for reputation. Facility operators are more willing to take action when they believe other facilities are doing their part. Both of these sets of findings reflect the dynamics of a collective sense of obligation to take action. Figuring out how to bring this about is of course a key challenge. While not directly addressed in this research, other findings (May 2003) suggest that shared commitment is enhanced by associational ties (i.e., among trade groups), the emergence of strong industry leaders, and credible evidence that action is appropriate. The evidence from the research reported here suggests that public recognition of facilities for their leadership, such as environmental stewardship awards, has a potentially useful role in this equation.

The findings of this study more generally point to the duality of deterrent fears and civic intentions as motivations to address potential environmental harms. Given the limitations of the voluntary approach, deterrence must serve at least as a backstop to it. Yet, fostering deterrence need not entail an elaborate enforcement regime since steps can be taken to instill a general deterrent effect. At the same time, individual facilities' sense of duty to address harms can be enhanced by fostering a greater collective sense of a need for action.

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Endnotes

[1] Not considered here are voluntary codes developed by industry associations that serve as complements to mandatory regulations by encouraging firms to go beyond required minimum compliance levels (see Potoski and Prakash 2002).

[2] The exceptions are those marinas that have repair or other facilities that are considered potential point sources of pollution and thus are subject to permit requirements.

[3] The weighting scheme established a stratification of boatyards and marinas in Washington, northern California, and southern California. The data were weighted so that representation of boatyards and marinas in each stratum reflected the appropriate population values for the stratum.

[4] Each item was originally measured on a scale of 1 (low) to 5 (high) for which an index was computed as the mean of the four items. Firms with strong deterrent fears are selected as those scoring 4.5 or greater on the combined index.

[5] Each item was originally measured on a scale of 1 (strong disagreement) to 5 (strong agreement) for which an index was computed as the mean of the two items. Firms with strong sense of duty to comply are selected as those scoring 4.5 or greater on the combined index.

[6] Because not all practices are relevant to a particular facility, the index of best management practices for each facility is based on the percentage of relevant best management practices for a given facility.

[7] The Cronbach alpha reliability measure for this index is .63.

[8] The Cronbach alpha reliability measure for this index is .67.

[9] The four factors are lack of information about appropriate measures, uncertain effectiveness of water quality measures, lack of standards or requirements, and difficulty in maintaining water quality measures. The Cronbach alpha reliability coefficient for this index is .80.

[10] In order to maximize the contrast between those facilities that are regulated and those that are not, the data exclude 7 percent of boatyards without permits and 8 percent of marinas with permits. This excludes boatyards that fall under the minimum thresholds for permits and marinas that have permits because they also undertake repairs. As a consequence of these deletions, all regulated facilities are boatyards and all non-regulated facilities are marinas.

[11] The findings reported in May (2003) differ in minor ways from those reported here in Tables 1 and 2. Those differences are explained by the fact that the present analyses exclude marinas with permits and boatyards without permits, whereas the earlier publication included each of these. As discussed in note 10, the exclusion of these facilities provides for a stronger contrast between regulated and unregulated facilities.

[12] No statistically significant differences are found for the measures reported in Table 3 between those unregulated marinas that received information and education and those that did not.

[13] Separate OLS regression modeling that use measures for each dependent variable based on five-point scales and the same explanatory variables as the logistic regressions were also undertaken. The findings from the OLS models were very similar with those reported here, but because of the restricted range of the dependent variables the logistic modeling is preferred. The only differences were for the deterrent fear modeling for which under the OLS models sanctions had a statistically significant positive effect and facility size had a statistically significant negative effect; neither was statistically significant in the logistic model. A Chow F-test for pooled data undertaken as part of the OLS modeling shows that it is appropriate to pool the data for the two types of facilities when modeling variation in each set of motivations.

[14] This is the percentage point difference between the predicted likelihoods of high deterrent fears for regulated and unregulated facilities. The predictions for these and other effect analyses reported in the discussion that follows are based on the logistic models of Table 4. For each of the effect analyses a comparison is made between predictions for changes in the variable of interest. These predictions are based on mean values for other explanatory variables except for assistance and sanctions. The values for those variables are set to correspond to a typical facility (i.e., values of one for general information, zero for other forms of assistance, and zero for sanctions.) Where appropriate in what follows, effects are separately reported for regulated boatyards and unregulated marinas.

[15] Separate analyses show a stronger negative effect of sanctions upon sense of duty to comply for unregulated marinas than for regulated boatyards. This difference is consistent with the backlash explanation since marinas would be more likely to view sanctions as unwarranted than would boatyards, given that marinas are not subject to mandatory regulations. An alternative explanation that could not be examined with these data is that facilities with lower sense of duty to comply are more likely to commit infractions and thus have sanctions imposed.

Methodological Appendix

Table A1. Marine facilities "Best Management Practices"

Boatyards	Marinas
Use of vegetation or other natural buffers to limit surface water runoff into marine waters.	Use of vegetation or other natural buffers to limit surface water runoff into marine waters.
Use of catch basins, diversion or filtration systems to control surface water runoff other than hull cleaning areas.	Installation of catch basins, diversion or filtration systems to control surface water runoff.
Designated hull cleaning area with concrete pad that diverts waste water away from marine waters.	Marina fuel dock/station spill containment and recovery equipment.
Catch basins/sediment trap for hull cleaning waste water.	Marina fuel back-pressure/automatic shutoff on fuel nozzles.
Recycling and filtration of hull cleaning waste water.	Posted prohibitions on discharge of used oil, antifreeze, and paint solvents into dumpsters.
Use of tarps under boats when sanding hulls or other surfaces.	Installation of receptacles for disposal or recycling of waste oil.
Use of dustless sanders for sanding operations.	Installation of receptacles for disposal and treatment of bilgewater.
Use of a sanding vacuum recovery system for recovery of sanding dust and particles.	Installation of sewage pump-out facilities at the marina.
Dedicated, enclosed paint spraying area.	Regular maintenance of pump-out facilities by marina staff or third parties.
Use of high pressure, low volume paint spraying equipment.	Notification of marina tenants of third-party pumpout and oil waste collection services.
Designated receptacles for disposal of oil, paint, solvents, or used boat cleaning materials.	Established fish-cleaning areas with receptacles for cleaning waste.
Third-party pickup and disposal of used oil, paint, solvents, or used boat cleaning materials.	Restrictions on boat maintenance/cleaning to above the waterline.
Posted prohibitions on discharge of oil, paint, solvents, or used boat cleaning materials into general waste dumpsters.	Designated areas for maintenance/cleaning of hull areas with grids for collection of waste materials.
Use of environmental friendly cleaning materials.	Distribution of educational materials to marina tenants about marine environmental practices.
Storm water management written plan.	Periodic marina-sponsored recycling or waste disposal events for disposal of oil, solvents, batteries or other waste.
A plan to put in place additional measures to address potential environmental harms.	Use of environmental friendly cleaning materials.
Regular monitoring and testing of water quality at boatyard.	Storm water management written plan.
Prohibition on do-it-yourself work at the boatyard.	An established plan to put in place additional measures to address potential water quality impacts.
Requirements for written acknowledgment of environmental regulations by third party vendors or for do-it-yourself work.	Regular testing of water quality at the marina.
Use of vegetation or other natural buffers to limit surface water runoff into marine waters.	Training or education for marina employees concerning water quality issues and control measures.
	Written prohibitions concerning waste disposal (sewage, oil, bilge) into waters as part of marina tenant agreements.
Source: Compiled from US EPA (1993, 1994) and Washington State Department of Ecology (1999a, b).	

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Session II: Compliance Issues

Discussant No. 1: Jon Silberman, U.S. EPA, OECA/NCEI

COMMENTS ON:

Corporate Self-Policing and the Environment: Factors Predicting Self-Disclosure of Clean Air Act Violations Under the EPA's Audit Policy

Paul Stretesky
Colorado State University

April 26, 2004

Introduction:

- **Introduce self:**
  – 20 years experience with EPA, 17 of them in enforcement, including experience amending and implementing EPA's Audit Policy.

- **Thank you's**:
  Audit Policy article: – Bert Frey, Deputy Regional Counsel, R3 – 312-886-1308
  – Phil Milton, Audit Policy Coordinator, ORE-SLAP, 564-5029
  Marine Facilities article: – Cheryl Hawkins, OPEI - Office of Business & Comm. Innov.
  – Larry Wells, R1-Off. Env. Steward. - Assistance & P2

- **Opening statement**: "What data does – and all it does – is tell you where you've been. It's experience, insight, & intuition that tells you what's going to happen next."

- **My perspective in reviewing and commenting** on the two papers is:

  – this is all about enhancing environmental performance by improving how and when the government intervenes to address pollution;

  – all comments are intended constructively/"for your consideration" as you revise papers.

- **Key ???**: Is the study protocol fair and appropriate?

  - does the researcher ask the "right questions?"
  - does the data appear accurate/reliable/complete?
  - do we agree with the factual conclusions drawn from the data?
  - do we agree with the policy recommendations derived from the factual conclusions?
  - how can the study (which is a draft, interim product) be improved?

- **Emphasis on practical application of the results**:

  – How might EPA use the study results to actually improve our policies or programs?

  – Do the data/conclusions augment, reinforce, contradict, or alter existing assumptions/ approaches?

  – Should EPA do: more of the same?; less of the same; different things? or simply get (or stay) out of the way?

WE'VE ALL HEARD THE COMMON APHORISM:
"You can **lead** a **horse** to **water** but can't make him **drink**."

- Unfortunately, for some of us – including those of us who work with the Audit Policy – our job description is to figure out how to get those horses to drink!

- Assume, for the moment, leader = EPA; horses = regulated community; water = AP;, drinking = using it, & my objective is encourage drinking. What are my options?

-1- **make sure it's really "water" and it's potable.** Maybe the horse isn't drinking because "he's asking for water and you're giving him gasoline" (like a B.B. King song").

4 AP examples of "sweetening the water:

3 May 2000 AP amendments to: (1) increase disclosure period from 10 days to 21 days; (2) clarify "repeat violations" condition for company-wide disclosures; (3) address mergers and acquisitions;

(4) end of FY '99: ORE issues guidance: "Reduced Penalties for Disclosures of Certain CAA Violations" (addresses Title V-related disclosures to allow more of them to qualify)."

Also in May 2000: EPA amended Small Business Compliance Policy to make more attractive.

-2- **revisit your "leadership"**:

- leadership ≠ simply pouring water into a bucket and leaving it there, hoping horses will somehow "stumble onto it";

- ensure the water is visible and immediately apparent as such to horses (now we're talking "outreach and communication" ... especially important for small businesses).

-3- **make sure you've got the right "horse"**

– Essentially a targeting issue; can also be a resource/capacity-building or timing issue;

– Maybe you should drop the horse you're struggling with now, deal with him some other time or way/try to find others that are likely to be more cooperative.

-4- **make sure your horses are "thirsty"**

– Also be a targeting issue ... but equally often, it's a "conditions" issue;

– **consideration 1**: **timing**. "sequencing" issues for "integrated strategies": wait until the timing is better from the horse's perspective;

– **consideration 2**: **thirstiness**: find a way to intervene somehow to make the horse "thirstier!"

– This is where considerations of the issue of type and scope of government interventions to change existing conditions in order to impact behavior and performance – the focus of this conference – comes to the forefront.

Overview of **EPA AP "lessons learned"**:

- **Summary of everything EPA has learned** over the past 8 years about AP use in one sentence:
    - "The AP works best, and is used much more often, when we employ it in the context of an integrated compliance strategy that includes targeting a sector with known compliance issues and then employing interventions to give firms – usually within the same sector – the choice of "voluntary auditing and disclosure" -or- "inspections and enforcement."
- **Corollary**: the AP does not/hasn't produced significant results when we've simply "thrown it out there" and waited for firms to knock at our doors.

– This has pretty much held true no matter what the firm-specific or overall Regional inspection and enforcement numbers have been.

- **Other long-held Agency views of AP use** based on our 8 years of experience:

  – **Large firms with resources** -and- auditing & EMS capacity and experience are more likely to use the AP specifically for those reasons.

  – **Small businesses** are unlikely (= "virtually never happens") to use the Small Business Compliance Policy absent EPA or State interventions to ***both*** -1- build **capacity**, and -2- build **trust**, e.g., by coupling non-inspection site visits with technical assistance ("non-enforcement options).

- **Key *resource-related* lesson learned:**

  "The best scenarios for increased AP use require the fewest possible numbers of inspections and enforcement actions for the involved sectors, companies, or firms."

  "Ideally, our strategies should produce significant self-disclosures with **just one or even *no* associated inspections or enforcement** because site visits and lawsuits are resource-intensive to all concerned parties.

  "That's why so many of our Compliance Incentive Programs (CIPs) rely solely on invitation letters with just a small number of (or 1) high-profile enf. actions. This = "**leveraging**" our resources and impacts."

Illustrative examples of **integrated strategies** including AP use:

- "Carrots appear tastier when backed with a stick" – **EPA Region 1's ongoing compliance work with its colleges and universities**:

  - 1999: R1 identified negative compliance trends at these schools;

  - Regional compliance assistance staff's initial step was to schedule a compliance assistance workshop for colleges and universities.

- When R1 first advertised the workshop, out of 350+ colleges and universities in New England, fewer than 40 individuals responded, many from the same college.

- The Region then issued an administrative penalty action against the University of New Hampshire, at the same time contacting the president of each school by letter to highlight the action and encourage attendance at the seminar.
- Response to the post-enforcement action letter was overwhelming; over 330 requests were received to attend the compliance assistance workshop, which attracted a capacity audience; a second workshop had to be scheduled.

- As part of that process, the AP was explained and info. provided on how to work with EPA to develop auditing agreements ➜ self-auditing and disclosures.

- Today, nearly half of New England's colleges and universities have taken part in the New England Colleges and Universities Audit Initiative.

• "Walk before you run" AKA "build capacity" – **R2, Patterson, NJ Refrigeration Repair/Geographic Initiative**:

  - Best way to promote small business use of the AP is to combine it with on-site, compliance assistance visits ("mock inspections" that aren't inspections) together with a credible fear of enforcement for nonparticipants.

  - Standard practice of sending "notice letter of upcoming inspections if you don't self-disclose" didn't work with these small businesses – Region got 1 taker who turned out to be in compliance.

  - In response, Region developed on-site compliance assistance visit program ➜ auditing and disclosures.

  - **#1 lesson**: These small businesses wouldn't/couldn't self-audit (low knowledge and resource levels) even after receiving the Region's compliance incentive letters. But site visits/technical assistance obtained their involvement.

• "Clean up now ... before we catch you" – **National Iron & Steel Minimill Compliance Incentive Program**

- In August 2000, EPA sent letters to 41 minimills inviting them to participate in a voluntary multimedia audit program where violations disclosed within six months could be self-disclosed under the Audit Policy.

- After the letters were sent, EPA met with the Steel Manufacturers Association and member companies to discuss the initiative and answer questions.
- Of the 41 minimills receiving letters, 28 minimills responded; EPA also received letters from 10 minimills that did not even receive invitation letters but wanted to participate.

- 24 companies ended up disclosing violations at 38 minimills. Responses included cleaning up spilled hazardous electric arc furnace dust, repaired cracked secondary containment around storage tanks, etc.

• "Your colleague's in violation so you probably are, too!" – **Telecommunications Industry Compliance Incentive Program**

  - In January 1998, GTE voluntarily disclosed CWA and EPCRA violations to EPA. EPA and the co. developed a company-wide settlement, including auditing, resolving violations at 314 facilities.

  - Afterwards, EPA sent letters to the rest of the telecom industry explaining our knowledge of their likely compliance issues and offering the opportunity to self-audit and disclose.

  - As a result, including the GTE settlement, more than 3,500 telecommunications facilities came into compliance with four environmental laws (CAA, CWA, RCRA, and EPCRA) through 25 civil settlements, 24 of them attributable to the use of EPA's Audit Policy.

<u>Research/nomenclature tips to researcher to improve paper</u>:

• **Understand what EPA and the States are actually doing** with the AP today, and why:

  - Empirical studies that confirm preexisting assumptions, experiences, and programs are OK ... but the ones that raise the discussion to "the next level" of potential policy and strategic improvements are better.

- ▸ **Know what has worked ... and what hasn't**:

  E.g., 1 big, well-publicized case can have an order-of-magnitude larger deterrence impact than 20 "pin-prick" cases when it comes to Audit Policy use (we develop our integrated strategies and initiatives with that in mind).

- ▸ CAA violations, especially on the part of the larger companies, often involve huge delayed or avoided EBN and/or result from differences in regulatory interpretation, not ignorance (i.e., AP unlikely to be a "solution").

- ▸ Paper is devoid of recognition of historical AP "lessons learned" and uses – that's why I used most of my presentation today talking about what EPA already knows and how we're acting on it/integrated strategies.

• Be careful to **employ terms of art accurately** ... 2 examples:

- ▸ # of enf. actions alone, or inspections alone, is a component of deterrence but is not = "deterrence."

  – Also, can't tell from the data sets whether enf. actions under *other* statutes are also influential – they might be key factors in prompting AP use;

  – Whenever possible, be holistic/synergistic/integrated & systems-oriented, rather than reductionist – "look at the big picture."

- ▸ "**Whether the co. received information concerning a compliance incentive**, e.g., a letter providing AP-related incentives, including info. that EPA may target insp's." ≠ "compliance assistance" ... that's ***specific deterrence***!

- ▸ Make sure you get your dependent variables correct, e.g.:

  – Pg. 15: "The findings of this research add to the corporate behavior literature and are surprisingly consistent with other studies that find that specific deterrence does not appear to be related to levels of corporate **compliance** ." ... NO!!! The dependent variable here is NOT "compliance" – it's Audit Policy use.

– Also:

* Can produce compliance with or without AP use.
* Or can promote increased self-auditing and correction of violations without self-disclosure ... also leading to increased compliance.

- **Summary/in general**: say what the data actually shows (e.g., CIP program letters work well in spurring AP use) in lieu of applying broad labels ("deterrence"; "compliance") that aren't strictly accurate.

- **Tell us why you chose just the CAA, & FY '99-'00** (e.g., manageable data set)?

  – How might this affect the **transferability** of your results across sectors, programs, and years?

  – Would a **breakdown of the violations by *type*** (e.g., emissions limit violations versus failure to install required capital equipment versus reporting/ recordkeeping) be helpful in this regard?

- **Re-check your numbers**:

  - ORE data pull for this paper ID'd nearly 100 CAA self-disclosures for same time researcher found 59 (taking CAA Section 211 mis-fueling violations/HQ handled these) into account;

  - Did you ask that your data run also include the Small Business Compliance Policy?

  - What about impact of acquisitions & mergers (not discussed at all in paper)?

  - Preexisting strong positive relationship between facility size, inspection frequency, & likelihood of enf. ... how does this impact your statistical analysis?

- **Consider the possibility of behavioral and/or "AP-content-related" explanations for results contradicting your hypotheses**:

- **Behavioral example:** what researcher calls “specific deterrence” – finding that ##s of co.-specific enforcement actions or inspections are not significantly associated with increased audit policy use ... **considerations I’d look at include**:

  – causality issue of whether what really happening is specific deterrence not working to promote AP use, or that actors who attract inspections and enforcement are simply least open to using compliance incentives?

  – e.g., are the same characteristics that lead bad actors to be more likely to be sued the ones leading them to be unlikely to use incentive programs proactively?

  ☞ Such companies might be, up-front, more recalcitrant and less civic duty-oriented and thus less likely to voluntarily audit, correct, and disclose violations.

  - **“Audit Policy content” is important too, as the Policy has been specifically configured to promote disclosures by persons who have not yet been inspected or enforced against.** Examples:

  – persons with “repeat violations” get bumped by AP Cond. 7;

  – Persons inspected or notified of insp’s get “bumped” by AP Cond. 4 (independent disclosure);

  – persons sued may get settlements which include self-auditing as injunctive relief; making it harder to qualify under AP in future;

  ☞ Perhaps, when you take these factors into account, the better hypothesis is to expect the odds of self-disclosure to be *lower* for someone who has, in the past, been regularly inspected and enforced against!

- And finally ... general suggestion:

  - Tease behavioral observations and policy recommendations from the research (don’t “just present the data ...”).

<u>Concluding comments</u>:

- You can “lead a horse to water” when you take the time to understand the horse, ensure it’s thirsty, and offer it attractive water.”

- Tell us, in your final report, based on the data & analysis, what are your recommendations or considerations for how best to achieve these goals?

Session II: Compliance Issues
Discussant No. 1: Jon Silberman, U.S. EPA, OECA/NCEI
COMMENTS ON:

Regulation and Compliance Motivations:
Marine Facilities and Water Quality

Peter May
University of Washington

April 26, 2004

<u>**Introduction**</u>:

- Before I say anything else about this paper, I must ask Prof. May about a specific finding in his paper:

    - In the section on "ATTITUDES TOWARDS GOVERNMENT," you write:

      "Those facility operators with more conservative attitudes about government are more likely to have high deterrent fears and less likely to have a strong sense of duty to comply. These are important findings because they suggest that the willingness (and reluctance) to address harms is related to more basic predispositions."

    - My question is: could you please be specific, in your final report, as to what new policies and programs you recommend the Bush Administration sponsor to address this finding? :)

- Prof. May has put his finger squarely on **two key issues facing us all today**:

    - (1) "How to enhance the commitment to protect water quality by creating a stronger sense of civic duty – [what Prof. May calls] a 'societal contract for protecting water quality.' "

    - (2) Not whether voluntary programs are more effective than traditional regulation [per se], but [rather] how can voluntary programs be improved?" [and better complement regulatory programs?]

<u>This **study is extremely timely** for the C&E program – I'd like to briefly mention 2 reasons</u>:

- (1) Current strong EPA focus on environmental performance through **voluntary programs**:

– Voluntary programs are designed to motivate people and organizations to take actions not required by regulation by going beyond compliance or achieving regulatory objectives in more effective and efficient ways.

– In general, voluntary programs use partnerships, market forces, and incentives, rather than mandatory regulations, to achieve environmental results.

– EPA is currently home to more than seventy voluntary programs dealing with a diverse set of issues, from climate change and waste reduction to innovative technologies.

– The Deputy Administrator has asked EPA's Innovation Action Council to determine how to enhance the effectiveness of our voluntary programs to make them more customer-focused and results-oriented ... this research can help.

- (2) OC and others are interested in making better use of so-called **"social marketing"** to enhance peoples' sense of civic duty:

– Social marketing is based on the premise that, "Things don't just happen – people have to want to make them happen."

– In his slides for last week's presentation to the National Environmental Assistance Summit on "performance-based compliance assistance," Office of Compliance Director Mike Stahl described it as a " blend of two ideas: performance-based management and social marketing."

– "Social marketing" means employing commercial marketing techniques in outreach and assistance, not just to inform, but to actually change behavior.

(1) define problem in behavioral terms;
(2) engage stakeholders in market research;
(3) identify perceived obstacles, benefits of behavior;
(4) segment & target audience based on their specific characteristics;
(5) tailor messages to audience segments;
(6) feedback loop – monitor & adjust the message.

- Tools include: -1- education to increase awareness;
  -2- social marketing to increase openness to change & incentives;
  -3- enf. & deterrence to address resistant to change & compliance.

- Challenges to performance-based marketing include:
  – compliance assistance initiative require more upfront planning & analysis;
  – tailored assistance makes generalizing from results ("transferability") more difficult.

- But the results of studies like this one, and Prof. Kagan's "Tracking Deterrent Messages in Environmental Enforcement" study, can really help.

<u>**General reaction to May report** by myself and my Regional and HQ contacts</u>:

- Overall, it's a through examination with logical findings:

  – Our experience agrees with Prof. May's findings in many respects (I'll cite just a few examples):

  ☞ traditional regulation is critical to continued progress in protecting and improving water quality (and potentially more effective than the voluntary approach alone):

  – **Myth**: EPA has already harvested the "low hanging" environmental protection fruit.

  – **Fact**: Approx. 25% of NPDES permittees still experience *significant noncompliance* with their permit limits each year.

  ☞ ... but, voluntary approaches can be quite effective, too;

  ☞ Both deterrent fears and sense of duty to comply are important motivators;

  ☞ Actions to address water quality are stronger when facility operators view water quality harms as a shared problem that they have a civic duty to address;

  ☞ Civic duty can have a stronger impact on regulated than unregulated facilities, perhaps because regs and permits signal what is desired by society.

  ☞ Mandatory-approach inspections may not have the off-putting effect on the sense of duty to comply as some hypothesize.

  ☞ But imposing sanctions can be off-putting when the recipients view them as overly harsh.

  ☞ Regulators should consider, when crafting regulatory goals and strategies, how performance is affected by variable such as inspections, reputation, and attitudes toward government.

  ☞ Building commitment and capacity to take action is important to increase compliance and performance, particularly by small businesses.

<u>**Summary of EPA reactions** to draft report</u>:

- Everyone with whom I discussed this report's conclusion agreed essentially with its findings.

- The report adds to our knowledge of the impacts of regulatory and voluntary programs, though more along the lines of buttressing what we already know (as opposed to providing startling new insights).

- It would be helpful to us, Prof. May, if you could beef up discussion of potential policy changes, or new assistance, enforcement, and/or integrated strategies you believe your findings suggest for improving marine facilities' awareness, compliance, and stewardship.

- Do this through added holistic analysis of your factual findings, your general understanding of the relevant compliance & motivational literature, and most importantly, your personal in-depth interactions with the marine facilities sector, "on the ground," in the course of preparing this report.

- You may also want to look at what other Regions and States are doing in the area of improving the marine facilities' environmental performance, e.g., Regions 1, 2, 3, and 4, Connecticut, Florida, and Maine.

- **We especially would benefit from analysis and development of these types of finding:**

- (Pg. 17) Social influences to enhance civic commitment/shared obligations to protect water quality include:

- "Social influences are a key to enhancing civic commitment and shared obligations to protect water quality and can be enhanced by, e.g.:

  – strengthening associational ties (i.e., among trade groups);
  – facilitating the emergence of strong industry leaders;
  – providing stakeholders with credible evidence that action is appropriate."
  – increasing facilities' concerns for their reputations;
  – inspiring the dynamics of a collective sense of action;
  – leveraging associational ties, e.g., among trade groups;
  – supporting the emergence of strong industry leaders;
  – sharing credible evidence/information that action is appropriate;
  – providing public recognition of leadership facilities, e.g., env. stewardship awards.

  - Don't stop with general recommendations. Use your knowledge of this sector and the compliance/behavioral literature generally to take us to the next level of understanding as to how, specifically, EPA, States, and other stakeholders can leverage these types of social influences to improve compliance and performance in this and other sectors.

  - There are many folks here at the Agency who will consider carefully and use what you produce.

– SELECTED COMMENTS ON RESEARCH PROTOCOL AND TRANSFERABILITY OF RESULTS–

Dearth of environmental indicator and/or actual performance information may affect reliability of results:

- Example 1: commitment of marine facilities to address water quality problems is measured in 3 ways:
  (1) % of BMPs undertaken;
  (2) self-ID of level of priority to facility of env. protective actions;
  (3) self-rating of their efforts from "less attention than most" to "we are a leader."

- Example 2: Two measures serve as proxies for the extent of water quality problems:
  (4) respondent perceptions, on a ten-point scale, of water quality at their location five years ago;
  (5) amount of waterfront that is adjacent to the facility.

- Typical reactions to these measures from EPA personnel:

  (1) "All BMPs are not created equal" – e.g., distributing env. literature versus developing and implementation a formal Stormwater Management Plan;

  (2) No actual water quality measures are developed/considered at all! Perceptions can be wrong/some QA/QC of the opinion/perception-based survey responses (= "blunt tools") would be helpful.

Potential Limits on the Transferability of Results:

- **Inherent problem exist in analyzing voluntary programs, generally:**

  - Because voluntary programs are by nature so diverse, it can be difficult to generalize/transfer results from one type of program and sector to another.

  - It would be helpful to add some discussion of this issue – with observations and recommendations – to the paper.

- **Geographic factors**: There may also be significant issues associated with generalizing from Washington State marine facilities to those in other areas, e.g., New England.

  - **Example:** ***Distinction between "regulated" and "unregulated" may be less black & white than the paper suggests***:

    – R1: Boatyards differ from marinas in that their ***primary*** function is boat maintenance, repair, and storage. Marinas, however, also conduct a significant amount of repair, maintenance and equipment cleaning.

– Consequently, marinas are, in fact, subject to many regulations (i.e., they're not "unregulated").

– E.g., Region 1 has determined, through site assessment visits, that approximately 70% of the marinas visited were required by law to have storm water permits.

– Many of the activities described under the BMP table (pg. 20) appear interchangeable between marinas and boatyards.

The paper may present a more "black and white" approach to regulatory versus voluntary programs than is justified:

- Comment of an EPA reviewer with significant voluntary programs experience: "While the paper asserts that mandatory and voluntary approaches are not strictly either/or propositions, they are then pitted against each other through hypotheses such as, 'the mandatory approach is more effective than the voluntary approach in gaining commitment to address potential harms by those entities that potentially contribute to these harms.' "

    ▸ "EPA views voluntary programs less as a *replacement* for regulations, more as an *adjunct* means to fill regulatory voids where there are no rules or where we can ask people to voluntarily go above and beyond the regulatory requirements to be good corporate citizens in the communities in which they reside."

Expanded discussion of "role of stakeholders":

▸ Region 1 comment: "Our experiences have shown that local governments and local organizations (including some local organizations with authority in certain areas), NGOs, and customers play a role in affecting compliance. These stakeholder impacts do not appear to be addressed in the report. In addition, the report does not distinguish among federal, state, and local authorities regarding regulations."

- **Recommendation: expand discussion of research on how to enhance civic commitment and shared obligations to protect water quality.**

    ▸ Comment of an EPA reviewer with significant voluntary programs experience: "Researcher makes brief mention, only, of the value of strengthening organizational ties (i.e. among trade groups), fostering the emergence of strong industry leaders, and providing credible evidence that action is appropriate. More extensive discussion of these topics would have been useful for us as policy-makers and regulators."

Role of technical and financial assistance:

- Region 1 comment: "The conclusion that technical and financial assistance is often very important to facilitate and direct actions is a significant one to keep in mind, especially for the NPDES individual permit requirement for pressure wash discharging."

- Question for researcher: Are there other specific areas you want to recommend as a focus for government efforts to target technical and financial assistance to this sector?

CONCLUDING THOUGHTS:

- **EPA STRONG LY AGREES:** Pg. 17: "Given the limitations of the voluntary approach, deterrence must serve at least as a backstop to it. Yet, fostering deterrence need not entail an elaborate enforcement regime since steps can be taken to instil a general deterrent effect."

- This is good news for resource-strapped regulators who are open to thinking creatively and innovatively.

- "Everyone talks about wanting to be able to tell the federal government where to go and what to do. Here's your chance to do so and you're being paid to do it. So be specific in your recommendations!

Session II: Compliance Issues
Discussant No. 2: John Horowitz, University of Maryland
COMMENTS ON:

Corporate Self-Policing and the Environment:
Factors Predicting Self-Disclosure of Clean Air Act Violations under the EPA's Audit Policy

Paul Stretesky
Colorado State University

and

Regulation and Compliance Motivations:
Marine Facilities and Water Quality

Peter May
University of Maryland

April 26, 2004

By John K. Horowitz, University of Maryland, College Park, horowitz@arec.umd.edu

Stretesky's paper examines the characteristics of firms that disclosed a Clean Air Act (CAA) violation during a period in which EPA had a policy that appeared to reward self-disclosure of violations. To conduct this research, he must examine both self-disclosed violations and violations that were uncovered by EPA but not disclosed. My comments are most technical (although they go to the heart of the inferences that can be made from these data.). In contrast, Jon Silberman raised issues about the nature of CAA violations and of EPA's policy.

To study the effect of the EPA's policy, Stretesky uses a statistical technique labeled case control design. This approach entails taking a random sample of non-disclosers (that is, violations that were uncovered by the EPA) and comparing this to the full sample of disclosers. The population ratio of non-disclosers is about 95 percent; only 5 percent of violations were self-disclosed. Under the case control design method, where only a sample of non-disclosers is analyzed, the data set's ratio of non-disclosers is 50 percent. It is easy to see why he might like to do this. When the true probability of a dichotomous (yes-or-no) variable is 50-50, the power of his statistical tests is maximized. When the true probability is much more skewed, as it is with these data, the statistical power is much lower. Of course, these claims apply to data that is naturally distributed 50-50, not to data that is simply selected to be distributed so.

I have serious reservations about this method. At a minimum, Stretesky should explain this statistical technique further. I think it likely that the method is flawed, probably because the standard errors of the estimates are biased downward. My intuition is simple: Under this technique, the author has thrown out information. This will raise the standard errors. Since he does not correct for this problem in calculating his standard errors, the standard errors reported in the paper are surely too small.

There is also, of course, a severe sample selection problem: Even if all of the non-disclosed violations are analyzed, they will represent only those non-disclosed violations that were detected. If the characteristics that lead to a violation being detected are correlated with the characteristics that determine whether a violator will disclose or not, then his coefficient estimates are again biased. This correlation surely exists. There is probably little the author can do about it, although he knows the data and circumstances better than I and may have some ideas. Even if he cannot solve the sample selection problem, he needs to discuss it and its ramifications.

My comments about May's paper revolve around the nature of the question he is addressing. This paper looks at difference in the environmental behavior and attitudes of marinas and boatyards. For short-hand, he labels marina behavior "voluntary," because most of them are not required to have NPDES permits, and boatyard behavior "mandatory." May recognizes that these labels are mere short-hand for describing a complex situation. I would argue that they have greatly obscured the issue he is addressing, and may have led to errors in the analysis.

First, since the main difference underlying his analysis is whether a facility has an NPDES permit, it seems odd for the author to have thrown out data points in which the boatyards did not have NPDES permits or the marinas did have such permits.

May recognizes that marinas are not completely unregulated, and argues that the true characterization is a continuum in which marinas are "less regulated" and boatyards are "more regulated." But is even this characterization valid? Several pieces of evidence suggest that at least some marinas face substantial regulation; see Table 3 on p. 12 or p. 16. This evidence suggests that a continuum may not be the right metaphor. Marinas may simply face *different* regulations. The interpretation of the results is thereby called into question.

I suspect May is correct in claiming that marinas bear a less onerous regulatory burden than boatyards. I suggest that he document this more fully, rather than relying on the NPDES distinction.

Finally, I want to note the problems of treating the sentiment of "duty to comply" as a socially desirable aspect of regulation. This seems to send us into a house of mirrors in which people comply more when they don't have to and comply less when they have to. Perceived "fairness" – of the law, of the enforcement of the law, and of the penalties – may be a better measure of what May is trying to understand.

Summary of the Q&A Discussion Following Session II

Joanne Berman (U.S. EPA, Office of Enforcement and Compliance Assurance)
Ms. Berman commended both the presenters for including compliance assistance in the presentations, but said she "was a little befuddled" by how they were using the term. She cited the "official" description of "compliance assistance is to help the regulated community understand and comply with the laws." Saying that she appreciated their going on the University of Pennsylvania website, she apologized for the dearth of material saying, "that's in part because for *federal* folks compliance assistance is something new and we're trapped in the measurement of it—we're in the process of trying to find ways to track and then measure it. This may not help for your 1990-2000 data, but from my perspective compliance assistance is *not* the audit policy itself but what we did ancillary to the providing the audit policy. For example, if you were using the audit policy and re-developed audit protocols, then what we do a lot of times in these initiatives you spoke of is—the development of the protocol and the distribution of it is where we would find out whether compliance assistance had a value in using the audit policy, and I wasn't sure you knew that—I see you shaking your head that you did, but it wasn't clear to me from your presentation."

In addressing Peter May's presentation, Ms. Berman noted that sometimes "folks kind of clump compliance assistance with voluntary programs," and she said in her work "that's *not* the case because the definition says that there has to be a connection *between* compliance assistance and the work that we do." She went on to add that "in the initiatives you spoke about . . . when we do compliance assistance, we've learned that it needs to be an integrated approach, and I could give you a laundry list of how we do it with inspections, how we do it with enforcement, how we do it with the audit policy." She concluded by encouraging the researchers to "think of compliance assistance in conjunction with *all* these other tools." She also said that as we move toward the concept of social marketing, EPA would really benefit from any data concerning whether compliance assistance actually has an impact on changing behavior.

(Note: Neither of the presenters responded to Ms. Berman's comments.)

Pete Andrews (UNC-Chapel Hill, Department of Public Policy)
Addressing Peter May, Dr. Andrews questioned how valid it is to generalize based on data from "two segments of the marine industry," which he sees as "a somewhat unique industry." Assuming that the focus was on smaller boat yards as opposed to big shipyards, Dr. Andrews characterized the clientele as "recreational boaters—fairly affluent Americans who care about the environment as well." He added that, "as a monopoly, [smaller boat yards] can just keep raising their price because nobody can take the business away from them—at least I don't see a lot of opportunities for that on the East Coast." He wondered how the research would play out in looking at dairy farmers, or school systems, or "other kinds of *players* who are sort of below the radar in important segments in terms of environmental performance."

Peter May (University of Washington, Center for American Politics and Public Policy)
Dr. May responded by first asserting that he believes the marine facilities they surveyed have a more "heterogeneous clientele" than Dr. Andrews indicated. Addressing "the broader question of where does this fit in?" Dr. May continued by asserting that the way this type of research is conducted today "it's hard to really come up with clear patterns across all these different settings," and he said he thinks "the way we're thinking about these things is wrong. We're tending to think about it too much on a sector basis, or too much on a size basis. There has to be some other way of thinking about these kinds of things. . . We're thinking about it as too much of the attributes of the industry and not enough about the attributes of the regulatory context broadly defined. We *need* to think about that regulatory context, and this is why I like the work that Bob and Neil [Kagan and Gunningham] . . .and others are doing . . . is that it brings in that context more, in terms of how reputation plays in, and a variety of these more elusive kinds of things."

He continued, saying, "To me, the generalizability isn't a question of [categorizing industries and finding similarities]—I'd rather think about regulatory *regimes* and a particular *kind*, and this particular kind of regulatory regime is voluntary by the firms that aren't paid a lot of attention, but where reputational influences are important."

Conceding that he was still searching for "the answer," Dr. May re-asserted that "it's not a question of the industry—it's a question of some of these other kinds of economic and social influences. That's why I said whatever this typology is that's not there anymore has to come into play." He closed by characterizing his response as "a non-response," or "a long essay that says I don't know."

Jon Silberman (U.S. EPA, Office of Enforcement and Compliance Assurance)—a follow-up response
"One of the reasons why I encourage Professor May to milk as much as he can out of the work that he actually did with the marine facility sector is so that even if there are transferability limitations on the work, we'll still get a very valuable product out of his research."

Matthew Clark (U.S. EPA, Office of Research and Development)
"Jon, I just wanted you to define what "social marketing" means."

Jon Silberman
"I just happen to have a definition. It means: employing commercial marketing techniques and outreach and assistance not just to inform but to actually *change* behavior. If it were used in an integrated context, you would combine it with education to increase awareness. You would use social marketing to increase openness and change and use of incentives, and [you would use] enforcement and deterrence to address resistance to change or non-compliance issues."

Robert Kagan (University of California at Berkeley)
Dr. Kagan stated that he was "troubled by the notion that a violation is not a violation," or, to be more precise, the notion that "some are *serious* and some are *less* serious," and he said he believed this was Jon's point as well. He wondered whether the data set would allow the researchers to break the violations down by, for example, "those that carry big fines versus those that carry small fines" or some other way of distinguishing "that's more technical" as opposed to just "those that result in some significant harm."

Jon Silberman
Mr. Silberman responded that "for better or worse, every EPA program has a definition of a term called "significant non-compliance," which actually makes value judgments in distinguishing between compliance considered to be more significant and compliance considered to be less significant," and he acknowledged that there are always differing views about where that line should be drawn. He went on to clarify that the classification is used in many different ways, including "choosing between facilities to target, choosing the enforcement response—the response to the non-compliance, etc."

Irene Xiarchos (West Virginia University, Division of Resource Management)
Ms. Xiarchos began by commenting, "I'm very grateful that this is happening—at least for me it's a big deal." She went on to ask whether social marketing is targeted more to non-point source pollution or whether it is also directed toward point source pollution, where there are already some regulatory controls set up.

Jon Silberman
Mr. Silberman deferred to Joanne Berman for an answer because she is "working more directly with it."

Joanne Berman
Ms. Berman answered by saying, "Social marketing really is taking commercial marketing concepts and applying them to a social environment . . . It's a process you go through in order to understand your audience and then find the best approach to change that behavior." She reiterated that the process is "designed for *any* audience, to understand the early adopters and then go all the way to the laggards. So, what we would do with social marketing is do some research on your audience, understand *why* there are early adopters and *why* they're early adopting—focus your attention and resources on *those*." She continued to explain that after identifying your partners and your audience, you would work on "spreading the word, so eventually compliance and beyond compliance—whatever behavior you would like to [foster]—gradually increases and moves forward." Ms. Berman also clarified that enforcement becomes part of the process of dealing with laggards, "because you'll never get some folks to change their behavior." She concluded by summarizing, "So, generally, the process is to get them to change their behavior, and then when the hammer comes in, it would be your last resort," but social marketing "could be used in any context."

Corporate Environmental Behavior and the Effectiveness of Government Interventions

PROCEEDINGS OF

SESSION III: APPROACHES TO ENVIRONMENTAL PERFORMANCE

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Prepared by Alpha-Gamma Technologies, Inc.
4700 Falls of Neuse Road, Suite 350, Raleigh, NC 27609

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DISCLAIMER

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A Multi-Agent Model of a Small Firm

Clinton Andrews, Ana Baptista, Shawn Patton
Edward J. School of Planning and Public Policy
Rutgers University, New Brunswick, New Jersey
cja1@rci.rutgers.edu, abaptist@eden.rutgers.edu, shawn@shawnpatton.com

This paper presents a bottom-up view of industrial ecosystems by examining the interpersonal dynamics that influence corporate environmental behavior. Employees of profit-making firms don't always behave in the shareholders' best interests due to misaligned incentives, impaired information flows, and bounded rationality. Even worse, there are sometimes conflicts between shareholder interests and the broader public interest, evident in the moral struggles of people over their dual roles as employees and as citizens. Employees operate within the formal, regulative structures of the firm and government, as well as the informal, normative or cultural structures of social networks.

The paper triangulates to identify useful insights about personal networks and corporate environmental behavior, using interviews at firms, review of archival data, and a computer simulation model. Interviews and archival data provide empirical grounding, while an innovative multi-agent simulation modeling exercise supports formal theorizing. The empirical work is based on case studies of plastics processing firms in New Jersey. The simulation model characterizes production technologies, social and economic structures, and interpersonal interactions under a variety of conditions. The model may eventually prove helpful to managers interested in improving on existing organizational practices and procedures. The model could also help regulators understand corporate environmental behavior more fully.

Findings are relevant to both the eco-park and industrial ecosystem levels of analysis.
This work is funded by a U.S. Environmental Protection Agency STAR grant.

The next section reviews the relevant literature. Then the paper provides an introduction to the industrial sector studied, describes case studies of four firms and findings from those cases, introduces the multi-agent simulation model and modeling processes, and draws conclusions.

Literature on networks and organizations

Studying organizations

It is difficult to study organizations because they are so highly complex and adaptive. They exhibit structural complexity, having both functional and product hierarchies within whose mesh individual employees act. Organizations are also goal-oriented systems that survive by adapting to changing external conditions. The leaders of organizations work full time to change that which researchers study.

The range of organizational phenomena is rich enough that distinct disciplinary approaches to their study have developed. Often researchers talk past rather than to one another over interstitial issues such as linking structure and agency. The normal progressive spiral of science from induction to deduction, pattern matching to hypothesis testing, evidence to theory and back again, seems to operate inefficiently. Many theories co-exist, and empirical work fails to eliminate most of these rivals. This paper attempts to get the "wheel of science" (Wallace, 1971) spinning productively by directly triangulating across extant theory, qualitative data, quantitative data, and simulation modeling.

As discussed elsewhere (Andrews, 2001), there is much useful economic theory for industrial ecologists to draw upon. It explains why firms exist (scale economies, transaction cost reductions), how they respond to changing external conditions (internal structural change, external influence projection), and how they relate to other firms (contracting, mixed-motive strategizing). Some strands of the contracting literature also assign agency to employees within a firm, typically highlighting mismatched incentives and informational asymmetries.

Prescriptive management theories have progressed over time from the efficiency studies of Taylorism, to classical management theory that emphasized commanding and controlling, to the gentler and more respectful human relations approach of Mayo, to the systems approach of Senge and others.

Classical and neoclassical economic theories provide an atomized explanation of economic actions, whereas reformist economists view economic actions as embedded within social structures. According to these theories social relations between individual actors impedes competitive markets and individuals pursue a narrow utilitarian, self-interest. This view is called "undersocialization". "Oversocialization" is when behavioral patterns are so internalized that social relations have only a peripheral effect on behavior.

Granovetter (1985, 487) posits a middle position between over and under socialization "*Actors do no behave or decide as atoms outside a social context, nor do they adhere slavishly to a script written for them by the particular intersection of social categories that they happen to occupy. Their attempts at purposive action are instead embedded in concrete, ongoing systems of social relations*." He furthermore rejects the neoclassical undersocialization theory arguing that "*anonymous markets of neoclassical models are virtually nonexistent in economic life and that transactions of all kinds are rife with the social connection*." In actuality, business relations today are mixed up with social relations all the time. For example (p. 496), "*in industrial purchasing, buying and selling relationships rarely approximate the spot-market model of classical theory…and evidence consistently suggests that it takes some kind of 'shock' to jolt the organizational buying out of a pattern of placing repeat orders with a favored supplier.*" The reasons for this type of seemingly irrational behavior include costs associated with searching for new suppliers and establishing new relationships. These relationships are formed through trade associations, country clubs, and other social gatherings. The survival and success of small firms in the market are in part due to a dense network of social relations overlaid on top of the business relations that connects such firms and reduces pressures for integration.

Social Networks

There is a distinction between the 'formal' and the 'informal' organization of the firm with the formal represented by the organizational chart and the informal represented in the social networks within the firm. Organizational charts do not reflect the way the work gets done inside an organization. There are many actors in employees' social networks, all of whom have the potential to influence the employee. There are two main types of actors that have this influence, and Shah (1998, p.250) call them "*cohesive and structurally equivalent actors.*" Cohesive actors or referents are individuals with close, interpersonal ties, or friends. Structurally equivalent actors are individuals who share a similar pattern of relationships with others and thus occupy the same position in a network. Shah (1998, p.249) has shown that "*employees rely on structurally equivalent referents for job related information and on cohesive referents for general organizational information and as social comparison referents.*"

Informal practices and social networks serve distinct purposes within a firm. For example, firms' internal information is not necessarily acted upon, particularly in the context of promotion practices. According to Granovetter (1985, 499), "*internal promotions have affirmative incentive properties because workers can anticipate that differential talent and degrees of cooperativeness will be rewarded*." Long term employees also have built up strong informal networks within the firm (Granovetter, 1985, 501), "*when many employees have long tenures, the conditions are met for a dense and stable network of relations, shared understandings, and political coalitions to be constructed*."

Individuals are more likely to obtain general organizational information (i.e. office gossip, organizational culture, office politics) from cohesive actors, according to Shah (1998, p.252). Social comparison theory suggests that similarity plays an important role in referent selection. Demographic variables such as gender, age, tenure, and education account for different aspects of similarity within workplaces. People often select referents of the same gender, job category and education. Similarity in tenure and age may also serve as relevant dimensions for career comparisons. In the cases studies to follow, there is some evidence that long tenure and seniority on the job elicits greater influence in the work environment than simple hierarchical positions. The studies also show that there is greater cohesion in the workforce because of the similar ethnic backgrounds of the low skilled workers of Hispanic origin. This demographic trait is also a link to higher levels in the organization through internal promotions.

Workplace uncertainty, socialization practices and performance ambiguity may all lead to different types of socialization within the firm. A routine, well-defined assembly line task may elicit few inquiries regarding job responsibilities and performance. More complex, loosely structured positions may generate many inquiries. The plastics manufacturing firms included in this case study would fall under the category (Toone and Jackson) of small batch production or "job-order manufacturing for customized products in which production is done according to demand in small runs and lots."[1]

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[1] Toone, Roland and Jackson, Dave. 1987. The Management of Manufacturing: The competitive Edge. Springer-Verlag; New York, p. 22

Formal vs. Informal networks

According to Scott (2001, 153), there are two distinct features of firms today. "*First, there exists a remarkable similarity in the structural features of organizational forms operating within the same organizational field…..Second, students of organizations have long observed the presence of both a formal and informal structure, the former reflecting officially sanctioned offices and ways of conducting business, the latter, actual patterns of behavior and work routines. An uneasy tension exists between these structures.*" The formal and informal networks that frame inter- and intra-firm behavior are defined as follows by Schermerhorn and colleagues (1988, 199):

- "Formal groups are created via formal authority for some purpose. They typically have rather clear cut superior-subordinate relationships, and they often appear on formal organizational charts." Formal groups are designated by an organizational authority and can be seen in the production pressures and technical demands of a company. Formal groups are specified by the organization chart (and by a task group in a matrix management situation).
- Informal groups on the other hand are not formally recognized but typically consist of subgroups or cliques within formal groups. These informal groups can be people within a firm that eats together or goes on breaks together. Informal groups emerge spontaneously. Informal groups consist of groups of individuals that want to achieve some mutual objective (not the organization's but the group's), sometimes they are merely friendship groups or people who have something in common. According to Scott (2001), "This is really where/how things get done in organizations." Informal groups can be seen in the regulative, normative and cultural-cognitive elements of the company, including company sponsored social activities of the sort mentioned in the case study to follow.

Informal networks exist because they help individuals do their work by "offering a network of interpersonal relationships with the potential to 'speed up' the work flow or gain favors in ways that formal lines of authority fail to provide" (Schermerhorm et al, 1988, 200). These informal groups also help individual employees meet needs beyond what the formal groups can provide, including:

- Social satisfaction – friendship and social relations
- Security - "opportunities to find sympathy for one's feelings and actions, especially as they relate to friction with the formal organization; opportunities to find help or task assistance from persons other than one's superior"
- Identification – sense of belonging by associating with people who are similar

Organizational life cycle

As organizations increase in size, they typically become more heterogeneous in their orientations and in the products and services they provide. This often results in movement from a simple to a more complex structure.

Organizational Life Cycle Entrepreneurial Stage	Collectively Stage	Formalization and Control Stage	Elaboration of Structure Stage
Marshalling of resources	Information communication and structure	Formalization of rules	Elaboration of structure
Lots of ideas	Sense of collectivity	Stable structure	Decentralization
Entrepreneurial activities	Sense of collectivity	Emphasis on efficiency and maintenance	Domain expansion
Little planning and coordination	Long hours spent	Conservatism	Adaptation
Formation of a "niche"	Sense of mission	Institutional procedures	Renewal
Prime mover has power	Innovation continues		
	High commitment		

Table 1: The Organizational Life Cycle

Source: Cameron, K. S. , and Whetten, D. A. 1983. Models of organizational life cycle: Application to higher education. *Rev. Higher Educ*. 6(4): 269-299.

Many firms, especially smaller enterprises, never reach the later stages in the organizational life cycle, either because they disappear or because they don't reach a size that requires much formalization. Nevertheless, the importance of the distinction between formal and informal social networks grows as structures become more complex.

Industry Background

The industry sector studied in this project is plastics products. It was chosen because the technology is relatively simple, it has eco-efficiency and pollution reduction opportunities, there are many small and medium-sized firms available as case study candidates, and it is undergoing a dramatic transformation due to competitive pressures from economic globalization.

Plastics Product Manufacturing

The two basic groups of plastic materials are the thermoplastics and the thermosets. Thermoplastic resins consist of long molecules, each of which may have side chains or groups that are not attached to other molecules, so they are not cross linked (SPI, 1999a). Thus, they can be repeatedly melted and solidified by heating and cooling so that any scrap generated in processing can be reused. No chemical change generally takes place during forming. Usually, thermoplastic polymers are supplied in the form of pellets, which often contain additives to enhance processing or to provide necessary characteristics in the finished product (e.g., color, conductivity). The temperature service range of thermoplastics is limited by their loss of physical strength and eventual melting at elevated temperatures.

Thermoset plastics, on the other hand, react during processing to form cross-linked structures that cannot be remelted and reprocessed. Thermoset scrap must be either discarded or used as low-cost filler in other products. In some cases, it may be pyrolyzed to recover inorganic fillers such as glass reinforcements, which can be reused. Thermosets may be supplied in liquid form or as a partially polymerized solid molding powder. In their uncured condition, they can be formed to the finished product shape with or without pressure and polymerized by using chemicals or heat.

Figure 1: New Jersey Plastics Industry Employments and Shipments
Source: SPI (2002)

New Jersey is one of the top ten states accounting collectively for 60% of the total U.S. plastics industry shipments (SPI, 2002). Unofficial statistics suggest that both employment and shipments have dramatically declined in this industry since 2001.

Plastic Injection Molding Industry

Injection molding is the principal method of forming thermoplastic materials. The production process is organized around runs of product (e.g., an order for 100,000 plastic coffee cup lids). Large volume runs of simple items (like coffee cup lids) have low profit margins because there are too many competitors for this type of simple product. On the other hand, the most profitable firms deliver high quality, complex, molded products often in smaller runs (e.g., an order for 1000 laptop computer housings). Generally, the injection molding business has a range of production specialties. At the smaller end, the precision molders make very small parts and at the large end they can make larger, more complex parts (e.g., automotive parts). There are two types of injection molders:

- Custom, contract molders make parts specific to the needs of their customers
- Proprietary, captive operations make their own products

The relevant NAICS codes that apply to this industry include:

NAICS Code	**Description**
326199	All Other Plastics Product Manufacturing
325991 & 3261	Plastics Product Manufacturing
32613	Laminated Plastics Plate, Sheet, and Shape Manufacturing,
32614	Polystyrene Foam Product Manufacturing
3087	Custom Compounding of Purchased Plastics Resins
325991	Custom Compounding of Purchased Resin

Technology & Innovation

Injection molding is a branch of the plastics industry that involves injection under pressure of molten plastic into the cavity of a mold followed by cooling and removal of the solidified part that retains a replica of the mold. The injection molding industry is arguably in its infancy. It was only during the 1960s that reciprocating screw technology became commercially viable. With the advent of the microprocessor, there have been significant advances in process control during the 1980s and 1990s. There have been equally significant advances in screw technology, multi-color molding, insert molding, gas assisted injection molding, and other niche processes. There have also been major advances in polymer materials, mold making, and of course, predictive analysis tools for avoiding problems before they occur and optimizing every phase of the design-to-manufacturing process.

However, in spite of all these advances, the injection molding industry continues to exhibit signs that it is still a very young industry. For example, it remains common to set up and optimize the process using time-consuming and inefficient trial-and-error methods. While molders may be able to obtain acceptable quality parts using this method, the process usually requires constant fine-tuning to maintain quality parts because it was not set up using a rigorous scientific quality control method. Failure to setup and optimize using a rigorous method normally results in a process that is not robust and therefore, is difficult to control. Beyond the setup, optimization, and control of the process, there are additional injection-molding manufacturing tasks that must be performed, optimized, standardized, and integrated across the company-wide enterprise. These additional tasks include, but are not limited to, production scheduling, preventive maintenance, process and production monitoring, statistical process control, statistical quality control, and production reporting. It is also becoming increasingly common for an injection molder's customers to demand value-added operations such as part traceability, while simultaneously demanding per-part price decreases. Facing these challenges, injection molders must not only implement systems and processes to achieve the value-added demands, but also accomplish them cost-effectively while improving the efficiency of their existing operations.

Employee Tasks

Injection molders typically work in small independent firms with relatively few employees (5-100). Most of the employees are semiskilled workers who load plastic pellets into the injection molding machines, mixing in some recycled plastic waste as available. Once the plastic has cooled and re-solidified the mold opens and the plastic product is removed. If the machine's temperature is set too high, air pollution can result in the form of fugitive volatile organic releases. In a typical machine, every 30 seconds the machine completes a cycle, dumping a cooled molded plastic piece onto the factory floor. Injection molding machines require thorough maintenance, otherwise they become unreliable. Workers take the molded plastic pieces and break off the extra bits of plastic (little nubs and frames). The amount of plastic waste is a function of the mold design and the amount of product made.

Workers then put the waste plastic into a grinder and store it for use as recycled feedstock. Recyclability is a function of the type of plastic material used (some plastics can't be recycled once heated). Un-recyclable plastic is disposed of offsite. Workers inspect the product and reject some pieces (these get recycled) and pack the product into boxes for shipping. These boxes are shipped to customers according to a supply schedule. A process engineer supervises multiple injection molding machine lines and orders raw materials. A marketing manager solicits orders for products and a plant manager coordinates the marketing and production activities, settles employee disputes, and seeks to maintain profitability.

Industry Outlook

The injection molding business's golden era spanned the1970s - 80s when there was less competition at the machine and process level and firms produced very high profit margins. Now there are abundant machinery manufacturers and processors inundating the market. Processors range from small family operations with a handful of machines to larger companies with hundreds of machines. Other dynamics are also lowering the margins, including increased competition from Asian imports. Asian markets have very low costs, particularly labor costs, relative to U.S. operations.

Plastics Injection Molding Process

In injection molding, plastic material is put into a hopper that feeds into a heated injection unit. A reciprocating screw pushes the plastic through this long heating chamber, where the material is softened to a fluid state. At the end of this chamber there is a nozzle that abuts firmly against an opening into a cool, closed mold. The fluid plastic is forced at high pressure through this nozzle into the cold mold. A system of clamps hold the mold halves shut. As soon as the plastic cools to a solid state, the mold opens and the finished plastic is ejected from the press SPI, 1999b).

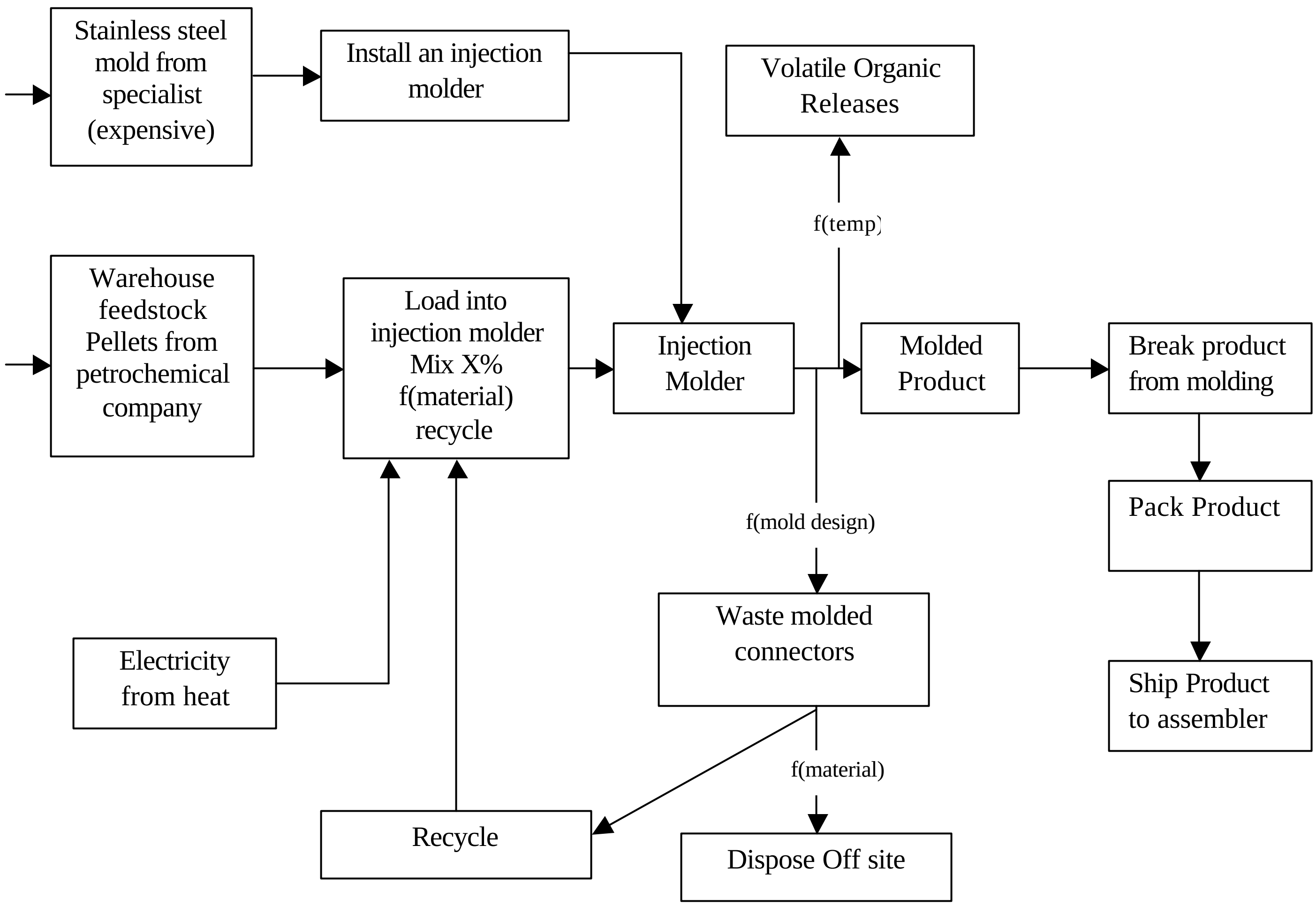


Figure 2: Plastics Injection Molding Process Diagram

Methods

Three plastics injection-molding firms in New Jersey and one multinational chemical corporation were selected for study. The three plastics firms were selected because they were accessible and because they have relatively simple manufacturing processes that could be more easily modeled. The multinational chemical company was studied less formally, specifically for their approach to environmental management. The case studies of the three companies include in depth interviews with the presidents or owners of each firm, analysis of business, financial and environmental records, and site tours of the manufacturing floor. Each interviewee reviewed and signed an informed consent form and their names and the names of their companies remain confidential.

Firm	Description
Company 1	Plastics, Injection molding, Single establishment, family run
Company 2	Plastics, Injection molding, Single establishment, family run
Company 3	Plastics, Injection molding and extrusion, Subsidiary of Multinational company
Company 4	Multinational chemical firm

Case Study Findings

In depth interviews with the presidents or managers of the three injection molding companies revealed a great deal of information regarding the importance of: formal and informal networks in workplace practices such as innovation and safety measures, the role of a family run vs. a corporate culture environment, external market dynamics, stable workforce dynamics. The following hypotheses reveal a rich picture of this particular industry and also highlight some important lessons more generally, regarding organizational behavior's ties to workplace practices.

Hypothesis 1a: *As the external environment becomes increasingly competitive, the family-run businesses decrease the social amenities available to employees.* ***Supported.***
Hypothesis 1b: *As family run businesses experience a generational shift, the social practices of the company also shift.* ***Supported.***

Interviews with all three companies revealed that there has been a shift in the business culture towards a less social work place indicated by the decrease or elimination of company sponsored social activities such as company sports teams or company picnics. In the case of the first two companies, which are run by a second generation of family members, this shift to less social activities also coincides with a shift towards a more competitive market environment and less profitability. Interestingly, the third company which operates under a more corporate culture (subsidiary of multinational company) and is not run by family members, offered many more social amenities to their employees than the first two family run companies. This difference may mean that the decrease in social activities in the first two companies may be primarily due to scarcity of resources to support such activities. On the other hand, the quality, scope and relevance of the social activities in place at Company 3 cannot be measured by this case study and therefore it is difficult to compare and contrast the activities of one company with past activities of the others. The generational shift evident in the two family-run companies was also accompanied by a downturn in the economy and increased competition in the industry. Were these social activities cut because the second generation was not as socially tied to the employees or had a different relationship with employees than their predecessors? Or is this decline a direct outcome of scarce resources to dedicate to social amenities?

According to Company 1's President, the decline of company sponsored social events might be attributable to both a generational shift and a resource allocation issue. The current owner feels that if his father were still running the business that many of the social activities he sponsored would probably still be in place. This is because part of his father's "style" was that he felt more comfortable interacting with the employees through these types of activities as opposed to more informal contact on a daily basis. The current owner thinks it was partly due to his age that he didn't relate as easily with the employees so that the social activities were a mechanism for reaching them. The owner today and his brother take a much more relaxed approach in which they feel comfortable with their employees and interact with them on a daily basis in a less structured way on the factory floor. In this case, the social activities would be nice but they are not really necessary for them to get to know the employees. On the other hand, if the current economic situation allowed for more profitability with a surplus of money available, a situation more similar to when their father ran the business, then they might well consider offering more social activities. In many ways the decision to offer company-sponsored social activities is product both of resources and personal style.

At Company 2 on the other hand, the original owners, the fathers, were very "hands on" interacting mostly on the factory floor as technical tool-makers, they were very close to the factory workers. The second generation in this company was less "hands on" and more focused on the business aspects of the company. At company 2, the owners attribute the decline in social activities more to a lack of resources and the sense that employees were not participating in the activities. In the past the company hosted several company sponsored social activities such as picnics that have since faded when they moved to a new facility a few years before, "*We used to have picnics, a company picnic. The last one was before we moved over here, but we stopped them because our business had fallen and the money wasn't really there for that or we didn't want to use it for that. I think there was also some distaste on our part that we didn't feel our employees were participating at that point*."

Company 3 offered a wide range of social activities including a bowling team, company luncheons, educational training, and other activities. Company 3's manager sees a great deal of value in sponsoring these events. The manager states, "*I would say that happens [interaction between positions] in the sports driven activities like bowling. It gets the full gamut of employees. You get staff management out there bowling and the maintenance folks and set up operators and packers, one big team*." This type of socialization is also seen as a positive contributor to company morale on the factory floor. The general manager describes the effects of such social activities on the company as follows, "*It helps on the factory floor. I don't know if I can quite put my finger on it, but when you have a crew that's been around, that's as senior as the one I've got, there's a wonderful camaraderie but there's also a totem pole*."

Hypothesis 2: *Family run businesses have strong social ties to employees, and thus may be less likely to streamline and cut labor. This theory is based on the human relations theory of organizational behavior.* ***Not supported.***

This dynamic works well for explaining promotional or recruitment/ hiring practices but is not the driving factor in the business. Company 1, for example, relies on informal communication networks and close ties/familiarity with employees to determine promotions and even hiring or firing decisions. But Company 1's president also emphasized the need to continuously streamline and cut low skilled positions by automating these jobs, thereby reducing high labor costs allowing them to stay competitive in the marketplace. Company 2 actually detailed the difference in approach to employees with the increased competitive market, *"The biggest difference between business today and 15 years ago is that you can't stand still. Fifteen years ago you could stand still and just make product and move things along, add an extra employee here or there. If they weren't contributing too much we just let it go. Today it's to the point where you can't afford any of it. And it's hard to get business because there's so much competition."* The second generation of owners has to consider this increased competition when making decisions about the labor force. Company 3 on the other hand, while not a family-run business, emphasizes the importance of family members working together in the company, *"It makes us a small, entrepreneurial, family run business with a push of a big organization behind us. It makes us human. Christmas parties are more fun. We don't have kids working here but we have had families over the years, a husband and wife, a 45-year employee with her son who's been here 25 years. So yes, we have families."* Increased competition in the business is driving the streamlining of the workforce, and this raw economic factor outweighs most personal connections to workers. However, this case study was unable to document the exact pattern of hiring and firing practices conducted by each firm and had to rely on management's account.

Hypothesis 3*: Informal communication networks will be important for a variety of business management aspects for family run businesses.* ***Supported.***
Informal networks seem to be important for how the family firms in particular (Company 1 and 2) handle issues such as: environmental and safety procedures, supplier and customer relations, promotional, hiring and recruitment practices (and termination). Informal Networks are important for recruitment, hiring, and promotional practices inside all three firms. Recruitment practices in Company 1 and 2 are also based on more informal networks or "word of mouth" from current employees. This informal mechanism of bringing in new employees is another reason why many family members work together on the factory floor. By hiring in this manner, existing external social networks are transplanted into the workplace. Seniority and tenure in the workforce matters more, in terms of stored knowledge and experience in the workplace, than formal credentials. This reliance on experiential knowledge is evidenced by the promotional practices in all three companies where promotion to higher skill levels occur from within the company as opposed to bringing in new experts from the outside. For termination, Company 3 relies on a more formal process involving the corporate human resources department, while the first two companies rely more on informal processes for reviewing individual employee behavior and performance both for promotional and termination consideration.

Companies 1 and 2 describe an incremental approach to innovation in which they try a new idea for a little while and then determine whether it is viable to go on before making a large investment in a new product or process. This type of innovation also relies on informal information networks like trade journals and trade shows, relationships with machine manufacturers and customers and relationships with senior employees that are familiar enough with the business to develop new ideas. In Company 1 and 2, the owners were directly involved in the innovation process with no formal R&D staff in place. Company 3 on the other hand relied on corporate R&D support services for larger scale innovations in the production process. But Company 3 still developed many of its practical innovations on the factory floor with help from long term employees.

Company 3 seemed to rely on factory floor employees to improve safety measures in particular. The company set up a subcommittee and a suggestion box on the floor to encourage employees to bring their interests and innovation to bear on the issue of workplace safety. The manager of Company 3 emphasized the possible importance of employees' previous experiences or knowledge outside the firm to bring innovations and improvements to safety procedures in the workplace. The manager perceived this input from employees as a driving factor in the improvement of their safety record. Informal networks also seem to be important mechanisms for financing for the two family run businesses, Company 1 and 2. These two companies rely on long term banking relationships as their main source of financing and this relationship is based on trust in the reputation of the firm. The corporate firm, Company 3, relies on more formal mechanisms for financing through their corporate structure. Within this structure, Company 3 had to follow a formal process for justifying any new financing.

Formal networks are important for a variety of functions in all three companies although it is more prominent in Company 3. Company 3 is tied to a corporate parent that imposes a more formal structure on the firm than is evident in the first two single establishment firms. All three companies comply with federal and state environmental (EPA), Safety (OSHA) and labor standards. All three also seem to pursue environmental (recycling waste) and safety improvements according to an eco-efficiency principle in which the improvements are done independent of economic activity but the impact of the improvements are felt both in economic and environment and safety measures. While all three companies are compliant with some type of trade standards, Companies 1 and 2 are moving towards increased compliance with newer industry standards like ISO 9001 and 14001. Company 3 seems to have many of these certifications in place already, which again may be a reflection of more stringent corporate standards and more available resources to come up to compliance. All three companies describe the impacts of increased supply chain management schemes which put pressure on them to take on more of the risk. The three companies also have a flat organizational structure with manufacturing jobs representing the bulk of the employee base at the bottom of the hierarchy.

Hypothesis 4*: There will be high turnover in laborers because of low skill, low wage nature of work.* ***Not supported.***

The low level employees in the company are generally low wage earners with pay ranging from $6.25/hour to $8.50/hour. While this wage seems relatively low, compared with other low skill level jobs in the service sector, these manufacturing jobs represent better opportunities because of the accompanying benefits packages. Despite the low wages and the repetitive nature of the work, all three companies describe an extremely stable workforce with low turnover in all levels of workers. This low turnover may also be due in part to the opportunities for promotion within the company. The owner of Company 1 stated, "Everyone in our supervisory positions have been promoted from below, but she [an employee we met on the floor] was the first one to cross the picket line, so we have a special affection for her." Company 2's described promotions from lower levels, "There's a lot of that particularly with us. I think most molders are probably like that. You've got somebody who started second shift to stand by a machine, he shows a little bit of mechanical skill and interest in the job and we say well let's try him out here. If it works out well, it keeps on going. Right now our customer manager, which is probably one of the most important things we do here, he started out as an assistant foreman on second shift. He's a young guy who's going to school, he spoke good English which is important, showed a lot of energy and a lot of interest and moved up to assistant supervisor..." The manager for Company 3 also states, "We seek to grow people within the organization…we have various folks in our business who started in the plant."

Each interviewee recounted "success" stories of employees who started out in a very low level position like operator or packer and how they worked their way up the hierarchy through promotions due to good work habits, positive attitude and interest in moving up. The firms seem to reward good worker traits and reinforce this through internal promotions. The firms also did not put much emphasis on high levels of education or schooling but emphasized more the importance of experience and reliability. The Hispanic low-level workers are newer to the firms and are working their way up through the ranks. In Company 1 for example, the recent promotion of a Hispanic worker into a supervisory position is seen as a positive impact on lower level workers' morale because they feel closer to the upper ranks and they can aspire to also be promoted. This same worker was promoted because the owners of the company admired her loyalty to the company during a union strike when she crossed the picket line first. This illustrates how promotions are based on more than just efficiency or lines of command within the organization.

The interviewees described some overarching traits that are desirable for hourly, low skilled workers which include; manual dexterity and proficiency on the machines, reliability in attendance, quality of products and functions, willingness or interest to learn business, loyalty. For salaried or higher skilled workers, interviewees emphasized the level of commitment and interest in the business, accountability, reliability and positive attitude in the workplace. Free rider or shirking problems in the industries arose in one example from Company 2 when the interviewees described problems of accountability with employees. The company does not look favorably on employees who shirk responsibility for problems or mistakes on the factory floor. This shows that where there is a lack of accountability, shirking will occur and the human resources process weeds out people who tend to be unaccountable.

Outlook on the Injection Molding Industry

Company 3's business prospects for the future seem to be more secure than Company 1 and 2 due to their relationship with a larger parent corporation which provides them with greater flexibility, mobility and resources than the small family run companies. While Company 3 is small in terms of the number of employees at the facility, they can afford to be leaner (in terms of employees) because of the additional resources provided by the parent company. The drive of the plastics industry towards Asia seems to be easily accommodated by the parent company's relationship with other business units located in Asia. Both Company 1 and 2 experienced both a generational shift and a large market shift in their businesses in recent time. The plastics industry became increasingly competitive in the late 1990s while their fathers were transitioning the companies into the hands of their sons. This dual shift may account for a transition in both the business strategies employed by the firms to remain profitable and the social dynamics of the employee base. Traditionally, these family-run companies relied on long term, low skilled factory floor employees and repeat customers with little marketing or research and development efforts. Today, all three companies face increased competition from Asian companies that offer the same products but have much lower labor costs than US firms. This shift in the market has forced US firms to streamline their labor force and become increasingly automated to increase efficiency and reduce labor costs. The companies are also forced to find competitive advantages in their product marketing and innovation.

Company 1 in contrast to Company 2 is more optimistic about its future prospects in the business. This optimism is primarily due to Company 1's multifaceted strategy for surviving in the increasingly competitive market through streamlining, increased automation to reduce labor costs, horizontal integration via the acquisition of smaller operations and cornering a niche market in fire safety equipment along with a large multinational company contract. Company 2 has increasingly automated but is struggling to market their business and tap into new customer bases that they can keep long term. Company 3 is perhaps the most economically stable due to its connections to business units worldwide and their corporate resources.

One indicator for the strength of social networks in each company can be seen in the company sponsored social activities. Company 1 and 2 both experienced a decrease in the number of activities sponsored by the company at the same time that the dual generational and market shifts occurred. Interestingly, Company 3 seems to offer many more company sponsored social activities than the family run companies - suggesting that it's not just the familial nature of the company but rather the financial stability of the firm that matters a great deal in terms of supporting such social activities. Despite the drive towards automation, all three companies rely on a stable workforce characterized by low turnover and long term employees. The importance of these long-term employees in the workplace is reflected in the "totem pole" hierarchy or informal hierarchy that is established within the rank file between long term employees and new hires. According to this totem pole, long-term employees' rank overrides any professional credentials a newcomer brings to the workplace.

The entry-level employees in all three companies are comprised of mostly Hispanic and other non-English speaking people. The similar ethnic background of the entry-level employees and the internal promotion practices creates a very close knit employee base which may also have many connections outside the workplace. It is difficult to characterize the nature or extent of these social networks because this study did not interview or study these employees directly. Company 3's manager emphasized the importance of personal and social networks in improving the safety on the factory floor in particular. Social networks, social activities outside work and the presence of family members working on the floor were perceived as a benefit to the company in terms of improvements in safety along with more general improvement in morale and productivity. But unlike the other two companies, Company 3 did not have family members running the operation, only working as lower level employees.

The competition from China is putting increased pressure on all the firms to cut back low skilled operators. At the same time, the owners seem to value company loyalty as evidenced in their respect and admiration for long-term employees. It will be interesting to see how these two forces – increased drive to streamline the workforce and a close connection with the employee base will evolve over time.

Model-building activity

Researchers can productively induct theory from case studies that, like good computer programs, offer parsimony and logical coherence (Eisenhardt, 1989). This begs a question: why not express theory in the form of a computer program? Parsimony was a goal of the modeling effort, and logical coherence was a handy byproduct of the debugging process. The dual challenges with any type of modeling are to simplify reality appropriately and to communicate the results effectively (Andrews, 2002). Both challenges proved significant during the modeling process.

Multi-agent simulation

Object-oriented programming languages like Java make it possible to specify and replicate software agents relatively easily. These agents can be purposive and autonomous, and they can interact with one another and with an external environment. Multi-agent simulation modeling, so called, is an intellectual descendent of game theory, artificial life, and cellular automata, and it is gaining wide use as a social science research method (Epstein and Axtell, 1996). There is already some experience with applications to organizational behavior research (Carley and Prietula, 1998) and industrial ecology (Axtell et al, 2002).

Using the Brookings Institution's Ascape multi-agent simulation framework (Parker, 20000), a Java programmer created PolyModel, a simulation of operations at a plastic injection-molding firm. Approximately 100 employees interacted with the production technology and one another, subject to changes in the firm's external environment. The model included technology details, organizational structures, and parameter values taken from Company 1 in the case study. The model tested alternative theoretical constructs explaining the behavior of employees, to be roughly validated against the evidence from case study Companies 2 and 3.

The current model includes 22 classes of agents, related as follows.
PolyModel contains People, the Factory, and the External Environment.
The Factory includes a Warehouse, Production Lines, and a Shipping Department.
Employee extends Person.
Owner, Plant Manager, Marketer, Engineer, Shift Supervisor, Shipping Clerk, Materials Mixer, Maintenance Technician, Machine Operator, and Janitor all extend Job. Each Employee has a Job.
Remaining Java classes serve as computational infrastructure.

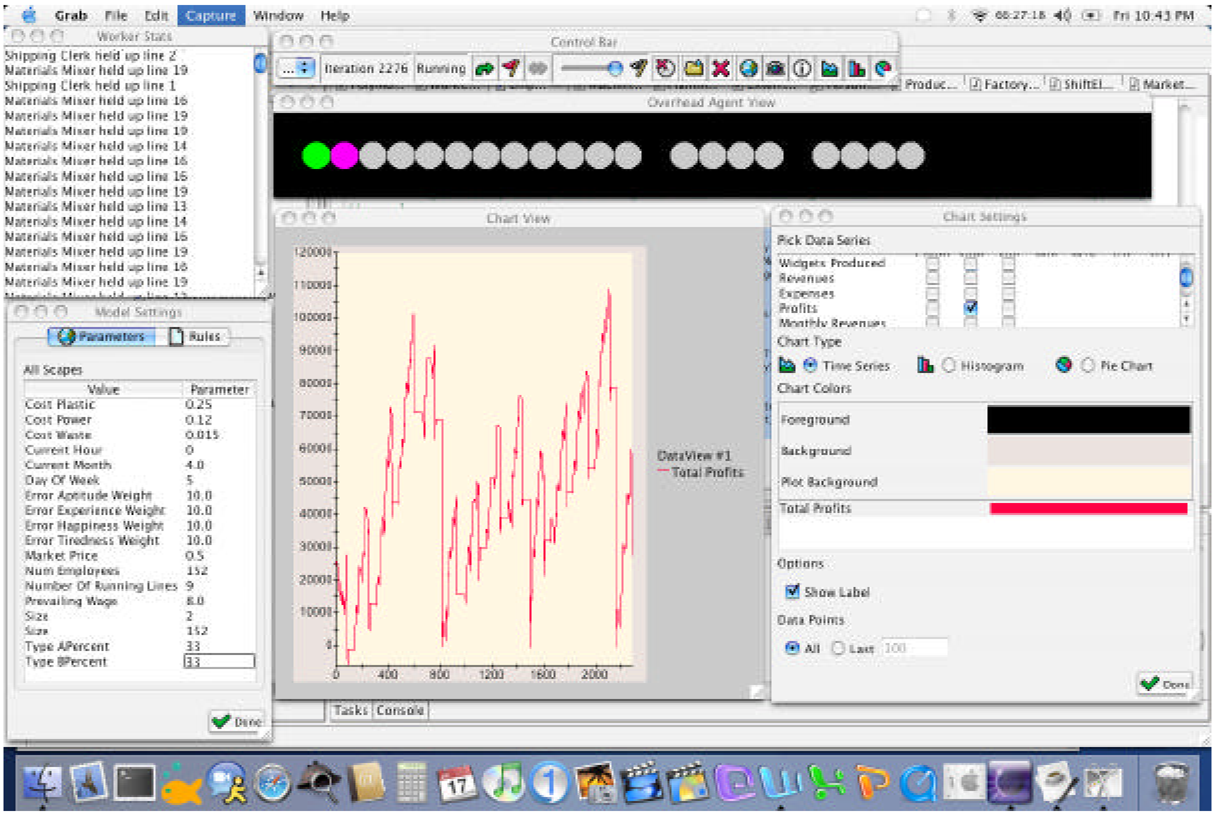
The time step in the model is hourly, so the firm cycles through the workday and the work week over a period of years. Each employee assesses whether to go to work every morning, based on health, social pressures, and finances. The plant manager determines how many production lines and associated employees are needed based on pending orders for widgets. The marketer brings in orders and tries to keep ahead of production so that the capacity factor of the plant is high. The janitor keeps the factory clean, and other employees become unhappy if the factory gets dirty. The materials mixer ensures that raw materials reach the production lines, and the shipping clerk packages completed products and sends them out the door. The maintenance technician keeps the production lines in working order. The machine operators perform several sequential duties (load plastic pellets, set molder temperature, separate widgets from scrap plastic). The shift supervisor encourages machine operators to work more carefully and reports on employee performance to the plant manager. All employees are subject to worker error that affects the quality of their performance, and the probability that error will occur is a function of aptitude, experience, tiredness, and happiness.

```
	}

	public double getWorkerError(){
		double aptFactor = ExternalEnvironment.getAptitudeWeight() * (100-
this.getAptitude()) / 100;
		double expFactor = ExternalEnvironment.getExperienceWeight() *
(65-this.getDaysWorking()/250)/65;
		double hapFactor = ExternalEnvironment.getHappinessWeight() *
(100-this.getHappiness())/100;
		double tirFactor = ExternalEnvironment.getTirednessWeight() *
this.getTiredness()/100;
		return aptFactor + expFactor + hapFactor + tirFactor;
	}
```

Happiness is a weighted additive function of wealth and social embeddedness. MoneyGrubbers like wealth (90, 10), SocialAnimals like their friends (10/90), and TheRestofUs are more balanced (50, 50). Wealth increases by getting paid at work, social embeddedness increases by making more friends at work and elsewhere. Friendship depends on affinity (similar intrinsic characteristics) and frequency of interaction.

As the screenshot below shows, the dynamics of these employee interactions provide realistic drama and aggregate up to firm-level performance measures of interest to management. Parameters are adjustable on the fly, and various diagnostic tools allow the user to investigate the causes of particular dynamic behaviors.

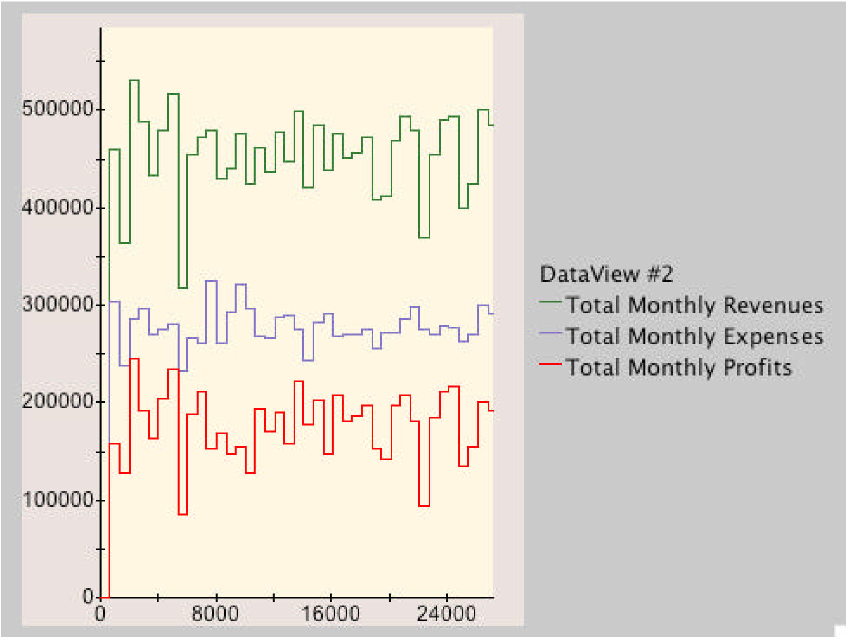


Developing the model required intense interaction between the programmer and the qualitative researchers. Much conversation centered on eliciting precisely what was the theory being formalized in the model. As the researchers played with the resulting simulations, the theoretical framework evolved.

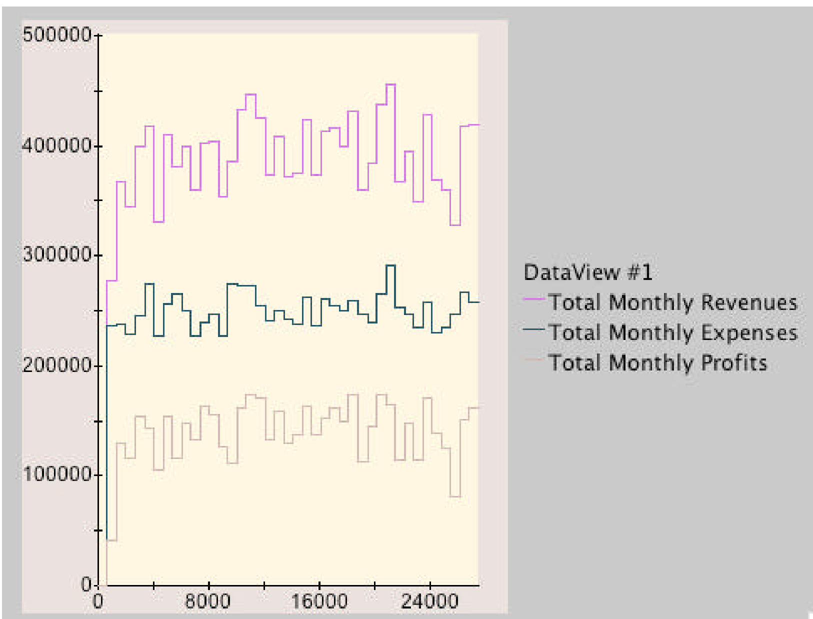
Illustrative Result—Bringing in Worker Error

This paper briefly shows one illustrative result. The project is ongoing and the model, underlying theories, and empirical evidence continue evolving. The model may eventually become robust enough to serve as a management-training simulator for the plastic injection molding industry.

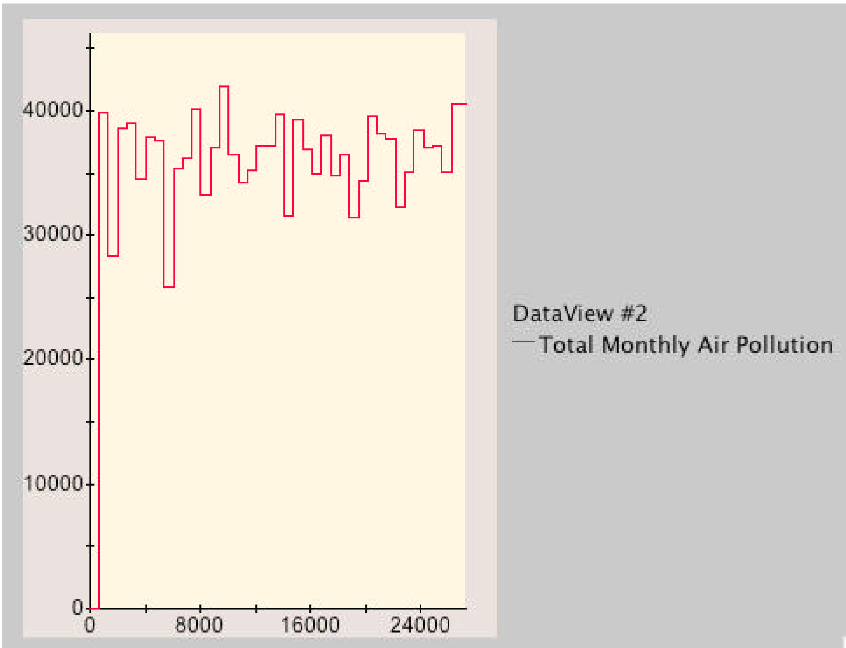
The frictionless neoclassical model of the firm typically assumes that every employee behaves like *homo economicus*, a rational, omniscient, selfish maximizer. Only principal-agent problems detract from corporate performance in that model. Our model allows us to turn worker error on and off, and thereby compare results under contrasting assumptions regarding that element of bounded rationality. As the following graphs show, a firm having imperfect (aka realistic) employees is less profitable and pollutes more. Policies to reduce worker error can now be tested *in silico*. More detailed theorizing about the determinants of worker error also becomes possible.



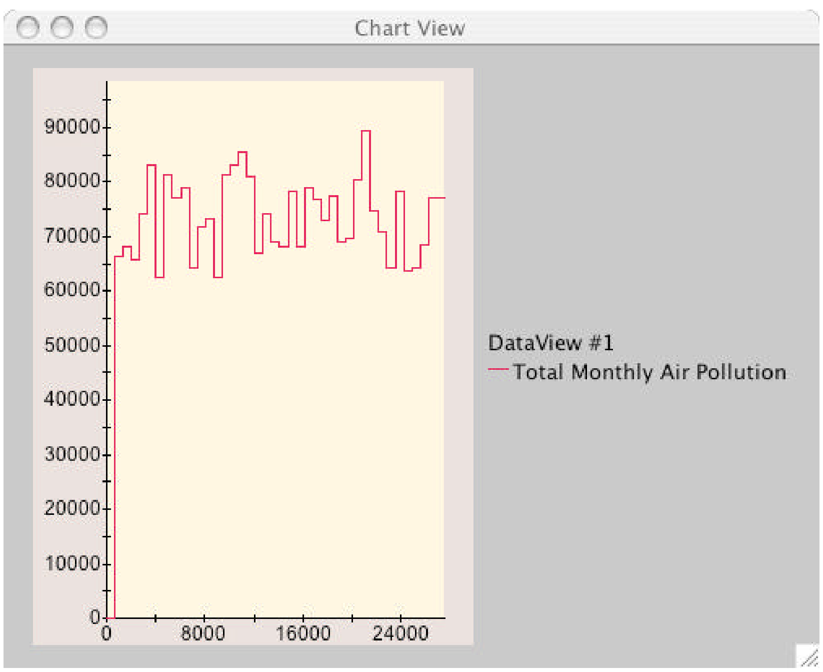
Homo economicus: Profits without worker error



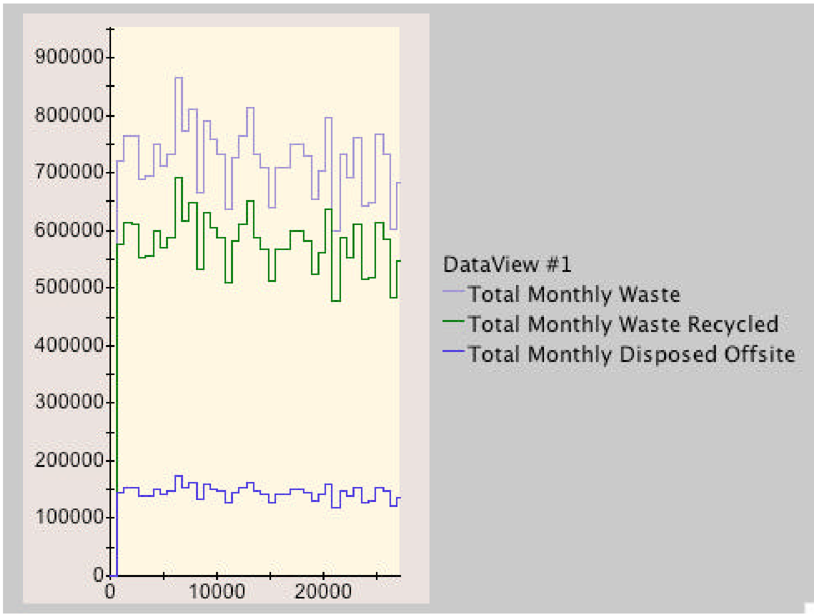
Realistic employee: Profits with worker error



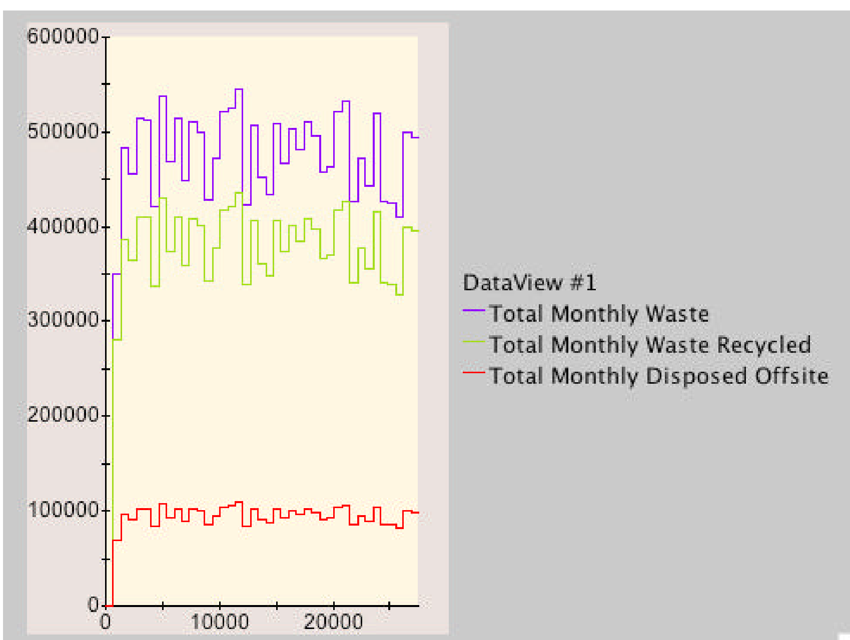
Homo economicus: Air pollution without worker error



Realistic employee: Air pollution with worker error



Theorizing worker error #1: Error = f(experience)



Theorizing worker error #2: Error = f(experience, aptitude, happiness, tiredness)

Conclusions

Theory building

Regarding the motivating question for this research—what are the relative roles of informal social networks and formal regulatory structures?—the modeling and case study evidence support three insights to date. First, informal networks are very important for hiring new employees and for helping employees to decide to take job actions like strikes and sick day protests. Second, formal structures are hugely important for explaining almost everything else. In this industry there also appears to be a substantial amount of technological determinism. In other words, the type and economics of the technology explain much of the firm's overall behavior.

Lessons learned

There are two major lessons learned for researchers interested in using multi-agent simulation models and case studies in a grounded theory-building context. First, this project shows that highly diverse skill sets are needed. In fact, it is unlikely that a single individual will have the requisite range of skills, necessitating recruitment of a multidisciplinary team consisting of an interviewer, case study developer, and Java programmer. Second, iterative modeling and interviewing is crucial because new questions arise, and alternative theories need to be explored and elaborated.

The benefit of developing multi-agent simulations in this inductive way is that they appear to inform action more directly than a deductively-based model built from principles rather than evidence might. It becomes a humbler but perhaps more valuable type of social science.

Case studies are informative but static research products. By taking the next step and constructing a simulation model, this research becomes more dynamic and iterative. It becomes easier to communicate theoretical expectations and to revise them. It potentially can help with *in silico* management training and strategy development so that fewer costly mistakes get made by firms and their regulators.

Future work

There are many valuable extensions of this work that deserve future attention. First, the establishment-level model should be extended to the case of the branch plant with a corporate parent. Then the modeling effort should expand vertically to include the supply chain, and horizontally to include sectoral competitors. It would also be interesting to adapt this modeling approach to industrial clusters and eco-industrial park tenants. In addition, much more needs to be done to explore the potential for socially responsible behavior to affect overall corporate performance. Other extensions suggested by the case studies include further investigation of the special characteristics of family owned companies, and of the value and measurement of employee loyalty.

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Do Facilities With Distant Headquarters Pollute More?: How civic Engagement Conditions the Environmental Performance of Absentee Managed Plants

Don Grant

University of Arizona

Social scientists have long speculated that factories with distant headquarters are a threat to communities and their physical environments. Over fifty years ago, when “war plants” were being created outside the nation’s industrial heartland, several researchers warned that absentee managed plants are the “puppets of big business” and will exploit the social and natural resources of their host communities. Today, as the winds of globalization and capital flight disperse still more facilities across the landscape, researchers continue to express concerns about the local impact of absentee managed plants. They worry that due to advances in transportation and communication technologies, more corporations than ever before will be able to externalize their pollution by setting up plants in far-flung, less regulated areas.

However, scholars have not analyzed the environmental performance of absentee managed plants. Nor have they explored how their tendency to pollute varies by the types of communities that harbor them. To begin to remedy this situation, I examine how the emissions of absentee managed plants are conditioned by their host communities.

This topic is an especially important one. Precisely because more companies can manage operations from afar, absentee managed plants are rapidly becoming the modal type of industrial organization. Hence, if they are an environmental threat, as some suggest, then a type of organizational virus is spreading throughout the eco-system that demands analysis. There is also a strong perception within the anti-globalization movement today that absentee managed plants pollute more than locally managed ones. Critics of globalization assume further, like Mills, that there is little communities themselves can do about this problem because their survival depends on attracting and accommodating footloose plants.

I contend that critics' logic is simplistic and overlooks the potential impact of local civic engagement on pollution outcomes. First, to suggest that communities are powerless to "outside predators" ignores how responsibility for protecting the environment from globalization and other forces has gradually devolved from the nation-state to the local level. A prime example of this development in the U.S. is the Emergency Planning and Community Right-to-Know Act. This act seeks to curb industrial pollution by requiring manufacturers to submit data on the toxins they emit. It also makes states responsible for developing right-to-know programs that disseminate this information to their citizens. The rationale behind this decentralized strategy is that manufacturers are more apt to voluntarily reduce their future emissions when confronted by an active and well-informed group of local citizens.

Critics also ignore recent studies on civil society that speak to the ability of communities to root organizations in place and control their behavior through informal means. This research suggests that while a community can do little to change the physical distance between itself and an absentee managed plant's headquarters, it can reduce the social distance between itself and the plant by incorporating the latter in a dense network of local organizations where citizens often meet and discuss community problems. Through their involvement in these organizations, absentee managed plants may come to identify with their host community and work to maintain its physical integrity.

In this paper, I seek to demonstrate that absentee managed plants emit fewer toxins when embedded in communities that are more civically engaged. At the same time, I argue that right-to-know proponents and civil society theorists espouse two different models of civic engagement. Hence, I compare the effects of the local institutions that they allege facilitate the civic engagement of pollution. Specifically, I contrast the effects of states' new right-to-know programs with those of more traditional institutions -- i.e., voluntary associations, churches, and so-called third places (i.e., barber shops, cafes, and other informal sites of public life).

Until recently, it was impossible to determine the environmental effects of absentee management or any other organizational form because there were no organizational data on pollution. However, using the Environmental Protection Agency's Toxics Release Inventory – the same data that facilities must submit under the Emergency Planning and Community Right-to-Know Act – (using these data) I am able to test for the first time the effects of absentee management on the emissions of chemical plants in the United States. I focus on the chemical industry because it is responsible for a disproportionate share of toxic releases. Also, as a result of plants continuing to migrate from the corporate centers of the Rustbelt region to Sunbelt states, and other plants owned by foreign firms moving to the U.S. to seize new investment opportunities, an unprecedented number of chemical plants in this country now have out-of-state headquarters.

To situate my study in its broader context, I next review competing perspectives on the environmental performance of absentee managed plants offered by proponents and critics of globalization (OVERHEAD). Proponents suggest that plants with remote headquarters often use more efficient and cleaner technologies than locally managed ones. They argue that as companies mature and develop standardized production processes, they decentralize their branches to periphery regions to capture the efficiencies of their best input-saving technologies. Proponents of globalization also contend that multi-locational firms typically have more uniform operating procedures and greater resources to invest in environmental initiatives. They suggest further that because environmental groups are eager to sue companies capable of paying large settlements, the satellite plants of major corporations are under intense pressure from their headquarters to manage their chemicals as effectively as possible and perhaps even overcomply with regulations.

In contrast, critics of globalization argue that firms are increasing their power by decentralizing production, a phenomenon Harrison describes as “concentration without centralization.” According to these scholars, firms often relocate plants to distant areas as a way to avoid regulation and externalize their pollution. They suggest, therefore, that absentee managed plants are among the dirtiest. Dependency researchers, for example, argue that the maquiladoras created in the free trade zones of northern Mexico and other parts of Latin America are especially poor environmental stewards. They predict that as international competition for jobs intensifies, developing countries will feel pressure to create additional “pollution havens” to attract plants. The same dynamic allegedly operates within the United States, where many chemical firms have tried to flee costly regulations and fend off foreign competition by relocating plants in the "better business climates" of southern and southwestern states. This strategy reinforces an already strong tendency among multi-locational businesses to stress the exchange value of natural places over their potential use values, i.e., to treat them as expendable commodities. Consistent with this reasoning, Davis (1992) finds that the owners of chemical companies with multiple out-of-state plants are significantly less willing to sacrifice production to meet environmental standards.

So, which group is right? FIGURES 1 and 2 provide a preliminary answer to this question. They report how the emission[1] levels of chemical plants with out-of-state[2] headquarters compare with the emission levels of other chemical plants in the year 2000 according to the Toxics Release Inventory. Since the TRI's inception in the mid-1980s, the number of industrial chemicals determined to be toxic and therefore tracked by the EPA has more than doubled from 319 to 667. Figure 1 compares the amount of toxins released by different plants using the EPA's original list of 319 or core chemicals. It shows that the average emission level of plants with out-of-state headquarters (4.2 million toxic pounds) is approximately 25% greater than the average emission level of other plants (3.4 million toxic pounds). Figure 2 shows that when we use the expanded or current list of toxins, the differences between the two plant types are even more pronounced. Absentee managed plants' average emission level (9.9 million toxic pounds) is roughly 57% more than that of other plants (6.3 million toxic pounds). Hence, there is empirical support for critics' claim that toxic emissions are concentrated in plants that are managed from afar.

Of course, it could be that absentee managed plants emit more toxins, on average, simply because they use more toxic chemicals. That is, firms may be emboldened to process larger quantities of dangerous chemicals when they can do so from a safe distance. Hence, when one takes into account the amount of toxins that plants have at their disposal, it may be that plants with distant headquarters are no more prone to pollute than other plants. Even so, the total amount of toxins emitted by plants is of paramount importance to local communities. Also, while communities may be unable to set formal limits on how many toxins a plant processes, communities can informally pressure a plant to minimize its toxic releases. Whether communities can reduce the emissions of plants with the *least* attachment to place – absentee managed ones – is the focus of this inquiry.

As suggested earlier, in assuming that communities are powerless to outside organizations, critics ignore recent legislation designed to empower local citizens as regulators. In particular, the Emergency Planning and Community Right-to-Know Act marks a significant departure from traditional regulatory policy. Instead of specifying the pollution reduction methods to be used by industry, which had been the practice under previous command-and-control approaches, this act seeks to reduce industrial pollution by disclosing information on manufacturers' pollution behavior. Specifically, it requires all states to establish a system of Emergency Planning Committees, which are to take data on the hazardous materials used by local manufacturers and make that information available to inquiring citizens. The assumption underlying this "regulation through information" approach is that local residents will be able to use pollution data to exert pressure on manufacturers to lower their emissions.

Critics also ignore recent research on civil society. This work suggests that businesses rarely operate in a social vacuum. Rather they are subject to demands from several other kinds of organizations, including their host communities. This research stresses the fact that communities have always possessed problem solving capacities and local institutions such as churches, associations, and "third places" have long served as forums for civic engagement. These institutions have thus helped to root actors to places and enhance the local quality of life.

While both literatures concur that civic engagement matters for the environment, they disagree over the mechanisms involved in the civic engagement of pollution and whether civic engagement is more relevant to some businesses than others. They also stress the importance of different local institutions for facilitating civic engagement and reducing industrial pollution. Indeed, I would argue that they subscribe to TWO DIFFERENT VERSIONS of the civic engagement thesis.

Proponents of the regulation through information approach subscribe to what might be called a strong version of the civic engagement model, which suggests that state-sponsored institutions like right-to-know programs enable citizens to voice their grievances and organize public protests against polluters. A strong model of civic engagement also assumes that because manufacturers in general tend to pollute, right-to-know programs should improve the environmental performance of plants regardless of their ownership status. Hence, it would predict that civic engagement in the form of state-sponsored right-to-know programs lowers the emissions of all plants.

In contrast, civil society scholars tend to subscribe to a qualified or weak version of the civic engagement model that emphasizes how local institutions function to coopt certain types of businesses. This model suggests that civic communities emerge out of local clusters of small, locally owned and managed establishments. While not denying that large corporations can and do operate in such communities, it contends that without a class of small business owners, the odds of establishing a civic community are considerably less. Thus, it argues there are two types of communities or local economies, those largely organized by corporate capitalism and those by community capitalism. Workers in the former tend to look outward to the global economy and their allegiance lies more with the firm than the community. Workers and residents of the latter look inward to the community since it is their primary source of support.

According to a qualified version of the civic engagement model, civic communities are best understood as "problem solving" places and the local institutions where citizens most often assemble and address community problems are voluntary associations, churches, and "third places". From this perspective, civic institutions provide not so much a format for venting grievances as they create venues for citizens to solve mutual problems like pollution. These problems can be resolved amicably or though direct confrontation. The point is that the more such problem solving places exist in a community, the better equipped a community will be to solve problems that face it.

It follows that the problem solving capacity of local communities has special importance for the environmental performance of absentee managed plants. Absentee managers have no motive to behave in a socially and environmentally responsible fashion and therefore will pollute if they can. Local managers would like to pollute but they do not feel they can because they have more personal and material ties to their host community and are integrated in its structures. Local institutions are important, then, because they smother absentee managed plants and their managers with social pressure to behave appropriately in the absence of strong local connections. Thus, they compensate for the lack of such ties. Hence, a weak version of the civic engagement model would predict that civic engagement in the form of associations, churches, and "third place" lowers the emissions of just absentee managed plants.

While the idea that civic engagement can protect communities from all or a subset of polluters is reassuring, SERIOUS DOUBTS nonetheless remain. First, arguments about the environmental benefits of civic engagement stand in dire need of empirical analysis. In the few cases where pollution outcomes have been examined at all, researchers have looked at emissions at highly aggregated levels of analysis (e.g., industry, state, nation). Consequently, it is still unknown whether states' right-to-know programs or the types of local institutions stressed by civic society theorists have any real effect on the environmental performance of individual plants. Nor has it been shown that such effects exist net of other plant characteristics that are thought to increase pollution.

Second, some argue that while there are demonstrated benefits of civic engagement for individuals (e.g., for finding jobs and avoiding crime), to suggest that civic engagement is also a property of communities borders on circular reasoning. They note a common tendency among researchers to examine positive outcomes, like low rates of crime, poverty, or pollution, and then infer the existence of civic engagement from the same outcomes.

Finally, research on civic engagement has been criticized for ignoring how factors like class and race may account for both civic engagement and its effects (Skocpol 1996, p. 25).

Our study seeks to address these concerns. First, we empirically model the impact of civic engagement on chemical plants' emissions. In the process, we address Portes's complaints about circularity by treating the factors that facilitate civic engagement as separate from their effects. It is probably true that civic engagement cannot be exactly measured at the community level. However, we are able to examine the relationship between pollution and what scholars claim are some of the institutions that facilitate civic engagement -- i.e., states' right-to-know programs, associations, churches, and "third places." Finally, we test these indicators of civic engagement alongside measures of race and class that may explain the former's impact.

DATA AND METHODS

To determine whether the emissions of all or just absentee managed plants are conditioned by civic engagement, a data set was constructed that incorporates measures of chemical plants' toxic releases and predictors of those releases. The unit of analysis for this study is the chemical plant and the data file consists of 1859 cases. Since it is at the site of production that industrial toxins are usually emitted, and absentee management is an attribute of individual plants, we focus on pollution outcomes at the plant level rather than the firm level.[4] We conduct a cross-sectional analysis of emissions in 2000 because the remoteness of a plant's headquarters is not likely to fluctuate much from one year to the next, nor is the civic engagement of a plant's surrounding community.[5] However, in other analyses not reported here, we looked at emission outcomes for 1990 and found the results to be virtually the identical.

As TABLE 1 indicates, our dependent variable is taken from the EPA's Toxics Release Inventory and is operationalized as the annual pounds of chemicals released on-site (weighted by their toxicity). Plants with high scores on this measure are those with high emission levels. To determine if the causes of emissions differ depending on whether one uses the EPA's original list of chemicals or its more recent, expanded one, we conduct separate analyses of each. Because toxic emissions are highly skewed, we transform the dependent variable when conducting our regression analyses by taking its natural logarithm.

One feature of the Toxics Release Inventory is that it lists for each plant a unique nine-digit identifier assigned by the Dun and Bradstreet Company. This number, in conjunction with the listed address of each plant, allows one to append to the TRI organizational data compiled by Dun and Bradstreet on each plant, including whether it is absentee managed.

Absentee managed plant is coded as a dummy variable (1=yes) and defined as any chemical facility whose headquarters is located out-of-state.[6]

Another key independent variable, *right-to-know funding*, is operationalized as the number of years since a plant's state first funded its right-to-know program under the Emergency Planning and Community Right-to-Know Act. Under this act, states are not provided any federal money to create their right-to-know programs. Hence, our measure is designed to distinguish states that have a real and long-term financial commitment to disseminating pollution information from those that run more nominal programs. Importantly, we do not claim that this variable measures actual citizen mobilization. Rather it is intended to capture the kind of local regulatory environment in which a chemical plant now operates that supposedly empowers citizens as regulators. According to the strong version of the civic engagement thesis, this variable should vary inversely with the emissions of all chemical plants.

To test the weak version of the civic engagement thesis, we interact our measure of absentee managed plant with three indicators of civic engagement institutions -- (log) number of associations, (log) number of churches, and (log) number of third places in a plant's county. While none of these three indicators directly measures the mechanisms said to be involved in the civic engagement of pollution, they do gauge the presence of institutions said to facilitate social connectedness and problem solving. Each of these three indicators is expected to have a negative statistical interaction with absentee managed plant or reduce just the latter's emissions.

Our models also control for several other industrial, political, demographic, and organizational factors that are summarized in Table 1 of your handout. We conduct analyses of the determinants of emissions using a random effects model available in LIMDEP.

FINDINGS

TABLE 2 examines the determinants of chemical plants' emissions using the EPA's original list of toxins or "core chemicals." Looking first at the controls in model 1, we see that log emissions are significantly lower when plants specialize in soaps/detergents. Conversely, log emissions are significantly higher when plants have more chemicals on-site and they and their parent firm are large. Contrary to what one might expect, the race and class characteristics of a plant's surrounding neighborhood are unrelated to the emission of core chemicals.[9]

Most importantly, we see that net of the various controls, absentee managed plant has no significant direct effect on log emissions. Other analyses not reported here revealed that the inclusion of log toxic chemicals on-site changed the effect of absentee managed plant from positive and significant to non-significant. This suggests that absentee managed plants have higher emission levels – as we saw earlier in Figure 1 – in large part because their potential for emissions is so much greater.

Findings from model 1, therefore, suggest that critics and supporters of globalization are both wrong -- absentee management per se has neither a harmful nor a beneficial impact on environmental performance. Still, communities have a special stake in minimizing the emissions of absentee managed plants precisely because the latter use such large quantities of chemicals.

This raises the question of whether certain types of communities are more successful than others at lowering the emissions of absentee managed plants or the emissions of all plants. Contrary to the expectations of the strong version of the civic engagement thesis, other results in model 1 indicate that local right-to-know programs have no direct bearing on the log emissions of all plants. Neither do log associations, log churches, and log third places. However, a qualified version of the civic engagement model suggests that the latter three factors may still condition the environmental performance of those plants with the weakest ties to communities -- absentee managed ones. In models 2 through 4, we explore this possibility by interacting absentee managed plant, respectively, with log associations, log churches, and log third places. Results indicate that the emissions of absentee managed plants are significantly lower when they are located in counties with more associations (model 2), churches (model 3), and third places (model 4).

In TABLE 3, we replicate our analysis of the determinants of emissions but this time using the EPA's more comprehensive list of toxic chemicals. In model 1, we see, as before, that plants have significantly lower emissions when they specialize in soap/detergents and higher emissions when they process more chemicals, are large, and their parent firm is large. Interestingly, when using the more recent, expanded list of chemicals, plants have significantly higher emissions when located in poorer neighborhoods. While one cannot generalize from this finding that poor neighborhoods are exposed to more absolute amounts of toxins, it does speak to how class influences the emissions of plants and the possibility that as more chemicals are added to the EPA's list of toxins, the environmental dangers faced by poor communities will become more obvious.

In model 1, we see once again that the effect of absentee managed plant is non-significant when controlling for other relevant factors, in particular the amount of toxins that a plant uses and stores on-site. The latter suggests that absentee managed plants release more toxins back in Figure 2 because they have more toxins at their disposal. Indeed, on average, absentee managed plants have on-site well over twice as many toxic chemicals than locally managed ones, 36 trillion toxic pounds compared to 14 trillion.

We also find support for the qualified, but not the strong, version of the civic engagement thesis. Right-to-know programs exert no significant, direct effect on the emissions of chemical plants, whereas the other three indicators of civic engagement have significant, negative interactions with absentee managed plant, suggesting again that they lower the emissions of plants with distant headquarters.

The negative sign of the interaction term in model 2 indicates that absentee managed plants have significantly lower emissions when nested in counties with numerous associations. In more substantive terms, as TABLE 4 shows, if there are no associations in a plant's county, the absentee management effect is .186 ($b_x + (b_{xy})Z$); if 10 associations, the effect is -.082; if 50 associations, the effect is -.271; and so on. This suggests that only a small number of associations needs to be in place before absentee managed plants begin to reduce their emissions. Table 4 provides similar statistics for the interaction effects of churches and third places.

Importantly, all of the interaction effects in Tables 2 and 3 hold after controlling for a variety of industrial, political, socio-demographic, and organizational factors that might explain them. That associations, churches, and third places each reduce the emissions of absentee managed plants speaks to how social connectedness in a variety of institutional forms benefits communities' physical environments. In sum, findings in both Tables 2 and 3 support the prediction of the weak version of the civic engagement model that absentee managed plants pollute less when embedded in civically engaged communities.[12]

Before leaving these results, let me note that we conducted several other analyses to determine whether states' right-to-know programs had any effect. We tested their interaction with absentee managed plant, we controlled for prior 1990 emissions to see if they affected changes in emissions, we looked at emissions in just 1990, we experimented with different measures of states' right-to-know programs, and so on. In every instance, results indicated that states' right-to-know programs have no significant direct or indirect bearing on the emissions of chemical plants net of other factors. This non-finding is an especially important one, because, as this FIGURE 3 indicates, if you were to just compare the average emissions of plants in states that have and have not funded their right-to-know programs in every year, you would be misled to believe that these programs actually make a difference.

CONCLUSION

To conclude, our findings are by no means the definitive word on absentee management and its interaction with community structures. Our analysis, for example, says nothing about the economic/environmental tradeoffs local communities sometimes make when deciding whether to recruit absentee managed plants. We have only considered absentee management as it manifests itself within the United States and therefore cannot say how absentee managed chemical plants might impact the environment in less developed nations.

As mentioned earlier, we also do not directly test the mechanisms involved in the civic engagement of pollution. It could be that local institutions decrease the emissions of absentee managed plants because they instill in them a greater sense of *loyalty* to their social and physical surroundings. It may be that these institutions give citizens more opportunity to *voice* their grievances. Or absentee managed plants with high emission levels may tend to *exit* or avoid civically engaged communities.[14] Until more detailed data become available, we have no way of determining which of these possibilities is more true.

These caveats notwithstanding, our study makes several SIGNIFICANT CONTRIBUTIONS.

First, in identifying which types of plants are most likely to pollute and under what conditions, our results are of great practical value in that they should help inspectors, state emergency response commissions, and the Chemical Manufacturers Association decide *where* to allocate their resources.

Second, our findings cast doubt on the efficacy of environmental federalism and states' right-to-know programs in particular. The fact that the latter have no effect on emissions in one of the dirtiest industrial sectors – chemicals – is striking and raises the question "Is the more decentralized regulatory environment in which polluters now operate real or illusory?"

Third, and on a more positive note, results suggest that although today's global economy is dominated by mobile employers, industry rarely is all-powerful and community-based forms of regulation are still viable. Communities possess problem solving capacities that can be activated to limit the destruction caused by businesses, especially those with the least attachment to place. However, the kinds of local institutions that facilitate the civic engagement of pollution may not be the ones that policymakers expect.

Fourth, our study suggests how organizational research might be advanced. It has become fashionable for organizational scholars to use biomaterial metaphors like embeddedness to describe and bound organizational properties. Yet, these terms say precious little about how such properties, in turn, influence real biomaterial outcomes. By following our lead and studying the environmental damage caused by nested organizational structures, researchers may discover the ecological significance of concepts like embeddedness and what makes an organization truly sustainable.

Finally, our empirical analysis greatly improves on past environmental studies that merely speculate about the pollution effects of absentee management and other organizational factors. By combining EPA data on facilities' emissions with information on their characteristics and those of their host communities, we have pioneered, I believe, an exciting possibility for secondary research. Our study also underscores the need to study organizations where they most immediately impact the environment – the plant level.

There are no doubt other organizational forms besides absentee management that influence plants' environmental performance. Indeed, the study presented here is but one part of a larger project funded by the EPA that investigates the pollution effects of several organizational forms. For instance, another organizational factor that we examined and discovered increases emissions is whether a plant is a subsidiary. This is an important finding because it speaks to the possibility that in allowing parent companies to create a "liability firewall" between themselves and their branches by reclassifying the latter as subsidiaries, the 1986 Tax Reform Act may have inadvertently encouraged parent firms to shift their most environmentally dangerous production activities into subsidiaries.

So, there are other organizational forms that might be studied. Likewise, the pollution outcomes studied here are not the only ones that can now be examined at the plant level. In future research, I plan to examine the organizational and communal determinants of plants' emissions using the EPA's newly released Risk-Screening Environmental Indicators or RSEI. Unlike the pollution data used in this study that gauge simply the pounds of toxins released by plants and their relative toxicity, RSEI data also take into account the degree to which people are potentially exposed to chemicals and the estimated size of the exposed population. RSEI data thus provide much more accurate measures of the potential risk-related impact of facilities on chronic human health. Using these new data, I plan to investigate the possibility that right-to-know programs may still reduce the most serious health-related emissions. I also plan to address an important but underresearched question in the environmental justice literature, which is What is it about the organization of hazardous facilities that explains why some pose a greater health threat in poor, minority neighborhoods than others? In short, we're entering a new phase of environmental and organizational research when several key empirical issues can finally be addressed.

that seeks to explain why some plants pollute more than others. For instance, another organizational factor that we examined and discovered increases emissions is whether a plant is a subsidiary. This is an important finding because it speaks to the possibility that in allowing parent companies to create a "liability firewall" between themselves and their branches by reclassifying the latter as subsidiaries, the 1986 Tax Reform Act may have inadvertently encouraged parent firms to shift their most environmentally dangerous production activities into subsidiaries. We have also begun examining whether chemical plants with the weakest local ties – those owned by foreign companies – pollute more.

Finally, I hope

In future research I plan to gain further insight into the determinants of facility-level emissions using the EPA's newly released Risk-Screening Environmental Indicators. Unlike the pollution measures used in this study and others that gauge simply the pounds of toxins released by facilities and their relative toxicity, RSEI data also take into account the degree to which people are potentially exposed to chemicals and estimated size of the exposed population. Thus, RSEI data provide much more accurate measures of the potential risk-related impact of facilities on chronic human health. Using these new data, one can address an important but grossly underresearched question in the environmental justice literature, which is What is it about the organizational features of hazardous facilities in disadvantaged neighborhoods that explains why some endanger human lives more than others. In short, we're entering a new phase of environmental and organizational research when these and other issues can finally be examined empirically. I'll stop on that forward looking point.

Of course, the big issue is whether certain kinds of plants pose a greater health risk. The measure of pollution used in this study only gauges the pounds of toxins released by a facility and their relative toxicity. Fortunately, the EPA's newly released Risk-Screening Environmental Indicators allows one to do this and more – i.e., it also takes into account the degree to which people are potentially exposed to chemicals and the estimated size of the exposed population. Using these data, I plan in future work to address a key yet underresearched question in the environmental justice literature, which is what

What is it about the organizational features of hazardous facilities that explains why some in the same disadvantaged neighborhood

pose a greater health risk to disadvantaged neigh

in disadvantaged neighborhoods that explains why some endanger human lives more than others.

Also, depending on how many of these institutions are present, a community may or may be able to curb the emissions of plants with the weakest local ties.

Fourth,

First, its empirical analysis greatly improves on past studies by environmental and organizational sociologists that merely <u>speculate</u> about the pollution effects of absentee management. By combining EPA data on facilities' emissions with information on their host communities, we have empirically demonstrated for the first time that the spatial properties of plants have important environmental consequences and the local conditions under which this is especially true. Our study should also sensitize researchers to the need to study organizations where they most immediately impact the environment – the facility level.

Second, our findings inform work on globalization and the spatialization of capital. Prior research has noted how capital mobility can create new forms of locational concentration (Sassen 1991) or "sticky spaces in slippery space" (Markusen 1996). Our study compliments these studies by suggesting how local institutions help root absentee managed facilities in place and minimize their environmental destruction. Likewise, our research resonates with recent theorizing about the spatialization of the U.S. economy (Grant 1994; Brady and Wallace 2000) and the "spatial decentralization" of production (Romo and Schwartz 1995). But whereas this body of work stresses how footloose employers have severed their postwar accord with workers and citizens, our study suggests that a new accord may be possible that is grounded in social capital. This does not imply that a move toward a less capable and involved national government is required for civic engagement to thrive, as conservatives have suggested. Nor does it mean that translocal agents (e.g., NGOs, social movements, political parties) will not play a role in creating livable places (see Evans 1997; Putnam 1993, p. 176). Rather, our results suggest that in the present global period, viable compromises between employers and workers/citizens might still be constructed at the local level. In light of the recent concerns raised about the relevance and efficacy of civic engagement (Portes 1998; Skocpol 1996, p. 25), this is promising news for communities within the U.S.

Finally, and perhaps most importantly, our study demonstrates that if scholars are to study the impact organizations have on the environment (Perrow 1997), they must consider not simply the characteristics of businesses but those of other organizations with which businesses interact. As research on structural embeddedness and civil society suggests, communities are also strong organizations and how they cultivate the problem solving capacity of their citizens can strongly influence the behavior of external organizations like absentee managed plants. While our study cannot say whether more amicable or contentious strategies work best with absentee managers, it speaks to the more fundamental point that communities function as problem solving places. Indeed, although today's global economy is dominated by mobile employers, industry rarely is all-powerful. Communities possess organizational resources that can be activated to limit the destruction caused by businesses, including those with the least attachment to place.

NOTES

[1] Emissions, which are reported in pounds by the EPA, are weighted here by their toxicity (see Grant, Jones, and Bergesen 2002 for details on toxicity weights).

[2] In the context of this study, "out-of-state" is not meant as an indicator of globalization, but absentee management.

[3] Unlike many other pollutants, which are subject to strict safety standards, the Environmental Protection Agency only requires manufacturers to report their toxic releases, leaving it up to local communities to act on that information as they see fit.

[4] Examining emissions at the firm level would also introduce several complications, since firms may own plants in several industries with very different eco-organizational properties.

[5] We explored the possibility of examining changes in emissions between 1990 and 2000, but several factors discouraged us from doing so. In particular, because of changes in reporting requirements and the fact that hundreds of new toxins have been added to the TRI list of chemicals since 1990, the facilities included in the 1990 and 2000 Toxics Release Inventory are often not the same. Indeed, a plant that processes the same chemical and in the same amount in these two years, may be required to report information on emissions for just one of these years. Importantly, we did replicate our 2000 analysis with 1990 data using the core list of chemicals and found the results to be basically the same. Hence, although the chemical plants included in the 1990 and 2000 Toxics Release Inventory may differ, the pattern of relationships between emissions and other factors appear robust across the two time points.

[6] Grant et al.'s (2002) analysis of 1990 data tested the effect of branch plants in general and therefore did not isolate the pollution behavior of branches with out-of-state headquarters. By distinguishing absentee managed plants from others, we are able to test the thesis advanced by critics of globalization and capital migration that the *spatial* characteristics of plants have important environmental consequences.

[7] A related study examines the emission rates of foreign owned plants in the United States (Grant and Jones forthcoming). It, however, focuses on a small subset of all absentee managed plants and with 1990 data that excludes roughly half of the industrial toxins now tracked by the EPA. Nor does it address the key question of this paper, which is whether the environmental performance of absentee managed plants varies by the local civic cultures in which they are embedded. Hence, it examines the effects of absentee management in a very preliminary fashion.

[8] The sources of these indicators are the Encyclopedia of Associations 2000 (Gale Research Corp. 2000), Census of Churches (Association of Statisticians of American Religious Bodies 2002), and the County Business Patterns (U.S. Bureau of the Census 2002).

[9] We also considered the possibility that past environmental fines might influence emissions but discovered that because less than .005% of plants had ever been penalized, this factor could not be included in our models without creating severe problems of multi-collinearity.

[10] In substantive terms, findings suggest that if there are no churches in a plant's county, the absentee effect is .467 ($b_x + (b_{xy})Z$); if 10 churches, the effect is .115; if 50 churches, the effect is -.131; if 100 churches, the effect is -.238; and if 1000 churches, the absentee effect is -.590 (the sample range for churches is 2 to 4044). Results indicate that if there are no third places in a plant's county, the absentee effect is .307 ($b_x + (b_{xy})Z$); if 10 third places, the effect is .049; if 50 third places, the effect is -.130; if 100 third places, the effect is -.209; and if 1000 third places, the absentee effect is -.467 (the sample range for third places is 0 to 12773).

[11] Importantly, Tolbert et al. (1998) suggest that their indicators of civic engagement probably underestimate the importance of local institutions that are older and have especially deep roots in community.

[12] We experimented with other specifications of the dependent variable such as expressing emissions as a fraction of all chemicals on-site (log(emissions/chemicals on-site) and discovered that the results mirrored those for log emissions.

[13] For example, if one were to estimate simultaneously the determinants of emissions, the siting of absentee-owned plants, and housing segregation (Hefland and Peyton 1999; see also Downey 2003), it might be found that race and ethnicity are significant predictors of emissions. However, the type of longitudinal data needed for such a simultaneous equation are unavailable or limited.

[14] Although, to our knowledge, nowhere in the literature on industrial location has it been suggested or shown that civic engagement actually influences the siting of chemical facilities.

Everyone is remarkably well preserved. You look just the way I remember you. And it's equally great to meet others who been hired since and helped to take the dept., in many respects, to a new level of excellence
questions: 1) Do absentee owned plants or plants with distant headquarters emit more toxins than local managed ones? and 2)

My funded project seeks to address two basic questions: 1) how does the ownership status of a regulated facility affects its environmental performance?, 2) what the implications of this for the effectiveness of community-based forms of regulation? Today, I will be talking about a portion of this larger project that looks at absentee owned plants and how their environmental performance is conditioned by right-to-know programs, and other types of local civic engagement.

There are few human-made environmental problems that are not caused by or through organizations (Perrow 1997; Clarke 1989). While individuals' lifestyles, consumption habits, and so on contribute to environmental degradation (York, Rosa, and Dietz 2003), many, if not most, pollutants are emitted at the site of production or have their source in industrial organizations. And yet sociologists have rarely examined the impact that different organizational forms have on pollution

Today, I will be talking about a portion of a larger project funded by the EPA that examines how the ownership status of a facility affects its environmental performance and the implications this has for community-based forms of regulation. Specifically, I will address two questions: 1) Do absentee owned plants or those with distant headquarters pollute more? and 2) What effect, if any, do right-to-know programs and other local channels of civic engagement have on these plants' emissions?

This is true in developing countries where pollution is often unregulated by national governments and local communities must therefore negotiate environmental standards with manufacturers (Hartman, Huq, and Wheeler 1997). It is true as well in developed countries where command-and-control approaches to regulating industrial toxins have been slowly replaced by strategies that rely on the participation of local citizens (Ringquist 1995).

Actually, my talk today is essentially the same one I gave just 3 days ago in D.C. at the EPA's Conference on .

We also show that states' new right-to-know programs have no effect on the emissions of absentee managed plants. Rather their environmental performance depends on the presence of other local institutions that have traditionally facilitated civic engagement, namely churches, voluntary associations, and so-called third places.

[The study I will present today is part of a larger research project funded by the Environmental Protection Agency on the organizational determinants of pollution and effectiveness of community-based forms of regulations. Specifically, my talk addresses two questions: 1) Do plants with distant headquarters pollute more? and 2) Can civically engaged communities do anything about it? Is the environmental performance of these absentee owned plants conditioned by the civic engagement of their host communities?

Social scientists have long speculated that]

The study I will present today is part of a larger research project funded by the Environmental Protection Agency on the organizational determinants of pollution and effectiveness of community-based forms of regulations. Specifically, my talk addresses two questions: 1) Do plants with distant headquarters pollute more? and 2) How is the environmental performance of these absentee owned plants conditioned by the civic engagement of their host communities?

In addition, there is a substantial body of empirical research that suggests absentee managed plants influence social outcomes, including poverty, infant mortality, industrial conflict, and underdevelopment. Whether absentee managed plants also impact environmental outcomes has yet to be determined.

***use later I report findings using the 2000 edition of the Toxic Release Inventory both because it is the most current and it covers more than twice as many industrial toxins than earlier editions. We focus on the U.S. for reasons of data availability and because the spatial restructuring of production has been especially great in this country during the global era. As a result of factories migrating from the corporate centers of the Rustbelt region to the "better business climates" of the Sunbelt states in response to global competition and other plants operated by foreign firms moving to the U.S. to seize new investment opportunities, an unprecedented number of plants in the U.S. are now absentee managed.

***

We study the effects of absentee management at the facility (as opposed to firm) level because industrial toxins are emitted at specific production sites and the environmental performance of individual facilities is of more immediate concern to local communities.

*** In conclusion where I discuss practical relevance, mention World Bank

**Write long version for OSU, then whittle it down for EPA (*where EPA talk begins, etc.)
In conclusion, note that this study was part of a larger project funded by EPA (I also examined other organizational forms)

** If this sounds like a talk you might give to policymakers, that is because it is.

** in other analyses, we examined whether plants with the most distant headquarters pollute more, but found that not to be the case.

Particularly relevant to our study, scholars at the World Bank have begun exploring how civic engagement affects the emissions of individual facilities (Hartman, Huq, and Wheeler 1997; Pargul and Wheeler 1995; Pargal, Hettige, Singh, and Wheeler 2002). They contend that in developing countries, where formal regulation (e.g., uniform air quality standards, mandated pollution technologies) tends to be weak or non-existent, informal regulation exercised by communities (e.g. public appeals, protests) may strongly influence corporate environmental performance. They speculate that civic engagement may also influence certain types of corporate pollution in the U.S. that are largely unregulated, such as toxins released by manufacturers.[3]

In short, a growing body of research suggests that communities can improve the environmental performance of manufacturing plants by reducing the social distance between themselves and plants. According to this work, unless plants develop social ties to their host communities, they are unlikely to participate in public conversations about local environmental priorities. However, where there are numerous institutional settings that allow residents and plant managers to meet and develop a common appreciation of place, plants are more likely to participate in public conversations about the environment and curb their emissions.

It may also be that because pollution data are self-reported, the EPA needs to use better quality control measures. If more intentional and unintentional mistakes made in submitting information are caught and corrected, the effectiveness of right-to-know programs might be more apparent. There is also the possibility that existing pollution data are basically sound but how they are processed and interpreted by intermediaries, such as interest groups, varies widely. Along these lines, other studies report that the goals of regional environmental groups and local citizens often conflict.

As I explained to EPA officials and other policymakers at a conference in D.C. just three days ago, it might still be the case that states' right-to-know programs work in other sectors of the economy than the one studied here. Nonetheless, the fact that such programs cannot explain emission decreases in one of the dirtiest sectors – the chemical industry – is striking. It begs the question of what might explain recent reductions in emissions if not states' right-to-know policies? It could be, as some industry spokespersons suggest, that most of these improvements were the result of businesses themselves taking the initiative in devising environmental solutions. However, empirical support for this claim is thin and limited to qualitative studies of a small, select set of chemical companies (Baram et al. 1990). Another possibility is that changes in emissions are due to the efforts of national actors – e.g., the news media and organizations like Environmental Defense (see U.S. Environmental Protection Agency 2003). Previous research has shown, for example, that when national news media report the emissions of major companies, it can cause the value of their stocks to drop (Hamilton 1995). Whether companies respond to stock market declines by improving their environmental performance, though, has still to be determined. These and other possibilities need to be examined more systematically to determine whether the more decentralized regulatory environment in which polluters now operate is real or illusory.

findings suggest that community-based forms of regulation may still be viable in an age of globalization.

though the local institutions that facilitate the civic engagement of pollution may not be the ones policymakers expect. Nor do they influence the emissions of all plants.

Fourth, our study demonstrates that if scholars are to study the impact organizations have on the environment (Perrow 1997), they must consider not simply the characteristics of businesses but those of other organizations with which businesses interact. As research on structural embeddedness and civil society suggests, communities are also strong organizations and how they cultivate the problem solving capacity of their citizens can strongly influence the behavior of external organizations like absentee managed plants. While our study cannot say whether more amicable or contentious strategies work best with absentee managers, it speaks to the more fundamental point that communities function as problem solving places. Indeed, although today's global economy is dominated by mobile employers, industry rarely is all-powerful. Communities possess organizational resources that can be activated to limit the destruction caused by businesses, including those with the least attachment to place.

There is evidence consistent with each of these arguments. On the one hand, several studies document the success of states' right-to-know programs in educating their citizens and providing them with technical know-how needed to interpret and act on complicated pollution information. Others show that, on average, total emissions tend to be lower in states with more aggressive right-to-know programs. And the EPA reports that, for the nation as a whole, total pounds of on-site emissions have decreased by 56.6% since the Emergency Planning and Community Right-to-Know Act was passed (U.S. Environmental Protection Agency 2002).

On the other hand, several studies document how residents and business leaders become integrated in communities through their participation in volunteer associations, churches, and third places and how such civic engagement translates into lower rates of unemployment, poverty, and crime. Others studies suggest that these effects are especially strong in communities with many absentee managed businesses. And still others have demonstrated how corporate leaders, especially managers of satellite plants, can be persuaded to contribute to local environmental projects through their involvement in local religious and voluntary organizations.

Our goal in this paper was to advance our understanding of the environmental degradation caused by different organizational forms. Toward that end, we analyzed the effects of absentee management on chemical plants' environmental performance using the EPA's 2000 Toxics Release Inventory. Findings confirm the suspicion of critics of globalization that absentee managed plants emit greater amounts of toxins. However, results also indicate this is largely because absentee managed plants process substantially more chemicals. In fact, when we take into account the amount of chemicals that plants have on-site and other factors that influence facilities' emissions, we discover that the environmental performance of absentee managed plants is no worse than that of other plants. Whether plants with distant headquarters emit more chemicals largely depends on the presence of local institutions that facilitate civic engagement. Specifically, when embedded in communities with more associations, churches, and third places, absentee managed plants emit significantly fewer toxins.

Compliance and Beyond: Strategic Government-Industry Interactions in Environmental Policy and Performance – The Role of Technical Information in Reducing Automobile Emissions

Jennie C. Stephens and Edward A. Parson

Paper presented at the EPA Corporate Environmental Behavior Research Workshop, April 26-27, 2004

1. Introduction

Technical knowledge and associated uncertainty in technical feasibility play a critical role in government industry interactions during the development and implementation of environmental policy and regulation. Improvements in environmental performance are dependent on making technical changes to an industry's processes or products. While government takes actions to promote environmentally beneficial technological change to reduce industry's environmental impact, those targeted industries are generally reluctant to make technical changes unless they perceive an associated competitive advantage. Within this government-industry relationship characterized by this conflicting basic interest, technical information and its associated uncertainty are often integral to strategic interactive behavior. Firms identified as potential targets of regulation, either acting individually or cooperatively through industry associations, often use technical information as they seek to oppose, influence, or delay (and occasionally promote) environmental regulations. Governments seeking to formulate, enact and implement socially beneficial environmental policies must attempt to understand technological details and feasibility of technical alternatives although they often have limited independent information.

The design and implementation of government regulation to encourage technological change for environmental improvement involves a dynamic process whereby regulators and industry representatives interact and respond to each other (Yao 1988). While much of the literature examining the influence of government regulation on technology development provides useful insights on relative effectiveness of different regulatory mechanisms on innovative behavior (Kagan 1977; Ashford 1993; Kemp 1997; Jaffe, Newell et al. 2000; Taylor, Rubin et al. 2003), the complexities of industry-government interactions surrounding uncertainty associated with technological feasibility are often omitted at this scale of analysis. Recognizing the critical role that perceptions of technical feasibility of new technologies plays in both industry's attempts to influence government decisions and government's attempts to influence industry's decisions, this research focuses on the detailed interactions related to knowledge, uncertainty and technical details.

This paper explores the role of technical information in government-industry interactions in the fifty-year history of efforts to reduce automobile emissions. By simultaneously focusing on the strategic behavior of both the automobile manufacturing industry and the U.S. government, we are working toward identifying resultant characteristic patterns of outcomes that arise from the interactions. This case is one of six case studies, chosen to represent diversity in the targeted industry, government programs, historical time, pollutants and geographic relevance, that will be included in the final product of this research effort, a forthcoming book edited by Parsons and Stephens. The other five case studies included in this book explore strategic interactions between government and industry with respect to technical information during efforts to reduce: 1) dioxin in the pulp and paper industry, 2) perfluorocarbons in the aluminum manufacturing industry, 3) chlorofluorocarbons in the chemical industry, 4) methyl bromide in the agricultural strawberry and tomato industry, and 5) workplace exposure to vinyl chloride in the vinyl chloride industry.

This paper will first describe the historical details associated with government-industry interactions during each of the three time periods. A discussion of the unproductive cycle of mistrust that has developed over the years between the government and the industry is followed by discussions on the implications of cooperation versus competition within an industry and the critical role of third parties, and finally some concluding recommendations for policymakers that can be drawn from this case.

2. Three distinct Time Periods of Government-Industry Interaction

The history of the government's attempts to encourage the U.S. automobile manufacturers' to develop and implement technologies to reduce automobile emissions provides a particularly interesting perspective to improve understanding of government-industry interactions regarding technological information exchange because the history can be divided into three time periods with distinctly different industry-government relationships defining strategies of interaction (Figure 1). During the earliest period, before 1970, the federal government had minimal influence over the industry, and the industry resisted technological change primarily through an industry-wide cooperative agreement that removed competitive incentive to develop or implement pollution control technologies. During an intermediate period, after the passage of the unprecedented technology-forcing 1970 Clean Air Act Amendment (CAAA), competitive incentive among individual firms was restored and the industry was forced by the government to develop technology to meet specific emission standards in a predetermined (but subsequently and repeatedly extended) amount of time. During the most recent time period, from the debate preceding the 1990 CAAA until now, a more complex and less intense industry-government relationship has developed as many more actors have become involved in the more complicated technical and regulatory details. While industry resistance to technological change is clearly evident in all three time-periods, the industry strategies associated with this resistance have co-evolved with the changing regulatory framework and the changing industry-government relationship.

This paper reviews the empirical history and then highlights the most interesting observations about government-industry interactions within this history, while the full chronological details of government-industry interactions during these three time periods are described in more details elsewhere (Stephens 2004; Parson and Stephens Forthcoming).

2.1 The Early Years: Minimal Government Involvement, 1955-1970

When the automobile was first implicated as a major contributor to the urban air pollution problem in the early 1950s (Haagen-Smit 1952), the U.S. automobile manufacturers responded by creating an industry-wide, cooperative agreement which eliminated competition among individual firms to develop pollution control technology. This cooperative approach also severely restricted third party inventions through a cross-licensing agreement that specified royalty-free exchange of patents and a formula for sharing the costs of acquiring patents developed outside the industry; by removing incentive for industry consideration of third party inventions, the industry eliminated any potential market for third party innovators. Individual firms signed on to this cooperative agreement because it minimized the risk to them that another firm would gain competitive advantage by being the first to develop commercially viable pollution control technology (DOJ 1971). The following excerpt from the minutes of an April 1955 meeting of the patent Committee of the industry trade group, the Automobile Manufacturers Association (AMA) explains this strategy.

> *"No one company should be in a position to capitalize upon or obtain competitive advantage over the other companies in the industry as a result of its solution to this problem."* (DOJ 1971)

Despite the industry's public declaration that their cooperative program was designed to accelerate technical developments in emissions reduction, the opposite effect, to slow-down technical progress, has been identified as the intended result of the program by evidence collected during a grand jury investigation assessing antitrust collusion allegations against the industry in the late 1960s (DOJ 1971). Following this investigation, an antitrust civil suit alleging 16 years of industry conspiracy to prevent development of pollution control technology was issued; the case was settled by consent decree in which the industry did not admit to any illegal activity but did agree to a series of restrictions prohibiting the exchange of restricted technical information, prohibiting the issuing of joint announcements, and requiring open access to existing patents and technical reports to third parties, those outside the industry (1969).

During this early period of coordinated industry resistance, the emissions problem was perceived by the automobile industry as a management, public relations challenge, rather than a fundamental problem for which a technical solution had to be developed. This perception allowed the industry to successfully resist making changes by controlling the pace of technological development. The industry did slowly implement several simple technical solutions in response to public pressure and regulatory threats urging them to develop a technological response to the air pollution problem. One example of this is the industry's installation in 1963 of a simple valve that allowed for recirculation rather than direct release of pollutants from the crankcase; this positive crankcase ventilation (PCV) valve had been used in military vehicles for decades so it was not a new technology, yet the industry presented the development as a result of their diligent efforts to find technical solutions to the automobile emissions problem (DOJ 1971).

During this early period when the federal government had minimal influence over or interaction with the automobile manufacturers, the California state government began addressing the industry's resistance by encouraging the development of pollution control technology through state regulation. Recognizing the industry's slow pace of development and implementation of technological improvements, California passed legislation in 1960 that was designed to stimulate competition within and outside the industry and provide a mechanism for government regulators to review the subsequent technical developments. The Motor Vehicle Pollution Control Act (MVPCA) set strict emission standards, a 70% reduction in HC and a 57% reduction in CO, that were to be enforced one year after two satisfactory emission control devices were certified by the state to meet the standards; all new cars would have to install one of the certified devices (California 1960). In drafting this legislation, California legislators identified and addressed two critical mechanisms with potential to accelerate the pace of emissions control technology development and reduce the effectiveness of the industry's attempts to resist change: 1) the competitive pressure of third-party innovators, and 2) the asymmetry of information between regulators and the industry. The MVPCA was designed to reduce barriers to market entry of those developing pollution control technology external to the automobile industry by creating incentive by ensuring a market for devices certified to meet the standards (CAMVPCB 1965; Krier and Ursin 1977). At this time catalyst technology was a suspected possible technology, so in response to this legislation a period of intense catalytic research began as many catalytic chemists jumped at the opportunity to work toward this exciting potential application of catalytic technology (Lester 1983; Briggs 1984). By requiring a detailed state certification of all devices, the legislation also created a pathway for information sharing; in the certification process the state regulators gained the opportunity to evaluate the potential of different technical approaches developed.

In 1964, when four externally developed devices (three of which were based on catalytic technology) were certified by the state triggering enforcement of the emission standards the following year, the automobile manufacturers revealed to the state their own internally developed technical changes, which consisted of a series of engine modifications rather than catalytic technology. Once the state certified these industry developed engine modifications, the automobile companies each chose to implement their own internally designed approaches rather than implement the externally developed catalytic devices (Krier and Ursin 1977). So although this legislation motivated and encouraged third party inventors, the inventions were excluded from implementation because the potential market was removed once the state certified the industry developed technologies. Nevertheless, the technological progress that was made in the early 1960s by third parties was influential in demonstrating to both the industry and the government the potential of catalytic technology; this potential was incorporated into the 1970 federal legislation discussed in the next section.

Engineers involved in the development of the catalytic technology have suggested that if cooperative relationships among industry, government and third parties had existed, an effective combination of engine modifications and catalyst systems could have resulted in an efficient pollution control technology that could have surpassed the California standards by the mid-1960s (Briggs 1984). Instead the industry's engine modifications approach with a limited level of reductions prevailed while the catalytic technology with a far greater potential level of reductions was not developed for implementation until the industry had to respond to the more stringent federal regulations issued in 1970.

2.2 Industry Resistance within a New, Stringent Regulatory Regime: 1970 - 1988

Reacting to deteriorating urban air quality in many parts of the country and the industry's apparent reluctance to make voluntary technical changes to reduce automobile emissions, a frustrated federal government responded with an unprecedented, stringent technology-forcing set of regulations in 1970. The 1970 Clean Air Act Amendments

(CAAA) mandated emission reductions for hydrocarbons (HC) and carbon monoxide (CO) of 90% below 1970 levels by 1975, and for nitrous oxides (NOx) 90% below 1971 levels by 1976 (U.S. 1970). These standards were more stringent than the California standards discussed in the previous section, which required a 70 and 57% reduction respectively for HC and CO and did not include a NOx standard. Responding to the federal government's aggressive regulatory attempt to accelerate the development of pollution control devices, the auto manufacturers intensified their research efforts while simultaneously intensifying their resistance, highlighting potentially critical technical uncertainties in their claims that the standards could not be met in the designated time.

While the auto manufacturers took every opportunity to weaken and delay the standards throughout the 1970s, third parties, those external to both the U.S. government and the U.S. automobile manufacturing industry, played a critical role in reducing the effectiveness of the industry's strategies to resist change. To appease industry's concern about the technical feasibility of meeting the strict standards set in the 1970 CAAA, the legislation included two flexibility mechanisms: 1) automakers were allowed to apply for a one-time, one-year extension if they could demonstrate to the Environmental Protection Agency (EPA) administrator that the technology was not yet available, and 2) upholding the standards was contingent on the assessment of technical feasibility to be carried out by the National Academy of Science (NAS). These flexibility mechanisms provided two different avenues for third parties to influence the industry-government dialogue.

During the extension hearings the testimony of independent companies developing pollution control technology influenced both the industry and the government. Independent suppliers of catalytic converters (the primary technology considered capable of meeting the standards), provided manufacturer-conflicting testimony to federal regulators about the feasibility of implementing the new technology during the 1972 and 1973 hearings to consider whether or not the industry deserved an extension to meet the standards (EPA 1972). Additionally, technological developments made by several non-U.S. auto manufacturers provided regulators with a more optimistic perspective on the technological possibilities of reducing emissions than the one promoted by the U.S. automakers. Specifically Honda developed an alternative engine design (a stratified charge engine) that could meet the 1975 standards without a catalytic converter (Abernathy and Ronan 1978). Although initially the EPA denied the industry's request for an extension in 1972, the U.S. court of Appeals ordered the EPA to reconsider the automakers' request in 1973 and this time the one-year extension was granted. Although arguments of technical infeasibility were used in the 1972 hearings, the 1973 hearings focused more attention on the potential business catastrophe that could result if insufficient time was allowed for the transition to the new catalytic technology.

The second flexibility mechanism, the stipulation that upholding the standards was contingent on the NAS assessment of technical feasibility, incorporated another way for an independent entity, a third party, to influence industry-government interactions and reduce industry's resistance. The 1973 NAS report was extensively researched, and the auto manufacturers were required by law to respond in full to any requests for information of any kind from the NAS committee members (Lester 2003). The reports major conclusions were that the 1975 HC and CO standards could be met in the given time frame, but to meet the 1976 NOx standard additional time would be required (NAS 1973). The report reviewed technical obstacles to successful implementation of catalytic converters questioning whether the technology could be optimized by the 1975 model-year. A major quandary noted within the report was the recent development of Honda's stratified charge engine that could meet the 1975 standards with potential to meet the 1976 NOx standards too. This report provided regulators with an independent technical assessment of the feasibility of meeting the standards and also created a common-ground base of information to which the government and industry could both refer to in future debates.

In addition to Honda's technical developments minimizing the U.S. industry's claims of technical feasibility, other foreign automobile manufacturers were also influential. Although technical progress was being made in the early 1970s with the development of a catalytic converter that could successfully oxidize HC and CO, a major unresolved technical challenge was whether an effective device that could simultaneously reduce NOx could be developed. As it became clear in 1976 that the auto manufacturers were not going to meet the standards scheduled to come into effect for the 1978 model year an additional set of amendments to the CAA were debated. Initially during this debate, the industry emphasized the uncertainties, infeasibility, and potential drawbacks related to the development of a catalytic device that could successfully reduce all three regulated pollutants (HC, CO, and NOx), a so-called three-way converter. In mid-1976, however, Volvo produced a car to be sold in California with a three-way catalytic device able to meet all three standards. In response, the U.S. manufacturers shifted their resistant arguments away from claims of technical infeasibility focusing instead on the economic uncertainty of implementation and the technical challenges associated with scaling-up production; ensuring effective and safe catalytic converters on every new car, they argued, would require more time. The industry lobbying efforts were successful in preventing agreement in Congress on what revisions should include, so the actual amendments to the CAA were not passed until August 1977, when the automakers were already shipping out to the dealers their 1978 models which did not meet the current standards. The 1977 CAAA delayed the HC standard until 1980, the CO standard until 1981, and weakened and delayed the NOx standard to come into effect in 1981 (1977).

In the years following, the three-way catalytic converter was improved upon and became standard on most U.S. cars by 1980. Throughout the 1980s, the automobile industry's concern about emission control regulation reduced as President Reagan's administration demonstrated interest in weakening rather than strengthening pollution control, and Congress was deeply divided on the issue. In 1988 this situation changed as it became clear that additional changes to the air pollution legislation were necessary and inevitable (Cohen 1995).

2.3 A Mature Industry-Government Relationship: 1988 to present

Despite the success in the development of the three-way catalytic converter, air pollution continued to be a growing problem throughout the 1980s due to the increasing number of cars on the road (Taylor 1987). Following a decade of inaction on air pollution legislation, Congressional action began to be seriously debated in 1988 building upon proposals developed by a few key Congressmen during the 1980s (Bailey 1998). President George H.W. Bush, recognizing the political collateral associated with being the President who updated and strengthened the CAA, placed passing new air pollution legislation high on his priority list (Cohen 1995). Further reductions in automobile emissions was only one of three main goals of the 1990 legislation; the other two goals were to reduce acid rain by cutting sulphur dioxide and nitrogen oxides emissions and reduce emissions of air toxics by mandating control technology. With regard to automobile emissions, the 1990 legislation mandated phasing in the California emission standards at the national level in all new cars starting in 1994. These standards, known as Tier 1 standards, required a reduction in NOx emissions from 1990 levels of 60% and a reduction in HC of 40%. A second round of standards, known as Tier 2 standards, would further reduce emissions by 50% from 2003 to 2006, unless an EPA review found that these more stringent standards were infeasible or unnecessary (NESCAUM 2000). This potential flexibility in the Tier 2 standards resulted from a compromise measure to appease those concerned about the impacts of the legislation on the automobile industry; by providing a future opportunity to resist the most stringent standards the legislation was more acceptable.

During the debate surrounding the 1990 CAAA standards, the automobile industry once again pointed out the uncertainties that the technology required to meet the emission standards being considered could be developed and implemented (Anonymous 2004). Claims of infeasibility were made although the Tier 1 standards were already being met successfully in California cars. The industry also predicted other negative consequences of making the technical changes necessary to meet the new standards, including reduced fuel economy, higher costs to consumers, reduced drivability, and more recalls (Doyle 2000). The costs associated with the new standards, they argued, were far greater than the associated benefits. Although claims of shutdown of the industry if the standards were upheld like those used in the 1970s were not made, the industry predicted job losses and an economic downturn would result from the strict standards (NESCAUM 2000).

Unlike the 1970 and 1977 CAAA, the 1990 amendments were a high priority for the President; President Bush, after having declared himself the environmental president, was determined to reinforce the nation's air pollution laws (Cohen 1995). In this context, the industry's resistant claims were not as effective in influencing the regulation as they had been in the 1970s. Additionally, the familiarity of the industry's resistant claims to similar claims made in the 1970s that did not materialize weakened the industry's legitimacy and associated level of concern about how stricter standards would impact the industry. And again, despite their claims to the contrary before the regulation was in place, the automobile manufacturers have been able to successfully produce and sell cars that are in compliance with Tier 1 and the subsequently determined Tier 2 standards without any major associated negative consequences (Anonymous 2004).

During this most recent time period, a higher level of complexity compared to the 1970s in the regulatory process, the legislation, and the implementation of the legislation compared to the 1970s has diffused the intensity of interactions between the automobile industry and the government. A much larger number of politicians and industry lobbyists were integrally involved in drafting the 1990 legislation, and far more government beaurocrats and industry representatives have had to focus on the implementation of the new legislation (Cohen 1995). This increased complexity has complicated the relationship between the auto industry and the government and minimized the influence of the industry's strategies of resistance on government decision-making.

One prominent example of this complexity is the involvement of the oil industry. In addition to setting stricter national emission standards for automobiles, the 1990 CAAA also mandated changes to fuel used in automobiles to reduce air pollution. The debate on reformulated gasoline and alternative fuels engaged the oil industry rather than the automobile industry, and this involvement of another large, mature industry in the regulatory debate lessened the intensity of the automobile industry's interactions with the government considerably.

This effect of complexity of players limiting the effectiveness of the industry's strategies to resist making changes can be explained in the context of third parties. The oil industry, in this context, can be viewed as a third party that has altered the intense dynamic between the automobile industry and the government. Once again in this most recent time period, third parties have played a critical role in reducing the effectiveness of industry's strategies of resistance.

3 Analysis of Government-Industry Interactions in This Case

3.1 Arguments of Technical Feasibility – A Cycle of Mistrust

Throughout the fifty year history (1955-present) of efforts to reduce automobile emissions, arguments of technical feasibility have recurred. A reinforcing cycle of mistrust associated with technical details in the industry-government relationship has developed encouraging industry to persistently make claims of technical infeasibility. Following an initial 15 years of minimal industry action in reducing automobile emissions from 1955-1969, the U.S. government became skeptical of the sincerity and level of commitment of the industry's efforts to find technical solutions and responded in 1970 by mandating drastic emission reductions that could not be achieved with current technology. The government's setting these stringent standards, an action that has been described as motivated more by political considerations than technical realities (Ingram 1978; Lundqvist 1980), created an intense hostility and perpetuated a cycle of mistrust on technical details between the government and the industry.

The industry, knowing that the government developed the emission standards without confidence in technical feasibility, felt obliged to highlight the uncertainty in feasibility and the strong likelihood that the standards could not be met. Because the industry felt that the government developed the standards without understanding potential technologies, the industry's internal processes, or the costs of implementing changes, the industry has consistently made claims of technical infeasibility often based upon the most extreme, pessimistic possibilities. Increasingly throughout this history, government regulators recognized the industry's tendency to be pessimistic about future technology, so the regulators have come to view industry's perspective on technical feasibility with skepticism and have continued to uphold and enforce standards that the industry has claimed cannot be met. This mutual mistrust still persists today, although due to the familiarity resulting from the longevity of the industry-government relationship both industry and government are now better able to interpret each other's actions and claims, i.e. in the most recent debates the industry's claims of technical infeasibility have not been taken seriously.

An additional factor feeding into this cycle of mistrust is the industry's apparent perception that their public position on technical feasibility must emphasize the technical uncertainties and potential obstacles in order to counteract the overly optimistic claims of technical feasibility being publicized by third parties, including environmental advocacy groups or pollution control technology companies hoping to develop a market for their product (i.e. catalytic converter manufacturers). The industry, predicting that regulators would reconcile differing perceptions of technical feasibility by averaging the most extreme views, has attempted to offset the optimistic claims of others by claiming a position that is as far on the other end of the spectrum of potential feasibility as possible.

Despite this cycle of mistrust and the hostile government-industry relationship, automobile emissions have been reduced immensely. Whether effective pollution control technology could have been developed sooner or more easily with a different, less hostile type of government-industry relationship is debatable.

3.2 Cooperation vs. Competition within the Industry

When the automobile was first implicated as a major contributor to the urban air pollution problem in the early 1950s (Haagen-Smit 1952), the U.S. automobile manufacturers responded by creating an industry-wide, cooperative agreement which eliminated competition among individual firms to develop pollution control technology. This cooperative approach also severely restricted third party inventions through a cross-licensing agreement that specified royalty-free exchange of patents and a formula for sharing the costs of acquiring patents developed outside the industry; by removing incentive for industry consideration of third party inventions, the industry eliminated any potential market for third party innovators. Individual firms signed on to this cooperative agreement because it minimized the risk to them that another firm would gain competitive advantage by being the first to develop commercially viable pollution control technology (DOJ 1971). The following excerpt from the minutes of an April 1955 meeting of the patent Committee of the industry trade group, the Automobile Manufacturers Association (AMA) explains this strategy.

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Despite the industry's public declaration that their cooperative program was designed to accelerate technical developments in emissions reduction, the opposite effect, to slow-down technical progress, has been identified as the intended result of the program by evidence collected during a grand jury investigation assessing antitrust collusion allegations against the industry in the late 1960s (DOJ 1971). Following this investigation, an antitrust civil suit alleging 16 years of industry conspiracy to prevent development of pollution control technology was issued; the case was settled by consent decree in which the industry did not admit to any illegal activity but did agree to a series of restrictions prohibiting the exchange of restricted technical information, prohibiting the issuing of joint announcements, and requiring open access to existing patents and technical reports to third parties, those outside the industry (1969).

During this early period of coordinated industry resistance, the emissions problem was perceived by the automobile industry as a management, public relations challenge, rather than a fundamental problem for which a technical solution had to be developed. This perception allowed the industry to successfully resist making changes by controlling the pace of technological development. The industry did slowly implement simple technical solutions in response to public pressure and regulatory threats urging them to develop a technological response to the air pollution problem. One example of this is the industry's installation in 1963 of a simple valve that allowed for recirculation rather than direct release of pollutants from the crankcase; this positive crankcase ventilation (PCV) valve had been used in military vehicles for decades so it was not a new technology, yet the industry presented the development as a result of their diligent efforts to find technical solutions (DOJ 1971). Very different strategies are employed during this period of a cooperative regime than those employed later during the more competitive regime.

3.3 Role of Third Parties

During the early period from 1955-1970 when the federal government had minimal influence over or interaction with the automobile manufacturers, the California state government was addressing the industry's resistance by encouraging the development of pollution control technology through state regulation. Recognizing the industry's slow pace of development and implementation of technological improvements, California passed legislation in 1960 that was designed to stimulate competition within and outside the industry and provide a mechanism for government regulators to review technical information from within and outside the industry. The Motor Vehicle Pollution Control Act (MVPCA) set strict emission standards, a 70% reduction in HC and a 57% reduction in CO, that were to be enforced one year after two satisfactory emission control devices were certified by the state to meet the standards; all new cars would have to install one of the certified devices (California 1960).

In drafting this legislation, California legislators identified and addressed two critical mechanisms with potential to accelerate the pace of emissions control technology development and reduce the effectiveness of the industry's attempts to resist change: 1) the competitive pressure of third-party innovators, and 2) the asymmetry of information between regulators and the industry. The MVPCA was designed to reduce barriers to market entry of those developing pollution control technology external to the automobile industry by creating incentive by ensuring a market for devices certified to meet the standards (CAMVPCB 1965; Krier and Ursin 1977). At this time catalyst technology was a suspected possible technology, so in response to this legislation a period of intense catalytic research began as many catalytic chemists jumped at the opportunity to work toward this exciting potential application of catalytic technology (Lester 1983; Briggs 1984). By requiring a detailed state certification of all devices, the legislation also created a pathway for information sharing; in the certification process the state regulators gained the opportunity to evaluate the potential of different technical approaches developed.

In 1964, when four externally developed devices (three of which were based on catalytic technology) were certified by the state triggering enforcement of the emission standards the following year, the automobile manufacturers revealed to the state their own internally developed technical changes, which consisted of a series of engine modifications rather than catalytic technology. Once the state certified these industry developed engine modifications, the automobile companies each chose to implement their own internally designed approaches rather than implement the externally developed catalytic devices (Krier and Ursin 1977). So although this legislation motivated and encouraged third party inventors, the inventions were excluded from implementation because the potential market was removed once the state certified the industry developed technologies. Nevertheless, the technological progress that was made in the early 1960s by third parties was influential in demonstrating to both the industry and the government the potential of catalytic technology; this potential was incorporated into 1970 federal legislation.

Engineers involved in the development of the catalytic technology have suggested that if cooperative relationships among industry, government and third parties had existed, an effective combination of engine modifications and catalyst systems could have resulted in an efficient pollution control technology that could have surpassed the California standards by the mid-1960s (Briggs 1984). Instead the industry's engine modifications approach with a limited level of reductions prevailed while the catalytic technology with a far greater potential level of reductions was not developed for implementation until the industry had to respond to the more stringent federal regulations issued in 1970.

The critical role of third parties in reducing the effectiveness of industry's resistance to making technical changes is demonstrated in the 1970s also, when the auto manufacturers applied for an extension to the standards set in the 1970 Clean Air Act Amendments (CAAA). To appease industry's concern about the technical feasibility of meeting the strict standards set in the 1970 CAAA, the legislation included two flexibility mechanisms: 1) automakers were allowed to apply for a one-time, one-year extension if they could demonstrate to the Environmental Protection Agency (EPA) administrator that the technology was not yet available, and 2) upholding the standards was contingent on the assessment of technical feasibility to be carried out by the National Academy of Science (NAS). These flexibility mechanisms provided two different avenues for third parties to influence the industry-government dialogue.

During the extension hearings the testimony of independent companies developing pollution control technology influenced both the industry and the government. Independent suppliers of catalytic converters (the primary technology considered capable of meeting the standards), provided manufacturer-conflicting testimony to federal regulators about the feasibility of implementing the new technology during the 1972 and 1973 hearings to consider whether or not the industry deserved an extension to meet the standards (EPA 1972). Additionally, technological developments made by several non-U.S. auto manufacturers provided regulators with a more optimistic perspective on the technological possibilities of reducing emissions than the one promoted by the U.S. automakers. Specifically Honda developed an alternative engine design (a stratified charge engine) that could meet the 1975 standards without a catalytic converter (Abernathy and Ronan 1978). Although initially the EPA denied the industry's request for an extension in 1972, the U.S. court of Appeals ordered the EPA to reconsider the automakers' request in 1973 and this time the one-year extension was granted.

4. Conclusions

The details of this case suggest that the only time a firm has an interest in explicitly stating that an ambitious environmental performance goal is feasible is when they want to sell the technology required to achieve the goal e.g., Honda's CVCC engine, and Engelhard, the catalytic converter company that provided testimony to EPA on the feasibility of catalytic converters in 1972. For other firms, the strategic choice is between aggressive claims of infeasibility to oppose a proposed regulation, and passive acceptance. This choice is probably subject to a tipping point, by which it becomes disadvantageous to continue claiming infeasibility when either a) enough technological information has been revealed that the claims pass from appearing reasonably cautious to appearing dishonest and obstructionist, or; b) political forces behind a proposed regulation have become strong enough that there is no reasonable probability of infeasibility claims succeeding in stopping it. Better recognition by policymakers of these incentives and disincentives associated with admitting or denying technical feasibility of meeting a regulation could allow for improved communication between government and industry.

This case also provides useful insight on the potential role of industry cooperation. If the purpose of a cooperative body is principally to let firms monitor each other's efforts and announcements, its effect is likely to be to suppress rather than facilitate innovation even if they don't (as the automakers did) have explicit agreements to discourage efforts. Government or outside independent expert participation in cooperative bodies is probably a sufficient guarantee against such uses of cooperative bodies. If the threat of a required environmental performance target is credible, the cost of failing to meet it is high enough, the collective interest of the industry is to meet it, and there's only potential benefit, no harm, in facilitating cooperative work toward it, a cooperative effort may also be productive. Additionally, for some industries, more fragmented industries with lots of smaller firms with less R&D capacity in each firm, cooperative bodies may provide crucial increments of technical capacity to solve environmental problems

Additionally, this case has demonstrated in several different ways the critical role that third parties can play in facilitating more productive interactions with regard to technical details in government-industry interactions. The asymmetry in access to technical information between industry and government (regulators often rely on technical information provided to them by the industry because independent technical information is limited or non-existent) can be minimized by the active involvement of third parties. Third parties need to be encouraged to reveal information about capabilities without jeopardizing their commercial relationships.

Finally this research demonstrates the dynamic, interactive nature of the relationship between industries and governments; these interactions should not be overlooked in considerations of how best to create incentives for industry development and implementation of environmental regulations.

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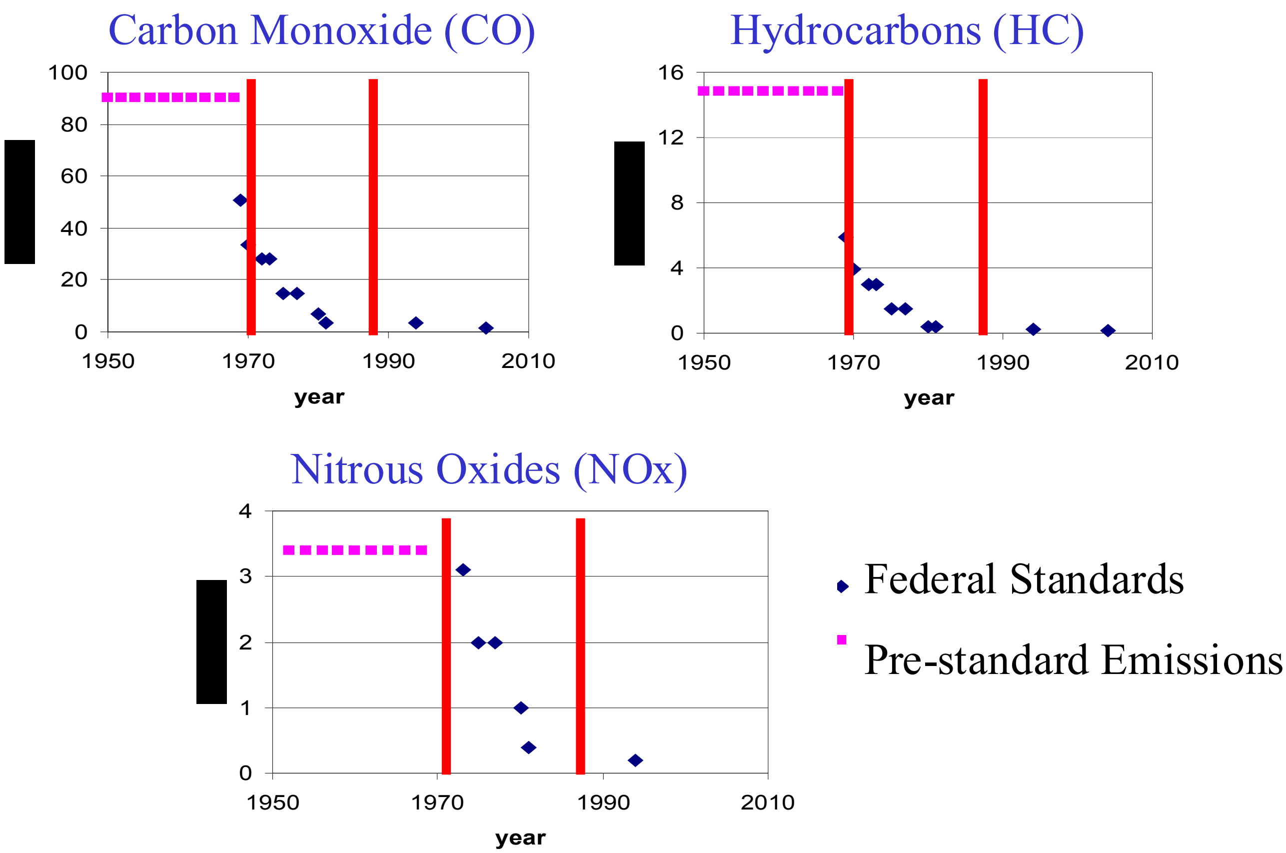


Figure 1. These graphs demonstrating the pre-standard emissions and the decreasing federal standards for the three primary automobile pollutants, carbon monoxide (CO), hydrocarbons (HC), and nitrous oxides (NOx) also show how the fifty-year history can be divided into the three distinct time periods described in the text.

Comments on
"A Multi-Agent Model of a Small Firm"

by

Carl Pasurka*

for

EPA workshop on
"Corporate Environmental Behavior and the Effectiveness of Government Interventions"

Washington, DC

April 26, 2004

*Any errors, opinions or conclusions are those of the author and should not be attributed to the U.S. Environmental Protection Agency.

This study investigated interpersonal dynamics that influence corporate environmental behavior. In its present form, most of the study is not relevant to the U.S. EPA. This study focuses on: (1) an overview of networks and organizations, (2) a survey of the plastics industry in New Jersey, (3) a case study of three companies, and (4) a simulation. This study claims that its ability to analyze (1) eco–parks and (2) industrial ecosystems will make it relevant to the U.S. EPA.

I will focus my comments on those sections with economics content. In the "Industry Background" section, the study employs 2001 data. Currently, 2002 data are available from The Society of the Plastics Industry (SPI). While 2002 data reveal that employment and shipments declined by approximately 10 percent between 2001 and 2002 for New Jersey, it remains among the top ten states in shipments of plastics (source: The Society of the Plastics Industry http://www.plasticsdatasource.org/facts/nj.pdf)

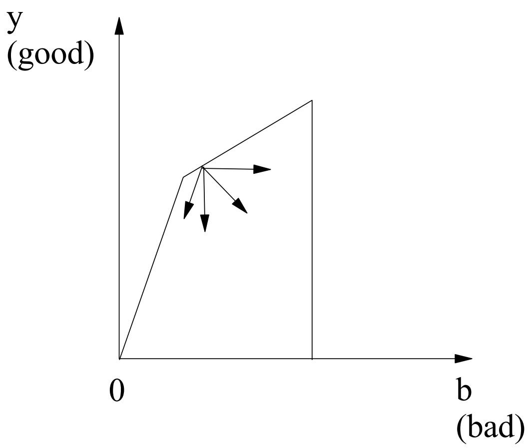
Another data issue is the discrepancy among data sources with regard to the size of the plastics industry in New Jersey. The following table shows the employment and value of shipments for plants included in NAICS codes 3259 and 3261 for New Jersey according to the 2001 *Annual Survey of Manufactures* and the Society of the Plastics Industry (SPI):

	Annual Survey of Manufactures	SPI
Employment	36,371	51,011
Shipments	$6.4 billion	$11.7 billion

Source: U.S. Census Bureau http://www.census.gov/mcd/asmdata/2001/nj34.htm

In the section "Illustrative Result - Bringing in Worker Error," the study concludes that firms with imperfect employees are less profitable and pollutes more. My initial interpretation of this statement is that worker error is a source of technical inefficiency (i.e., firm produces inside its production possibilities frontier). Hence, inefficiency manifests itself in the form of reduced good output production and increased bad output production.

However, there are several possible definitions of increased technical inefficiency. One definition is a proportional contraction of good outputs and expansion of bad outputs. Additional definitions involve contraction of good (bad) outputs while maintaining original level of production of bad (good) outputs. Finally, technical inefficiency can reveal itself as a proportional contraction of good and bad outputs. These different definitions of technical inefficiency are illustrated in the following diagram:



Joint Production Frontier

I wish to submit several questions/recommendations to the author. First, how are the results of this study relevant to analyses of eco-parks and industrial ecosystems? Second, the underlying economic assumptions of simulation model should be made more transparent. Most important, the study contained no explanation of the production technology. For example, if an imperfect worker mistakenly turns off pollution control equipment, why would the firm be less profitable? Finally, is worker error a justification for firm over compliance in order to avoid violations of regulations?

Comments on
"Compliance and Beyond: Strategic Government- Industry Interactions in Environmental Policy and Performance"

by

Carl Pasurka*

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This study focuses on the role of knowledge, uncertainty and arguments about perceptions of technical feasibility in the development of environmental policy. Environmental policy seeks to reduce emissions (i.e., bad outputs) which are the undesirable by-products of a society's production and consumption activities. The study investigates issues associated with the design of regulations that encourage technical change which incorporates environmental improvement. Regulations change the mix of good and bad outputs produced which influences the direction of technical change. A key question is what is the extent of this regulatory induced technical change?

Several definitions of technical change may be employed when discussing cases when both good and bad outputs are produced. One definition is a proportional expansion of good and bad outputs. A second definition of technical change involves expansion of good output production while maintaining the original level of bad output production. The third definition of technical change, which is most relevant for this study, involves a proportional expansion of good output production and contraction of bad output production.

The focus of this study is the development of regulations on motor vehicle emissions. Economists have experienced great difficulty in assessing the costs of pollution abatement activities associated with motor vehicles. This was shown by the discrepancy between EPA and Bureau of Economic Analysis estimates of pollution abatement costs associated with motor vehicles. This provides some indication of the difficulty of assessing the cost of implementing regulations and may provide an indication of the difficulty of assessing the technical feasibility of new technologies for reducing automobile emissions.

I had several questions for the authors. Would this study reach different conclusions if it were analyzing the interaction between the auto industry and regulators for other regulations? For example, what has been the relationship between the auto industry and government regulators during the implementation of regulations associated with sea belts, air bags, and Corporate Average Fuel Economy (CAFE) standards?

Is the discussion about the role of (1) third parties and (2) cooperation in R&D efforts in industries with smaller firms relevant to the environmental R&D efforts of other industries?

Are the conclusions of this study relevant to extant literature? This includes the literature on asymmetric information between regulators and industry, and the role of monitoring and enforcement activities. Several articles that appeared in the *Journal of Environmental Economics and Management* may be relevant to this study:

Hackett, Steven (1995) "Pollution-Controlling Innovation in Oligopolistic Industries: Some Comparisons between Patent Races and Research Joint Ventures," *Journal of Environmental Economics and Management*, 29, No. 3 (November), 339-356.

Stafford, Sarah (2002), "The Effect of Punishment on Firm Compliance with Hazardous Waste Regulations," *Journal of Environmental Economics and Management*, 44, No. 2 (September), 290-308.

Brunnermeier, Smita and Mark Cohen (2003), " Determinants of Environmental Innovation in US manufacturing Industries," *Journal of Environmental Economics and Management*, 45, No.2 (March), 278-293.

Comments on
"Do Facilities with Distant Headquarters Pollute More?: How Civic Engagement Conditions the Environmental Performance of Absentee Managed Plants"

by

Carl Pasurka*

for

EPA workshop on
"Corporate Environmental Behavior and the Effectiveness of Government Interventions"

Washington, DC

April 26, 2004

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This study addresses the question of whether the extent of civic engagement affects the environmental performance of plants operated by absentee managers? Toxic Release Inventory (TRI) data are used as a proxy for the environmental performance of plants. The TRI data are collected under the Emergency Planning and Community Right-to-Know Act and are self-reported data. Mary Streitweiser (1994) found substantial variation in emission intensities of 3-digit SIC industries within the chemical industry in 1987. These results are shown in the table accompanying these comments.

The author employs regression analysis to determine which factors are associated with TRI emissions of chemical plants. In this study, the quantity of TRI emissions from a plant is its measure of environmental performance. However, two factors affect the quantity of emissions: (1) its emission intensity (i.e., bad output production per unit of good output production) and (2) its scale of operation (size of plant). Hence, a plant can emit relative small quantities of toxic emissions per dollar of output but emit a relative large quantity of toxic emissions if it is a large plant.

After reading this study, I have several questions for the author. Does civic engagement affect a plant's emission intensity or scale of operation? The emission intensity of a plant may be determined by technology over which local managers may have little or no control. Is a plant's scale of operation affected by a community's attitude? Does civic engagement affect what type of plant is located in a community?

What is the effect of plant age on emissions? Do newer plants employ technologies that produce less pollution per unit of good output production than older plants?

Would regional/state dummy variable explain some of the differences in plant TRI emissions among states/regions?

Different communities seem to have different views about companies with external managers. Are absentee managers imposed on communities or are they actively pursued by communities? While there is a recent example of a California community resisting the construction of a new Wal-Mart, there are other examples of communities using tax incentives to influence the plant location decisions of companies.

Is the existing economics literature relevant to this study? For example, is there a link between findings of this study and economics literature on factors affecting plant location decisions? In addition, this study found that race and class characteristics of a neighborhood are unrelated to emissions. This is a topic that has been of interest to some economists

Is there a link between the findings of this study and economics literature on TRI? For example:

Henriques and Sadorsky (1996), "The Determinants of an Environmentally Responsive Firm: An Empirical Approach, " *Journal of Environmental Economics and Management*, 30 , No. 3

(May), 381-395.

Konar, Shameek and Mark Cohen 91997), "Information As Regulation: The Effect of Community Right to Know Laws on Toxic Emissions," *Journal of Environmental Economics and Management*, 32, No. 1 (January), 109-124.

Brooks, Nancy and Rajiv Sethi (1997), " The Distribution of Pollution: Community Characteristics and Exposure to Air Toxics," *Journal of Environmental Economics and Management*, 32, No. 2 (February), 233-250.

Khanna, Madhu, Wilma Quimio, and Doa Bojilova (1998), "Toxics Release Information: A Policy Tool for Environmental Protection," *Journal of Environmental Economics and Management*, 36, No. 3 (November), 243-266.

Khanna, Madhu and Lisa Damon (1999), "EPA's Voluntary 33/50 Program: Impact on Toxic Releases and Economic Performance of Firms," *Journal of Environmental Economics and Management*, 37, No. 1 (January), 1-25.

	Sum Toxic Releases[1]	Mean Toxic Intensity[2]	Standard Deviation	Coefficient of Variation	Interquartile Range
Chemicals & Allied Products (28)	2,794.27	19.03	89.17	4.69	8.06
Industrial Inorganic (281)	360.09	34.07	172.30	5.06	7.21
Plastics & Resins (282)	441.41	11.30	35.07	3.10	7.22
Drugs (283)	85.23	13.73	33.09	2.41	8.26
Soaps & Cosmetics (284)	25.75	3.22	11.86	3.68	0.85
Paints & Allied Products (285)	65.05	9.15	27.14	2.97	7.49
Industrial Organics (286)	1,106.63	34.50	110.04	3.19	22.09
Agricultural Chemicals (287)	649.19	50.45	135.99	2.70	22.58

Misc. Chemicals (289)	60.93	7.48	35.08	4.69	4.07

[1]pounds of toxins releases and transfers (in millions)
[2]pounds of toxins / $1000 value of production

Source:
Streitwieser, Mary (1994), "Cross Sectional Variation In Toxic Waste Releases From The U.S. Chemical Industry," Center for Economic Studies, Working Paper CES-WP-94-8
http://148.129.75.160/ces.php/abstract?paper=100230

Discussant's Comments on Papers in the Session on "Approaches to Environmental Performance" at the EPA Conference on "Corporate Environmental Behavior and the Effectiveness of Government Interventions" April 26, 2004

Donald S. Siegel*
Professor of Economics
Department of Economics
3502 Russell Sage
Rensselaer Polytechnic Institute
110 8th Street
Troy, NY 12180-3590
United States
Tel: (518) 276-2049
Fax: (518) 276-2235
sieged@rpi.edu

The purpose of this report is to provide feedback to authors of the three papers presented in the session on "Approaches to Environmental Performance." These studies are quite diverse, in terms of their theoretical perspectives and empirical methods, as well as the disciplinary backgrounds of the authors. As my comments will reveal, they are also at different stages of development. I begin with the paper that is closest to a "final product."

Paper #1: Do Facilities with Distant Headquarters Pollute More? How Civic Engagement Conditions the Environment Performance of Absentee Managed Plants

This lucid and insightful paper is an econometric analysis of the determinants of the environmental performance of chemical plants. A major contribution of this study is its attempt to link several indicators of "civic engagement" to the propensity of absentee managed plants to emit chemical toxins. A key finding is that absentee managed plants tend to have better environmental performance when they are located in communities where there is more civic engagement.

I have two theoretical concerns. The author should reflect on several recent papers that analyze incentives firms have to be environmental socially responsible (henceforth, ESR). For example, McWilliams and Siegel (2001) outline a theory of the firm/supply and demand perspective on ESR. Their model assumes that firms weigh the costs and benefits of engaging in this activity. Some of these benefits include a greater ability to differentiate products, enhance the firm's reputation/image, and build or sustain good relations with key stakeholders (e.g., employees, government, and investors). In sum, firms are responding to growing demand from various stakeholders, including consumers, employees, and portfolio managers representing social investors, who examine pollution measures such as the TRI in their overall assessment of firm environmental performance.

The McWilliams and Siegel framework suggests that ESR is an integral part of a firm's corporate and business-level strategies. More specifically, the authors conjecture that the propensity of firms to engage in ESR is positively correlated with firm size (a variable Professor Grant includes in his empirical analysis), scope of activities, R&D, and consumer income/wealth. That is, larger, more diverse, and more technologically advanced firms derive greater benefits from engaging in ESR. Information asymmetry between firms and consumers (and other stakeholders) regarding the social desirability of managerial practices also appears to play a critical role in determining the incidence of CSR. In a previous paper (McWilliams and Siegel (2000)), the authors report empirical evidence that is consistent with a theory of firm perspective. That is, they find a strong positive correlation between the social performance of firms and the rate at which they invest in R&D and advertising. Another key paper in this area is a study by Russo and Fouts (1997), who outline a "resource-based view" of ESR. The authors hypothesize that ESR can constitute a resource that generates a competitive advantage. They confirm this hypothesis using extensive data on environmental and firm performance.

The agency theory perspective also bears mentioning in this context. Agency theory is based on the principal agent framework. An example of a principal/agent relationship concerns shareholders, who own the firm (and thus, are the principals) and the CEO and senior management, who are the agents of shareholders. It is well known that agents (managers) often pursue policies that are not in the best interest of principals (shareholders). This leads to what is referred to in the literature as "agency costs," or costs associated with insufficient effort by employees and administrative costs associated with policies to deter such slack effort. In this context, agency costs may be relevant when senior management at corporate headquarters is overseeing the environmental performance of numerous manufacturing plants.

My point is that there may be diseconomies of scope in monitoring the environmental performance of many establishments, perhaps because managerial resources are spread too thin. The literature (see Jensen (1993)) also suggests that agency problems may be more severe for large, diverse, publicly-traded firms, where is there typically greater separation of ownership and control. Thus, at minimum, it might be useful to include a dummy as a right-hand-side variable in the econometric analysis denoting whether shares of the corporate parent of the plant are publicly traded. Note also that our previous discussion in this section on the strategic use of ESR strongly suggests that the "returns" to ESR may also be higher for publicly-traded firms.

I also have several comments relating to measurement issues and the econometric analysis. The author estimates the following equation:

$$\text{(1)}\quad \mathbf{ENVPERF= f\ (ABSENT,} \sum_{i=1}^{I} \beta_i\ \mathbf{CIVENG,} \sum_{j=1}^{J} \delta_j \mathbf{DEMO,}$$

$$\mathbf{PLANT,\ FIRM,\ IND)} + u_i$$

where the environmental performance (ENVPERF) of the plant is presumed to be a function of a dummy variable denoting whether the plant has an "absentee owner" (ABSENT), a vector of indicators of "civic engagement" (CIVENG), several demographic factors (DEMO), including race and class, plant and firm characteristics (PLANT, FIRM), and a few sub-industry dummies (IND).

It is important to note that there are several econometric concerns regarding OLS or simple random effects estimation of equation (1). These concerns are measurement error and specification error, which could result in biased, inconsistent, and inefficient parameter estimates. The first issue is measurement error in the dependent variable. Note that we don't observe the plant's "true" environmental performance (ENVPERF*), but rather an imperfect, self-reported indicator based on the toxic release inventory (TRI) data:

$$\text{ENVPERF} = \text{ENVPERF*} + \varepsilon$$

where ε is the measurement error. As we know from basic econometric theory, errors of measurement in a dependent variable yield unbiased, although inefficient estimates if these errors are uncorrelated with the independent variables. Thus, the following assumptions must hold. $\text{Cov}(\varepsilon, \text{ABSENT})=0$; $\text{Cov}(\varepsilon, \text{CIVENG})=0$;

However, I conjecture these assumptions could be invalid, since plants with absentee owners and those that are located in communities where there is more "civically engagement" may have an incentive to overstate their environmental performance. In the former case, overstatement could arise because of the monitoring problems noted earlier. In the latter case, overstatement might result from managers being aware of the fact that communities with greater civic engagement will expect to see superior environmental performance in local manufacturing facilities. Alternatively, managers may believe that tightly knit communities will actively oppose the facility if they perceive that the plant is inflicting environmental damage on the community.

Some additional measurement problems should also be addressed. The measure of absent ownership is a dummy variable denoting whether the plant's corporate headquarters is located in the same state as the facility. A better measure would be based on the distance between the plant and its corporate headquarters. I am also a bit concerned about the fact that "civic engagement" is a rather fuzzy construct. Thus, further justification of these measures is needed or the author may choose to employ an econometric method that attempts to control for such measurement error.

Another econometric concern is specification error, in this case a key omitted variable- R&D. McWilliams & Siegel (2000) have shown that R&D is positively correlated with corporate social and environmental performance, as well as firm size (an included regressorin Professor Grant's model). I am also concerned about possible "Schumpeterian" effects. Joseph Schumpeter, the eminent Harvard economist, asserted that larger and more diverse firms have a greater propensity to engage in innovative activity than small firms. He also argued that such companies reap higher returns to R&D than small firms. There is some empirical evidence of Schumpeterian effects in the chemical industry (see Link (1980) and Mansfield (1980)). In his excellent book, Scott (2003) presents an economic analysis of new primary data on environmental research in the chemical industry and reports evidence that is consistent with previous Schumpeterian findings.

There are several possible "solutions" to the measurement/econometric problems I have identified. The first is instrumental variables estimation (e.g., 2SLS, 3SLS) or some form of systems equations estimation (Griliches (1986)). Another approach is multivariate reverse regressions, which can be used to derive bounds on the extent of the impact of the measurement error on the parameter estimates. I believe that the best approach would be a "multi-indicators, multiple-causes" (MIMIC) model, a type of LISREL model, in which you would attempt to "explain" the measurement error (see Siegel (1997)). A MIMIC model is essentially a full-information version of instrumental variables. These models have been used in numerous sociological studies.

<u>Paper #2 "Compliance and Beyond: Strategic Government-Industry Interactions in</u>

<u>Environmental Policy and Performance"</u>

This paper seeks to advance our understanding of how firms react to the threat of regulation. According to the authors, they have several options. They can attempt to oppose, influence, delay, or support such initiatives. The authors wish to analyze these strategies. On the other side of the equation, they also wish to examine how regulatory agencies react to such efforts. I presume that the ultimate objective is to design better policy initiatives that take account of strategic interaction s between firms and regulatory agencies.

I have several concerns with the current version of the paper. The first is that there is a major disconnect between the title and the text. The papers reports findings from a single case study. I am also a bit unclear about whether this is supposed to be an exercise in grounded theory development. If this is true, the authors need to explain why this approach is warranted in this context. After reading the introduction, I thought that the authors would propose to develop a <u>taxonomy</u> of strategies employed by firms and public agencies. Alas, such a taxonomy was not considered in the remainder of the manuscript. I would like to encourage the authors to move in this direction, since this would be a really useful outcome.

The paper would also greatly benefit from additional discussion/consideration of economic theories of regulation. "Capture" theories of regulation are of course highly relevant in this context. These refer to instances when regulatory agencies are "captured" by the firms they are supposed to control. In his seminal paper, Stigler (1971) argued that firms will actually lobby for additional regulation when such legislative initiatives yield either direct monetary subsidies to these corporations, impose constraints on substitute products or subsidies on complementary products, create conditions that make it easier for incumbent firms to fix prices or collude along some other dimension of competition, and when it enhances the ability of incumbent firms to control entry.

The authors should also consider the tension between corporate social responsibility (CSR) and regulation (Siegel (2001), McWilliams and Siegel (2002)). My point is that there is a possibility that CSR could be used to forestall regulation. Pre-emptive CSR strategies should also be considered. That is, it is conceivable that CSR (and regulation) can be used a means of raising rivals' costs. Marvel (1977) demonstrated the strategic use of CSR in the British textile industry in the early 1800s. The bottom line is that a polluting firm might actively seek additional environmental regulation if this would raise rivals' costs more than its own.

Another important trend needs to be considered: the growth of "strategic research partnerships (SRPs). An SRP is defined as any cooperative relationship involving organizations that conduct or sponsor R&D. The end result is that R&D is increasingly a collaborative activity. The increase in SRPs can be attributed to the following policy changes: an expansion of public -private partnerships, explicit relaxation of antitrust enforcement to promote collaborative research (e.g., the National Cooperative Research Act (NCRA) of 1984), and policies promoting more rapid technological diffusion from universities to firms (e.g., the Bayh-Dole Act of 1980). Examples of partnerships involving private firms only are strategic alliances/networks, licensing agreements, research joint ventures (RJVs), and industry consortia (SEMATECH). Examples of public-private SRPs include co-operative R&D Agreements (CRADAs) between federal laboratories and firms, NSF Industry-University Co-operative Research Centers (IUCRCs) and Engineering Research Centers (ERCs), university licensing, sponsored research agreements, and entrepreneurial startups, and publicly-funded R&D programs such as the U.S. Commerce Department's Advanced Technology Program (ATP).

The authors mention the role of "third parties." I would like them to consider two additional players: activists/NGOs and social investors. Baron (2001) and Fedderson and Gilligan (2001) assert that activists and NGOs may play a vital role in reducing information asymmetry between firms and consumers regarding the "social desirability" of a firm's managerial practices. Social investors and ethical funds could also be key financial stakeholders in certain industries. This highlights the importance of firms that attempt to measure the social performance of companies for portfolio managers of "screened" mutual funds and other social investors (e.g., Kinder, Lydenberg, and Domini).

Paper #3 ""A Multi-Agent Model of A Small Firm"

I would like to begin with some words of praise. The authors deserve a great deal of credit for mixing quantitative and qualitative methods. That is highly unusual in the social sciences and in my view, an approach that is ideal for an interdisciplinary topic such as corporate environmental.

This paper addresses a wide range of organizational issues, including questions that are unrelated to environmental activity. I encourage the authors to ask a smaller set of clearly-defined research questions that are more targeted to environmental issues. In the next version of the paper, the authors need to provide much more information on the qualitative methods and techniques employed. As far as I can tell, you interviewed only one person from each firm. I could be wrong about this, but this is not clear in the text. You should add a separate section on this issue and have a chart or table presenting the set of questions you asked these managers. I am also concerned about your small and possibly biased sample: four firms in a single industry (plastics) in a single state (New Jersey). You need to include more material to convince the reader that this industry is somehow representative of manufacturing industries and worthy of attention.

I would also like to see a more structured approach to the qualitative work. As outlined in Miles and Huberman (1994), there are techniques that can be employed to quantify the qualitative data from the structured interviews. This involves a detailed analysis of the interview transcripts, often using a software package such as Nudist. The first stage of analysis is data reduction, or the identification of themes that emerge from the interviews. The second stage is data display, or the generation of frequency counts of the number of times a particular theme is mentioned. The quantitative results can be used to draw conclusions from the interview transcripts (See Siegel, Waldman, and Link (2003) for an example of this approach).

As far as I can tell, the method used to identify social networks is quite crude. Nahapiet and Ghoshal (1998) and (Gant, Ichniowski, and Shaw (2002) present more sophisticated ways of conceptualizing and measuring the incidence and effects of social networks. For example, Nahapiet and Ghoshal (AMR-1998) identify three dimensions of social capital. The first is the structural aspect, which refers to the configuration of ties/relationships that emerge in the network. Another dimension is the relational aspect, which describes the nature of the relationships that people have developed with each other. Finally, there is the cognitive aspect, which refers to resources that provide shared representations, interpretations, and systems of meaning among the various actors in the network.

My final concern relates to the simulation model. It is well known that such models are highly sensitive to assumptions researchers make regarding key parameter values. Thus, it is incumbent upon the authors to present a clear statement of the assumptions of the simulation model. Given the importance of this concern, I believe it would be best to include this information on a separate chart or table.

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Organizational Practices on the Productivity of University Technology Transfer Offices: An Exploratory Study," *Research Policy*, Vol. 32, No. 1, pp. 27-48 (A previous version of this paper appeared as NBER Working Paper #7256, July 1999).

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Summary of the Q&A Discussion Following Session III

Magali Delmas (U.C. Santa Barbara)
Directing her comments to Dr. Grant, Dr. Delmas stated that she "really likes the idea of actually looking at the firm characteristics and the plant characteristics and looking at how community pressure can impact environmental performance and how these firm characteristics mitigate this." However, she said she wondered whether headquarter location is the right measure and went on to provide some feedback from her current research into "how environmental measures at the city level respond to stakeholder pressure." She said she has received conflicting opinions from those she has interviewed, with some saying that the main action stakeholder is the corporate headquarters and others saying, "No, it's the community, and it doesn't relate to the location of the headquarters." So, this has led her to wonder "what type of other measures [could be used] to tease out whether this is kind of a centralized type of management, with everything kind of done at a corporate level, or whether it's more decentralized, with the city or the plant actually having some decision-making power.

Dr. Delmas added, however, that they found that "headquarters location *matters* in terms of adopting environmental management practices," and she said cities where headquarters are located more commonly implement environmental management practices.

Don Grant (University of Arizona)
Dr. Grant responded, "This kind of goes back to Carl's [Carl Pasurka, one of the discussants] first attack [laughter] about how you go about measuring absentee management plants," and he agreed with Dr. Pasurka that in a lot of the current economic geography literature the standard policy is to measure in terms of miles between a plant and its headquarters. He went on to explain that the reason he chose to measure in terms of whether a plant is headquartered in the same state was "because of all the covenants beginning in the early 1980's . . . when states were competing for businesses and they were trying to lure them by lowering their environmental standards." Acknowledging that the other method might work as well, he concluded by saying, "Those are the only two alternatives I've ever come across. If there's a better one, let me know.

Andrew Hutson (University of North Carolina, Chapel Hill)
Addressing Dr. Grant also, Dr. Hutson said, "You've embedded your argument in the larger globalization debate, and I'm wondering if the data you use aren't more appropriate simply just for looking at different regional variations within the United States. Citing the different dynamics that come into play on a global scale—e.g., regulatory dynamics, administrative capacity, community pressures (with people being better organized)—and the fact that multi-national firms "may have different and better incentives [than smaller, local firms] to have structured, formal environmental management in place," Dr. Hutson questioned the "generalizability" of Dr. Grant's findings for the larger, global debate in which he embedded his work.

Don Grant
Dr. Grant responded that he had been "*very* careful not to suggest" that his findings could be generalized and applied to other situations in the world. He stated that the reason he couched his argument in terms of the globalization debate is "that's how it's typically addressed *today*," as opposed to 50 years ago when it was more of a domestic issue. He added that he believes that the most relevant literature is the literature that has to do with domestic plant growth and re-location.

Going on, Dr. Grant stated, "By the same token, I wanted to suggest in the paper that there are future avenues of research" and once more studies have produced more data, he will then be able to test the generalizability of his study. He agreed with Dr. Hutson that at the present time it's important to stress that studies that have uncovered the absentee management effect are limited to the U.S. He concluded by adding that they had looked at the effects of foreign-owned firms on environmental performance—an issue particularly relevant to the chemical industry because so many of those firms *are* foreign-owned—and they found no evidence that foreign ownership "has a bad effect on emissions."

Wayne Gray (Clark University)
Dr. Gray addressed his comments to Dr. Grant, also, and said he was "just a bit concerned" that Dr. Grant was getting his comparisons between locally managed and absentee-managed plants from *within* the chemical industry, which isn't necessarily a very homogeneous group. As Dr. Gray put it, "There are a lot of different sub-industries within chemicals and such" and, depending on the product being produced, some of those might be inherently more likely to be absentee-managed. He gave the example of products that have high transportation costs. A firm producing such a product would be more likely to have production facilities "spread all over the country" and necessarily absentee-managed, whereas other products that are more easily shipped might be more centrally produced. Dr. Gray wondered whether that factor was "correlated with any sort of sensitivity in terms of how easy it is for them to reduce their pollution." He wasn't sure how much or what kinds of controls had been used in the study "in terms of the particular kind of products, either . . . controlling for the 4-digit industry or something like that *or* the interaction effect with the local community."

Don Grant
Dr. Grant admitted that they haven't explored that in great detail, but agreed that there is much heterogeneity within the industry. He added the example of continuous-processing plants and batch-processing plants (e.g., soaps and detergents) and said that issues such as these might have implications for how far a facility can be from the corporate headquarters. He closed by saying, "We really haven't delved into these sub-industry differences, but I think there could be something there."

Irene Xiarchos (West Virginia University)

Returning to the issue of the distance factor, Ms. Xiarchos asked Dr. Siegel why one would want to measure "the exact distance of the headquarters from the location where the product is produced."

Don Siegel (Rensselaer Polytechnic Institute)
Dr. Siegel responded by clarifying that the argument in question is that "the farther away the senior managers and corporate headquarters were, the more likely they were to be disengaged from what was going on at the plant." He presented the example of himself, living in Albany, New York, ten or fifteen miles from the Massachusetts border, yet 500 miles away from Buffalo, which is in the same state. He believes categorizing by distance provides a much more precise picture of an area of influence.

Irene Xiarchos
Ms. Xiarchos countered that "rather than looking at distance specifically," maybe going by geographic/political levels or boundaries—county, state, region, country, continent—would yield a more meaningful stratification. She reiterated that she didn't "think the distance measured in kilometers would necessarily make a difference."

Don Grant (University of Arizona)
"It's a great empirical question. Again, the reason why I studied it as we did was because in the context of environmental regulation, states matter, and so the state boundaries are factored into our absentee management."

Pete Andrews (University of North Carolina, Chapel Hill)
"I'd really like to hear Clinton Andrews respond to some of the comments that were made about his paper, because having not read the paper but listening to the presentation, I'm really *intrigued* by the *potential* of this area, but the comment is also correct that it is very unspecified in terms of the actual presentation."

Clinton Andrews (Rutgers University)
Dr. Andrews acknowledged that in a half-hour presentation that includes "empirical stuff plus some modeling results, there's not much time to go into the details," but said he would gladly present more details to anyone with the time and inclination to gather around his laptop computer. He went on to say that he *did* feel compelled to clear up the discussion of worker error, and he explained: "The way we did it, which is just one way among many of conceptualizing it, was that workers had to interact with their technology and basically adjust it. The technology had optimal set points, and the workers would basically err in hitting those set points. . . . When it's structured that way, then you inevitably find that profits are going to go down and pollution is going to go up because of the form of that particular technology and the production function."

Rob Axtell (Brookings Institute)
Dr. Axtell followed up on Professor Siegel's comments on Dr. Grant's paper, his concern being primarily the re-writing of the model as a locational choice model—in other words,

taking a free-choice model and adding local structures to that. He said this can potentially present a problem because “when you think about it, normally the emissions level would depend on the civic engagement variable. But it could also be the case that the civic engagement level is in fact dependent on the level of emissions in some important way.” He just wanted to reiterate that this is a difficult econometric and specification problem.

Don Siegel
Dr. Siegel responded by saying, “I don’t think you can address that problem with cross-sectional data. If you had panel data . . . and you could add some data over time, you could probably do that.”

END OF SESSION III Q & A

Corporate Environmental Behavior and the Effectiveness of Government Interventions

SECOND DAY
INTRODUCTORY REMARKS BY

JIM GULLIFORD
REGION 7 REGIONAL ADMINISTRATOR

A WORKSHOP SPONSORED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S NATIONAL CENTER FOR ENVIRONMENTAL ECONOMICS (NCEE), NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH (NCER)

April 26-27, 2004
Wyndham Washington Hotel
Washington, DC

Prepared by Alpha-Gamma Technologies, Inc.
4700 Falls of Neuse Road, Suite 350, Raleigh, NC 27609

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Introductory Remarks by Jim Gulliford

Region 7 Regional Administrator

at the

Corporate Environmental Behavior and the

Effectiveness of Government Interventions

Washington, D.C.

April 27, 2004

Good morning. Thank you, Matt, for the kind introduction. It's indeed a pleasure to be here with you today. I hope that when I've finished, you will take with you – a message of change – change in the way we look at new environmental regulation or rule roll-out.

I want to cover a couple of topics -

- First, I would like to talk a little about Administrator Mike Leavitt's vision of collaboration and a "Better Way";

- And then, I’ll go over how Region 7 managed the roll-out of the proposed and final CAFO rule. This is important as we identify opportunities to change our behaviors toward the environment.

When Administrator Mike Leavitt was confirmed, the message he brought was one of collaboration . . . meeting in the middle. This message talks of a “Better Way” by:

- facilitating collaboration;
- harnessing technology; and
- creating market incentives.

We need to assure compliance in order to enforce the law. Let me explain what that means. In his 500 Day Plan, Administrator Leavitt makes the point that we need to make compliance our enforcement objective. In other words, we will use the intent of the law to support our outreach and inspections to achieve compliance with rules and regulations.

When it came to new regulations and rules in the past, there wasn't much collaboration. Regulations were rolled out, with little or no outreach, training, or communication, and the regulated community was required to comply with the regulation. I know we can do a better job. It's just going to take some effort to change the process or behavior.

We're here to talk about ways to change environmental behaviors. The biggest environmental improvement comes from behavior change, not from command and control enforcement. We don't really have all the command and control tools to enforce in the ag sector, for example non-point source pollution.

Now, let's talk about the process Region 7 used in rolling out the proposed and final CAFO rules.

When the CAFO rule was introduced, the Secretary of Agriculture and former EPA Administrator Christie Todd Whitman made a joint announcement. I believe it is critical to build meaningful relationships among EPA, federal, state and local agencies, and other partners to realize environmental gains.

The rule covers some 11,000 large animal feeding operations nationally, 4,300 of which are in Region 7. The rule, as it stands today, will cut the annual nutrient runoff from CAFOs by about 61 million pounds. We expect it will also cut sediment loads by 1.1 billion pounds. That's quite an environmental benefit.

I'm very proud of the way the roll-out was handled in my

Region. Since agriculture is the largest industry in Region 7, the new CAFO rule affected an incredibly large part of our regulated community. We knew that if we handled the roll-out the way new regulations had been managed in the past, we were going to have a huge problem. So, we decided to be proactive.

Early on, we put together a strategy that involved outreach, holding workshops, training events, and meetings with the ag community. We heard what was said – worked through the problems – and developed a stronger partnership with the ag community.

In the summer of 2002, we listened to the ag community about their concerns. Early in December, we met with industry associations informally on a state-by-state basis, just before the rule came out.

On December 19, 2002, right after the rule was signed, we met with regulated producer associations, USDA, and the state environmental agencies. The revised rule for Concentrated Animal Feeding Operations became effective on April 14, 2003.

We held the meeting in Kansas City, Kansas, and introduced our partners to the details of the Rule. At the meeting, 150 individual state attendees met to determine how to work together to get the word out and to help the regulated community best understand the new regulation.

We knew we needed their networks to help us get the message out, and they knew that having our expertise regarding the Rule would help with clarifying the Rule for their organization members.

We were involved in these outreach activities in order to remove ambiguity about who is covered, and ensure the effective management of manure at the largest CAFOs. We also reminded everyone that as we transitioned to the new rule, we still had an existing rule that we would continue to enforce!

We held approximately 40 outreach meetings throughout Region 7 states.

As EPA, state regulatory agencies, and CAFO operators began the transition into implementing this revised Rule, there was a great deal of outreach and support from EPA and our partners, including USDA, and many farm service organizations. Let me give you a couple of specifics.

In Missouri, we participated in roughly ten meetings related to the revised CAFO regulations. The first was held in early January

2003, to build consensus on an agenda designed to educate producers on the requirements of the CAFO regulations.

Participants included representatives from the Missouri Departments of Agriculture and Natural Resources, producer groups, NRCS, the University of Missouri, and the Missouri Farm Bureau. Outreach meetings were held in six locations across the state. Over 500 producers attended the meetings.

In Nebraska, Region 7 participated in six outreach meetings designed to educate producers on the requirements of the CAFO regulations. Participants included representatives from the Nebraska Department of Environmental Quality (NDEQ), NRCS, the University of Nebraska at Lincoln, and several stakeholder groups.

Similar to Missouri, these outreach meetings were at locations across the state and reached more than 500 producers. You get the pattern.

We also joined the state in a meeting with the Sierra Club to provide an overview of the revised CAFO regulations and Nebraska's plans for permit program revisions.

We sponsored and participated in CAFO Regulations Implementation Workshop in Nebraska City, Nebraska. The focus of this event was to:

- Share current scientific knowledge and resources relevant to implementation of the CAFO regulations;
- to facilitate regional discussions for implementation of CAFO regulations and consistency between state regulatory agencies; and

- to promote communication and possible collaborative activities among technical resource community and regulatory agencies – discussing opportunities for innovation and new technologies for compliance.

Let me switch gears for a minute to discuss Alternative Technologies. When the proposed regulations, which were based on the use of total containment and subsequent land application, appeared to be inflexible regarding the type of technology that could be used, Region 7 opened the lines of communication regarding alternative technologies.

The Rule gives limited opportunity for the use of alternative technology. If it can be shown that another type of system can achieve equivalent results, then the permitting authority may use this alternative system as the basis for writing the NPDES permit. This is not a relaxing of the standard but, on a site-by-site basis, using an alternative system that will achieve the same or better environmental results.

In September 2003, a meeting was held in Des Moines to discuss how alternative technologies could meet the new CAFO Rule requirements. Several groups are working with Iowa State University and other land grant university experts to demonstrate and monitor proposed alternative technologies, and develop models that would support the use of those technologies to satisfy the requirements.

One example of alternative technologies is the application of anaerobic digester systems – These systems:

- cover lagoons
- recover methane for producer energy needs or sale to local

energy grids.

The benefits to the environment include reduced greenhouse gases, odor reduction, possible hydrogen sulfide reduction, and reduced opportunities for the release of pathogens to surface and ground water. (Hosted St. Louis meeting – technical experts ~ ISO.

As you can see, the Region was very involved in rolling out the revised CAFO rule. We took the responsibility to make sure that the regulated community knew what was in the CAFO rule, and what was going to be required to be in compliance with the Rule.

John Silberman talked yesterday about the keys to making the Agency's "Audit Policy" successful – the obligation of leadership, proactive outreach, communication, and availability.

We didn't stop at the signing of the rule. We continue to hold training opportunities, workshops, and meetings as needed. In fact, next month we will be meeting with the state of Iowa regarding their re-written regulations. We need to do more of this kind of collaborative work.

However, all this does not change EPA and the states' responsibilities as enforcers. We know that a key element of compliance is good enforcement. We haven't missed an opportunity to remind operators that we are continuing to enforce our current rule, and we will enforce the new rule as well.

Timely and appropriate enforcement actions result in compliance, not only at a specific facility where the action is taken, but they also act as a deterrent to others in the regulated community. The regulated community wants to stay in compliance with the Rule, thereby avoiding an enforcement action against them.

By its nature, the livestock and poultry industry operates on a pretty narrow margin. Compliance, and avoiding penalties, is an important objective for producers.

All of our efforts resulted in less confusion about the revised CAFO Rule. We also saw better implementation of the Rule. And as a whole, the environment will benefit from the realization of cleaner water. As Administrator Leavitt says – compliance is where we find environmental benefits.

We are taking important steps in Kansas City, but we at EPA know we cannot address these issues effectively on our own. Developing new and enhanced partnerships is becoming increasingly important.

In retrospect, Region 7 gained the benefit of many partnerships being built through this effort. We were able to leverage our outreach resources more efficiently. And, the producers received timely and accurate information regarding the proposed and final CAFO rule requirements.

We intend to take advantage of this as we work on additional ag initiatives – offroad diesel ext; then others.

I hope as I close that you have a better sense of Region 7's priority of developing a better approach to regulation roll-out, fostering mutually beneficial working relationships with the ag sector, and of our sincere desire to produce significant environmental improvements.

Thanks for sharing a portion of your agenda with me–

continued success for the rest of the day.

Corporate Environmental Behavior and the Effectiveness of Government Interventions

PROCEEDINGS OF

SESSION IV: EVALUATION OF VOLUNTARY PROGRAMS

A WORKSHOP SPONSORED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S NATIONAL CENTER FOR ENVIRONMENTAL ECONOMICS (NCEE), NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH (NCER)

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THE ISO 14001 MANAGEMENT STANDARD: EXPLORING THE DRIVERS OF CERTIFICATION

ANDREW A. KING
Tuck School of Business
Dartmouth College
100 Tuck Hall
Hanover, NH 03755
Tel: (603) 646-9185
Fax: (603) 646-1308
andrew.a.king@dartmouth.edu

MICHAEL J. LENOX
Fuqua School of Business
Duke University
PO Box 90210
Durham, NC 27708
Tel: (919) 660-8025
Fax: (919) 681-6244
mlenox@duke.edu

ANN TERLAAK
School of Business
University of Wisconsin-Madison
4261 Grainger, 975 University Ave
Madison, WI 53706
Tel: (608) 262-5227
Fax: (608) 262-8773
aterlaak@bus.wisc.edu

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THE ISO 14001 MANAGEMENT STANDARD:
EXPLORING THE DRIVERS OF CERTIFICATION

Abstract: In this paper, we explore the drivers of certification with the ISO 14001 environmental management standard. Scholars and practitioners debate whether ISO 14001 certification signals superior underlying environmental performance or signifies merely the adoption of specific environmental management practices. Our paper helps to resolve this debate by developing a theory of why and when organizations will choose to certify with ISO 14001. We propose that certification with a management standard will be more likely when it is difficult to communicate credibly environmental practices to supply chain partners. We develop hypotheses concerning the type of information that will be communicated through certification. We empirically investigate our hypotheses using a rich longitudinal database. We find evidence that organizations certify with ISO 14001 to reduce information asymmetries with supply chain partners. In particular, we find that geographically and culturally remote suppliers are more likely to seek certification. We do not find evidence that certification serves as a signal of superior environmental performance. Rather, our findings suggest that suppliers use certification to communicate about environmental improvement efforts. In our conclusion, we discuss the implications of our findings for public policy makers and firm managers. (190 words)

Keywords: institutions, management standards, industry self-regulation, ISO 14001

The use of certified management standards to regulate business activity is of growing interest to academics, business managers, and policy makers. These standards stipulate neither product specifications nor process attributes. Instead, they require and certify the existence of a set of internal organizational practices and routines. For business managers, these standards may increase efficiency or solve inter-firm coordination problems. For policy makers, these standards may provide an alternative to costly government regulation. Prominent examples of certified management standards include the OHSAS 18000 standard (for occupational health and safety), the International Organization of Standardization's ISO 9000 and ISO 14001 management standards (for quality and environmental management), and the Eco-Management and Audit Scheme (EMAS).

In this paper, we explore certification with the ISO 14001 environmental management standard. Sponsored by the International Organization for Standardization (ISO) and designed by an international technical committee (TC 207) comprising more than 500 members, ISO 14001 specifies a set of environmental management guidelines and practices. It creates a system for third-party auditors to certify compliance with the standard. From the outset, the role of this standard has been a source of considerable debate. For example, in testimony before the U.S. Congress, members of the standard setting committee expressed differing expectations. Some suggested that certification would help "to distinguish companies that are doing the bare minimum from those that are committed to environmental excellence" (Morella, 1996). Others noted that "ISO 14001 compliance may become a standard of due care in assessing whether a company was [acting] in good faith" (Mazza, 1996). Still others suggested that the program might provide direct operational advantages (Collins, 1996).

Our paper helps to resolve this debate by developing a theory of why and when organizations will choose to certify with ISO 14001. We propose that certification with a management standard will be more likely when it is difficult to communicate credibly environmental practices to supply chain partners. We develop hypotheses concerning the type of information that will be communicated through certification. We hypothesize that certification will either help buyers choose high performing suppliers or help them monitor performance improvement among existing suppliers. We empirically investigate our hypotheses using a rich longitudinal database. Finally, we discuss the implications of our findings for public policy makers and firm managers.

THEORY & HYPOTHESES

Certified management standards like ISO 14001 include two fundamental elements. First, they codify a set of standard practices and behaviors. Second, they provide a certification system that allows organizations to demonstrate their compliance with these practices and behaviors. Most of the pioneering work on ISO 14001 and similar standards has emphasized the importance of the former element and made use of certification only as a mechanism for measuring the adoption of the specified practices (Corbett & Kirsch, 2001; Delmas, 2002; Guler, Guillen, & Macpherson, 2002). This research has tended to model adoption as a process of institutional pressure or information based contagion.

A handful of recent studies have proposed that *certification* represents a distinct and important element of these standards and fundamentally changes the way the standards are used (Anderson, Daly, & Johnson, 1999; Jiang & Bansal, 2003). These studies suggest that more consideration should be given to how certification could help resolve problems of credible communication. This evidence suggests that managers in organizations may choose to certify with standards such as ISO 14001 when they recognize that asymmetric information could cause inefficient exchange with skeptical supply chain partners (Anderson et al, 1999; Jiang & Bansal, 2003).

Asymmetric information causes two main problems among exchange partners. First, it makes it harder to assess the quality of potential partners (the 'selection problem'). Second, it makes it more difficult to evaluate improvement efforts among existing partners (the 'monitoring problem'). Akerlof (1970) used the pre-owned car market to illustrate how asymmetric information could result in a selection problem. He postulated a market in which sellers have some information about the quality of used autos (maintenance, history, improvements, etc.) that buyers do not. He pointed out that if buyers recognize the possibility that sellers could make false claims of superior quality, buyers would be unwilling to pay a higher price for cars with allegedly higher quality. In response, sellers would withdraw their high quality vehicles, leaving only lemons in the market. As a result, even if both suppliers and buyers would prefer to deal in high quality used cars, this selection problem will cause a market in which only low quality cars are bought and sold.

The second type of asymmetric information problem, the monitoring problem, occurs when asymmetric information makes it difficult to know if agreements have been met. Asymmetric information between suppliers and buyers may make it difficult to observe fully the actions of the supplier (Silverman, Nickerson & Freeman, 1997; Williamson, 1985). For example, a customer that pays a mechanic to do repair work on a vehicle may be unable to determine if the work has been done properly. As with the selection problem, this monitoring problem can cause an inefficient market for goods and services, and thereby harm both suppliers and buyers.

We theorize that certified management standards such as ISO 14001 reduce asymmetric information problems by allowing suppliers to credibly communicate information to buyers. To begin testing our theory, we first seek to uncover whether certification with ISO 14001 occurs more frequently when organizations are likely to have less information about supply chain partners. We then develop hypotheses to distinguish the use of certification to solve the selection or the monitoring problem. We focus our theory on intermediary supply relationships.

Certification and Information Asymmetries

Numerous factors influence the transfer of credible information and thus its distribution among parties. A common finding across many literatures is that the physical distance between two parties is a critical factor (Allen, Lee et al., 1980; Hamilton, Godfrey & Linge, 1979; Katz & Tushman, 1979). Distance reduces information transfer through its direct effect on transfer costs and by its association with other restricting factors (Mariotti & Piscitello, 1995). For example, distance may reduce the number of shared information links and so prevent receiving parties from checking the veracity of information through redundant sources (Lane & Bachman, 1996). Distance may also reduce the frequency of interaction and so reduce the propensity of parties to develop a reputation as a credible source (King, 1999). Empirically, numerous studies in various social settings have documented that information transfer decreases rapidly with increasing physical distance between two parties (Adams, 2002; Allen, Lee, & Tushman, 1980; Hamilton, Godfrey & Linge, 1979).

Given the propensity for physical distance to reduce information transfer and increase asymmetric information, we should expect suppliers to use certification to communication credibly with buyers when buyers are more physically distant.

> *H1a: The more distant an organization is from its buyers, the greater the propensity for the organization to certify with the ISO 14001 management standard.*

Aside from physical distance, social, cultural, and institutional distance can reduce information transfer and increase information asymmetries (Caves, 1982). One explanation is that a shared culture or belief system facilitates the processing of transferred information (Hofstede, 1980). Numerous studies have shown that cultural and physical distance increases the difficulty and cost of selecting and monitoring foreign suppliers (Buckley & Casson, 1979; Hamilton et al., 1979; Kogut & Singh, 1988). Such "liability of foreignness" is one of the central tenants of international business theory (Zaheer, McEvily & Perrone, 1998). Following this tradition, we argue that information asymmetries should be especially high in international supply relationships. As a result, organizations that are more likely to supply foreign buyers will be more likely to certify with a management standard.

> *H1b: The more an organization sells to foreign buyers, the greater the propensity for the organization to certify with the ISO 14001 management standard.*

Certification and Selection

In the above section, we hypothesize that certified management standards like ISO 14001 help resolve asymmetric information problems. We did not explore whether they resolve selection or monitoring problems. In this section, we develop hypotheses consistent with the use of certified management standards to reduce the selection problem, i.e., we consider the potential that buyers use certification to determine which organizations to use as suppliers. Recall that a selection problem occurs when buyers cannot observe underlying product or firm quality. Akerlof's market for lemons exemplifies how this situation can result in inefficient markets. To overcome this inefficiency, sellers (suppliers) may employ signals that allow buyers to differentiate high from low quality suppliers.

Because a certified management standard does not stipulate any outcome requirements (instead, it specifies a set of management practices), it can only provide a signal of superior organizational performance by causing organizations to act in ways that reveal what they know about themselves. It must entice high performing organizations to certify, while dissuading low performing ones from doing so. In his seminal contribution, Spence (1973) used the job market to provide an explanation for how such signaling might function. The idea is that high productivity workers (e.g., more motivated or intelligent people) choose to get a college degree not because they seek to learn something, but because they seek to differentiate themselves from those that choose not to get a degree. Because the cost of getting a degree (studying, writing papers, etc.) is less for high productivity workers than it is for low productivity ones, and assuming that employers are willing to pay a premium to the high productivity workers (once they can identify them), only high productivity workers will obtain a degree. In contrast, a low productivity worker will refrain from seeking a degree since the premium that could be obtained from having a diploma will be less than the cost of acquiring it.

To serve as a signal of superior performance, certification with a management standard like ISO 14001 must follow a similar logic. Specifically, the cost of certifying must be lower for high performing suppliers and buyers must be willing to pay a premium to high performing suppliers. With respect to the first requirement, there are many reasons for buyers to pay a premium to suppliers with higher environmental performance. Environmental problems at the supplier can cause supply disruptions. For example, "in 2001, a refinery fire in Illinois caused shortages lasting for weeks and forced the EPA to temporarily rescind reformulated gasoline requirements in the Chicago area (Slawsky, 2004)." Environmental problems at the supplying organization can damage the reputation of its supply chain partners. For example, it was concern about the practices of suppliers that damaged the reputation of Nike, Starkist, and Unilever (among many others) and caused these organizations to create management practices that their suppliers must follow. Finally, under U.S. CERCLA statutes, supply chain partners can be held responsible for improperly disposed toxic waste (Snir, 2001).

With respect to the second requirement, there are several reasons to believe that environmentally responsible organizations can certify at lower cost. Technical committees (like TC 207 for ISO 14001) seek to make it easier for high performing organizations to certify by designing the management standard so that it includes practices that have been found to improve organizational performance (Collins, 1996). The logic of such a design is that high performing organizations should have implemented some of the required practices and thus need to adopt fewer additional practices to obtain certification (Collins, 1996). Empirical research provides further evidence that certification cost are inversely related to performance (Naveh, Marcus, Allen, et al, 1999). For the ISO 9000 quality management standard (which is the older brother of ISO 14001 and served as a model for its design), Marquardt (1992) observes that certification costs depend on where you start. "If you've just won a Baldridge Award, registration of a plant or business may take you a few days. But if your quality system needs to be improved or created from the ground up the process can take as long as a year and cost $100,000 or more" (Marquardt, 1992: 51). In the case of ISO 14001, a survey found that a majority of respondents felt that leading organizations could certify with ISO 14001 more cheaply than environmental laggards (Ferrer et al, 2003).

The literature on business and environment adds a specific reason to believe that the cost of certification to ISO 14001 should be lower for high performing organizations. Scholars suggest that organizations are responding to environmental pressures in stages (OTA, 1986). They first ignore environmental problems, then perceive them to be a regulatory issue, and only later understand them as a source of strategic advantage (Hoffman, 1997; OTA, 1986). As an organization moves through these stages, its environmental (and potentially economic) performance improves because its response shifts from one emphasizing technical buffers to one emphasizing proactive environmental management (Russo & Fouts, 1997). These theories would suggest that organizations in the later stages of evolution (and thus with higher performance) will be more able to certify with environmental management standards. Bansal and Hunter (2003) indeed find that organizations with better environmental reputation (and presumably performance) were quicker to certify with ISO 14001 than those with lower performance, possibly due to relatively lower certification costs.

The above discussion suggests that some of the conditions are present that would allow certification with ISO 14001 to act as a signal of underlying organizational performance. Whether or not organizations use it in this way is an empirical question. Evidence to support or disconfirm such a signaling theory can best be found by evaluating whether high performing organizations tend to certify. No signaling equilibrium can exist in which low quality suppliers (or all suppliers) certify. If low performance suppliers certified, ISO 14001 would no longer convey superiority, and no supplier would certify because doing so would entail a cost with no benefit (recall that buyers are only willing to pay a premium to certified suppliers if the signal provides credible evidence of superior performance). Thus, if certified management standards act as a market signal, and if we observe any certification at all, we should expect higher performing organizations to have a greater tendency to certify.

> *H2: The higher the environmental performance of an organization, the greater the propensity for the organization to certify with the ISO 14001 management standard.*

Certification and Monitoring

In the above discussion, we assumed that suppliers use certification with ISO 14001 to signal about underlying performance attributes, and that buyers use certification to identify better performing suppliers. The functioning of ISO 14001 as such a signal assumes that the attributes about which certification communicates are stable. It also assumes that buyers can easily switch suppliers and thus have a continuous need to identify high performing suppliers. In this section, we discuss how suppliers may use certification to provide buyers with credible information about performance improvements (rather than performance levels) in existing supply relationships.

Stakeholder-agency theory suggests that institutions for monitoring organizational behavior are needed when stakeholder interests are not aligned with the interests of agents (organizations), and when information asymmetries between stakeholders and agents prohibit direct observation of agents' activities (Hill & Jones, 1992). In the arena of environmental performance, incentives between suppliers and buyers may be misaligned, because some of the cost of poor supplier performance is borne by the buyer. As discussed in the previous section, environmental problems at the supplier can impose costs on buyers through supply disruptions and spill-over reputation damage (Reinhardt, 1997).

As a result of these conditions, buyers have an incentive to encourage suppliers to improve or maintain their environmental performance. Unfortunately, asymmetric information problems may prevent the buyer from providing effective incentives to suppliers. Because environmental improvement efforts usually involve internal processes and management procedures, buyers may be unable to observe actions at supplying organizations. Certification with ISO 14001 may partially resolve this monitoring problem by providing a mechanism for gaining credible evidence of a supplier's due diligence or performance improvements.

The need for monitoring a supplier increases the more the relationship between buyers and suppliers is ongoing. When buyers can easily switch to new suppliers, the selection problem (i.e., the problem of selecting high quality suppliers) is paramount and market pressures provide incentives to suppliers to improve and signal performance. When buyers cannot easily switch to new suppliers, however, buyers seek to motivate and monitor improvement efforts among ongoing suppliers.

Joskow (1988) demonstrated that partner specific specialized assets cause switching costs that determine the degree to which buyers and suppliers have an ongoing vertical relationship (Joskow, 1988; Williamson, 1985). Idiosyncratic firm and facility level differences may determine the extent of these costs. In many cases, however, industry level differences influence the degree organizations tend to have partner specific assets and thus the tendency for these organizations to have an ongoing relationship with supply chain partners (Maddigan, 1981). These industry specific effects have been shown to be both wide-ranging and tractable to measurement (Balakrishnan & Wernerfelt, 1986; Maddigan, 1981). When organizations in an industry tend to have ongoing relationships with their suppliers, and if buyers use ISO 14001 to solve monitoring problems among long term supply partners, we should expect:

> *H3: The more an organization is engaged in ongoing vertical relationships with its buyers, the greater the propensity for the organization to certify with the ISO 14001 management standard.*

Suggesting that a certified management standard can help solve a monitoring problem implies that certification will be associated with some desired organizational activity. In the case of ISO 14001, it seems likely that stakeholders are seeking to monitor the existence of environmental management systems (EMS) and that these systems improve environmental performance. Note that implementation and certification of an EMS are distinct concepts and may occur at different points in time. An EMS represents a set of procedures and guidelines that systemize and control an organization's environmental management process. ISO 14001 stipulates a particular form of an EMS. To be certified with ISO 14001, an organization must have a stated environmental policy, must determine and monitor the environmental impacts of its activities, must set environmental objectives and measurable targets, must monitor actions and take corrective actions where appropriate, and must continuously review this process. An organization could have all of these elements and choose not to certify, it could have all of these elements and choose to communicate their existence by certifying, or it might choose to adopt the elements it lacks in order to certify.

We theorize that certification with ISO 14001 provides a means of credibly communicating about the existence of a performance improving EMS. We are agnostic about whether certified organizations are informing supply chain partners about the existence of a previously adopted EMS, or whether they are adopting additional EMS activities in order to certify. To the extent that certification follows the former logic we should expect that the existence of an EMS is associated with performance improvement and that certification with ISO 14001 will simply reveal this. To the extent that certification follows the latter logic, we should expect to see that ISO 14001 certification itself is associated with performance improvement.

H4a: Adoption of an environmental management system will improve an organization's environmental performance.

H4b: Certification with the ISO 14001 management standard will improve an organization's environmental performance.

DATA & METHOD

We test our hypotheses by examining a sample of 8358 facilities (49413 observations) drawn from the population of U.S. manufacturing facilities from the year 1995 to 2001. Facility data were derived primarily from the U.S. EPA's Toxic Release Inventory (TRI) and Dun & Bradstreet's (D&B) directory of facilities. We also gathered industry-level data from the Bureau of Economic Analysis (BEA) and the Census Bureau of Foreign Trade. We gathered demographic information from the Internal Revenue Service (IRS) and the Census Department. Our sample is limited by the reporting requirements of the TRI. Facilities must report to the TRI if their manufacturing processes generate scrap above certain levels and if they have more than nine employees.

The most recent TRI data extends only to 2001, but data on ISO 14001 certification is available through 2002. Because certification with ISO 14001 did not begin in earnest until 1996, we limit our sample to the years from 1996 to 2002 for the dependent variables (1995 to 2001 for the independent variables) in evaluating the propensity of facilities to certify. In analyzing the effect of management practices and ISO certification on improvement, we extend the panel back to 1994 to allow at least a two-year pretest window.

Measures

Dependent variable. The primary dependent variable for our analysis is certification to the ISO 14001 environmental management standard. We gathered certification data from the QSU database of ISO 14001 certified facilities (QSU, 2002a). Certification occurs at the facility level. We coded *ISO 14001 Certification* as simply whether a facility is ISO 14001 certified during a particular annual period. *ISO 14001 Certification* takes a value of "1" for all certified facilities in a given year and "0" otherwise.

Independent variables. To test Hypothesis 1a, we measured the geographic distance from a facility to the nearest major buyer (*Distance to Buyers*). To calculate this distance, we first used TRI data to gather longitude and latitude information for each facility. We then used the BEA input-output tables to determine the major (largest percentage) buying industry for each selling industry. For each supplying facility (identified by its 4 digit SIC code), we then calculated the great circle distance (in miles) to the nearest member of this buying industry. We take the natural log of this measure to reduce its skew.[1] To test Hypothesis 1b, we created *Foreign Buyers*. This variable measures the degree to which facilities in an industry sell to buyers outside of the United States. It captures the percentage of all goods produced by members of an industry that are shipped to buyers outside of the U.S. We used Input-Output data from the BEA to create this variable.

To test Hypothesis 2, we calculated a facility's environmental performance using the King & Lenox (2000) method of estimated relative pollution among facilities in an industry. The method estimates the relationship between facility size and facility toxic waste generation in each 4-digit Standard Industry Classification (SIC) code and year.[2] We measured the

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[1] To ensure the robustness of this measure, we also calculated an alternative variable that measured the number of such buyers within a 50 mile radius of the facility. Analysis of using the natural log of this count variable confirmed the sign and significance of our results.

[2] For any four-digit SIC Code level, if there was an insufficient number of facilities to estimate the production function, we aggregated to the three-digit code. We were able to estimate production functions at the four-digit level for 99% of the facilities.

standardized residual, or deviation, between observed and predicted waste generation given the facility's size and industry sector.

$$ln(W_{it}) = \alpha_{jt} + \beta 1_{jt} \ln(s_{it}) + \beta 2_{jt} \ln(s_{it})^2 + \varepsilon_{jt} \quad (1)$$

$$Environmental\ Performance_{it} = -\varepsilon_{jt} / \sigma_{jt} \quad (2)$$

where W_{it} is the toxicity weighted sum[3] of all Toxic Release Inventory waste generated by facility i in year t, s_{it} is facility size, and α_{jt}, β_{1jt}, and β_{2jt} are the estimated coefficients for sector j in year t. Size is measured using the number of employees working at facility i in year t. We reversed the sign of the residual to reflect the fact that more waste than predicted for a facility represents lower environmental performance.

To test Hypothesis 3, we measured *Ongoing Vertical Relationship* as the likelihood that a facility is in a long-term relationship with its buyers. To create this variable, we adopted a method similar to that developed by Maddigan (1981) and Balakrishnan & Wernerfelt (1986). First, we used data from the BEA to identify pairs of supplying and buying industries. For each supplying industry in each pair, we then used the entire 1997 D&B database (500,000 facilities) to calculate the percentage of suppliers that was owned by a corporation that also owned a facility in the buying industry.[4] We then used shipment data from the BEA input-output tables to

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[3] To account for toxicity differences in facility waste generation, we weight the 246 toxic chemicals that have been consistently reported in the TRI by their toxicity using the threshold "reportable quantity" (RQ) for an accidental spill as required in the CERCLA statute (See King & Lenox, 2000). We then sum all of the toxicity-weighted was created by a facility to calculate the total waste generation for the facility.

[4] This ownership structure was updated for other years by tracking changes in ownership reported in the TRI.

weight this percentage.[5] We take the natural log of this weighted percentage value to reduce the skew of our final variable. Thus, the final value estimates the log percentage of any dollar produced by each industry (SIC code) that is shipped to a vertically integrated buyer. Previous research suggests that this industry level variable approximates well an industry's propensity to employ long-term contracts or have ongoing vertical relationships with buyers (Balakrishnan & Wernerfelt, 1986; Maddigan, 1981).

To test Hypothesis 4a, we measured the existence of an operating environmental management system by analyzing the reports of pollution reduction activity in the TRI (*EMS*). As part of their annual TRI submission, facilities report changes they have made to the production processes that could reduce waste or control pollution. The types of changes can be broken into two main categories: 1) technical modifications and 2) changes in the environmental management process. Facilities also report the sources of these technical changes. We coded *EMS* as a binary variable indicating whether or not these sources provided evidence of systematized environmental management practices. Sources of change that indicated evidence of an operating EMS are: (1) internal pollution prevention opportunity audits, (2) materials balance audits, (3) participative team management, (4) employee recommendations under a formal company program.

Control variables. Experience with related management standards has previously been shown to influence the tendency for an organization to certify with the ISO 14001 environmental management standard (King & Lenox, 2001). Previous experience may increase a facility's absorptive capacity with respect to management standards. This would allow adoption at lower

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[5] Some supplying-buying industry pairs have greater interaction (according to dollar values shipped) then other pairs, and these differences must be captured to account more accurately for the supply chain relationships.

costs and thereby increase adoption propensities. To account for this tendency, we measured whether a facility participates in the Responsible Care Program. The Responsible Care Program is sponsored by the American Chemistry Council and, like ISO 14001, requires the establishment of environmental management practices. We captured program participation using a binary variable (*RC Member*) that indicates if that facility was owned by a firm that participated that year in the Responsible Care Program. We also created a binary variable (*ISO 9000 Certified)* that is coded such that a "1" indicates any year in which the facility is certified with the ISO 9000 quality management standard. ISO 14001 was modeled after ISO 9000, and the structural resemblance of the two standards may facilitate certification with ISO 14001 subsequent to certification with ISO 9000. We gathered ISO 9000 certification data from the ISO 9000 Registered Company Directory of North America (QSU, 2002b).

Supply chain pressures could influence the tendency of facilities to adopt environmental management practices and to certify. These supply pressures could emanate from both waste and product streams. More specifically, 'buyers' of waste may request their suppliers to adopt environmental practices and certify with ISO 14001 with the expectation that this would make the supplying facility's waste more predictable and less toxic, thereby facilitating waste treatment. To capture the pressures from waste stream partners, we created two binary variables. *Offsite Waste Transfer* indicates whether or not the facility transfers waste to an offsite waste processor that either recycles or treats the waste. *POTW Waste Transfer* measures the potential for regulatory pressure from Publicly Owned Treatment Works (POTW). To create the measure, we determined if the facility sent any waste material to a POTW in each year. A value of "1" indicates evidence of a physical connection to the POTW. To capture the pressures emanating from product supply streams, we created *Auto Supplier*, which is a binary variable that indicates whether or not the facility sells products to automobile assemblers. Ford, GM, and Toyota have all announced that they will give preference to ISO 14001 certified facilities.

Regulatory and stakeholder pressures could also influence the propensity to certify with ISO 14001. To account for these, we created several other control variables. *Industry Waste Generated* measures the degree to which an industry generates toxic waste (and thus is likely to be the target of regulation and stakeholder pressure). It is measured as the mean of the natural log of the toxicity weighted waste generation for all facilities within each 4-digit SIC code. *Regulatory Pressure* measures the stringency of state-level environmental regulation. It is constructed using a measure devised by Meyer (1995) based on the logged aggregate emissions per state over the sum of the Gross State Product in four polluting sectors (chemicals, pulp & paper, textiles, and petroleum products). Research has also shown that local stakeholder pressure is related to the affluence of the surrounding community (Walsh, Rex, & Smith, 1993). To measures the *Affluence* of citizens in the area surrounding a facility, we calculated the annual average local income using IRS data on the 5-digit zip code area. Scholars have argued that the Responsible Care initiative could reduce stakeholder pressure on an industry by reducing the likelihood of regulatory action. To control for this potential effect we also measured the annual percentage of the facilities in the industry (*RC Industry*) that participate in the Responsible Care initiative.

Finally, a number of firm and facility attributes could influence a facility's decision to certify. A facility's size could influence the availability of resources and thus its propensity to adopt an environmental management system or certify with ISO 14001. We measure *Facility Size* as the normalized (by industry and year) log of the number of employees at that facility. Foreign ownership could also influence the propensity for certification. Foreign parents may use certification as a means to monitor their overseas facilities. Foreign parents may also require certification of their international facilities in an attempt to standardized practices across facilities. We created a binary variable that measures whether a U.S. facility is owned by a foreign parent (*Foreign Owned*). Foreign ownership was determined using D&B's Who-Owns-Whom dataset. In some cases, the database did not list a nationality. For these, we individually verified the nationality of the ultimate parent. We coded the variable *Foreign Owned* to be "1" if the ultimate parent firm is non-U.S. owned, "0" if it is U.S. owned. Common corporate ownership of buyers and suppliers could influence the propensity for certification since vertical integration can reduce market incentives and thereby increase the need for monitoring. Alternatively, common ownership may facilitate information transfer between supplier and buyer, thereby reducing the need for certification. We created a binary variable, *Vertically-Integrated Buyer*, to capture these potential effects. The variable takes on a value of "1" if at least one potential buyer of the facility's output (as determined by the BEA input-output tables) has the same corporate parent as the facility. Finally, *Firm Size* measures the annual count of the number of facilities owned by the target facility's parent. The count is logged to reduce the skew of the distribution.

Table 1 summarizes our measures and provides the pair wise correlation between variables.

Insert Table 1 about here

Method

Our analysis requires evaluation of a facility's propensity to certify with the ISO 14001 standard. It also requires that we evaluate the effect of environmental management practices.

For the first analysis, we use a discrete time random effect logistic model. For each facility, we predict certification with ISO 14001. As soon as a facility is certified, we no longer consider it in our sample, as it is no longer at risk to certify. The model is specified as:

$$P_{it+1} = F(Z) = F(a_i + \mathbf{bX}_{it}) = e^{(Z_{it})}/(1 + e^{(Z_{it})})$$

where P is the probability that facility i will certify with ISO 14001 in the next year (t+1). The vector $\mathbf{X}_{it}$ represents the characteristics of the i^{th} facility in year t. The facility random effects are measured as a_i. We use a random, rather than a fixed effect specification because the fixed effect model would disregard all observations that do not certify with ISO 14001 within our panel. Furthermore, a fixed effect specification would prohibit the interpretation of any variables with values that do not vary across groups (or time). To investigate the robustness of our model specification, we also employed a maximum likelihood proportional hazard model (with an exponential base-line hazard) and a Cox's non-parametric partial-likelihood estimation procedure. The Cox estimation is inefficient, but does not require specification of a particular functional form of the base line hazard. These robustness checks generate results that confirm the reported ones in coefficient sign and significance.

Our model includes a potential selection problem. It is possible that some unobserved disturbance causes both the decision to adopt an EMS and to certify with ISO 14001. For example, organizations with a particular culture or leadership might tend to adopt both. Even if EMS is included in a second stage regression, this disturbance term will tend to bias coefficient estimation. Unfortunately, solving this problem in a logistical regression analysis of panel data is on the frontier of statistical knowledge. For all but a few cases of simple attrition, correcting for selection in panels longer than two periods remains impractical (Honore & Kyriazidou, 2000; Kyriazidou, 2001).

To address the selection problem, we therefore chose to shrink the panel to a cross section to eliminate the panel analysis problem and to allow use of estimation techniques with normally distributed disturbance terms. We use the approach developed by van de Ven and van Praag (1981) which specifies a selection model (adoption of an EMS) and a probit model (certification with ISO 14001).

$$\text{Prob(ISO=1)} = \text{prob}(\mathbf{B}\mathbf{x}_i + \upsilon_{1i} > 0) \quad (4)$$

$$\text{Prob(EMS=1)}=\text{prob}(\mathbf{Z}\mathbf{x}_i + \upsilon_{2i} >0) \quad (5)$$

where **B** & **Z** are separate coefficient vectors and $\mathbf{x}_i$ is our set of explanatory variables. The two disturbance terms υ_{1i} and υ_{2i} are assumed to be bivariate normally distributed but correlated ρ. Using methods developed by Heckman (1979) and van de Ven and van Praag (1981), both the coefficients and this correlation can be calculated either through a two stage procedure or through a single maximum likelihood estimation. We employ the second approach.

Finally, we use a differences-in-differences approach to analyze the effect of environmental management systems on environmental performance. This approach vastly reduces the propensity for unobserved organizational attributes to bias estimates and cause spurious findings. Specifically, we estimate:

$$y_i\,(t+1) = \mathbf{B}[y_i(t),\mathbf{x}_i(t)] + \delta_i + \varepsilon_i \quad (6)$$

where *i* index the facilities, y_i is the facilit*y*'s environmental performance, **B** is a vector of estimated coefficients, $\mathbf{x}_i$ is a vector of measured facility level attributes, δ_i is dummy variable capturing unmeasured facility fixed attributes, and ε_i is the error term. Because of the lagged independent variable, this formulation is prone to autocorrelation. We use a method developed by Anderson and Hsiao (1982) to correct for this potential problem.

Our sample is a large one and this can cause an inflated tendency to reject the Null hypothesis. Previous research using large samples has tended to correct for this by reporting significance only for $p < 0.01$ and $p < 0.001$.

ANALYSIS & RESULTS

Analysis of Certification

Table 2 presents the first part of our analysis of the causes of certification with the ISO 14001 environmental management standard. Model 1 presents estimates for a baseline specification that includes only our control variables. The estimates suggest that the propensity to certify with ISO 14001 is greater in the presence of related practices (*ISO 9000 Certified*), supply chain pressures (*POTW Waste Transfer, Auto Supplie*r), and larger facility and firm size. Interestingly, *RC Industry* is associated with a lower propensity to certify, suggesting that a high degree of participation in Responsible Care among firms in an industry may reduce the need for ISO 14001 certification. Furthermore, facilities that have foreign parents (*Foreign Owned)* are more likely to certify with ISO 14001. We also find that vertical integration between a facility and its buyers (*Vertically-Integrated Buyer*) increases the propensity to certify. Finally, facilities with existing environmental management systems (*EMS*) are more likely to certify, presumably to take credit for previously pursued activities. (Note that we include *EMS* as a control variable in Table 2. *EMS* will become an independent variable as we test Hypothesis 4a).

In Model 2, we add our measures capturing the likelihood of information asymmetries and the need for signaling and monitoring. The addition of these independent variables in Model 2 provides a significant increase in the explanatory power over the base case (as indicated by a significant incremental χ^2 test). Coefficients estimated in Model 2 support Hypotheses 1a, 1b, and 3. Consistent with H1a, we find that the propensity for a facility to certify with ISO 14001 increases with greater distance between the facility and its buyers. Consistent with H1b, we find that a facility's propensity for certification increases with the tendency of the industry to export to foreign buyers[6]. Taken together, these results suggest that certification with ISO 14001 is more likely if information asymmetries in the supply chain are high, thereby supporting our proposition that facilities use certification to reduce asymmetric information with buyers.

Insert Table 2 about here

Turning now to whether facilities use ISO 14001 to help resolve problems of asymmetric information in selection or monitoring, we find support only for the monitoring hypothesis. We find no significant evidence that superior environmental performance (i.e., relative facility waste generation) positively influences certification propensities. Thus, we have no evidence that ISO 14001 is operating as a signaling mechanism. We do find consistent evidence that ISO 14001 certification may act as a monitoring device. With respect to Hypothesis 3, we find that the coefficient for *Ongoing Vertical Relationship* is positive and strongly significant, suggesting that the greater the likelihood that a facility is in an ongoing vertical relationship with its buyers, the higher the propensity for ISO 14001 certification.

Interestingly, our analysis provides hints that asymmetric information between corporate parents and local facilities may also be an important driver of certification. Throughout our analysis, we find evidence that foreign owned facilities are more likely to certify with ISO

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[6] To ensure that this effect was not caused by exports to particularly environmentally sensitive regions, we investigated the effect of exports to different regions. We could find no evidence that exports to Europe, Australia, Asia, or Central America had a different effect on certification than exports to North America (Canada and Mexico).

14001. Information asymmetries between foreign parents and domestic facilities may have caused facility managers to seek certification in order to signal to corporate parents about their management abilities. We also find that *Vertically-Integrated Buyer* – one of our control variables - consistently and significantly increase certification propensities. This suggests that suppliers that are vertically integrated (i.e., commonly owned) with their buyers are more likely to certify with ISO 14001. This finding lends further support to Hypothesis 3. It suggests that the move towards integrated governance structures (like long term contracts as hypothesized in H3 or hierarchy as captured by this control variable) is associated with greater monitoring needs (due to higher switching costs and lack of market incentives), thereby triggering certification.

To explore the potential for confounding unobserved industry effects, we include two-digit SIC code fixed-effects in Model 3. Our results are consistent with Model 2. With the exception of *Foreign Buyer*, the coefficients for the variables of concern remain significant at a minimum of $p<0.01$. The inclusion of industry fixed-effects does reduce the significance of *Foreign Buyer* but does not change the coefficient estimate. Since *Foreign Buyer* is an industry level variable (calculated on the 4-digit SIC code level), co-linearity with industry fixed-effects may cause its significance to drop if the variable varies little across two-digit SIC codes. Note that an incremental χ^2 test suggests that the inclusion of industry fixed-effects does not improve model fit, suggesting that we have no evidence of other unobserved industry effects – at least as captured at the two digit SIC code.

Separating Adoption and Certification

Similar industry and organizational attributes might determine the propensity both to adopt environmental management practices (systems) and to certify with ISO 14001. If we fail to capture in our right hand side variables some factors that explain both adoption and certification, our analysis of the causes of certification could be biased. To account for these missing factors and correct this problem, we perform a two-stage estimation. In the first stage, we estimate the facility and industry attributes that are associated with a higher propensity to have an environmental management system (EMS) in place.[7] In the second stage, we estimate which facilities are likely to certify with ISO 14001. This method also has the appealing property that it allows us to analyze the factors that cause adoption of EMS practices and compare these factors with those that cause certification.

As explained in the methods section above, this two-stage estimate requires us to collapse our data into a cross-section so that we can use a probit specification. To check that such conversion from a panel to a cross-section does not change our results, we first estimate a model similarly to Model 3 (in Table 2) using our collapsed panel. We report the results of this Model (Model 4) in Table 3. Note that because some facilities enter the panel after 1996, collapsing the panel reduces our data set to 7899 facilities. The estimates from our probit model in Model 4 are similar in direction and significance to those in Model 3 in Table 2. We continue to find a significant positive effect for *Distance to Buyer*, *Foreign Buyer*, *Ongoing Vertical Relationship*, *Vertically-Integrate Buyer,* and *EMS*. Our estimate for *Environmental Performance* remains negative and is now significant at the $p < 0.01$ level.

Insert Table 3 about here

We present the results of our two-stage analysis in Model 5 in Table 3. The first column

[7] We use the idea of stages for expository convenience. In the actual analysis the two stages are calculated simultaneously using a maximum likelihood estimator.

reports the likelihood that a facility will have an EMS. The estimates from this "selection model" are then used to correct for potential unobserved attributes that might bias our estimates in the second stage probit model. Due to the particular structure of this technique, the second stage estimates reported in Model 5 for ISO 14001 certification are based only on data from those facilities that had an EMS prior to 1996 (reducing our sample to 3300 facilities). An alternative specification using only those that did not have such an EMS delivered similar results.

Estimates from this model (see the far right column in Table 3) confirm the findings presented in Table 2. We again find support for both H1a and H1b – facilities with more distant and more foreign buyers are more likely to certify. We again find support for our hypothesis that certification will be higher for facilities in industries with ongoing vertical relationships with buyers (H3). Finally, we find strong evidence to disconfirm Hypothesis 2 – facilities with lower (not higher) environmental performance are more likely to certify.

Our two-stage approach allows us to differentiate the sources of EMS adoption from the causes of certification. Comparing the two columns of Model 5, some important differences appear. In general, we find that technical, regulatory, and experience differences explained differences in the tendency to have an EMS. In contrast, factors influencing the need for communication with buyers about improvement efforts influenced certification.

Specifically, as shown in Table 3 column 2, technical and regulatory differences strongly influence EMS adoption (but less so certification with ISO 14001). *Regulatory Pressure* and *Industry Waste Generation* have a significant effect on implementing an EMS. Likewise, facilities that transfer waste to public or private outside processors (*Offsite Waste Transfer, POTW Waste Transfer*) tend to have an EMS. This pattern of results seems to suggest that facilities facing greater demand from regulators or waste handling stakeholders tend to adopt an EMS. This may suggest greater ability among these stakeholders to directly monitor EMS activities and environmental performance. In contrast, only *Offsite Waste Transfer* has a significant effect on ISO 14001 certification. Unlike in Model 3, *POTW Waste Transfer* is no longer significant, suggesting that the results found in Table 2 may have been confounded by an unobserved EMS selection problem.

Consistent with previous studies (King & Lenox, 2001), we find that ISO 9000 certification is associated with the adoption of environmental practices – in this case a functioning EMS. We also find evidence that *Responsible Care Participants* are more likely to have an operating EMS, but can find no evidence that these facilities have a higher propensity to certify with ISO 14001. This seems to suggest that participants in the Responsible Care program are indeed implementing some of the associated environmental management practices. However, we find evidence that facilities in industries with many RC participants have a lower propensity to certify with ISO 14001 -- suggesting that conflicts or substitution exist between the two programs.

Our results suggest that organizations with lower relative environmental performance are more likely to implement an EMS. The implementation of a formal management system may reflect a desire to catch up among industry laggards. Interestingly, we find that suppliers that tend to have *ongoing vertical relationships* with their buyers are less likely to adopt an EMS. This is consistent with our hypothesis that without a credible means of monitoring actions at suppliers, buyers have difficulty encouraging real investments in performance improvement. Our other independent variables (*Distance to Buyers, Foreign Buyer*, and *Vertically Integrated Buyer*) have no significant effect on adopting an EMS.

Performance Improvement Analysis

We can now turn to testing our final hypotheses in support of a theory that ISO 14001 allows buyers to monitor improvement efforts at suppliers. To analyze whether EMS adoption or ISO certification is associated with improvement (H4a and H4b), we specify a cross sectional time series regression predicting waste generation in the next year (see Model 6 in Table 4). We include facility and year fixed effects to control for underlying facility heterogeneity and time effects. Because we also control for this year's waste generation, this model represents a form of the highly conservative and robust differences-in-differences approach. We also include a log count of the number of non-management source reduction changes reported for each facility (*Pollution Reduction Activity*). This variable uses TRI information.[8] To ensure robustness, it was coded in three different ways: 1) as a binary variable, 2) as a count variable, and 3) as a log count variable. The reported results use the last formulation but the sign and significance of the reported results are robust to all formulations. Including this variable helps to ensure that our measure of EMS does not simply reflect change activities.

We find that the existence of an EMS in year t is associated with significant increases in environmental performance in year t+1 (H4a). With respect to Hypothesis 4b, we do not find significant evidence that certification is associated with such improvement. The coefficient for ISO 14001 certification is significant at only the $p<0.05$ level. In a sample of this size, such a finding must be viewed with great caution. Thus, we have strong support that adoption of an

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[8] Source of change that indicated technological change activity included external pollution prevention opportunity audits, employee recommendations independent of a formal company program, state and federal government technical assistance programs, trade association/industry technical assistance programs, and vendor assistance.

EMS provides evidence of improvement, but we do not find evidence that certification itself is associated with improvement.

Insert Table 4 about here

This lack of evidence may suggest that ISO certification does not itself cause improvement but merely provides credible evidence of an underlying and possibly pre-existing EMS that causes improvement. We should be careful, however, not to commit a type-II error and confuse a lack of a finding with disconfirming evidence. The short timeframe over which most organizations have been certified makes it very difficult to estimate ISO 14001 generated improvements. For now, all we can say is that a facility's certification with ISO 14001 is associated with having an EMS (both logically and statistically), and having an EMS is itself related to improvement.

DISCUSSION

In summary, we find evidence that organizations certify with ISO 14001 to reduce information asymmetries with supply chain partners. In particular, we find that geographically and culturally remote suppliers are more likely to seek certification. We do not find evidence that certification serves as a signal of superior environmental performance. Rather, our findings suggest that suppliers use certification to communicate about environmental improvement efforts. Specifically, we find that in the face of high switching costs and in the absence of market incentives - aspects that are inherent in more integrated governance structures like long term contracts or vertical integration – certification may serve to fulfill the greater need for monitoring supplier behavior.

Our results are robust to a large number of controls and specifications. We attempt to control for unobserved heterogeneity by including industry and year fixed-effects. We utilize a two-stage selection model to address potential concerns about self-selection. While we only investigate one certified management standard, our sample covers a wide number of industries, which gives us greater confidence in the external validity of our findings.

Despite our conservative approach to our analysis and our robustness tests there are reasons to interpret our findings cautiously. Scale and chemical emission thresholds for reporting to the Toxic Release Inventory could cause a potential sample selection problem. Our sample may fail to pick up facilities with superior environmental performance that are not required to report to the TRI. We have investigated this problem statistically and believe our results to be robust. Nevertheless, we believe care should be exercised in extrapolating our findings to predict the behavior of firms of all sizes and industries.

Another potential confound is that we measure the existence of an EMS through a facility's report on pollution reduction activities. This could cause a measurement error for facilities that have an environmental management system in place but do not routinely make changes to production processes or that have made a number of pollution reducing improvements in the past and no longer have the need to further reduce pollution levels. Fortunately, the effect of this bias should be conservative, because it should make it harder to find a relationship between adoption of an EMS and improvements in environmental performance.

Finally, ISO 14001 is still in its relatively early stages of diffusion. As the standard diffuses and more facilities seek certification, the profile of those seeking certification may change. In particular, as the number of ISO 14001 certifications rises, the pressure on non-certifiers to certify will likely increase. As these pressures increase, the marginal costs and benefits will shift such that organizations that face relatively low information asymmetries may seek certification. While this does not contradict our fundamental thesis that the desire to monitor and communicate about behavior is driving certification decisions, it suggests caution in extrapolating our analysis to all temporal periods of the adoption process.

CONCLUSION

In this article, we explore the drivers of ISO 14001 certification and we answer specific questions about how this certified management standards may function. We theorize that certification with ISO 14001 provides one way of reducing asymmetric information. We develop hypotheses for when organizations will use certification to communicate credible information to supply chain partners. We then explore what kind of information is conveyed by certification.

Our findings suggest that organizations certify with ISO 14001 to overcome problems of asymmetric information. We find that certification does not provide evidence of superior organizational performance (as expected by many of its creators). Instead, we find evidence that suppliers use certification to communicate improvement efforts to long-term supply chain partners (buyers).

Our research should not be interpreted to support an overly simplified functionalist notion of the ISO 14001 standard. Evidence suggests that many of the framers of this new standard expected it to serve a different social purpose than it came to have. Many expected ISO 14001 to provide a means of credibly differentiating organizations with better environmental performance (Mazza, 1996). Our analysis suggests that this expectation went unfulfilled. Yet it also suggests that the standard came to play an alternative functional role.

Our research emphasizes a fundamental paradox in the design of certified management standards like ISO 14001. It suggests that standards that include beneficial practices may seldom act as a market signal. For a certified management standard to be useful as a market signal, high performing organizations must benefit from certification, while low performers must not. If low performers gain significant operational benefits from certifying, this condition will not hold. Moreover, if supply chain partners target their incentives to organizations where improvement can most easily be achieved, they may tend to encourage the worst performers to adopt and certify. Thus, our research suggests that the more an environmental management standard provides direct operational benefits, the less likely it will provide a means of signaling superior performance.

Our findings suggest avenues for future research. First, our analysis suggests the need for additional consideration of the design of management standards. In future research, we hope to analyze other attributes that cause standards to function either as a tool for improvement or as a means to signal. Second, future research could extend our analysis to other stakeholder relations. Our study focused on the potential of management standards to address problems of asymmetric information within supply chains but provides hints that management standards may also play a critical role in reducing information asymmetries within firms. We found that facilities in larger corporations and those that were foreign owned tended to certify with ISO 14001. This may suggest that managers use certification as a signal in the market for corporate resources, or that corporate parents employ certification as a means to monitor their facilities. Future research should assess how certified management standards are used within firms, and whether internal use alters their function.

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TABLE 1a
Descriptive Statistics

Variable	Description	Mean	Std Dev	Min	Max
Distance to Buyers	Log of geographic distance to nearest buyer	2.23	1.29	0	6.22
Foreign Buyers	Log percent of industry production shipped to buyers outside the U.S.	1.42	0.75	0	4.06
Environmental Performance	King & Lenox (2000) measure of environmental performance	-0.06	0.98	-4.34	4.08
Ongoing Vertical Relationship	Log of industry percentage of suppliers with vertically integrated buyers.	0.37	0.34	0	2.39
$EMS_{(t-1)}$	Binary variable indicating existence of an environmental management system	0.46	0.50	0	1
Responsible Care Participant	Binary variable indicating facility owned by a member of Resp. Care	0.09	0.29	0	1
ISO 9000 Certified	Binary variable indicating ISO 9001 certification	0.25	0.43	0	1
Offsite Waste Transfer	Binary variable indicating the facility transfers waste offsite (not to POTW).	0.83	0.37	0	1
POTW Waste Transfer	Binary variable indicating a facility is connected to public water treatment	0.34	0.47	0	1
Auto Supplier	Binary variable indicating facility supplies the automotive industry	0.06	0.24	0	1
Industry Waste Generation	Log average total waste generation for sector in which the facility operates	4.84	1.46	1.15	11.89
Regulatory Pressure	The regulatory stringency of the facility's state.	0.13	0.02	0.11	0.21
Affluence	Average family income within the facility's zip code.	10.2	0.28	6.16	13.11
RC Industry	Percentage of facilities in industry that are owned by RC members.	0.09	0.12	0	0.67
Facility Size	Natural log of facility employees. (normalized by industry and year)	0.07	0.95	-4.79	5.73
Foreign Owned	Binary variable indicating that a facility is foreign owned	0.04	0.20	0	1
Vertically-Integrated Buyer	Binary variable indicating a potential buyer shares the same corporate parent	0.58	0.49	0	1
Firm Size	Count of firm facilities	1.49	1.43	0	5.32

n = 49413

TABLE 1b
Descriptive Statistics: Correlations

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Distance to Buyers	1.00																	
2. Foreign Buyers	0.00	1.00																
3. Environmental Performance	-0.01	0.00	1.00															
4. Ongoing Vertical Relationship	-0.05	0.26	0.01	1.00														
5. $EMS_{(t-1)}$	0.01	0.11	-0.11	0.02	1.00													
6. Responsible Care Participant	-0.04	0.13	-0.04	0.15	0.14	1.00												
7. ISO 9000 Certified	0.01	0.17	-0.04	0.09	0.11	0.12	1.00											
8. Offsite Waste Transfer	-0.02	0.01	-0.17	-0.04	0.13	0.03	0.10	1.00										
9. POTW Waste Transfer	-0.03	0.06	-0.05	0.02	0.12	0.02	0.09	0.32	1.00									
10. Auto Supplier	0.09	0.12	-0.01	-0.03	0.02	-0.06	0.03	0.05	0.06	1.00								
11. Industry Waste Generation	0.00	0.21	0.02	0.46	0.13	0.24	0.03	0.04	0.04	0.00	1.00							
12. Regulatory Pressure	-0.16	-0.07	0.05	-0.05	0.01	-0.05	-0.01	0.06	0.05	-0.04	-0.09	1.00						
13. Affluence	-0.12	0.04	0.01	-0.03	0.04	0.02	0.04	0.05	0.04	0.00	-0.02	0.15	1.00					
14. RC Industry	-0.07	0.29	0.00	0.33	0.13	0.44	0.07	-0.02	0.01	-0.13	0.55	-0.09	0.02	1.00				
15. Facility Size	0.03	0.01	0.00	0.00	0.16	0.12	0.16	0.14	0.13	0.00	0.00	-0.04	0.04	0.00	1.00			
16 .Foreign Owned	-0.02	0.04	-0.02	0.03	0.06	0.05	0.04	0.05	0.01	-0.02	0.06	-0.02	0.05	0.20	0.04	1.00		
17. Vertically-Integrated Buyer	0.07	0.20	-0.07	0.15	0.12	0.23	0.16	0.10	0.06	0.08	0.14	-0.11	0.00	0.15	0.21	0.12	1.00	
18. Firm Size	0.06	0.17	-0.06	0.15	0.14	0.34	0.13	0.09	0.07	0.10	0.18	-0.13	-0.01	0.21	0.22	0.14	0.58	1.00

n = 49413

TABLE 2. Predicting Certification with ISO 14001, 1996-2002
(Discrete Time Random Effect Logistic Model)

	Model 1		Model 2		Model 3	
Distance to Buyer			0.09	*	0.08	*
			(0.03)		(0.03)	
Foreign Buyer			0.19	*	0.15	
			(0.06)		(0.07)	
Environmental Performance			-0.09		-0.09	
			(0.04)		(0.04)	
Ongoing Vert. Relationship			0.51	**	0.66	**
			(0.13)		(0.14)	
$EMS_{(t-1)}$	0.33	**	0.32	**	0.31	**
	(0.09)		(0.09)		(0.09)	
Responsible Care Participant	-0.29		-0.26		-0.27	
	(0.16)		(0.17)		(0.17)	
ISO 9000 Certified	0.80	**	0.72	**	0.72	**
	(0.08)		(0.09)		(0.09)	
Offsite Waste Transfer	0.29		0.30		0.36	
	(0.17)		(0.17)		(0.18)	
POTW Waste Transfer	0.28	*	0.27	*	0.27	*
	(0.09)		(0.09)		(0.09)	
Auto Supplier	1.45	**	1.42	**	1.41	**
	(0.10)		(0.11)		(0.22)	
Industry Waste Generation	0.03		-0.02		0.01	
	(0.03)		(0.04)		(0.04)	
Regulatory Pressure	-4.11		-2.33		-2.27	
	(2.99)		(3.03)		(3.07)	
Affluence	0.09		0.16		0.15	
	(0.15)		(0.15)		(0.16)	
RC Industry	-2.57	**	-2.87	**	-3.09	**
	(0.53)		(0.54)		(0.61)	
Facility Size	0.36	**	0.38	**	0.38	**
	(0.05)		(0.05)		(0.05)	
Foreign Owned	0.65	**	0.72	**	0.66	**
	(0.17)		(0.17)		(0.17)	
Vertically-Integrated Buyer	0.48	**	0.42	**	0.41	**
	(0.12)		(0.12)		(0.12)	
Firm Size	0.19	**	0.18	**	0.18	**
	(0.03)		(0.03)		(0.03)	
Constant	-5.50	**	-6.74	**	-6.89	**
	(1.54)		(1.59)		(1.62)	
Year Dummies	included		included		included	
Industry Dummies					included	
Log Likelihood	-2756.15		-2736.62		-2727.86	
Δ Chi square	-		39.07 (4)[oo]		17.51 (13)	
(Nested Comparison Model)	(constant)		(Model 1)		(Model 2)	

Number of facilities = 8358; Number of observations = 49413

** p < 0.001; * p< 0.01; [oo] Change in Chi square significant at p<0.01

TABLE 3. Predicting Certification with ISO 14001, 1995 cross section
(Probit and Heckman Corrected Probit Models)

	Model 4	Model 5	
	ISO 14001 Certification	EMS (Selection)	ISO 14001 Certification
Distance to Buyer	0.06 **	0.01	0.07 *
	(0.02)	(0.06)	(0.03)
Foreign Buyer	0.12 *	0.06	0.21 **
	(0.04)	(0.07)	(0.07)
Environmental Performance	-0.10 **	-0.15 **	-0.17 **
	(0.02)	(0.02)	(0.04)
Ongoing Vertical Relationship	0.34 **	-0.14 *	0.34 *
	(0.08)	(0.06)	(0.12)
$EMS_{(t-1)}$	0.15 *		
	(0.05)		
Responsible Care Participant	-0.12	0.21 **	-0.07
	(0.09)	(0.06)	(0.13)
ISO 9000 Certified	0.11	0.17 **	0.17
	(0.07)	(0.05)	(0.09)
Offsite Waste Transfer	0.24 **	0.24 **	0.43 *
	(0.08)	(0.04)	(0.14)
POTW Waste Transfer	0.13 *	0.16 **	-0.07
	(0.05)	(0.03)	(0.07)
Auto Supplier	0.85 **	-0.22	0.99 **
	(0.14)	(0.11)	(0.18)
Industry Waste Generation	0.03	0.14 **	0.04
	(0.02)	(0.02)	(0.04)
Regulatory Pressure	-0.49	3.97 **	0.23
	(1.63)	(1.00)	(2.25)
Affluence	0.10	0.06	0.09
	(0.08)	(0.06)	(0.12)
RC Industry	-1.40 *	-0.52	-1.62 *
	(0.32)	(0.20)	(0.44)
Facility Size	0.19 **	0.17 **	0.20 *
	(0.03)	(0.02)	(0.04)
Foreign Owned	0.31 *	0.06	0.25
	(0.10)	(0.07)	(0.14)
Vertically-Integrated Buyer	0.20 *	0.03	0.26 *
	(0.07)	(0.04)	(0.10)
Firm Size	0.08 **	0.05 **	0.06 *
	(0.02)	(0.01)	(0.03)
Industry Dummies	included	included	included
Observations	7899	7899	3300
Rho[9]			0.08
Chi Square	629.85 **		297.50 **

** p<0.001, * p< 0.01, [+] SIC 22 and SIC 39 removed because perfectly predicts no ISO certification

[9] *Rho* is the correlation between the disturbance terms in the selection and certification models. That this correlation is not statistically significant does not preclude the potential for biased estimates in uncorrected analyses.

TABLE 4. Predicting Environmental Performance, 1995-2002
(Fixed-Effects Specification)

	Model 6	
$EMS_{(t-1)}$	0.04	*
	(0.01)	
ISO 14000 $Certification_{(t-1)}$	0.03	
	(0.02)	
Environmental Performance $_{(t-1)}$	-0.35	**
	(0.00)	
Pollution Reduction Activity $_{(t-1)}$	-0.02	
	(0.01)	
Year Dummies	included	
Facility Dummies	included	
N	54138	
Facilities	10080	
F-stat	662.05	**

** $p<0.001$, * $p<0.01$

Participation in Voluntary Programs,

Corporate Reputation, and Intangible Value:

Estimating the Value of Participating in EPA's ENERGYSTAR® Program

Lou Nadeau,
Eastern Research Group

Jeff Cantin,
Eastern Research Group

and

Richard Wells,
The Lexington Group

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Abstract

This paper estimates the market value of the ENERGYSTAR® Buildings program to companies that participate in the program and the market value associated with energy efficiency in general. To do this, we specify econometric models of the relationship between intangible value, as measured by Tobin's *q*, and participation in the ENERGYSTAR® Buildings program. As part of our modeling effort, we also attempt to control the influence of two unobservable factors: corporate reputation and a company's "inherent" energy efficiency. We use data on 124 Real Estate Investment Trust (REITs) measured quarterly from 1999 to 2001. Our results indicate ENERGYSTAR® partnership results in a return of $16,026 per million dollars in assets owned, compared to not being a partner. This return represented 3.66 percent of the market value of these companies. Additionally, our models indicate that energy efficient REITs earn a return of $45,564 per million dollars of assets owned above less energy efficient REITs. The return for energy efficiency represented 10.4 percent of the market value of these companies. Finally, we estimate the "lost opportunity" of not joining the ENERGYSTAR® Buildings program (i.e., the value non-participants would have earned if they had joined). In the sample of REITs, 121 were not a partner for at least one quarter. Of these 121, 50 would have been better off as an ENERGYSTAR® partner at some point during the sample period. Of these 50, 20 of them would have been better off for the entire sample period. Furthermore, the lost value from not joining represented close to 10 percent of the asset value of these companies.

1. Introduction

In the past decade voluntary environmental programs have been increasingly utilized as a public policy tool because they provide greater flexibility than traditional command-and-control regulations and they enable public agencies such as the U.S. EPA to influence corporate decision-making in areas where they do not have a statutory mandate. One of the key challenges facing voluntary environmental programs is how to quantify the program's value to participants. In this paper, we develop a model that relates participation in the EPA ENERGYSTAR® Buildings Program to Tobin's *q*, a measure of corporate intangible value. We develop statistical models to explore this relationship and then estimate the value of the ENERGYSTAR® program to participants and the market value of energy efficiency in general.

The lack of evidence that a link in fact exists between participation and firm financial performance affects program recruitment efforts. By definition, voluntary programs rely on firms to make commitments to join the program. Although some companies may join voluntary environmental programs out of altruistic reasons, reliance on such altruism is not a viable strategy to increase and maintain program membership. Most companies will require some benefit to participation, whether it be tangible or intangible. Without some benefit, managers of public companies may be violating their fiduciary responsibility to shareholders if the programs result in significant cost for the companies. Prior evaluations of voluntary programs have cited "reputational value" as one of the key benefits reported by program participants (e.g., Wells, 2000; Reed, 2001). Still other studies have noted that public perception, a key component of reputation, has a significant influence on the decision to join voluntary programs (Khanna and Damon, 1999; Videras and Alberini, 2000; Arora and Cason, 1995, 1996). Companies report that they are able to translate their participation in such programs—and any associated public recognition—into an enhanced corporate reputation, which has a real (albeit intangible) value to them (Wells, 2000).

Public programs such as ENERGYSTAR® now operate in a period of increased emphasis on accountability. Voluntary programs can no longer rely on numbers of participants as a measure of success, but must now demonstrate positive results. For ENERGYSTAR®, key results would include reductions in greenhouse gases associated with the improved energy efficiency of participating companies. Another important result, however, would be to provide a mechanism that increases the market value of the participating companies. Voluntary programs that increase the value of participating companies and that reduce environmental impacts are successful on two scales. Additionally, there is an important connection between the two goals: programs that create value for participants will attract more companies leading to additional environmental improvements.

Finally, participation in a voluntary environmental program reflects a company's commitment to reducing its impact on the environment. Quantitative information on the relationship between voluntary program participation and financial performance would provide financial analysts and investors with a ready measure of how participation in these programs affects market value. That is, participation in ENERGYSTAR® may indicate which firms are energy efficient and thus provide a better investment opportunity. This would be the case if participation in the program is associated with higher levels of intangible value, after controlling for other relevant factors.

To investigate the relationship between financial performance and participation in the ENERGYSTAR® program, we construct econometric models that relate participation in the program to Tobin's q, a financial measure of intangible value. We use a sample of 124 Real Estate Investment Trusts (REITs) measured quarterly from 1999 through 2001. Our sample represents 75 percent of the equity REITs and more than 80 percent of market capitalization among equity REITs. In addition to controlling for a number of factors that influence financial performance, we also control for self-selection into the ENERGYSTAR® program. Based on our statistical results, we derive estimates of the market value of (1) participating in the ENERGYSTAR® program, (2) building energy assessments (i.e., benchmarking), and (3) energy efficiency in general.

ENERGYSTAR® is set of voluntary programs that are designed to protect the environment by promoting energy efficiency. The program covers products, construction of new homes, improvement of existing homes, commercial real estate, and corporate real estate. We focus on the ENERGYSTAR® Buildings Program, which is primarily concerned with improvements to commercial and corporate real estate. The program provides a comprehensive set of technical resources on ways to make buildings more energy efficient. The *Buildings Upgrade Manual*, for example, provides information on upgrades that can be made to lighting, fan systems, heating and cooling systems, and other building systems. ENERGYSTAR® also provides guidance on developing energy efficient purchasing policies and on developing energy efficient operations and maintenance policies. The program also supplies information and tools on how to assess the financial viability of upgrades. Finally, the program provides an online tool called Portfolio

Manager that can be used to benchmark a building's energy usage against similar buildings. Companies enter building-specific information into Portfolio Manager which then generates a score between zero and 100 that rates the building's energy efficiency compared to similar buildings.[1] Buildings that have a score exceeding 75 and that meet other requirements can then apply for a "label" from the ENERGYSTAR® program that certifies the building as one the most energy-efficient in the country. Combined, these resources provide a set of valuable resources for companies looking to improve the energy efficiency of their buildings.

Companies can become ENERGYSTAR® partners by submitting a "partnership letter" to the program. The letter must be signed by the Chief Executive Office or Chief Financial Officer of the company (or equivalent). In the letter, the company commits to:

- Measuring, tracking, and benchmarking its energy performance using the tools provided by ENERGYSTAR®;
- Developing a plan to improve energy performance; and
- Educating its staff and the public about being an ENERGYSTAR® partner.

Commitments are voluntary and the ENERGYSTAR® program does not monitor implementation of the commitments.[2] Additionally, partnership with ENERGYSTAR® is not a prerequisite for access to the energy-related tools discussed above. Those tools and resources are freely available to the public. Rather, joining ENERGYSTAR® is an outward statement by companies of their commitment to improving energy efficiency.

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[1] The Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) provides a set of buildings against which the Portfolio Manager database makes comparisons.

[2] Additionally, companies are not removed from the program for failure to meet commitments.

2. Previous Literature

There is growing body of literature that looks at the relationship between environmental performance and financial performance.[3] Although our study is related to and draws from this literature, the studies are substantially different from what we are doing in this paper. First, we are looking at how good energy performance, rather than good environmental performance, relates to financial performance. Energy performance has significant financial implications, especially for REITs, which are the subject of this paper. Certainly, environmental performance can also have financial impacts, but these effects are different than those of energy performance. Firms pay directly for energy usage resulting in a direct impact on costs. Improving environmental performance, on the other hand, usually has a more indirect effect on financial performance such as reducing penalties or future regulatory requirements. Second, we are looking at the financial benefits of joining a public voluntary program. To our knowledge, only one other study (Khanna and Damon, 1999) has addressed this issue. Most studies in this area look at some measure or measures of environmental performance and relate those measures to financial performance. Part of our study follows this path: we use participation in the ENERGYSTAR® program as a measure of energy performance and relate that to financial performance. Our analysis, however, goes beyond that and provides an estimate of the value of the program to participants.

Despite the differences between studies of the environmental-financial performance link and our study, these other studies still inform our work. In short, these studies tend to find a significant positive relationship between good environmental performance and good financial performance, although the validity of the results is often questionable. An overriding concern in these studies is whether or not the observed relationship reflects some other factor such as reverse causation (good financial performance leads to good environmental performance), good managerial practices, or other firm- or industry-specific considerations. This paper attempts to address these issues using statistical techniques and detailed data. In contrast to most of these studies, we focus on only one industry (REITs). Although this focus limits the applicability of the results to other sectors, we expect that is also represents an advantage over some of the other studies that used samples from a wide-ranging set of industries. By focusing on one sector, we can more easily control for some of the factors which influence firm value.

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[3] Koehler and Cram (2001) provide an extensive review of this literature. We provide a review of only those studies that are directly relevant for our work in this paper.

Three papers are particularly relevant for our work: Konar and Cohen (2001), King and Lenox (2001), and Khanna and Damon (1999). Konar and Cohen (2001) look at the relationship between Tobin's *q* and environmental performance for 321 firms in 1989. After controlling for a number of firm-specific factors, they find that firms with better environmental records have higher values of Tobin's *q*. To measure environmental performance, they use Toxic Release Inventory (TRI) emissions and the number of environment-related lawsuits pending against each firm. A distinctive feature of the paper is that the authors translate their estimates into the monetary value associated with environmental performance. They find that the average firm suffered a $380 million loss in intangible market value associated with environmental performance. That is, if firms had zero TRI emissions and no pending lawsuits, the market value of the average firm would have been $380 million higher. This number represented nine percent of the asset value of these firms. The amount also varied by industry, with chemical firms suffering a loss worth 31.2 percent of their asset value. Thus, environmental performance can account for a substantial portion of a firm's value.

King and Lenox (2001) attempt to answer a number of unresolved questions in the debate over the environmental-financial performance link by using a long panel of data. They use a sample of 652 firms measured annually from 1987 to 1996. In using a panel data set, they can control for firm-specific effects through panel data methods (e.g., fixed and random effects models). They attempt to address whether or not it "pays to be green" or whether it "pays to be in a green industry." They find that a firm's environmental performance, relative to other firms in its industry, is positively related to Tobin's *q*, after controlling for industry-level environmental factors and other firm-specific factors. Another statistical specification, however, contradicts this relationship to some degree. Additionally, they were unable to conclude that causation runs from environmental performance to financial performance. Thus, King and Lenox (2001) demonstrate that the relationship between environmental and financial performance is not a simple one. They conclude that the statistical relationship between the two is influenced heavily by model specification and choice of sample.

Khanna and Damon (1999) is the most closely related to this paper. They look at the relationship between participation in EPA's 33/50 program, reduction in the releases of toxic chemicals covered by the program, and financial performance. They focus on firms in the chemical industry and control for self-selection into the program. They begin by modeling participation in the 33/50 program. This model is later used to formulate controls for self-selection into the program. Next, they relate participation in the program to reductions in releases of chemicals covered under the program. They find that 27.9 percent of these reductions from 1991 to 1993 are attributable to the participation in 33/50. Khanna and Damon then relate participation in the program to two measures of financial performance: return on investment (ROI) and excess value as a percentage of sales (EV/S). ROI is measured as the ratio of income to total invested capital and is a good measure of the current financial performance of a firm. EV/S is measured as the difference between the market and book value of a firm divided by sales and is a measure of future prospects for a firm. They find that participation in the program is significantly and negatively related to ROI, but significantly and positively related to EV/S. Thus, Khanna and Damon conclude that firms suffer losses in the short-term from program participation, but gain over the long term. The estimates translate into a 1.2 percent decline in ROI and a 2.2 percent increase in EV/S.

In addition to the literature on the environmental-financial performance link, we also draw from the literature on participation in public programs. This literature is relevant for our model of decisions to participate in the ENERGYSTAR® program. Khanna and Damon (1999) make a contribution to this literature, but we also draw from Videras and Alberini (2000), Arora and Cason (1995, 1996), Henriques and Sadorsky (1996), and DeCanio and Watkins (1998). In brief, these studies relate participation in voluntary programs to a number of firm-related factors such as financial health, threat of future regulation, and past environmental performance. In developing our model of participation decisions by REITs we provide reference to these studies to justify our model.

3. REITS

Real Estate Investment Trusts (REITs) are companies that own and in most cases operate income-producing real estate. For the most part, they are public companies that are openly traded on the major stock exchanges. The REIT corporate structure was authorized in 1960 by an act of Congress which intended to make large-scale, income-producing real estate holdings available to small investors. REITs played a relatively minor role in the real estate sector until the Tax Reform Act of 1986 made REITs a more attractive investment option. Following the Tax Reform Act, the number of REITs began to grow significantly.

To be classified as a REIT, companies must meet three main requirements. First, a majority of the company's assets must be in real estate held for the long term. Second, the company must earn most of its income from real estate. Finally, the company must return 90 percent of its taxable income to shareholders. The primary advantage of organizing as a REIT is the reduced tax burden. The primary disadvantage to companies organizing as a REIT is the restriction on retained earnings. REITs can be divided into three general categories: equity, mortgage, and hybrid. Equity REITs primarily own and manage real estate. Mortgage REITs, on the other hand, primarily own loans or other obligations that are backed by real estate. A hybrid REIT is a company that engages in both equity and mortgage investment strategies. In our analysis, we focus on equity REITs because these are the companies that own property and thus have an interest in reducing energy costs.

The REIT market has grown substantially since the early 1970s. In 1971 there were 34 REITs with a total market capitalization of $6.5 billion ($2001) (NAREIT, 2003).[4] By 2001, there were 182 REITs worth a total of $161.9 billion ($2001) (NAREIT, 2003). Based on these numbers, the average market capitalization per REIT increased almost five-fold between 1971 and 2001, from $191.1 million ($2001) in 1971 to $889.8 million in 2001 ($2001).

Energy is an important component of a REIT's operation. Innovest (2002) notes that energy expenditures are a major part of a REIT's operating cost. Parker and Chao (1999) note that energy costs for REITs can represent between 20 and 40 percent of the company's total operating cost. This substantial reliance on energy makes REITs a good case study for looking at the relationship between energy efficiency and intangible value. Presumably, being an ENERGYSTAR® Buildings partner should provide some benefits to REITs given their substantial energy needs.

4. Conceptual Considerations

In this section we develop a conceptual framework to characterize the relationship between participation in ENERGYSTAR® and intangible value. To accurately model this relationship, however, we must also account for the influence of two other factors on intangible value: corporate reputation and a

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[4] The market capitalization value was converted from 1971 dollars to 2001 dollars using the Consumer Price Index.

REIT's propensity to be energy efficient. We begin with a general discussion of intangible value and its relationship to energy efficiency. We then develop a more formal model of the relationship between intangible value and participation in ENERGYSTAR®. We complete this section by developing a model of a REIT's decision to join ENERGYSTAR®, which we use to control for self-selection into the program.

Intangible Value

The market value of any firm can be viewed as the sum of two components: value derived from *tangible* assets and value derived from *intangible* assets (Konar and Cohen, 2001). Energy performance should influence both sources of value. Tangible value is derived from tangible assets such as buildings and other capital items, as well as a company's earnings. Intangible value is derived from intangible assets, which include anything that can be linked to future earnings but which does not appear on a standard corporate balance sheet. Generally, such assets are neither accounted for internally nor externally, hence it is difficult to assess their magnitude using standard accounting practices (Lev, 2001). By some estimates, however, intangible assets can make up as much as 80 percent of a company's value (Reed, 2001).

Lev (2001) groups intangible assets into three categories, related to:

- Discovery—The ability to innovate to capture market share.
- Organizational practices—Better and smarter ways of doing business.
- Human resources—Having better-trained and better-qualified people than competitors.

We expect that ENERGYSTAR® participation, or good energy performance in general, is most closely related to the second of these, i.e., it adds value because it represents a better way of doing business.[5]

[5] Certainly, energy efficiency could manifest itself in other ways, including those related to discovery and human resources. For example, a REIT could develop a new way of operating buildings that is more energy-efficient, representing a business innovation that feeds into its intangible value (discovery).

For REITs, adapting better business practices as a result of ENERGYSTAR® participation leads to a number of intangible benefits. First, energy efficient buildings cost less to operate, which should result in bottom-line benefits for REITs. Furthermore, lower operating costs increase the net operating income (NOI) which in turn increases the property value for a building.

Second, energy efficient buildings provide a more attractive space and work environment. Romm and Browning (1998) found that energy efficient lighting upgrades led to productivity improvements in a series of case studies. This can lead to better tenant retention and the ability to charge a premium for the improved space. Third, through its ENERGYSTAR® participation the company starts to gain recognition as an environmentally conscious business. This leads to improved public perception, which has been identified as an important source of value for companies joining voluntary programs (Wells, 2000; Khanna and Damon, 1999; Videras and Alberini, 2000; Arora and Cason, 1995, 1996).

Third, efficient energy management may improve the long-term sustainability of the company. That is, alliance with ENERGYSTAR® may help build intellectual capital in the company with regard to energy management techniques. Those techniques can provide insulation against energy shocks, supply interruptions, or price spikes. Finally, competency in energy management may be interpreted as an indicator of superior overall management (Innovest, 2003). Energy is a complex management issue, requiring an ability to recognize and address emerging issues. Companies that manage energy issues effectively may find that their overall management reputation is enhanced.

To formalize our notion of intangibles, we write a firm's market value (*MV*) as the sum of tangible and intangible value:[6]

$$MV = V_T + V_I \qquad (1)$$

If we divide through by V_T in equation (1), we get

$$\frac{MV}{V_T} = 1 + \frac{V_I}{V_T} \qquad (2)$$

The left-hand side of equation (2) can be interpreted as Tobin's q, the ratio of market value to replacement value of tangible assets. Thus, based on (2), a firm's q value is determined by the ratio of intangible to tangible values. A firm with no intangible value ($V_I = 0$) will have a q value equal to one.

[6] The following treatment of q draws from Konar and Cohen (2001).

Following Hirsch and Seaks (1993) and Konar and Cohen (2001) we specify V_I/V_T as a linear function of a set of explanatory variables:

$$\frac{V_I}{V_T} = \boldsymbol{X}\beta + \varepsilon \tag{3}$$

where $\boldsymbol{X}$ is a matrix of explanatory or control variables, β is a vector of regression coefficients on the $\boldsymbol{X}$ variables (including a constant term), and ε is an error term. Thus, we get the following expression for a regression model for Tobin's *q*:

$$q = 1 + \boldsymbol{X}\beta + \varepsilon \tag{4}$$

This model can be estimated using either *q* or *q*-1 as the dependent variable.

The Relationship Between Intangible Value and ENERGYSTAR® Participation

The goal of our analysis is to examine the relationship between intangible value and participation in ENERGYSTAR®. Our central hypothesis then is that participation in the program will lead to higher levels of intangible value. We expect that participation in the ENERGYSTAR® program represents a smarter way of doing business, resulting in higher intangible value. Decisions to join ENERGYSTAR®, however, are not random, but reflect a decision process on the part of companies. To accurately capture the impact of participation in the program on intangible value we must account for this self-selection into the program.

There are two other considerations that we expect to be important in looking at the relationship between participation in ENERGYSTAR® and intangible value: energy efficiency and corporate reputation. In regards to the first, it is clear that companies can pursue energy efficiency goals in the absence of the ENERGYSTAR® program. There may be some level of management commitment to energy efficiency for business reasons (e.g., lowering cost) or for social reasons (e.g., reducing impacts on the environment). Regardless of the reasons, a company's "inherent" propensity for energy efficiency will influence its intangible value independent of the ENERGYSTAR® program. Additionally, a company's energy efficiency will both influence and be influenced by its decision to join ENERGYSTAR®.

Corporate reputation is a more encompassing concept than energy efficiency, but will also exert an influence on the relationship between intangible value and ENERGYSTAR® participation. Companies with better reputations will have higher levels of intangible value as the market is willing to pay more to hold the stock of companies with better reputations. Thus, reputation will exert an influence on *q*. We might also expect reputation to have a positive influence on decisions to join ENERGYSTAR® and on energy efficiency: i.e., companies with better reputations may be more likely to join ENERGYSTAR® or be more energy efficient. Although these tend to be correlational rather than causal relationships, we need to address them in our modeling in some form.[7]

Although we expect both energy efficiency and reputation to be important factors influencing the relationship between intangible value and ENERGYSTAR® participation, we do not have data to objectively measure either energy efficiency or reputation. Nevertheless, we expect that both reputation and a propensity to be energy efficient will influence intangible value *and* decisions to join ENERGYSTAR®. Our solution is to assume that joining ENERGYSTAR® and not joining ENERGYSTAR® represent completely different scenarios for companies which must be represented by completely different regression models. The two different scenarios stem from the fact that corporate reputation and energy efficiency make companies that join ENERGYSTAR® significantly different than those that do not. Empirically, this is a switching regression model and we can write this as

$$q = \boldsymbol{X_1}\beta_1 + u_1 \qquad for\ D = 1 \tag{5a}$$

$$q = \boldsymbol{X_2}\beta_2 + u_2 \qquad for\ D = 0 \tag{5b}$$

where *D* is a binary variable equal to one if the company is an ENERGYSTAR® partner and zero if the company is not a partner, $\boldsymbol{X}_1$ and $\boldsymbol{X}_2$ are matrices of explanatory variables, β_1 and β_2 are vectors of regression coefficients, and u_1 and u_2 are regression error terms. The "program effect" in this model can be calculated by comparing the predicted *q* value from (5a) to the predicted *q* value from (5b) *for companies that join the program*. This is discussed in more detail in the econometric methods section.

[7] The converse might also be true: joining ENERGYSTAR® or being energy efficient will lead to an improved corporate reputation. That is, participation in ENERGYSTAR® or being energy efficient leads society to place a higher reputational value on those companies. This is partly what we are measuring in our statistical models.

This structure allows the set of explanatory variables ($\boldsymbol{X}_j$) to differ between partners and non-partners, although we expect that a number of common factors are relevant for both groups. As discussed below, however, two program-related activities (benchmarking and labeling) may influence partners' intangible value, but they are irrelevant for explaining variation in non-partner *q* values. Additionally, this structure allows the coefficient values (β_j) to differ between partners and non-partners for factors that are common to both regression models. Thus, we let the relationship between *q* and the explanatory factors differ completely between the two groups. We expect that the relationship between *q* and its determinants (i.e., the variables in the ***X*** matrices) will be substantially different for partners than for non-partners and that the difference between the two stems from energy efficiency and corporate reputation considerations. In other words, companies that join ENERGYSTAR® differ from those that do not join ENERGYSTAR® with respect to energy efficiency and corporate reputation. Without objective data to measure these differences, we need to model them separately.

An alternative to the switching regression model in (5a) and (5b) is to pool the partners and non-partners and use a binary indicator to capture the effect of being an ENERGYSTAR® partner. This is a standard program evaluation model and can written as:[8]

$$q = \boldsymbol{X}\beta + \alpha D + u \qquad (6)$$

where α reflects the effect of participating in the ENERGYSTAR® program. Although this model appears to be more tractable, the estimated value of α will be biased if we exclude corporate reputation and a REIT's propensity for being energy efficient because each will have a positive influence on both intangible value and decisions to join ENERGYSTAR®. As discussed in more detail in the econometrics methods section, however, the biased estimate will incorporate both a "reputation effect" and a "propensity for energy efficient effect" into the estimated coefficient. Based on this, the biased estimate of α in an estimation (6) provides a measure of how energy efficiency in general affects *q* values, with "energy efficiency" being the sum of a program effect, reputation effect, and propensity for being energy efficient effect. In essence, a biased estimate will still be valuable because we have an idea about where the bias is coming from and we can therefore give the estimated coefficient a broader interpretation.

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[8] The '1' and '2' subscripts are removed to reflect that we have pooled the data.

We develop empirical models based on both (5a) and (5b) and (6). The estimates from (5a) and (5b) are used to develop an estimate of the program effect: i.e., the intangible value of the ENERGYSTAR® program to REITs. The estimated value of α from (6) is interpreted more broadly as the intangible value of energy efficiency, as proxied by ENERGYSTAR® partnership. In both sets of models, we control for self-selection of REITs into the program. This is discussed in more detail in the econometric methods section.

As noted above, there are two program-related activities that may affect a REIT's intangible value. First, companies that join ENERGYSTAR® are encouraged by the program to benchmark their buildings. Benchmarking involves entering building-specific information into EPA's Portfolio Manager database which then generates a score for the building.[9] Benchmarking is voluntary for the partners, but reflects a desire on the part of REITs to understand the energy efficiency of their buildings relative to similar buildings. Companies that own low-scoring buildings should be motivated to improve the buildings' energy efficiency because the benchmark score indicates that similar buildings are more efficient and thus operating at lower cost. The number of buildings that a company benchmarks, however, is not public knowledge. Thus, benchmarking acts more as an indicator of energy efficiency concern (among partners) than as an outward sign of energy efficiency. We measure benchmarking by calculating the percentage of total square footage owned that each REIT benchmarked in the previous year (*BENCH*).[10]

Buildings that achieve a score of 75 or higher can receive a label from the ENERGYSTAR® program, provided they meet other requirements, entitling the owner to display a bronze plaque bearing the ENERGYSTAR® logo.[11] A label is a certification by the ENERGYSTAR® program that the building meets high energy efficiency standards. Thus, labeled buildings represent the best performing buildings of their

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[9] Portfolio Manager ranks the building's energy efficiency (kwH per square foot) against a national database of buildings, developed by the Department of Energy, adjusted for building type, occupancy patterns, and climate (location).

[10] We have quarterly observations, so this measure can change from quarter to quarter. For example, for the third quarter of 1999, we calculated the percentage of total square footage that had been benchmarked between fourth quarter 1998 and third quarter 1999. Our presumption is that a benchmark score is valid for one year.

[11] To receive the label, the building owner must complete an application letter and a Statement of Energy Performance (provided by EPA) and then have a Professional Engineer certify that the data entered into the Portfolio Manager database is accurate and that the building conforms to industry standards for indoor environment.

type and are among the most energy-efficient in the country. Furthermore, EPA publishes lists of labeled buildings, making a label a form of public recognition for energy efficient operation. To the extent that the market acknowledges this public recognition, a label acts as an indicator to the market that the REIT owns and operates energy-efficient buildings. Thus, there may be some intangible value associated with building labeling. Similar to benchmarking, we measure labeling as a percentage of total square feet owned by the REIT (*LABEL*).

In addition to these energy-related factors, there are a number of other factors that will influence a company's intangible value. These other factors make up the ***X*** matrices in the equations above and can be divided into three groups: market conditions, firm-specific financial factors, and firm characteristics. We expect that better market conditions for REITs will result in higher intangible values, all else equal. To measure market conditions, we use the quarterly return to the National Association of Real Estate Investment Trust (NAREIT) index for equity REITs. The NAREIT Equity Index tracks the market performance of all equity REITs. We expect that this will act as a good proxy for general market conditions for our sample of REITs. For each quarter in the data, we calculated the percentage change in the NAREIT index from the previous quarter and used that as a measure of market growth or decline. We label this variable *NRET* in our empirical model.

There are a number of firm-specific financial characteristics that can have an influence on a firm's intangible value. First, we use the REIT's return on assets (ROA) as a measure of REIT profitability. We measure ROA both concurrently to q and lagged by one quarter. Second, the riskiness of a REIT's stock may also influence the value the market places on its intangible assets. To measure this, we calculated each REIT's stock market beta (*SBETA*) for the 1996-2001 time period and used that as a measure of riskiness.[12] Finally, we control for each REIT's baseline level of intangible value. We expect that each REIT's intangible value during the sample period (1999-2001) will be positively influenced by its intangible value in the period leading up to the sample period. If REITs with higher intangible values prior to the sample period are concentrated among partners, then we may find that partnership is significantly associated with higher q values than non-partners when such a relationship actually does not exist. In other words, good performance in terms of intangible value may carry over from the pre-sample

[12] Thus, there is *one* calculated value of beta for each firm which is used to measure riskiness in *each* quarter.

period to the sample period. To measure this, we calculated the average value of Tobin's q for 1996-1998 for each REIT and refer to this variable as q_b.[13]

Intangible value can also be influenced by a number of firm-specific non-financial characteristics. Studies of intangible value often use the size of the firm, measured as the number of employees, as a control variable. We use the total square footage owned by the REIT as a measure of firm size rather than the number of employees. Previous studies of Tobin's q values for REITs have also accounted for the concentration of a REIT's holdings in one sector (e.g., office, retail) (Capozza and Seguin, 1999). Our meaure of the concentration (*CONC*) is a Herfindahl index and is defined as:

$$CONC = \sum_{j=1}^{7} \left(\frac{s_j}{S} \right)^2$$

where s_j is the square footage owned by the REIT in sector j, and S is the total square footage owned by the REIT.[14] Finally, we also expect that the sector where a REIT has concentrated its holdings may influence q values. In equation (6), we control for the two major sectors in the data: office (*OFFICE*) and retail (*RET*) using binary control variables set equal to one if the REIT had more than 75 percent of its square footage in either the office or retail sector, respectively.[15]

Based on these considerations, we can write equation (6) as

$$\begin{aligned} q = f(&D,\ BENCH,\ LABEL,\ NRET,\ TSQFT,\ ROA, \\ &ROA_{t-1},\ q_b,\ SBETA,\ CONC,\ OFFICE,\ RET) \end{aligned} \qquad (7)$$

where D is the binary variable equal to one if the REIT was a partner and all variables are as defined above. Equation (5a) excludes D and equation (5b) excludes D, *BENCH*, and *LABEL*. We measure total square feet (*TSQFT*) in natural logarithm form to reduce the influence of any large square footage values. We discuss our implementation of this model more fully in the econometric methods section below.

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[13] Similar to the stock market beta, there is only one value, the pre-1999 q value, for each REIT.

[14] The seven sectors covered in our analysis are: office, retail, industrial and warehouse, health care, lodging, residential, and self-storage.

[15] We were unable to include the sector-specific controls in the switching regression model due to multicollinearity issues in the estimations.

Decisions to Join ENERGYSTAR®

We also expect that the decision to join ENERGYSTAR® is not random and can be represented by the following equation:

$$D^* = \boldsymbol{Z}\gamma + \varepsilon \tag{8a}$$

where D^* is the net benefit from joining ENERGYSTAR®, $\boldsymbol{Z}$ is a set of explanatory variables that influence the net benefits, and γ is a vector of coefficients. We expect that companies will join ENERGYSTAR® if the net benefits of joining exceed zero and will not join if the net benefits are negative. Thus, assignment into the two regression equations for q (i.e., (5a) and (5b)) can be written as

$$D = 1 \ \textit{if} \ D^* > 0 \tag{8b}$$

$$D = 0 \ \textit{if} \ D^* \leq 0 \tag{8c}$$

This specification assumes that the decision of whether or not to join ENERGYSTAR® reflects some assessment of the net benefits of joining the program by each REIT. If the REIT determines that the net benefits are positive, then it joins the program. We do not expect that each REIT performs a detailed net benefit calculation for this, but rather more of a subjective calculation. The goal of characterizing the decision to join is to include a set of factors in a statistical model of equation (8a) that reflects the net benefits of joining the ENERGYSTAR® program. We expect that four sets of factors are relevant: market conditions, company size, the firm's financial health, and the company's primary sector.

Improvements in the market conditions affecting REITs should have a positive influence on the decision to join ENERGYSTAR®. As overall conditions improve, REITs as a group will have more resources to allocate to voluntary programs such as ENERGYSTAR®. As conditions worsen, on the other hand, REITs would be expected to focus their energies on weathering the down market rather than joining voluntary programs. Videras and Alberini (2000) found that increases in industry-level sales were positively associated with an increased probability of joining EPA's Green Lights program, but were not associated with joining EPA's WasteWise or 33/50 programs. DeCanio and Watkins (1998) found that an increase in industry earnings per share was positively related to joining Green Lights. In our statistical model of the decision to join ENERGYSTAR®, we control for market conditions by using the quarterly return in the NAREIT equity REIT index discussed above.

Larger REITs may also have an incentive to join compared to smaller ones. The larger the REIT, measured either in terms of square footage or total assets, the more opportunity there is to reduce costs through energy efficiency programs. Previous studies that looked at voluntary program participation decisions all used some measure of company size (Khanna and Damon, 1999; Videras and Alberini, 2000; Arora and Cason, 1995, 1996; Henriques and Sadorsky, 1996; and DeCanio and Watkins, 1998). We control for REIT size in the model of participation decisions by including the total square footage owned by the REIT and the total assets owned by the REIT. In our statistical models, we measure each in logarithmic form to reduce the influence of large values.

REITs that are doing better financially relative to their sector peers should also be more likely to join ENERGYSTAR®. A number of other studies have examined this issue, but each found no relationship between financial health and participation (DeCanio and Watkins, 1998; Videras and Alberini, 2000; and Arora and Cason, 1995). We measure firm profitability by ROA concurrently and lagged by one quarter. Additionally, we also include the average q value for 1996-1998, the period preceding our sample period. We expect that firms that had a higher levels of intangible value at the beginning of the sample period will be more likely to join the program. We also include the firm's stock market beta as a measure of risk faced by owning the firm's stock. We expect that the riskiness of a firm's stock should affect decisions to join ENERGYSTAR®, but the direction of that effect is left to the empirical model.

Finally, decisions to join ENERGYSTAR® will be influenced by the types of buildings that are owned by the REITs. For example, in interviews with 33 REITs, Parker, Chao, and Gamburg (1999) found that in the retail sector the tenants tend to pay for energy costs while in the office sector the REIT tends to pay for energy costs. Additionally, the energy requirements and opportunities for energy efficiency upgrades will differ markedly across the sectors we use in our analysis (office, retail, industrial and warehouses, health care, lodging, residential, and self-storage). These sector differences may influence decisions to join ENERGYSTAR®. Finally, early recruitment efforts of the ENERGYSTAR® Buildings Program focused on office properties. Both Videras and Alberini (2000) and DeCanio and Watkins (1998) use industry sector controls in their analyses. Therefore, we include a set of binary variables that reflect the sector that each REIT operates in.

Based on these considerations, our model for joining ENERGYSTAR® can be written as

$$D = f(NRET,\ TSQFT,\ TA,\ ROA,\ ROA_{t-1},\ q_b,\ SBETA,\ SECTOR) \tag{9}$$

where *TA* is total assets, *SECTOR* is a set of control variables for the sectors in our data, and all of the variables are defined as above. We use a probit model to estimate this equation. The following section discusses our econometric method, which involves using the model of decisions to join ENERGYSTAR® in equation (9) to adjust for self-selection into the program.

5. Econometric Methods

In this section, we review the econometric issues involved in estimating the models discussed in the previous section. There are two models that we discuss: the switching regression model of (5a) and (5b) and the pooled model of (6). The switching regression model is used to derive estimates of the program effect of ENERGYSTAR® for REITs while the pooled model is used to derived the intangible value associated with energy efficiency overall. In this section, we also provide reasoning for this interpretation of the pooled model.

Switching Regression Model With Endogenous Switching

The model in (5a) and (5b), along with the self-selection into ENERGYSTAR® described by equations (8a)-(8c), is a switching regression model with endogenous switching. To begin, we specify the model formally as:

$$q_{1it} = \beta_1' \boldsymbol{X_{1it}} + u_{1it} \qquad for\ D_{it} = 1 \tag{10a}$$

$$q_{2it} = \beta_2' \boldsymbol{X_{2it}} + u_{2it} \qquad for\ D_{it} = 0 \tag{10b}$$

$$D_{it}^* = \gamma' \boldsymbol{Z_{it}} + \varepsilon_{it} \tag{10c}$$

$$\begin{aligned} D_{it} &= 1 \ \ if\ D_{it}^* > 0 \\ D_{it} &= 0 \ \ if\ D_{it}^* \leq 0 \end{aligned} \tag{10d}$$

where all variables and parameters are as defined above and *i* indexes REITs and *t* indexes time. Estimation of (10a) and (10b) in their present form will result in biased estimates because the error terms in both equations will have non-zero expectations due to the selection mechanism defined in (10c) and (10d) (Maddala, 1983).

To estimate this system, we follow the two-step procedure outlined in Maddala (1983). First, we define the following two ratios:

$$W_{1it} = \varphi(\gamma' Z_{it}) / \Phi(\gamma' Z_{it}) \tag{11a}$$

$$W_{2it} = \varphi(\gamma' Z_{it}) / [1 - \Phi(\gamma' Z_{it})] \tag{11b}$$

where φ and Φ are the density and cumulative distribution function of the standard normal distribution. The *W* ratios represent the conditional probabilities of joining ENERGYSTAR® and not joining ENERGYSTAR®, respectively, based on the values of the variables affecting the decision to join

ENERGYSTAR® ($\boldsymbol{Z}$) and the coefficients associated with those variables (γ). These ratios can be computed for each observation in the sample. We can now redefine equations (10a) and (10b) as[16]

$$q_{it} = \beta_1^{/}\boldsymbol{X_{1it}} - \sigma_{1\varepsilon}W_{1it} + v_{1it} \qquad for\ D_{it} = 1 \tag{12a}$$

$$q_{it} = \beta_2^{/}\boldsymbol{X_{2it}} + \sigma_{2\varepsilon}W_{2it} + v_{2it} \qquad for\ D_{it} = 0 \tag{12b}$$

where $\sigma_{1\varepsilon}$ is the covariance between u_1 and ε, $\sigma_{2\varepsilon}$ is the covariance between u_2 and ε, and v_{jit} $\{j = 1, 2\}$ are new residuals with zero conditional means.

The new equations can now be estimated using a two-stage process. First, we estimate a probit model for decisions to join ENERGYSTAR® ((10c) and (10d)), using D values in place of the unobserved D^* values. This provides a consistent estimate of γ which we call $\hat{\gamma}$. Next, we generate estimates of $\hat{W}_{1it}$ and $\hat{W}_{2it}$ by substituting $\hat{\gamma}$ for γ in (11a) and (11b). In the second stage, we estimate our equations for Tobin's q, (12a) and (12b), using $\hat{W}_{1it}$ and $\hat{W}_{2it}$ in place of W_{1it} and W_{2it}, respectively. The estimated coefficients for $\hat{W}_{1it}$ and $\hat{W}_{2it}$ will be consistent estimates of $\sigma_{1\varepsilon}$ and $\sigma_{2\varepsilon}$, respectively (Maddala, 1983).

As we noted in Section 4, we expect both corporate reputation and a REIT's propensity for being energy efficient to affect both partnership decisions and intangible value. The switching regression model, however, mitigates the effects of these omitted variables by separating the partners from the non-partners. To see this, we write our two q equations as

$$q_{1it} = \beta_1^{/}\boldsymbol{X_{1it}} + \theta_1 R^* + u_{1it} \qquad for\ D_{it} = 1 \tag{13a}$$

$$q_{2it} = \beta_2^{/}\boldsymbol{X_{2it}} + \theta_2 R^* + u_{2it} \qquad for\ D_{it} = 0 \tag{13b}$$

where R^* is an unobserved measure of corporate reputation and θ_1 and θ_2 measure the impact of reputation on q. We will focus this discussion on reputation because the propensity for energy efficiency can be handled in an analogous manner. Next, we can assume that corporate reputation and partnership have a simple relationship such as (ignoring i and t subscripts and any error term):

[16] The detailed derivation of these equations, along with a more detailed account of this method, can be found in Maddala (1983, pp. 223-228).

$$R^* = b_0 + b_1 D \tag{13c}$$

where b_0 and b_1 are regression coefficients. To see how having this unobserved relationship affects (10a) and (10b), we substitute (13c) into (13a) and (13b) and use the condition for D_{it} for each relationship:

$$q_{1it} = \beta_1^{\prime} \boldsymbol{X_{1it}} + \theta_1(b_0 + b_1) + u_{1it} \qquad for\ D_{it} = 1 \tag{14a}$$

$$q_{2it} = \beta_2^{\prime} \boldsymbol{X_{2it}} + \theta_2 b_0 + u_{2it} \qquad for\ D_{it} = 0 \tag{14b}$$

Thus, the terms $\theta_1(b_0 + b_1)$ and $\theta_2 b_0$ are unmeasured effects of corporate reputation on *q*.[17] Corporate reputation, however, is likely to have a significant firm-specific component, especially when measured over time in a panel. If we assume that b_0 can be written as b_i instead (i.e., as a firm-specific effect) then our unmeasured effects of corporate reputation can be handled with a panel data method such as random effects and by assuming that the remaining effect is subsumed into the error term. Thus, in the partner model, we are assuming that some of the reputation effect (i.e., $b_1\theta_1$) is randomly distributed among partners after controlling for other factors included in ***X***. This same assumption is not valid for a pooled model because reputation affects both decisions to join *and q* values.

<u>Pooled Model For Valuing Energy Efficiency</u>

The pooled model from equation (6) can be written more formally as

$$q_{it} = \boldsymbol{X_{it}}\beta + \alpha D_{it} + u_{it} \tag{15}$$

where α is once again the program effect of ENERGYSTAR® on intangible value. To account for self-selection into the program, we combine (15) with the REITs' decisions to join ENERGYSTAR® modeled in (10c) and (10d). Estimation of (15) without controlling for self-selection into ENERGYSTAR® will result in biased estimates of α due to the relationships in (10c) and (10d) (Maddala, 1983). To avoid this, we

[17] The other unmeasured factor that we consider important, a REIT's propensity for being energy efficient, can be handled in a similar manner, resulting in additional terms similar to the ones for corporate reputation in (14a) and (14b).

follow a path similar to the switching regression modes above and add the inverse mills ratio as a new regressor to our model.[18] This can be written as

$$q_{it} = \boldsymbol{X_{it}}\beta + \alpha D_{it} + \beta_w W_{it} + v_{it} \tag{16}$$

where $W_{it} = \varphi(\gamma' Z_{it})/\Phi(\gamma' Z_{it})$ is the inverse mills ratio, β_w is a regression coefficient,[19] and v_{it} is an error term with zero expectation.

This model can be estimated in a manner similar to the switching regression model. First, we estimate a probit model for (10c) using (10d) as observations on D^*. This provides a consistent estimate of γ that we can use to get an estimate of W_{it}. Second, we use our estimated W_{it} values in (16) to get consistent estimates of β, α, and β_w.

Our estimate of α in this form, however, will be a biased estimate of the *program effect* due to the unobserved influence on corporate reputation and energy efficiency. The nature of bias, however, allows us to make a broader interpretation of our estimated coefficient. To derive this broader interpretation, we begin by writing (16) with the unobserved value R^* as part of the equation:[20]

$$q_{it} = \boldsymbol{X_{it}}\beta + \alpha D_{it} + \theta R^* + u_{it} \tag{17}$$

where θ measures the reputation effect on intangible value. Substituting (13c) into (17) and collecting terms we get

$$q_{it} = \boldsymbol{X_{it}}\beta + (\alpha + \theta b_1) D_{it} + \theta b_0 + u_{it} \tag{18}$$

In our estimation, we will not be able to separate θ, α, and b_1 from one another because we have too many unknowns in too few equations. Thus, a regression of q on $\boldsymbol{X}$, D, and W will result in one value for the

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[18] The derivation of this correction for self-selection can be found in most advanced econometrics texts, such as in Greene (1993, pp. 706-710), or in Maddala (1983).

[19] In statistical terms, β_w is equal to the covariance between u_{it} in (15) and ε_{it} in (10c) multiplied by the standard error of ε_{it} in (10c).

[20] Once again, energy efficiency can be handled analogously to corporate reputation.

coefficient on D, say $\hat{\alpha}$, which will equal ($\alpha + \theta\ b_1$). In other words, the estimated coefficient on D in (18) will be the sum of the program effect (α), a corporate reputation effect ($\theta\ b_1$), and the "propensity for being energy efficient" effect. Given that we cannot separate out the pure program effect, we interpret our estimated coefficient in (16) as the intangible value of energy efficiency, operating through participation in ENERGYSTAR®, corporate reputation, and the efforts of REITs to operate in an energy efficient manner. A final point is that even if we assume that b_0 can be written as a firm-specific random effect b_i, we will still be unable to separate out the program effect from the other two unobserved influences. Nevertheless, we assume that there are firm-specific factors that are unmeasured in this model and use the random effect procedure in the estimations.

In both the switching regression model and the pooled model we use predicted probabilities from a first stage probit model. The first stage probit model contains many of the variables also in the second stage switching regression model and the pooled model. In order for our predicted probabilities to have some independent variation, we need to include a variable in the first stage probit model that acts as an instrument for joining ENERGYSTAR®. We use total assets as our instrument since it satisfies the criteria for a good instrument: it is related to the probability of joining ENERGYSTAR®, but is not correlated with the outcome variable (i.e., Tobin's q).

6. Data

Data for our analysis come from a variety of sources. We began by obtaining data from Standard and Poor's Compustat database for all companies in Standard Industrial Code 6798 (Real Estate Investment Trusts). This included 198 REITs active between 1996 and 2001. We then restricted the sample to equity REITs that had sufficient financial data over the sample period.[21] Next, we collected information on square footage by property type owned by the REITs from the companies' Security and Exchange Commission (SEC) filings and from corporate annual reports. This also resulted in some loss of companies from the sample due to missing or inadequate data. Additionally, some REITs were considered out of scope for this analysis and were also dropped.[22] Our final sample includes 124 equity REITs.

[21] Information on which REITs were classified as equity REITs was taken from NAREIT's web site (http://www.nareit.com).

[22] These were REITs primarily involved in manufacturing and development of homes.

Information on ENERGYSTAR® partnership and building benchmarking and labeling were obtained from EPA's ENERGYSTAR® Buildings Program. This included a list of partners in the Commercial Real Estate sector and the dates on which each partner joined the program. Information on benchmarking and labeling were taken from the program's Portfolio Manager database which tracks those activities. This information was matched to our sample of 124 REITs.

We followed the method proposed by Chung and Pruitt (1994) to calculate Tobin's *q*. Their measure of *q* can be written as

$$q = \frac{(MVE + PS + DEBT)}{TA} \tag{19}$$

where *MVE* is the market value of common stock (share price multiplied by shares outstanding), *PS* is the liquidating value of the firm's outstanding preferred stock, *DEBT* is the value of a firm's short term liabilities net of its short term assets plus the book value of the firm's long-term debt, and *TA* is the book value of the firm's total assets. This is a common formulation of *q* in the literature.

To calculate the stock market betas (*SBETA*), we used end-of-month stock prices for the period 1996 through 2001. For each REIT, we regressed the monthly stock price return on the monthly return to the Standard and Poors 500 Index. The estimated slope coefficient from these regressions are, by definition, stock market betas.

Our final data set is comprised of 124 REITs with quarterly observations spanning 1996 through 2001. In our statistical models, however, we restrict the sample to 1999 through 2001, since recruiting for ENERGYSTAR® did not begin until 1999. This results in a potential panel size of 1,488 observations (124 REITs × 12 quarterly observations). Due to missing data, however, our workable sample size was 1,434 observations. Of the 1,434 observations, 202 were for the partners and the remaining 1,232 were for non-partners.

There were 23 REITs (19 percent) that became partners over the course of the sample period. Companies could be in both the partner and non-partner samples since partnership was defined as being a partner at a specific time. Thus, a company that joined after the beginning of the sample period, but before the end of the period, would be in both samples. Of the 23 partners in the sample, only three were partners for the entire sample period.

Table 1 provides definitions and summary statistics for our data. The average value of Tobin's *q* for the 124 REITs during the sample period was 0.923. Partners had an average *q* value of 0.945 and non-partners had an average *q* value of 0.917, a difference that is not statistically significant. Over the sample period, 202 observations (14.1 percent) corresponded to REITs being partners. The average REIT in our sample owned 32.6 million square feet and had $1.6 billion in assets. Additionally, on average the REITs property type holdings tended to be very concentrated with an average Herfindahl concentration index of 0.89.[23] Finally, more than half of all the observations corresponded to retail REITs. The office and retail sectors combined for a total of 64 percent of all observations.

7. Econometric Results

In this section we present the results of estimating our equations for Tobin's *q* and the decision to join ENERGYSTAR®. We begin by discussing the probit model for REIT's decisions to join ENERGYSTAR® since this model is used to generate our control for self-selection into the ENERGYSTAR® program for both the switching regression model and the pooled estimation. We then review the results for our regression models for Tobin's *q*. In the section that follows, we translate the regression results into dollar values associated with the ENERGYSTAR® program.

[23] The construction of the index implies that values can range from 0.14 (equal diversification across property types) to one (complete concentration in one sector).

Decisions to Join ENERGYSTAR®

Table 2 presents the results of the probit model for decisions to join ENERGYSTAR®. We present both the estimated coefficient and the marginal effects of each variable on the probability of joining ENERGYSTAR®. The probit model was run for the sample of 124 REITs measured quarterly from 1999 to 2001 for a total of 1,434 observations. In the probit model we include a set of dummy control variables for the sectors using the retail sector as the base.

The estimated coefficient for the return to NAREIT index indicates that general market conditions are significantly and positively related to joining ENERGYSTAR®. Although significant, the actual impact on the probability of companies joining ENERGYSTAR® is small. The marginal impact for the return to the NAREIT index indicates that a one percentage point increase in the index increases the probability of the average company joining ENERGYSTAR® by 0.35 percentage points.

In terms of REIT size, the amount of assets owned by REITs is significantly and positively related to joining ENERGYSTAR®, but the total square footage is not related to the probability of companies joining the program. The marginal effect for total assets indicates that a one percent increase in the average company's total assets increases the probability of joining ENERGYSTAR® by 5.6 percentage points. The positive relationship between participation and size is consistent with previous studies that look at voluntary program participation (Khanna and Damon, 1999; Videras and Alberini, 2000; Arora and Cason, 1995, 1996; and DeCanio and Watkins, 1998).

The four REIT-specific financial characteristics that we used in the analysis are all significantly related to joining ENERGYSTAR®. Return on assets, both concurrently and lagged by one quarter, has a positive impact on joining ENERGYSTAR®. That is, firms that are doing better financially are more likely to join the program. This differs from previous studies which found little effect of financial health on decisions to join voluntary programs (Videras and Alberini, 2000; Khanna and Damon, 1999). Additionally, if we also take ROA as a measure of management effectiveness, firms that are better managed are more likely to join. Firms that had higher intangible values in the period leading up to our sample period, as measured by pre-1999 Tobin's *q* values, were also more likely to join ENERGYSTAR®. Finally, joining ENERGYSTAR® was positively related to firm-specific risk associated with the REITs' stock prices. REIT stocks, however, tend to be low-risk relative to the stock market. Our estimated betas ranged from 0.127 to 0.363. Thus, the finding that riskiness increases the probability of joining ENERGYSTAR® may be limited to our sample given the small range of betas.

Finally, the sector in which the REIT owned most of its property played a significant role in determining the probability of joining ENERGYSTAR®. We included controls for six of the seven sectors, making retail, the largest of our sectors, the base sector in the analysis. REITs in the residential, industrial and warehousing, lodging, health care, and self-storage sector were all less likely to join ENERGYSTAR® than retail REITs. Office REITs, on the other hand, were much more likely to join ENERGYSTAR® than retail REITs.

The estimated model in Table 2 was used to generate a values for $\hat{W}_{1it}$ and $\hat{W}_{2it}$.[24] For each observation, we calculated the value of $Z_{it}\gamma$ using each observation's values for Z_{it} and the estimated coefficients in Table 2 for γ. We then calculated $\varphi(Z_{it}\gamma)$, the standard normal density function, and $\Phi(Z_{it}\gamma)$, the standard normal cumulative distribution function, for each observation. Finally, we calculated the ratios $\hat{W}_{1it}$ and $\hat{W}_{2it}$ for each observation, using our values for $\varphi(\cdot)$ and $\Phi(\cdot)$. These two ratios are added to the models for Tobin's q to control for endogenous selection into the ENERGYSTAR® program.

Intangible Value

Table 3 presents the results for the switching regression model and the pooled regression model. The switching regression equation for partners had 202 observations and covered 23 REITs, while the non-partner equation had 1,232 observations and included 121 REITs. The pooled model contained all 1,434 observations and all 124 REITs. All three models were run using quarterly observations running from 1999:1 to 2001:4. In this section we discuss the statistical results. In the next section we derive quantitative measures of the value of the ENERGYSTAR® program and the value of energy efficiency based on these models.

We will start by discussing the non-program variables. Market conditions for REITs, as measured by the return to the NAREIT index, are positively related to q values. The coefficient is significant in the

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[24] Note that W_{1it} in the switching regression model and W_{it} in the pooled model are defined identically and are even calculated from the same probit estimation (Table 2). They are defined over different samples, however.

pooled sample and for non-partners, but the coefficient is not significant in the partners' model.[25] The magnitude of the effect, however, is small. A one percentage point increase in the return to the index increases *q* values by slightly more than 0.003 points, or 0.32 percent of the average *q* value for the sample period.

The riskiness of a REIT's stock has a significant negative effect on *q* values. That is, REITs with more volatile stock prices tend to have lower *q* values. The effect of volatility is more than four times larger among partners than non-partners. REITs, however, tend to be lower risk stocks and thus it is not possible to extrapolate this result beyond REITs.

Pre-1999 Tobin's *q* values are highly significant and exert a positive influence on *q* values in the sample. Larger values of the coefficient indicate a stronger influence of pre-1999 *q* on sample period *q* values. The relationship is strongest for partners with a coefficient of 0.83. Thus, partners that had high intangible values in the pre-sample period would also have high values in during the sample period. The use of pre-1999 Tobin's *q* controls for this carry-on effect of good performance.

Return on assets, both contemporaneous and lagged, is negatively associated with Tobin's *q* in our sample. The estimated coefficients, however, are only significant in two of six cases. In those two cases, they are significant only at the 10 percent level. Nevertheless, the prevalence of the negative signs does seem to indicate a negative relation. We expected that REITs with better profitability would have higher *q* values, so this result runs counter to our expectations.

The size of the REIT is significantly and positively related to *q* values. In the pooled model, a one percent increase in total square footage owned by a REIT increases *q* values by 0.024 points. The relationship is larger among partners compared to non-partners, however. A one percent increase in total square footage increase *q* values by 0.059 points for partners, but among non-partners the increase n *q* is only 0.027.

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[25] The lack of significance in the partner model may be caused by too few observations for partners. Specifically, the coefficient estimate on *NRET* for partners is (numerically) close to the estimated values in the non-partners and pooled models, but the standard error in the partners model is too large to generate a significant coefficient.

The concentration of a REIT's holdings across sectors is also positively related to *q* values. That is, REITs that are less diversified across property types tend to have higher *q* values. This result confirms previous research on the relationship between REIT property type concentration and firm value (Capozza and Seguin, 1999). This relationship, however, is not significant for partners. The pooled model also contains two sector controls: one for the office sector and one for the retail sector. Both control variables are negative and significant, indicating that non-office, non-retail REITs fared better over the sample period than REITs concentrated in the office and retail sectors.

The set of program-related variables (participation, benchmarking, and labeling) differs between the three equations. The non-partner model contains none of the program-related variables and the pooled model contains all three. In the pooled model we find that the partnership variable is significantly and positively associated with higher *q* values. As noted in the econometric methods section, however, this estimated coefficient reflects the sum of three influences: the direct effect of partnership on *q*, a reputational effect, and the effect of a company's propensity for being energy efficient. Combined, we interpret this coefficient as the effect of energy efficiency, as proxied by partnership in ENERGYSTAR®, on *q*. Thus, after controlling for market conditions, firm-specific financial factors, firm characteristics, and primary sector, we find a significant effect of energy efficiency on *q*. In the next section we translate the estimated coefficient in this model to a measure of the value of energy efficiency.

Our measure of benchmarking activity is included in the partner model and the pooled model. In both models benchmarking is associated with significantly larger *q* values. The estimated coefficient is larger in the partner-only model than in the pooled model because the pooled model contains non-partners that perform no benchmarking. The result says that REITs that benchmark a larger proportion of their buildings have higher *q* values. Benchmarking, however, is not something that is observed by the market. Thus, the market must be reacting to an outcome associated with benchmarking. Given that we have controlled for several other factors (firm-specific financial factors and pre-1999 *q*), we expect that the significant coefficient on *BENCH* reflects the market's valuation of energy efficient building operation. Energy efficient building operation will manifest itself in increased profits for these companies. Thus, companies that benchmark larger proportions of their buildings operate those buildings efficiently and this leads to higher intangible values by increasing profitability. Another possibility is that the market recognizes which REITs are more energy efficient and places some value on that energy efficiency. If the more energy-efficient REITs also tend to benchmark more of their buildings, then our significant coefficient on *BENCH* reflects the value of energy efficiency. In either case, the market is placing some intangible value on energy efficient operation.

Our measure of labeling, included in both the pooled model and the partner model, is not significant. This would seem to indicate that the market does not recognize an outward, objective sign of energy-efficient building operation. We expect that a statistical reason may also be leading to insignificance of the labeling variable. First, if we remove *BENCH* from either equation, *LABEL* is both positive and significant.[26] Second, all labeled buildings are also benchmarked ones. This implies that when we include both measures in the same model, we are measuring almost identical events.[27] The benchmarking variable has a larger variation and therefore consumes almost all of the explanatory power of the combined measure.

Before we turn to estimating the value of the program and energy efficiency in general, we note that the results associated with self-selection are mixed between the two formulations. In the pooled model, the self-selection term is significant—indicating that self-selection is a significant factor in explaining *q* values. In the switching regression models, the self-selection controls provide no explanatory power—indicating that self-selection plays almost no role in explaining *q* values. Nevertheless, we retain the self-selection framework because of the pooled model result and because there are good theoretical reasons to believe that self-selection will be important component of this evaluation.

8. Estimates of Market Value

In this section we translate the regression estimates from Section 6 into estimates of the market value of the ENERGYSTAR® program and of energy efficiency in general. There are four measures of participation in the program that we are interested in:

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[26] These results are not reported here, but are available from the authors upon request.

[27] The correlation between the two measures is 0.78.

- The value of being an ENERGYSTAR® partner;
- The value of benchmarking for ENERGYSTAR® partners;
- The value of energy efficiency, as proxied by ENERGYSTAR® partnership; and
- The value that non-partners would have earned had they joined ENERGYSTAR®.

The first of these, the value of ENERGYSTAR® partnership, is calculated using the ratio of the two equations in the switching regression model. The value of benchmarking is calculated using the partner's model in the switching regression model. The value of energy efficiency, is calculated using the pooled model. The last measure, which we refer to as the lost opportunity of not joining ENERGYSTAR®, is calculated using the switching regression model in a manner analogous to the first measure.

To calculate these values we begin by calculating the "premium" associated with each measure of participation. The premium is the defined as the q value associated with each participation measure relative to the q value associated with not participating. For example, for valuing the ENERGYSTAR® program, the premium measures the value of q for being a partner relative to not being a partner. A general expression for the premium can be written as:

$$Premium = \left[\frac{E[q \mid Participation]}{E[q \mid No\ Participation]} - 1 \right] \times \$1\ million \qquad (20)$$

where $E[\cdot]$ is the expected value operator. Thus, the premium is the ratio of two predicted q values and is converted into millions of dollars of a REIT's assets. To understand our formulation of this premium consider the following. Before subtracting off one and multiplying by $1 million, the premium reflects how much larger, in percentage terms, Tobin's q is for those participating in the program compared to those who do not participate in the program. Tobin's q reflects the value the market places on a firm's assets. Thus, before we multiply by $1 million, the premium reflects the percentage markup the market places on the assets of those firms performing the activity. Subtracting one and multiplying by $1 million converts the percentage to the value per million in assets.

We then multiply the premium by the average level of assets for the REITs that are participants to estimate the market value associated with the measure of participation. This follows from the fact that *q* values provide the market's valuation of a firm's assets. Thus, multiplying by the level of assets converts the premium into a market value. We begin by discussing the estimated premiums and market values for joining ENERGYSTAR®, benchmarking, and energy efficiency in general. We follow that with our estimate and discussion of the lost opportunities of not joining ENERGYSTAR®.

Value of Joining ENERGYSTAR®, Benchmarking, and Energy Efficiency

We estimate the value of the ENERGYSTAR® program by using the estimated switching regression model. The structure of this model allows us to estimate *q* values for partners if they had not joined ENERGYSTAR®. Thus, we can compare the *q* associated with partnership to the *q* associated with not being a partner for each partner in the sample at each time period. The *q* value associated with partnership is calculated by generating predictions from the partner model for each partner observation. The *q* value of partners *had they not joined the program* is calculated by generating predicted values for the partners using the non-partner model. Maddala (1983) suggests looking at the difference between these two numbers to gauge a program's effect. We use the ratio instead because relative *q* values are more easily interpreted as ratios. That is, for partner *i*, the benefit of participating in the program at time *t* can be calculated as

$$\frac{E[q_{1it}|D_{it} = 1]}{E[q_{2it}|D_{it} = 1]} = \frac{\boldsymbol{X_{1it}}\beta_1 - \sigma_{1\varepsilon}\hat{W}_{1it}}{\boldsymbol{X_{1it}}^*\beta_2 - \sigma_{2\varepsilon}\hat{W}_{1it}} \tag{21}$$

where $\boldsymbol{X}_1^*$ is the $\boldsymbol{X}_1$ matrix with *BENCH* and *LABEL* removed.[28] The average of equation (21) over all observations where $D_{it} = 1$ provides an estimates of the average benefit of participating in the ENERGYSTAR® program. We use this average ratio in calculating the ENERGYSTAR® premium.

[28] In calculating (21) it is necessary to adjust the matrix $\boldsymbol{X}_1$ in the denominator or the vector β_2 so that their dimensions make multiplication possible. Specifically, *BENCH* and *LABEL* do not have corresponding coefficients in β_2. To handle this, we remove those variables from $\boldsymbol{X}_1$ and re-label the new matrix $\boldsymbol{X}_1$*.

To value benchmarking, we use the estimated model for partners in Table 3 to predict a q value associated with some level of benchmarking (say $\bar{B}$) and compare that to a predicted q value associated with not benchmarking any buildings. This can be written as

$$\frac{E[q_{1it} \mid BENCH = \bar{B}]}{E[q_{1it} \mid BENCH = 0]} \tag{22}$$

We use the median level of benchmarking among partners to compute the numerator of (22) and evaluate all other variables also at their median levels. Equation (22) provides an estimate of the increase in q values for partners that perform a median level of benchmarking, compared to performing no benchmarking.[29]

As discussed in the econometric methods section, the estimated coefficient for the partnership variable in the pooled model will reflect the sum of three separate effects: the direct effect of ENERGYSTAR® on q, the reputational effect associated with partnership, and the effect of a company's propensity for being energy efficient on q. We interpret this combined effect as the effect of energy efficiency, as proxied by ENERGYSTAR® partnership, on intangible value. To calculate this value, we use the pooled model and predict the q value associated with partnership ($D = 1$) and compare that to the q value associated with not being a partner ($D = 0$). The ratio of these predicted q values can be written as

$$\frac{E[q_{it} \mid D = 1]}{E[q_{it} \mid D = 0]} \tag{23}$$

To calculate these predicted values, we set each variable in the equation equal to its mean value except for *D*, *BENCH*, and *LABEL*. We set *BENCH* and *LABEL* both equal to zero to remove the influence of these other program-related variables on our measure.

Table 4 provides our estimates for each of the three measures discussed above. We estimate that the ENERGYSTAR® premium is \$16,026 per million dollars of assets for REITs that are partners. That is, for every million in assets, ENERGYSTAR® partners earned an average return of \$16,026 in intangible

[29] The median amount of benchmarked space among the partners in our sample is 1.9 percent of total floorspace per quarter per REIT. In constructing the benchmarking variable, a building was considered to be "benchmarked" in a certain quarter if a benchmark score had been generated for it within the last year. The average amount of benchmarked space in our sample of partners was 9.2 percent of total floorspace per quarter.

value above what they would have earned had they not joined the program. Based on our formulation and our use of the switching regression model, we attribute this premium directly to a REIT's partnership in ENERGYSTAR®. Multiplying by the average level of assets for REITs that are partners, this premium translates into an average market value of $51.67 million, representing 3.66 percent of the average market value of these companies.

We estimate that benchmarking has earned partners a premium of $6,437 per million in assets. Thus, partners performing a median level of benchmarking (i.e., 1.9 percent of total square footage) earned an average return of $6,437 for every million in assets beyond what they would have earned if they performed no benchmarking. This translates to an average market value of $20.75 million for partners that benchmark, representing 1.47 percent of the average market value for these companies.

The estimated premium associated with benchmarking also indicates that active participation in the ENERGYSTAR® program has benefits. Not all ENERGYSTAR® partners benchmark their buildings. Our estimates indicate that a small amount of benchmarking (1.9 percent of total square footage) earns a return of 0.64 percent on assets. This return is *in addition to* the return earned for being a partner. Thus, a partner benchmarking about two percent of its floorspace earns a premium of $22,463 per million in assets, or a return of 2.2 percent. This translate to $72.42 million in market value, representing 5.13 percent of the market value of REITs that are partners.

Finally, we estimate that energy efficiency earns REITs a premium of $45,564 per million in assets. That is, taking participation in ENERGYSTAR® as a measure of energy efficiency, REITs that are partners earned a return of $45,564 for every million in assets above that of REITs that are not partners, and presumably less energy efficient. This translates into a market value of $146.89 million, representing 10.4 percent of the market value of these companies.

Lost Opportunities from Not Joining ENERGYSTAR®

We now look at the extent to which REITs that did not join the program lost intangible value from not joining.[30] Above, we estimated the intangible value that partners would have had if they had not

[30] The switching regression model assumes that partners and non-partners self-select into their respective groups, with self-selection based on an evaluation of the (unobserved) net benefits of joining.

joined ENERGYSTAR®, which provided a means of assessing the program benefits. In a similar manner, we can use our estimated models to predict the *q* value for non-partners if they had joined the program. We can calculate this in a manner analogous to equation (21). This can be written after making the appropriate substitutions as:

$$\frac{E[q_{1it}|D_{it} = 0]}{E[q_{2it}|D_{it} = 0]} = \frac{X^{*}_{2it}\beta_1 + \sigma_{1\varepsilon}\hat{W}_{2it}}{X_{2it}\beta_2 + \sigma_{2\varepsilon}\hat{W}_{2it}} \tag{24}$$

In calculating (24), we need to make an assumption on how much benchmarking and labeling each non-partner would have done under the program. Given that both are program-related activities, we think it reasonable to assume that non-partners would have done no benchmarking or labeling. Thus, we add two columns of zeros to $\boldsymbol{X}_2$ that correspond to these variables and call the new matrix $\boldsymbol{X}_2^*$. The average over all *i* and *t* where $D_{it} = 0$ will provide information on whether or not non-partners were better off not participating in the program. A more interesting measure, however, is the average of all observations where (24) is greater than one. These observations represent cases where the non-partners would have been better off as a partner and can be called "lost opportunity."

We calculated equation (24) for each of 1,232 non-partner observations. The average value for that calculation was 0.901, implying that, on average, non-partners had higher intangible value from not joining ENERGYSTAR®. There are, however, 377 observations (30.5 percent of the 1,232) in which the ratio exceeded one, implying that in those cases non-partners would have been better off by joining ENERGYSTAR®.[31] These 377 observations were distributed across 50 different REITs (41 percent of the non-partners). Thus, there were 50 REITs that would have been better off at some point between 1999 and 2001 had they joined ENERGYSTAR®. Of these 50, 20 of them would have been better off as a partner for the whole sample period. The average value of the ratio for observations that exceeded one was 1.099, which translated to an average lost premium of $98,925 per million in assets for those observations.[32] Thus, not joining ENERGYSTAR® resulted in a significant level of lost value for non-partners.

Finding cases where non-partners would have had higher intangible values had they joined ENERGYSTAR® does not invalidate that assumption because intangible value is only one component of the net benefit calculation.

[31] Once again, an observation corresponds to a REIT in a specific quarter. Thus, there were 377 quarters in which REITs could have had higher intangible values by joining ENERGYSTAR®.

[32] This estimate is large, but reflects only observations that exceed one.

9. Summary and Conclusions

This paper looks at the relationship between participation in the EPA ENERGYSTAR® program and a firm's intangible value. We used a sample of REITs measured quarterly from 1999 to 2001. We constructed models of the relationship between Tobin's *q*, a measure of intangible value, and participation in the ENERGYSTAR® program. Our models controlled for a number of factors, including self-selection into the ENERGYSTAR® program by companies, market conditions, firm characteristics, and firm-level financial factors. We found that the REITs involved in the ENERGYSTAR® program received a return of $16,026 for every million in assets above the amount they would have earned had they not joined the program. Based on the modeling procedure that we used, we attribute this return to the ENERGYSTAR® program. We also found that ENERGYSTAR® partners that benchmark a small number of buildings (1.9 percent of their total floorspace in a quarter) earn a return of $6,437 per million in assets. We attribute this benefit to activities that are associated with building benchmarking, such as efficient building operation. Finally, we found that energy efficiency, as proxied by participation in the ENERGYSTAR® program, earned partners a return of $45,564 per million in assets. This return translated into 10.4 percent of the market share of these companies. Thus, for REITs, where energy is a substantial concern, energy efficiency represents 10.4 percent of the market share of the energy efficient companies.

Our results are applicable to three distinct areas. First, we have provided estimates of the value created by a public voluntary program for program participants. The 1993 Government Performance and Results Act (GPRA) requires federal agencies to assess their performance. Our results are directly relevant to assessments of program performance under GPRA. Our results indicate that REIT partners earn a return of $16,026 per million in assets for being a partner. Furthermore, these results are directly attributable to the ENERGYSTAR® program. Although the key results for the ENERGYSTAR® program are related to reducing energy-related environmental effects, our results provide valuable information on the market value created by the program.

The results of this paper are also directly relevant for program recruitment efforts. The key for voluntary environmental programs to improve environmental conditions is recruit participants that take an active role in the program. Our results indicate that both joining the program and being an active participant create value for REITs. As noted above, REITs that join ENERGYSTAR® earned an average return of $16,026 per million in assets. Thus, joining ENERGYSTAR® has value. Additionally, REITs that took an *active role* in the program, as measured by benchmarking buildings, earned an *additional* return of $6,437 per million in assets for only a modest level of benchmarking (1.9 percent of total floorspace in any given quarter). Thus, a partner benchmarking about two percent of its floorspace earns a premium of $22,463 per million in assets. Both of these results should provide valuable information for the program's recruiting efforts.

Finally, our results should be directly relevant for investors and analysts that follow the REIT industry stocks. The results from our pooled model indicates that energy efficiency earned REITs a return of $45,564 per million in assets. This translated to a market value that represented 10.4 percent of the value of these companies. To measure energy efficiency in our model, we used whether or not the REIT was an ENERGYSTAR® partner. Thus, partnership in ENERGYSTAR® offers a convenient measure of which companies earn superior returns for their energy efficiency.

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Table 1. Definitions and Summary Statistics for Variables Used in the Analysis

Variable	Definition	Mean	Standard Deviation
Tobin's *q*		0.9231	0.2084
Partners	Ratio of market value to replacement value of assets.	0.9453	0.2188
Non-Partners		0.9174	0.2062
PART	Equal to one if REIT *i* was a partner in quarter *t* and zero otherwise	0.1409	0.3480
BMRATIO	Percentage of buildings that are benchmarked for REIT *i* in quarter *t*.	0.0151	0.0748
LBRATIO	Percentage of buildings that are labeled for REIT *i* in quarter *t*.	0.0041	0.0376
NRET	Quarterly return for NAREIT's Equity REIT Index, multiplied by 100.	2.887	6.001
SBETA	Stock market beta calculated over the 1996-2001 time period using end-of-month stock prices.	0.1271	0.0969
TSQFT	Total square feet owned by the REIT (millions).	32.59	70.57
Ln(*TSQFT*)	The natural logarithm of total square feet.	16.523	1.301
TA	Total assets in millions of dollars.	1,558.8	2,255.3
Ln(*TA*)	The natural logarithm of total assets.	6.933	1.175
CONC	Herfindahl index of property-type concetration.	0.8935	0.1790
q_b	Average value of Tobin's q between 1996 and 1998.	0.9076	0.3106
ROA	Return on assets	0.0104	0.0323
OFFICE (office)	Equal to one if more than 75 percent of the REIT's total square footage was in the office sector and zero otherwise.	0.1262	0.3322
RET (retail)	Equal to one if more than 75 percent of the REIT's total square footage was in the retail sector and zero otherwise.	0.5160	0.4999
IND (industrial/ warehousing)	Equal to one if more than 75 percent of the REIT's total square footage was in the industrial and warehousing sector and zero otherwise.	0.0753	0.2439
HC (health care)	Equal to one if more than 75 percent of the REIT's total square footage was in the health care sector and zero otherwise.	0.0635	0.2439
LODGE (lodging)	Equal to one if more than 75 percent of the REIT's total square footage was in the lodging sector and zero otherwise.	0.0962	0.2950
APT (residential)	Equal to one if more than 75 percent of the REIT's total square footage was in the residential sector and zero otherwise.	0.1632	0.3670
STOR (self-storage)	Equal to one if more than 75 percent of the REIT's total square footage was in the self-storage sector and zero otherwise.	0.0251	0.1564

Table 2. Results for Probit Model For Joining ENERGYSTAR® Program (N = 1,434)

Variable	Estimated Coefficient	Marginal Effect On Probability of Joining ENERGYSTAR® [a]
Constant	-4.402*** (-4.02)	-
Return to the NAREIT Equity Index (*NRET*)	0.026*** (3.01)	0.0035
Log of total square feet (ln(*TSQFT*))	-0.038 (-0.352)	-0.0051
Log of millions of total assets (ln(*TA*))	0.418*** (3.14)	0.0557
Return on assets (*ROA*)	1.364* (1.85)	0.1817
Return on assets, lagged one quarter ($ROA_{t\text{-}1}$)	1.551*** (2.02)	0.2065
Pre-1999 Tobin's q (q_b)	0.749*** (4.573)	0.0997
Stock market beta (*SBETA*)	1.294*** (2.32)	0.1723
Residential sector (*APT*)	-7.883*** (-55.16)	-0.0961
Industrial and warehousing sector (*IND*)	-0.386* (-1.86)	-0.0506
Lodging sector (*LODGE*)	-7.343*** (-47.64)	-0.0961
Health care sector (*HC*)	-7.343*** (-47.64)	-0.0961
Office sector (*OFFICE*)	1.202*** (9.94)	0.3634
Self-storage sector (*STOR*)	-7.664*** (-55.54)	-0.0961
Log-likelihood	-366.70	-
Likelihood Ratio Statistic	432.54***	-

Note: The base sector in this table is retail.
[a] This is the effect of each variable on the probability of joining the ENERGYSTAR® program. For the continuous variables (*NRET*, ln(*TSQFT*), ln(*TA*), *ROA*, ROA_{t-1}, q_b, and *SBETA*), this is measured at the mean value for each variable. For the remaining binary variables, this reflect the change in probability associated with setting the binary variable equal to one.

Table 3. Estimated Regression Models for Tobin's q

Variable	Switching Regression Model		Pooled Regression Model
	Partners (N = 202)	Non-Partners (N = 1,232)	(N = 1,434)
Constant	-0.8087** (-2.10)	-0.0340 (-0.52)	0.0709* (1.82)
ENERGYSTAR® partnership (*D*)	-	-	0.0417*** (3.82)
Benchmarking (*BENCH*)	0.2966** (2.10)	-	0.1445*** (2.19)
Labeling (*LABEL*)	-0.0460 (-0.20)	-	0.0950 (0.78)
Return to the NAREIT Index (*NRET*)	0.0034 (1.48)	0.0031*** (4.04)	0.0030*** (7.34)
Stock Market Beta (*SBETA*)	-0.4166* (-1.96)	-0.0995* (-1.96)	-0.1939*** (-7.15)
Log of Total Square Feet (ln(*TSQFT*))	0.0593*** (2.83)	0.0269*** (7.41)	0.0243*** (11.83)
Concentration (*CONC*)	0.0327 (0.33)	0.1907*** (6.04)	0.1789*** (9.35)
Pre-1999 Tobin's Q (q_b)	0.8300*** (9.98)	0.3810*** (25.64)	0.3974*** (49.8)
Return on Assets (ROA_t)	-2.7518* (-1.78)	-0.1291 (-0.95)	-0.1522* (-1.81)
Return on Assets, previous quarter (ROA_{t-1})	-1.508 (-0.97)	-0.081 (-0.59)	-0.0966 (-1.14)
Office Properties Sector	-	-	-0.0623*** (-5.00)
Retail Sector	-	-	-0.0469*** (-5.668)
Self-Selection Correction (W_{1it}, W_{2it}, W_{it})	-0.0111 (-0.29)	0.0015 (0.06)	-0.0066*** (-5.62)
R^2	0.8382	0.8184	0.8046
Adjusted R^2	0.8298	0.8172	0.8028

Asymptotic t-ratios appear in parentheses.
*** Significant at the one percent level.
** Significant at the five percent level.
* Significant at the ten percent level.

Table 4. Estimated Premiums and Market Value for ENERGYSTAR® Program, Benchmarking, and Energy Efficiency.

Measure	Estimated Premium (Value Per Million Dollars of Assets)	Market Value (Millions)	Percentage of Total Market Value
Value of Being an ENERGYSTAR® Partner	$16,026	$51.67	3.66%
Value of Benchmarking Buildings for Energy Performance	$6,437	$20.75	1.47%
Value of Being an ENERGYSTAR® Partner and Benchmarking Buildings (Active partnership)	$22,463	$72.42	5.13%
Value of Energy Efficiency	$45,564	$146.89	10.40%

Session IV: Evaluation of Voluntary Programs
Discussant No. 1: Charles Griffiths, U.S. EPA, NCEE
COMMENTS ON:

The ISO 14001 Management Standard:
Exploring the Drivers of Certification

Andrew King
Darmouth College

and

Participation in Voluntary Programs, Corporate Reputation, and Intangible Value: Estimating the Value of Participating in EPA's ENERGY STAR® Program

Lou Nadeau
ERG, Inc

April 27, 2004

Recently, two of my colleagues, Ann Wolverton and Keith Brouhle, and I were asked to write a book chapter on U.S. voluntary programs. We have been working on ways to evaluate the effectiveness of voluntary programs, so this was a good way to review the literature. Our conclusion was that the current economic literature has not produced strong evidence of improved environmental performance due to voluntary programs. Some programs have been recognized as improving performance, but, in general, voluntary programs have not yet been shown to produce dramatic improvements. We do recognize, however, that there are a number of objective, other than improved environmental performance, that might justify a voluntary program. Objectives such as improved economic efficiency (that is, the program might produce greater net benefits to society); savings in administrative, monitoring, and enforcement costs for the same environmental impact; the inducement of innovation; or increased environmental awareness.

As you might guess, the response from individuals in the voluntary program offices was mixed. Two responses, however, are of interest. First, one individual said that economists are obsessed with economic efficiency. If it doesn't look and smell like cap-and-trade, then they don't like it. His concern seemed to be that there are other, non-economic and non-quantifiable objectives for these programs that economists miss. The second comment was that the text was very negative. After recognizing that the economic literature may not have found much environmental impact of these programs, I was asked if I could include a sentence along the lines of "that said, well designed voluntary approaches can be a highly effective tool for environmental protection." The review offered no additional basis for the inclusion of this sentences, but I understood that it reflected a deep belief that voluntary programs are an important component of the EPA mission, even if the economists can't quantify it.

Certainly there has been a growth in voluntary programs. Our chapter identifies 55 voluntary programs administered by the EPA and established since 1991. There is also anecdotal evidence that they have had some impact. As one reviewer of our chapter informed me, Robert J. Eaton, when he was chairman of Daimler Chrysler and chair of the National Academy of Engineering said, "Life Cycle Management had convinced us that 'pollution prevention pays.' Not only doe it pay, but it can be a competitive advantage."

In this session, we have heard two excellent papers that attempt to get at the advantages of voluntary programs. Both are econometrically sophisticated. King, Lennox, and Terlaak (2004) explicitly take into account the correlation between establishing an EMS and ISO 14001 certification. Personally, I expected to see a two stage approach, particularly if we believe that ISO certification follows the establishment of an EMS. One approach would be to use an inverse Mills ratio as in the next paper. Nadeau, Cantlin, and Wells (2004) use this approach to explicitly account for self-selection into a program. In this paper, I would suggest allowing the participation variable to affect the slope term as well as the constant.

If we look at the left hand side variables in these papers, we see a very common construction, and one which I would like to talk about. Both studies looked at some outward mark of participation in a voluntary program, but not necessarily at the environmental improvements that this participation produces. King, et al. examine the establishment of an EMS or ISO 14001 certification in the majority of their paper, and only look at the effect on environmental performance at the end. Nadeau, et al. looked at the market value of participation in Energystar and not the environmental benefit of the program. Both sets of authors recognize this point. Nadeau, et al. state that they "... are looking at how good energy performance, rather than good environmental performance, relates to financial performance." The decision to look at this relationship, rather than environmental performance, may be related to the difficulty in finding measurable environmental gains due to participation in these programs. As King, et al. note regarding their program, "many expected ISO 14001 to produce a means of credibly differentiating organizations with better environmental performance. Our analysis suggests that this expectation went unfulfilled."

A more careful look at these analyses, however, may suggest a more complicated story. In King, et al., regulatory pressure affects the establishment of an EMS and an EMS is a statistically significant determinant of environmental improvements. EMSs, then, are important but are a less transparent measure of corporate environmental actions. In contrast, the outward mark of good environmental management, ISO 14001 certification, is not statistically affected by regulatory pressure and does not have a significant impact on environmental performance. Similarly, in Nadeau, et al., the measure of good environmental activity which is not witnessed by the market, benchmarking buildings, is a significant factor in the Tobin's q premium. The outward label of Energystar, on the other hand, is not statistically significant. So, while the outward mark of environmental performance, ISO 14001 certification and the Energystar building label, is not a significant driver in environmental or financial performance, the less evident measure is significant.

Why is this important? Because the outward mark is measurable and is often the only thing available for evaluation. It is, however, confounded by the fact that it could simply be a measure of EPA's efforts in recruiting partners. This has been the recent concern of OMB and others, that voluntary programs shouldn't measure success by the number of partners they recruit, since it is measuring the desired output, environmental gains, by measuring inputs, the success in recruiting partners. This may be why some researchers have not found big environmental gains by measuring participation in voluntary programs – it is confounded by the effort in recruiting those partners. The participation variable may be a noisy indication of the actual, unobservable measure of environmental performance. To the degree that participation requires or increases the unobservable measure of good corporate environmental activity, an EMS or benchmarking, then the voluntary program is responsible for improved environmental performance. It may be difficult to evaluate, however, because of a lack of appropriate data.

In this case, the authors were lucky to the appropriate data. King, et al. had TRI data, which included a measure of EMS activity. Nadeau et al. had internal Energystar benchmarking data. Many times, however, this type of data is not available, and it is precisely this lack of data that my coauthors and I have found as a limiting factor for evaluating voluntary programs. It is hard to avoid the conclusion that researchers have, so far, not found big environmental gains from voluntary programs. The point is that this may be due to the fact that the outward mark of environmental performance may only be a noisy indicator of actual underlying corporate activity. In other words, and as my reviewers were trying to emphasize, there may be unquantified factors that economists sometimes miss and perhaps we shouldn't be so negative about voluntary programs. Only more accurate, underlying data and additional research will tell.

Session IV: Evaluation of Voluntary Programs
Discussant No. 2: Jorge Rivera, George Mason University
COMMENTS ON:

The ISO 14001 Management Standard:
Exploring the Drivers of Certification

Andrew King
Darmouth College

and

Participation in Voluntary Programs, Corporate Reputation, and Intangible Value: Estimating the Value of Participating in EPA's ENERGY STAR® Program

Lou Nadeau
ERG, Inc

1. Strategic enactment of a new institution: Exploring the causes of certification with the iso-14001 management standard. By King, Lenox, and Terlaak

This is an excellent paper from both the theoretical and empirical perspectives. Using a strategic analysis approach the manuscript develops a conceptual framework and hypotheses to explain under what circumstances corporate facilities are more likely to certify with ISO-14000. The authors argue that supply chain's information asymmetries, which make the exchange of credible environmental reputation difficult, are one of main reasons why facilities decide to obtain ISO-14000 certification. These hypotheses are then tested using a proportional hazard model and 1995-2002 panel data for a sample US-based facilities.

Their findings suggest that ISO-14000 certification is used as a signal of environmental improvement efforts rather than an indication of superior environmental performance. Certification is more likely for facilities that are more distant in terms of geography and culture and for those with long term or vertically integrated associations to downstream buyers. My main criticism to King, Lenox, and Terlaak's approach is that they use US-based facilities to assess ISO-14000, an international standard whose participants are mostly outside the US.

2. Participation in voluntary programs, corporate reputation, and intangible value: Estimating the value of participating in EPA's Energy Star Program. By Nedeau, Canting, and Wells.

This paper relies on quarterly 1999-2001 data of 124 real investments trusts to estimate the market value (measured as Tobin's q) of the Energy Star Building program. The authors suggest that the Energy Star provides its partners with benefits of about sixteen thousand dollars per each million dollars of assets.

I believe that the manuscript uses a very good approach and valuable data to try to answer a critical question regarding the use of voluntary environmental programs as an alternative policy tool to promote environmental protection. Yet, I would encourage the authors to improve the paper in the following areas:

1. The review of the literature needs to incorporate the research on voluntary programs published in the management and public policy journals.
2. Given its focus on intangible assets and capabilities, the authors may find it valuable to incorporate arguments from the resource view of firm to support their hypotheses, discussion, and conclusions.
3. The authors put a big emphasis on the importance of reputation but only use an instrumental variable that accounts for this and other constructs. Thus, it is necessary to incorporate a direct measure of reputation in the analysis.
4. The issue of reverse causality needs to be addressed in the discussion and conclusions.
5. Finally, the authors need to include a section that explicitly highlights the limitations of their approach and findings.

Summary of the Q&A Discussion Following Session IV

Matt Clark (U.S. EPA, Office of Research and Development)
For people who are looking for money for data, I understand the Japanese and European economies are doing pretty well right now. [laughter]

I'm relaying a question from William D'Alessandro from Crosswinds Bulletin—one of the people who have joined in on the phone and the internet: Mike, could you re-state, for Bill's benefit, why companies certify ISO 14001?

Michael Lenox (Duke University)
In responding to this question, Dr. Lenox clarified that their research indicates that certifying "seems to be signaling simply that you have an EMS in place and *not* signifying some secure, underlying environmental quality."

Eric Otis (University of Pennsylvania)
Addressing the first of two questions to Dr. Lenox, Dr. Otis referred to the literature that TRI commonly uses and asked "whether a footnote isn't appropriate there as to what it really is measuring, because [he thinks] it's at least possible to say that EMS's and ISO 14000 programs actually are providing some environmental performance benefits that are not captured by the TRI measure." Characterizing the TRI measure as "very high level, gross information," Dr. Otis said he doubted whether this was the best measure for gauging firm-level environmental performance, and he advised Dr. Lenox to "at least qualify your result on that point."

Dr. Otis directed his second comment to Louis Nadeau regarding the correlation between "better firms, in terms of monitoring conditions, etc." and participation in the Energy Star Program. Dr. Otis questioned the assumed causation direction of the correlation and said he believes the causation can go both ways. In other words, since it is as likely that "better firms can afford to be doing Energy Star" as it is that "Energy Star [participation] is worth more money, . . . you really wouldn't want to conclude that there's a huge amount of value in Energy Star. It may be going the reverse direction—those firms that are better managed already can afford to do Energy Star Programs, which may be providing environmental benefits, but it's not then as clear what follows from what." Dr. Otis wondered whether Dr. Nadeau had accounted for "that potential reverse causation," which, he believes, "shows up in a lot of other studies as well."

Michael Lenox
Dr. Lenox responded that because they were dealing with manufacturing firms . . . at the facility level, "at *some* level, emissions is a *good* measure of facility-level environmental liabilities." He went on to acknowledge that what Dr. Otis said is "absolutely correct," in that the researchers used this measure "as a *proxy* for some kind of unobserved environmental quality, and there could be a number of attributes and elements in that."

Dr. Lenox went on to say that he and his colleagues, and other researchers as well, really *should* have been and really *need* "to be curious about the correlation between TRI measures and things like NO_x-SO_x emissions, accidents, violations and the like." He closed by saying that it was his hope and speculation "that there is *some* significant correlation between these various metrics," but he isn't aware of anyone who has actually performed an analysis of that as yet.

Lou Nadeau (ERG, Inc.)
Dr. Nadeau responded to the second question from Dr. Otis pertaining to the probable bi-directional nature of causation between a firm's participation in the Energy Star Program and that firm's financial health by saying, "It's a valid point—clearly, better companies tend to join Energy Star, and so any sort of correlation in compliance needs to be interpreted in that light." He said that they used the Heckman self-selection tool in the first stage of the study to capture the first level of causation, *from* corporate value *to* participation in Energy Star, and are "hopefully getting at the causation running *from* participation *to* value" in the second stage of the study. He closed by affirming that the team is attempting to control for as many things as possible.

Jon Silberman (U.S. EPA, Office of Enforcement and Compliance Assurance)
Mr. Silberman opened by stating, "First, I'd just like to point out that there is, in fact, an extensive amount of research out of Europe that also looks at the question of ISO 14000 certification and its relationship to performance, but since we have one of the leading European researchers, Chris Howes from the United Kingdom Environment Agency, waiting to speak at the other microphone, so I'll just stop there."

Mr. Silberman continued, directing this comment to Dr. Lenox: "I'm wondering if ISO 14000 coupled with certification is not functioning very similar to how a rule might function as a mandatory requirement out of government followed by inspections." He clarified this idea by adding, "if people who adopt EMS's without certification are doing better than people who certify, *is* the certification process potentially dumbing down people's EMS's by making them managed towards achieving a piece of paper that, based on my ISO 14001 auditor training and years of experience with ISO 14000, is *quite* easy to get and *totally* dissociated from actual performance?"

Michael Lenox
In response to the availability of data from Europe, Dr. Lenox commented that these data are often difficult to use from a researcher's perspective due to the lack of comparability across the data sets. As an example, he suggested that finding a European measure "that maps very nicely to TRI . . . would require some coordination that . . . would be very difficult to achieve."

Addressing Mr. Silberman's second issue, Dr. Lenox stated that "suggesting that the EMS is great and then the certification dumbs it down . . . would be an incorrect interpretation of our findings. It's simply the fact that there are forces that are driving the adoption of EMS's *independent* of certification, and that often the existence of an EMS makes it much easier, then, for you to get certification."

Chris Howes (Environment Agency, England and Wales)

Mr. Howes cited two European studies of environmental management systems—one that looked at performance data and compliance history from over 2,500 regulated sites, and another pan-European industry study that looked at data from 450 sites. He said these two studies had fairly common findings: basically, "there is no correlation between good environmental performance or compliance and certification with ISO 14001, or indeed registration to EMAS," (a European program that Mr. Howes characterized as "ISO 14000 *plus*"). Mr. Howes went on to say that "the very clear message with regard to *legal* compliance is: If we as a regulator wanted to target sites based on whether or not they had EMS's, which seems to be sensible thing to do, . . . we should target those sites *with* ISO 14001 *or* EMAS because they are *more* likely to have noncompliances and they are more likely to have poor environmental performance."

Citing a current 3-year project being managed by the Environment Agency (the REMAS Project—more information available at www.remas.info), Mr. Howes advocated looking at broad "benchmark performance and the existence, or otherwise, of EMS's at a much greater level of sensitivity" than is typical with ISO or REMAS. "It's looking at the elements of a management system that are in place and comparing those to compliance and to the normally regulated issues in terms of emissions to air, land, and water." Mr. Howes also mentioned the more recent regulatory categories for major industry in Europe of energy efficiency and resource efficiency. Getting to his main point, Mr. Howes asked, "if certification and registration in the U.S. and the rest of the world doesn't add value, shouldn't *this* be the issue for all stakeholders in ISO 14001—the public, regulators, and industry? . . . Shouldn't we be pushing for *outcomes*, not *process*, from ISO—from the accreditation bodies, from registrars?"

According to Mr. Howes, UKAS, the accreditation service in the U.K. that is somewhat equivalent to RAB [Registrar Accreditation Board, established in 1989 by the American Society for Quality], has recently come out and said that, essentially, "ISO 14001 is not driving improvement; . . . the qualifications of offices aren't good enough; the accreditation bodies aren't good enough." Ultimately, Mr. Howes wonders, "What are we [including the U.S. EPA and others] going to do about this?"

Jay Benforado (U.S. EPA, National Center for Environmental Innovation)
Before turning to the paper writers for their responses, Mr. Benforado paraphrased the question as: "Could you foresee some utility in certification of *performance* rather than certification of *process*?"

Michael Lenox
Dr. Lenox responded, "First of all, I take a little issue with the idea that certification doesn't add value. The question is: *Who* does it add value to and *to* what ends? I think it

does probably add value for those in the supply chain who want to try to have some, perhaps, management over those facilities. From a public *policy* standpoint, does this lead perhaps to a reduction in environmental emissions and the like? Once again, we're finding that might not be working the way we had hoped. So, *should* public policy perhaps get involved and step in and try to put more teeth in something like ISO 14001? Perhaps, *but* to the extent you're interested in self regulation, it begins not to look like self regulation much anymore, obviously, with the EPA stepping in and mandating and dictating."

Allison Christie Sajan (Natural Resources Canada)
Ms. Christie Sajan said that Natural Resources Canada has been looking at many of these same questions and that the companies they have heard from who have applied various types of environmental management tools, such as EMS's, believe they are realizing real benefits from these efforts. She commented that they are in the first phase of a 3-year study of companies that have *not* employed an EMS and would welcome any dialogue or suggestions.

Madhu Khanna (University of Illinois)
Dr. Khanna raised a question "related to the result . . . that firms who have an EMS *did* show some improvement in environmental performance but not the ones that actually got certified." She went on to say, "If I understand correctly what you're doing, you're looking at firms that just started that have an EMS, and the second group is firms that have an EMS but also got certified." Dr. Khanna concluded by saying she was "really intrigued by why it is that firms that actually went ahead and got the certification, which presumably verified that their EMS had all the right elements and so on, did *not* achieve the environmental improvements that the other firms did."

Michael Lenox
Dr. Lenox replied, "I apologize for that—that is not correct—the interpretation is that *that* is the pool of *all* who get EMS, not just the ones who *don't* get certified. So, we're looking at two pools here—those who get EMS and that effect on improvement, and then *certification*, which is a *sub-sample* of those who have an EMS. So, the argument, which is not surprising actually, is that certification in and of itself *does not* lead to any improvement, and I'm not sure why it would be expected to. If you have a functioning EMS, *that's* what should lead to improvement—not the certification per se. So, to be clear on that, in that pool of [firms with an] EMS is both those who get certified and those who don't get certified."

Madhu Khanna
Dr. Khanna then suggested investigating whether having an EMS and certification *together* is better than just having an EMS.

Michael Lenox

Dr. Lenox responded that "supposedly the certification variable tries to pick that up, and we *don't* find that. . . . Again, to be clear, there are incentives, perhaps, to improve environmental performance that drive you to adopt an EMS. There are *other* kinds of incentives that are dangled giving you incentives to certify that are not necessarily commensurate with that."

Corporate Environmental Behavior and the Effectiveness of Government Interventions

PROCEEDINGS OF

NEW GRANTEES IN CORPORATE ENVIRONMENTAL BEHAVIOR

A WORKSHOP SPONSORED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S NATIONAL CENTER FOR ENVIRONMENTAL ECONOMICS (NCEE), NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH (NCER)

April 26-27, 2004
Wyndham Washington Hotel
Washington, DC

Prepared by Alpha-Gamma Technologies, Inc.
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DISCLAIMER

These proceedings are being distributed in the interest of increasing public understanding and knowledge of the issues discussed at the workshop and have been prepared independently of the workshop. Although the proceedings have been funded in part by the United States Environmental Protection Agency under Contract No. 68-W-01-055 to Alpha-Gamma Technologies, Inc., the contents of this document may not necessarily reflect the views of the Agency and no official endorsement should be inferred.

TABLE OF CONTENTS

New Grantees in Corporate Environmental Behavior

Pollution Prevention: The Role of Environmental Management and Information

Madhu Khanna, George Deltas, Satish Joshi
Donna Ramirez

University of Illinois and Michigan State University

1

Pollution Prevention (P2)

- Promises several advantages over end-of-pipe controls
  - Focuses on multi-media pollution control
  - Prevents trace emissions/bio-accumulative pollutants
  - Requires greater integration between environmental and business decisions; encourages innovation and cost-effectiveness
- Waste reduction at source implies increased efficiency in production
  - Potentially higher profits and a win-win strategy
  - Differentiated products that respond to environmentally conscious consumers
  - Reduced environmental risks to shareholders
  - Improvement in corporate reputation

2

Approaches for Pollution Prevention

- Regulatory agencies encouraging P2
  - Voluntary programs, technical assistance and training
  - Environmental Leadership Programs/Adoption of Environmental Management Systems
  - Information collection and disclosure through the Toxics Release Inventory
    - Requires reporting on toxic releases and adoption of 8 types of P2 activities
- Firms are
  - Participating in stewardship programs
  - Adopting Environmental Management Systems (EMSs): Total Quality Environmental Management (TQEM)
    - Seeking continuous progress in reducing waste and improving product quality
    - Undertaking internal environmental audits, employee training and involvement
    - Making process and product modifications to increase efficiency and reduce waste

3

Motivation for this Research

- What is motivating some firms to adopt EMSs/TQEM and P2?
  - Which types of firms are more likely to adopt?
- Do EMSs encourage P2 and which types of P2
  - Visibility of EMSs may provide stakeholder benefits to firms even in absence of P2
  - Some P2 is costly; less observable by public
  - Adoption rates of TQEM high (50%) but of P2 low (25-33%)
- Is P2 effective in improving environmental performance of firms?
- Does pollution prevention really pay?
  - Which types of P2 in particular and for what types of firms?

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Theoretical Issues Addressed

- Can market pressures (consumer preference for green products) motivate P2 as a strategy to differentiate products and achieve social optimality?
- Are supplementary regulations needed (minimum quality standards, taxes/subsidies) and their implications for social welfare, firm profits and prices
- Incentives for P2, EMS adoption and social optimality of market based pressures when all consumers cannot observe P2 but can observe a firm's EMS

5

Empirical Analysis

- Motivations for P2: Role of TQEM and information provision about toxic releases
- Impact of P2 adoption on environmental performance
- Impact of P2 on economic performance of firms
  - Event study analysis of impact of P2 and EMS adoption on stock market reactions to toxicity weighted TRI
  - Impact of P2 on expected future profitability of firm, price earnings ratios and market shares

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Theoretical Framework

- Assumptions
  - Product attributes:
    - Greenness
    - Reliability
    - Others: style, design, convenience
  - All consumers care about greenness to same degree; differ in preferences for other attributes
  - Consumers willing to internalize the externality to some extent
  - Greenness measured by emissions intensity (P2)
  - Consumers can observe extent of P2
  - Rival firms in an industry seek to differentiate their products
  - Increasing greenness of product by a firm imposes fixed costs that increase with greenness
    - can lead rivals to match greenness or lower prices

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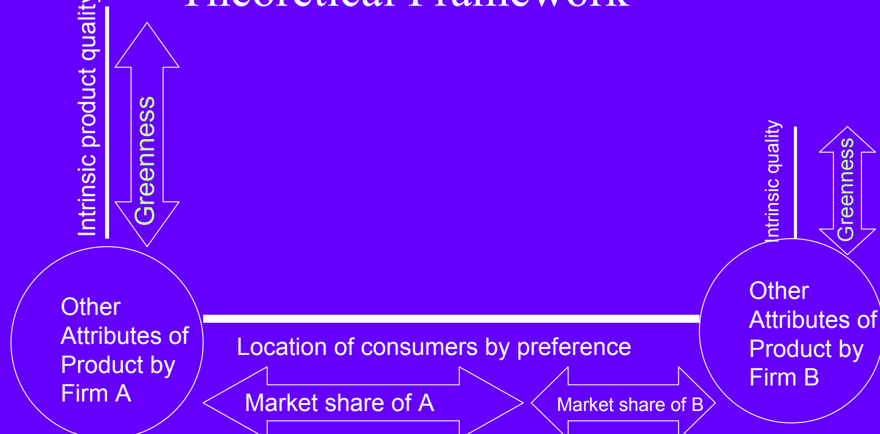
Theoretical Framework



Reliability and other attributes of brands pre-defined

Firms choose greenness and product prices to maximize profits

Consumers choose the product that maximizes their benefits net of prices

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Specific Questions Investigated

- Whether firms with a higher intrinsic quality are more/less likely to choose more P2
- Incentives for P2 due to
  - Impact of increased consumer awareness about environmental attributes of products
  - Cost sharing of P2 by regulators
- Impact of P2 on market shares, prices and profits
- Whether consumer preferences are sufficient to achieve socially optimal level of P2 by all firms
- Implications of minimum quality standards, taxes/ subsidies for P2, firm profits and social welfare.

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Initial Findings

- When consumers observe and care about product greenness
  - Firm with higher intrinsic quality does more P2, charges a higher price and has a greater market share than rival firm
  - Even if consumers fully internalize the environmental externalities, market pressures will not lead to an optimal provision of the environmental attribute
    - Need to supplement market pressures with regulatory intervention
  - Impact of a minimum quality standard on social welfare is ambiguous
    - Higher quality firm may overcomply with standard but would do less P2 than in absence of standard

Work in Progress

- Implications of product quality taxes/subsidies and cost sharing policies for P2, firm profits and social welfare
- Implications for P2 and social welfare when only some consumers observe product greenness but all care about it and firms adopt an EMS to indicate product quality

10

Sources of Data for Empirical Analysis

- Adoption of TQEM: IRRC surveys 1994-96
  - 228 parent company level observations each year
  - 3500 observations at the facility level each year
- Toxic Releases and P2 activities: TRI
  - Types of P2 activities: Good operating practices; Spill and Leak Prevention; Process and Product Modification
  - On-site Releases, Off-site Transfers, Hazardous Air Pollutants
- Superfund sites, inspections and civil penalties: IDEAS data
- Financial Performance: Research Insight Data
- Environmental Pressure Indicators: Census and other sources
- Sample of Firms: S&P 500 firms that report to TRI and completed IRRC survey 1994-96

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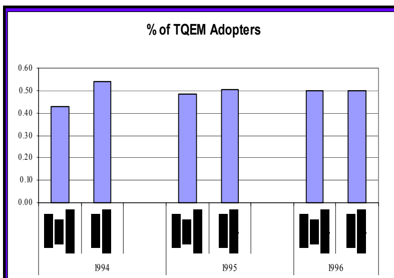

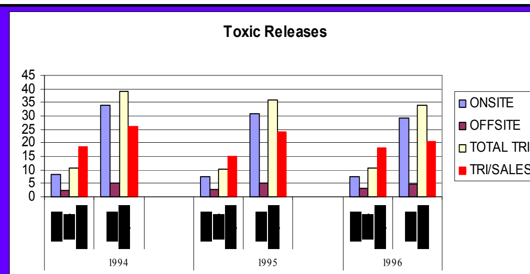

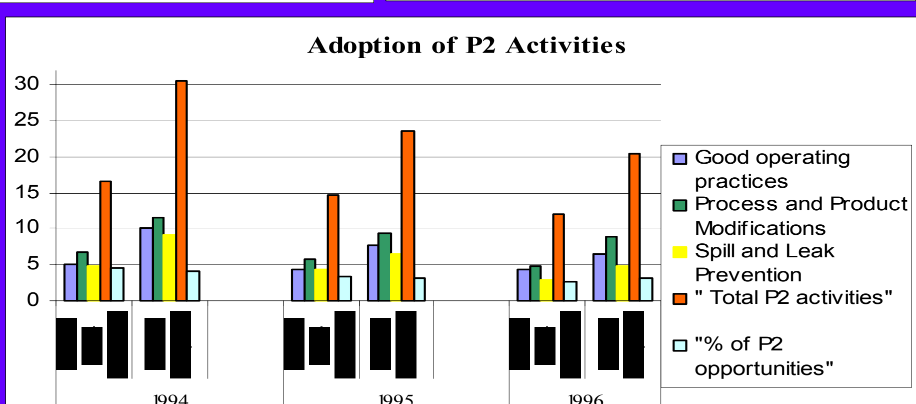

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Motivations for TQEM

Probit Analysis using Panel Data Methods

Explanatory Variables	Effect
Market Pressures: Final Good	+
Market Share	+
Asset/Sales	+
Regulatory Pressure: NPL sites	+
Volume of HAP	+
Civil Penalties	
Frequency of Inspections	
Information Provision: Off-site Transfers	+
On-site Transfers	
Firm Characteristics: Size	+
R&D expenditures	+
Older Assets	+

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+: Significant positive effect; Others Insignificant effect

Motivations for P2

Explanatory Variables	Good Operating practices	Spill and Leak Prevention	Process/ Product Modification	Off-site Transfers/ Sales
TQEM		+		-
Market Pressures: Final Good		-	+	
Market Share		-	+	
Regulatory Pressure: NPL sites	-	-	+	
Volume of HAP	+		+	-
Civil Penalties				-
Frequency of Inspections	+			
Info. Provision: Off-site Transfers past		-		+
On-site Transfers past	-	-	-	
Number of TRI Records	+	+	+	
Firm Characteristics: Size	-	-	-	
R&D expenditures	+		+	
Older Assets	+			
Sales/Asset	+	+	+	
Facilities in Non attainment Counties			+	
Facilities in States with high compliance expenditure	+			

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Impact of TQEM on Process/Product Modification Activities Varies Across Firm Types

- Firms in the Top Quartile of R&D expenditures:
  - Larger R&D expenditure more likely to lead to more P2
  - TQEM has an insignificant impact on P2
- Firms in the lower 3 quartiles of R&D expenditures
  - Larger R&D expenditures less likely to lead to more P2
  - TQEM has a positive impact on P2
- Firms in the top 3 quartiles of market share
  - Firms with larger market share more likely to do P2
  - TQEM has a positive significant impact on P2

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Event Study Analysis: Stock Market Reactions to Toxic Release Information

Hypothesis to be Tested:

- **H1:** There is a significant negative association between the quantity of pollutants released and a firm's abnormal stock returns.
- **H2**: The toxicity level of the releases is negatively associated with the stock market returns.
- **H3**: Higher P2 activities exhibit a positive association with stock market returns
- **H4**: A firm's degree of readiness to improve its environmental performance, signaled by its adoption of an EMS, and it's stock market returns are positively associated.

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Other Work in Progress

- Analysis of effects of TQEM and other practices (such as corporate reporting) on P2
- Facility level analysis of impact of P2 and source of information/assistance on P2 on Toxic Release performance and on criteria pollutants
- Impact of P2 on financial performance of firms

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The Effect of Self-Policing on Hazardous Waste Compliance

Sarah L. Stafford
The College of the William and Mary

EPA's Corporate Environmental Behavior Workshop April 27, 2004

Research Supported by STAR Grant R831036

Objectives

- Determine whether self-policing policies have affected compliance with hazardous waste regulations.
  - Understand the extent to which companies use self-policing.
  - Develop compliance model that incorporates self-policing.
- Provide feedback on the effectiveness of self-policing policies.

EPA's Corporate Environmental Behavior Workshop April 27, 2004

Self-Policing

- Self-Policing: a situation in which a regulated entity notifies authorities that it has violated a regulation or law.
  - Not necessarily the same as self-reporting.
- Federal “Audit Policy” encourages self-policing by reducing or eliminating penalties for self-disclosed violations.
- State self-policing policies and environmental audit privilege and immunity laws also encourage self-policing.

Theoretical Framework

- A self-policing policy without a change in inspection targeting or fines cannot increase compliance.
  - Can increase environmental protection by requiring remediation.
  - Should only effect inadvertent, not willful, violations.
- If a self-policing policy is combined with a redistribution of enforcement it can increase compliance.
  - Can affect willful violations as well as inadvertent.

Empirical Analysis

- Ideal analysis would consider effect of self-policing policies on auditing, self-policing, and compliance.
  - Comprehensive data not available.
- First, look for changes in compliance behavior after imposition of federal and state policies.
- Based on results, conduct more focused analysis.

Initial Analysis

- Use panel data on inspections and detected violations before and after imposition of federal and state policies.
  - Probability of inspection, and thus probability of detection, is not exogenous.
  - Use censored bivariate probit with errors clustered by facility.
- Data for 9,500 hazardous waste facilities from 1992 to 2001.
  - No newly regulated facilities, one-time generators, small quantity generators, or federal facilities.

Initial Results

- Federal policy accompanied by change in targeting, but no significant change in overall level of violations.
- State policies appear to have had a more significant effect:
  - States with audit privilege only: lower probability of inspections and violations.
  - States with audit privilege and immunity: higher probability of inspection, lower probability of violation.
  - States with self-policing: lower probability of inspections and violations.

Questions Still to be Answered

- Is the change in targeting due to self-policing policies or merely coincident?
- Can the change in violations be attributed to self-policing or are there other causes?

Follow-up Analysis

- Use data on 2001 self-disclosures to examine impact of self-disclosure on probability of an inspection.
  - Challenges:
    - How accurate is the data on self-disclosures?
    - Are there enough self-disclosures to make estimates?
- Find data on audit adoption to determine whether increased auditing could be responsible for decreased violations.
  - Possible sources?

Comparative Plant-level Analysis of Three Voluntary Programs

Richard Morgenstern
William Pizer
Jhih-Shyang Shih

April 27, 2004

RESOURCES FOR THE FUTURE

Status of Voluntary Programs for Environmental Protection

- 00's in Germany, Netherlands: national government, industry associations
- 000's in Japan: local agencies, firms
- in U.S. 'public voluntary programs' or 'government lead challenges' popular
- 54 EPA programs in 1999, up from 28 in 1996
- U.S. climate policy dominated by voluntary efforts: EPA, DOE, DOA

RESOURCES FOR THE FUTURE

Potential Advantages of Voluntary Programs

- Increased flexibility for government and industry
- Reduced confrontation
- Reduced transaction costs, litigation, etc.
- Pilot test new approaches, especially in absence of legal basis for mandatory program

RESOURCES FOR THE FUTURE

Are Voluntary Programs Really Effective?

- Concerns expressed that programs do not push firms beyond baseline performance
- Without regulatory or price signals few incentives to develop/use new technologies
- Shifts emphasis from 'worst' polluters to those willing to act voluntarily

RESOURCES FOR THE FUTURE

Two Types of Voluntary Programs

- Focusing on particular technologies, e.g., Green Lights
- Focusing on environmental performance, e.g., 33/50, Climate Wise, 1605b

RESOURCES FOR THE FUTURE

Goal of Research

Expand understanding of environmental effectiveness as well as efficiency of voluntary programs

- – Current information is often too aggregate, without clear baseline
- – Pollution prevention and GHG reduction are growing areas of policy interest

RESOURCES FOR THE FUTURE

Principal Contributions of Research

- Shift focus from firm-level to plant-level analysis, thereby controlling for changes in output, other key factors
- Improve modeling of participation, emission reductions: focus on differences between participants and non-participants
- Expand breadth of academic-style studies beyond 33/50 to include GHG reduction programs
- Validate/improve data quality

RESOURCES FOR THE FUTURE

Plant-level Data

- Unlike most previous studies which rely on firm-level information, focus is on plant-level data
- Available on confidential basis from US Census (LRD, QFR)
- Need to link Census data with public information: 33/50, Climate Wise, 1605b
- Builds on researchers' previous experience with Census Bureau data

RESOURCES FOR THE FUTURE

Methodology

Problem: firms self-select to join programs. Thus participation is not random

Method 1: Ignore problem

Method 2: Condition selection on observable data, e.g., size, profits, etc

Method 3: Condition selection on **un**observable data (analyze residuals) (Heckman & Hotz)

RESOURCES FOR THE FUTURE

Early Progress

- STAR grant awarded Fall, 2003
- Initial focus on literature review, assembling publicly available data, formal approval from Census (Predominant Purpose Statement)
- Currently on second round of PPS reviews
- Optimistic about near-term approval

RESOURCES FOR THE FUTURE

Expected Research Results

- Key characteristics of program participants vs non-participants
- Environmental performance of participants vs non-participants
- Factors influencing performance including size, profitability, industry, firm type, early/late joiner, etc
- Inter-program comparisons
- Effect of program participation on performance in other areas

RESOURCES FOR THE FUTURE

Oregon Business Decisions for Environmental Performance

U.S. EPA Funded Project on Corporate Environmental Behavior and Effectiveness of Government Intervention

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Project Team

- David Ervin, PI/PD, Portland State U.
- Madhu Khanna, PI, U. Illinois at Champaign-Urbana
- Patricia Koss, PI, Portland State U.
- Junjie Wu, PI, Oregon State U.
- Cody Jones, GRA, Portland State U.

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Project Objectives

1. Identify and measure the major elements of environmental performance, e.g., toxic waste compliance, solid waste recycling and water use efficiency, for Oregon firms.
2. Collect primary data on the set of environmental practices used by a random sample of Oregon firms.

Project Objectives cont'd

3. Collect data on firm, industry, regulatory, and 'voluntary' environmental program factors hypothesized to influence the environmental performance.
4. Test the influences of firm, industry, regulatory conditions, simultaneously with voluntary program factors, on the adoption of environmental practices.

Project Objectives cont'd

5. Test the influences of firm, industry, regulatory, and voluntary program factors on firms' environmental performance.
6. Infer the 'voluntary' program features (e.g., practices and incentives) and other conditions that significantly improve firm environmental performance.

Hypotheses

1. The decision to adopt a particular environmental practice is related to characteristics of the firm, industry, and regulatory environment, as well as voluntary program incentives.
2. The environmental performance induced by a particular environmental practice is also related to specific firm, industry, and regulatory characteristics and program incentives.

Hypotheses cont'd

- The effects of the firm, industry, and regulatory characteristics and program incentives vary across environmental performance elements, e.g., toxic releases and solid waste recycling.
- The effects of the firm, industry, and regulatory characteristics and program incentives on environmental performance vary across sectors, e.g., building construction, agriculture.

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Major Activities

- Review potential environmental programs available to Oregon industries
- Conduct industry focus groups to identify practices and performance measures
- Select stratified sample of firms
- Implement survey with Washington State University survey research center
- Conduct multivariate analyses to test hypotheses

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Approach/Methods

- 2-stage model to analyze, simultaneously, the determinants of program participation and environmental performance.
- 1st stage -- firm's choice of environmental plan (or combination of practices)
- 2nd stage -- explanation of environmental performance as influenced by firm, industry, regulatory and program factors

Approach/Methods

- Polychotomous-choice selectivity model to address self selection bias and interaction between practices
- Stratified random sample to assure sufficient number of participating and non-participating firms

Planned Schedule

- Environmental program review 1-5/04
- Industry Focus groups 6-9/04
- Survey instrument design 6-9/04
- Sample selection 8-9/04
- Survey enumeration 10/04- 3/05
- Data cleaning 4/05-6/05
- Analysis 7/05-12/05
- Writing and outreach 1/06-9/06

Progress – Environmental Program Review

- Many environmental programs are available to Oregon firms.
- Participation may be affected by business composition -- 97.6% of Oregon firms are classified as small.
- Most programs allow firms to choose best environmental practices.

Progress – Environmental Program Review

- A preliminary finding is that certain practices appear to be common across programs and industries
  - Supply chain management
  - Employee behavior modification
  - Environmental personnel
  - Training – employees, contractors, vendors

Progress – Environmental Program Review

Selected EPA Cross-Sector Programs	Incentives			Statistics
	"Green" Label/Public Recognition	Enforcement Discretion/ Regulatory Relief	Tech. Assistance	Oregon Participation
Climate Leaders			✓	2
Energy STAR/Climate Wise/Green Lights	✓			109
National Environmental Performance Track	✓	✓	✓	4
WasteWi$e	✓		✓	10

Progress – Environmental Program Review

Selected International Programs	Incentives: "Green" Label/Public Recognition	Incentives: Enforcement Discretion/ Regulatory Relief	Incentives: Tech. Assistance	Statistics: Oregon Participation
CERES Endorser Program	✓			2
Forest Stewardship Council Certification	✓			62
ISO 14001 Certification	✓			NA
Responsible Care/RC 14001 Certification	✓			3

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Progress – Environmental Program Review

Selected National/State/Local Programs	Incentives: "Green" Label/Public Recognition	Incentives: Enforcement Discretion/ Regulatory Relief	Incentives: Tech. Assistance	Statistics: Oregon Participation
Food Alliance (National)	✓			32
LEED Green Building Certification (National)	✓		✓	73
Eco-Logical Business Program for Auto Shops (Oregon)	✓		✓	45
The Oregon Natural Step Network (Oregon)	✓		✓	127
Eco-Logical Business Program for Landscapers (Regional)	✓		✓	NA
G/Rated Green Building Program (Regional)			✓	50

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Corporate Environmental Behavior and the Effectiveness of Government Interventions

PROCEEDINGS OF

LUNCH PANEL DISCUSSION

A WORKSHOP SPONSORED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S NATIONAL CENTER FOR ENVIRONMENTAL ECONOMICS (NCEE), NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH (NCER)

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Prepared by Alpha-Gamma Technologies, Inc.
4700 Falls of Neuse Road, Suite 350, Raleigh, NC 27609

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DISCLAIMER

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Transcript of Tuesday's Lunch Panel/Discussion

Matt Clark (U.S. EPA, Office of Research and Development)
I'll give you a very brief background. As you can see, we have a fairly significant number of researchers who are using facility-specific data from EPA, whether it's TRI or what we call PCS, which is our water pollution system, or some of the enforcement stuff, through ECHO and IDEA, or the air system, or the biennial reporting system for people who are working with hazardous wastes—there's a whole raft of these things that we want to try to align because every time I have a researcher who is trying to pull these things together, it's taking $100,000 off a grant. So, I don't want to keep spending that $100,000 over and over again, and what we're winding up with is—I mean, it would be nice if we could just bring all this stuff in, but you can't, because the researchers are looking at a specific industry, or like Dave Ervin, at a state, and things like that. We're hoping that there's some economy of scale here, some efficiency to be gained, by trying to address sort of holistically what the difficulties are associated with databases and to resolve some of those difficulties.

We had sort of an open meeting on September 3rd, I believe, of last year, and I'm just going to recap it. We had some of the same people who are up here talking, both the EPA database managers, who are describing their plans—a *great deal* of improvement in EPA databases has been made over the last few years—and some of the researchers expressing some of the difficulties that they've had in trying to pull stuff together. In a lot of ways, it works both ways, because the researchers need to know a little bit more than just what the data are—they have to know what the data *mean* and how they were collected.

So, just to recap it, there's a lot of interest in using EPA facilities-specific databases for research; the researchers are cumulatively expending a lot of time and resources matching and cleaning data. There are difficulties in combining information from different databases, most particularly for panel data sets, which is what people are most interested in using. And, there's difficulty on the researchers' end. To people who work in the field at EPA it becomes readily apparent that the researchers don't always understand the data's purpose—how and why it was collected, its limitations, and what it actually means. There has been *substantial* progress in creating single identifiers for facilities and linkages in the Facility Reporting System (FRS) and Envirofacts, which is another sort of a window to all our data world. And, there were problems in linking with Census that Randy Becker talked about, and Randy is *from* Census.

What we're trying to do today is sort of *move on*. We've been talking, and we seem to have had, perhaps not agreement, but a lot of nods in the audience in the September 3rd meeting that it might be a good idea to develop a combined database, a facility research database, and our thought was that we would use the LRD (longitudinal research database) model and develop some sort of sample of the roughly 1.8 million facilities or "things that are regulated out there" in the EPA data sets. When you start talking about panel data, that is just too much to deal with, so we have to figure out a way to limit it and make the kind of matches and corrections that we need. The idea is to match the data, on a facility basis, from a variety of databases, including enforcement and all the others I mentioned, and some I didn't mention. It would be *nice* if we could link it to Census, particularly the longitudinal research database, in some fashion. There are problems with the IRS, and privacy rights, and things like that, so we have to try to figure out how to address those, but also, somehow, to have ways to identify what kind of company it is and link to Dun and Bradstreet.

Clearly, we want to build a panel data set, which is going to be very hard. We're going to need things like dedicated servers—it's a lot of information and a lot of different facilities. I don't know how *big* it has to be, . . . and one of the things that we discussed in the meeting is that this is something that would have to be *regularly* updated—it has to be a living thing that we have to keep up-to-date over time—on a quarterly, monthly, whatever the right basis is—to keep it going. Ideally, it would be easily aggregated to state, industry sector, etc.

Now, we really have some questions here—it *seems* to be the way to go, but we don't know. We really want our panelists—and we'll give you a few minutes each—to talk about this. Is this a desirable thing to do—certainly from the researchers' perspective, but also from the database managers'? Is it something that would be useful internally? Secondly, is it feasible? And at what cost—half a million dollars--$1 million--$5 million--$10 million? What would it take to make this happen? What are the desirable components? Start talking about sampling protocol—do you want just a *random* sample of all the industries out there? Do we want to over-sample some of the bigger industries, the more highly regulated industries, and have a random sample of dry cleaners, auto part shops, and things like that? How do we stratify the samples, if that's the choice? What should be the elements in the sampling protocol? How would we stratify them—based on the NAIC codes—the size of the firm—the location—the state? Over sampling—what do we want to do, census the *big* facilities and polluting industries? What kind of documentation [do we want]? One of the things that the people at EPA and the researchers both pointed out is that they need some documentation to explain what the data mean and what the purpose was. Finally, what kind of accessibility can be granted? –and any other ideas.

Okay, so I'll just move on down the line of panelists here and get their input.

Pat Garvey (U.S. EPA, Office of Environmental Information)
I'm the National Program Manager for the Facility Registry database that Matt referenced that includes about 1.8 million unique places regulated or monitored by either the Federal government or state government. It has about 2.2 million IDs associated with that—so those large companies, like Alcoa, that might come under the Toxic Release Inventory might have hazardous wastes, might have a discharge pipe, might have an air stack—those are all IDs, programmatic areas that we would try to link together at a given place.

The whole research community has raised five related issues, and I'll review them quickly here. One is the issue of definition of terms. At EPA we have created this large database, and for lack of a better word, we've just used the word "facility." But, the database also has *monitoring* stations—the air quality subsystem monitoring stations (and it has the ability to have water monitoring stations)—brownfields properties, Superfund sites, all these things that are technically *not* facilities (i.e., there's not a company, an owner, or an operator there). But, the definition of terms, I think, skews the aspect of a researcher coming into a very large data set and saying, "None of these things meet the criteria that I want."

I know researchers have a strong desire for a *historical* perspective, but as Matt just said, the database is a *living* database—it needs to be *refreshed*. Dun and Bradstreet tells us that about 11 percent of all companies in the United States go *into* business or *out* of business *per year*. As soon as you go 3 or 4 years into a historical perspective, you've got potentially 44 percent of your universe either not part of the *initial* sample or not in the *final* sample because of that historical perspective.

We *do* have data gaps in key fields, and we *don't* have *key fields* defined as you [researchers] would want, such as a *primary* SIC code for a North American Industrial Code. We in the Facility Registry System collect *all* SIC codes ever reported by that company, because, as I'm sure all companies do their absolute best job in defining themselves because they have to report to TRI and other regulatory programs and have a high community right to know, they might be *creative* in the designation of their SIC code *or* a change of SIC code process, which would then throw them out of, maybe, historical perspective or trend analysis. The Agency has never dealt with trying to establish a definition of "primary SIC code," so many of our databases collect all the SIC codes, and thus you've got a big melting pot.

You've also got the other key fields that might not be populated because of burden reduction issues, so that the Office of Management and Budget or the Agency or the Administration has decided that, "Gee, for this individual data area, be it small-quantity generators for hazardous wastes or something else, we don't want to collect all the different kinds of data elements that complete a large database like the FRS."

Then, we also have the last issue—many of our *smaller, targeted* programs, such as Green Light or Energy Star and those kinds of things, deal more at the *company* level and not specifically at the facility level. So, if in your research problem you want to deal with small-quantity generators, which obviously constitute a large number, we've got databases that satisfy that need, but if you're looking at some of the *boutique* kinds of programs, such as Energy Star of brownfields or P2—you know them all better than I—their definition of "facility" or "site" versus "company" or "corporation" doesn't match up cleanly.

So, I think these are all very strong challenges that the research community has—*Good luck*!

Matt Clark
Randy will be talking about the length between Census and all the problems dealing with that. He's familiar also with being a researcher, not just being a bureaucrat.

Randy Becker (U.S. Bureau of the Census)
One of the reasons why you'd want to link EPA data to Census data is that we can fill in some of the missing information about plants, such as their size, which isn't generally collected in the EPA databases—that's the critical one. But, you can also fill in the information about industrial detail—we have our own industrial code—as well as production information, so you can look at how productive they are, how many production workers they employ, their input usage, their capital investment—and that's basic information that's collected annually on the Annual Survey of Manufacturers and the Census of Manufacturers. Plus, there are other databases as well that can be matched into those databases that I just mentioned, and most commonly we're talking about the Pollution Abatement Cost and Expenditures Survey, which was collected for a number of years and was collected again in 1999. It is now being redeveloped—we hope to have another one in the field in a couple of years.

So, there is interest in bringing the regulatory data to the census data. A couple of earlier speakers talked about the challenge of the census process, and part of that is that we get our information on what businesses are out there—we call it our business register—from the IRS. You may recall a number of years ago the IRS was raked over the coals by Congress because of its employees browsing the data, so they [Congress] took it out on the IRS and they took it out on agencies that the IRS provides data to, and they wanted to know who's looking at the data provided to the agencies. The Census Bureau is a very large user of IRS data, . . . so the IRS makes the claim that because they provide the underlying frame information, and some of that data makes its way into the final census data—that is, it's co-mingled—they think that they have some say on *who* looks at it and for what purposes, and so forth. So, this is, as of 1999-2000, very subject to a lot of regulatory oversight. Now, most of the Census Bureau is immune from that since there is legislation in place to actually use IRS data to draw samples . . . and so forth. Using the data to do research and handing it over to egghead academics doesn't necessarily sit that well with the IRS. (Of course I don't speak for the Census Bureau when I say all these things.)

But, essentially, that's the conflict that we're faced with, and we are now through the woods, as it were. There aren't much more reporting requirements and more processes in place to get things approved, as Dick Morgenstern was talking about earlier. But, there is a process in place and we're hoping that it's speeding along. So, there is a fixed cost to using Census data, but there is a great return, as well.

So, I think what we envision, and we talked about this at the September 3rd meeting, is that once EPA has their data together and all the facilities in a common identifier, one of the things that could be done is some sort of name-and-address matching with the Census data. Essentially, there would be a "zipper" file—that is, the Census ID and the EPA ID—and because *our* data is confidential (and I think some of the EPA's might be as well), but because *our* data is confidential, that zipper would reside at Census. However, any researchers who would want to link any EPA data could tap into that zipper that's been constructed and bring in whatever EPA data there are.

Some of the issues that Matt was talking about—we have 1.8 million on the EPA site and we have many more on the Census site. You know, if we're talking about sampling and restricting scope, . . . why not just do it all? As soon as you start restricting the scope, there's going to be someone out there who wants to look at something that's outside of that scope. The only real constraint is just computing power—and brain damage, to some extent—but I think it is certainly possible—the Census has experience with linking many, many more records and doing name and address matching. There's sophisticated statistical software out there to do name and address matching and so forth, so I'd say let's think big and if it doesn't work, we can always contract our motivation at that point, but let's not start out that way.

Ron Shadbegian (University of Massachusetts, Dartmouth)
I *do* have a lot of experience using the Census data and linking in EPA data to that, and as a number of people have already said, it's not an easy process to go through. In the old days we didn't have these wonderful computer matching programs, so we did a lot of linking by hand. The other problem is that name and address matching is fine, but not all facilities give their particular address—they give you the address of their headquarters or some post office box—so, there's a lot of hand wringing, and you look at those with the same zip code . . . there are a lot of tricks to sort of looking and trying to identify the matches that you don't get through the computer programs, so it's not an easy thing, necessarily, to do, but as a first crack, maybe that is what we would do.

We've also linked in data from other sources like the Lockwood Directory, which is a paper industry directory that gives information such as the size of the firms in terms of their capacity, whether they use pulping or not—do they by pulp?—do they make their own pulp?—what techniques do they use? So, we've used that sort of data in the past as well, and weaved that in with census data, and we've used Pollution Abatement Cost and Expenditure Survey to collect information on how much these plants spend on pollution abatement capital, on the air side, on the water side—how much they spend on operating costs on the air side, water side, solid waste side.

Wayne Gray and I have used these data sets that we've put together, and continually put together over time, to answer lots of interesting questions. We started off looking at the effect of EPA regulation on productivity, and our EPA regulatory measure was the pollution abatement expenditures—and so that quickly became: well, do pollution abatement expenditures *overstate* actual expenditures on pollution abatement or do they *understate* actual expenditures on pollution abatement? . . . So, we've looked at things like that. We've looked at the effect of regulation on pollution abatement investment, on production investment, and on compliance, as Wayne talked about yesterday.

So, there are lots of interesting things that you can do once you make that link with Census data, so I agree with Randy here in saying that we should go for the whole thing, and if we have to start paring it down, then we can do that as well.

Michael Barrette (U.S. EPA, Office of Enforcement and Compliance Assurance)
Thanks for inviting me today—I'll just give a few remarks about facility data. Let me provide just a little bit of background: First of all, I'm actually involved in two pieces of the puzzle, which is actually *using* the data as somebody that does targeting and analysis with our Regional offices in the enforcement program, and in system design and web help tools, including our integrated data for enforcement analysis (IDEA) system, which is basically a mainframe system that's extremely powerful, but only a handful of people really know how to use it, because it's so complicated. And then two spin-off projects from that—one is what we call OTIS, which is our Online Tracking Information System, an internal web-based tool that basically gets the IDEA data out using a web browser, and then ECHO, which launched about a year or so ago, which provides data . . . and we integrate information on RCRA, the Clean Air Act, the Clean Water Act, TRI, census/demographic data, things of that nature.

So, we're very familiar with the Facility Registry System—we've been working with Pat—we've worked with him basically to put together an error tracking system, so if somebody is using the databases and they see an error, they can submit that and it goes through a fairly elaborate process of getting it to the right data steward. The thing to keep in mind when using the facility data is there are, as Pat mentioned, somewhere in the range of 2 million records. Now, those records come from EPA in many strange ways—we have different reporting cycles; we have different regulations; we have some programs where you have to notify when you shut down and others where you don't have to notify. We have some states that are maintaining their own database and then they decide to just send us uploads, say, once a month, so they don't really view that data set as what they use to manage—they may pay less attention to it. We have other states that are entering [data] indirectly. We also have some systems that are modernized, some that we call legacy, and some that are kind of in between, being modernized now. The bottom line is that facility data that winds up at EPA come in many shapes and forms, and basically Pat's program has to figure out what matches up out of all those things that come in. Over the last 5 or 6 years we've seen a big improvement in the ability to match those things, and we've also added a data steward network on top of the computer programs. But, still, if you really want to work with a very tight data set and ensure there are no mistakes, you're never going to get a hundred percent with that system because things are constantly changing.

At headquarters we don't, obviously, know what's going on in the field, and so—I don't know if I'm stating this the way Pat would, but—what we have with FRS now is pretty much what you're going to have in the future with the exception that maybe more programs will be added. I think his budget's pretty much locked in—he's got a staff that's able to do data quality, to respond to errors, to respond to people who might send in batch files and ask them to clean them up and they always clean them up very quickly—but there's a lot of information out there that people maybe have not scrubbed down or looked at, and there's always going to be some type of mistakes. That doesn't mean that you should discount the system—you just have to keep that in mind when you're using it. One example is the fact that we have somewhere around a million facilities in the RCRA database. Well, there's no flag in RCRA that really tells you that they're not in existence anymore, so that's something we're working on—we're trying to get that in place by December 2005—to have an "inactive" flag in that database. But, you have to keep in mind that if you're using that database, as many as 30-, 40- 50-percent may be companies that are not in existence.

The other piece is that there has been some progress internally to start looking at corporations and how to match those together, but at this point in time EPA contracts with Dun and Bradstreet and it's not clear exactly what data will somebody outside the Agency use? That's kind of an ongoing thing, but it's something the enforcement office is very interested in—figuring out a good way to profile a company, because every week we get requests, whether from the Administrator or a voluntary program or the White House—somebody needs to know about a company—and there's no way that you could just press a button and say, "Okay, these are the ones that had enforcement actions, this is their TRI release, and this is how many had open violations." You'd have to do a lot of custom work to get that information. Hopefully, if we make some progress with Dun and Bradstreet, we'll be able to automate some of that.

The issue of developing a small subset, or a panel, of data that can be used by researchers—we actually have some experience in that because in 1995 the White House Reinvention Committee basically required EPA to publish data for five industries on the web, which we ended up doing in 1998 under the Sector Facility Indexing Project. Let me relate a couple of experiences with that: First of all, if you tap into the EPA systems and ask how many refineries there are, which is SIC 2911, when we ran that back in 1995 it was something like 850. That doesn't necessarily mean that the linkage data, or FRS, is wrong, but what it means is there's a lot of extra SIC code data in all these systems that it's pulling from, and anything that has any relationship to a petroleum refinery, somebody might have put in a 2911, and then all of a sudden what should be 180 facilities looks like 850. We couldn't put out the list of 850 because it was wrong, and we ended up having to—basically through brute force and a lot of grunt work—figure out which facilities were actually refineries, what were the EPA numbers across all the programs, which ones were operating and not operating, and we used some of the same sources, like Lockwood Post, the Department of Energy for the refineries, the auto industry has trade association data, and we actually got that nailed down and published the data in 1998.

But, it's a pretty intensive effort to make sure that that information stays correct, and we have to have contractor support every year to look at that information. There are all sorts of questions on definition—if a refinery is totally located with a chemical plant and you want to look at emission trends or you want to look at the release amounts versus the production, they may have reported both their chemical and their petroleum together, and how do you piece that apart? So, it's not really that easy to do—it's a very intensive effort that, I guess I would say, unless there's a dedicated staff that is spending money and doing that every year and making sure that there's data surveillance, it's very hard to accomplish and I think that, as some of the other folks have said, you're going to get a lot of people coming in that want to do other studies.

So, I don't know what the solution is, but one of the things (since I come from the enforcement compliance program) that we've tried to do is to focus in on a subset, which we call the "majors." The "minors" in most of the programs have fewer reporting requirements—the states don't have to tell us all that information. So, unless you're looking at compliance assistance to small facilities or something, we think that the data on the majors, which would be Clean Air Title V permitees, water major dischargers, RCRA large-quantity generators—we spend a lot of time scrubbing that data. The reporting requirements are more frequent, so we know the facility data are better. Once you start entering into the world of Clean Water Act minors or things like that, you never know what you're going to get, and those of you that have used the data probably know that. So, that's *one* way that you *could* develop a subset, but I don't know if that's necessarily the best way.

The only other thing I'll say is that for those of you that *are* interested in Clean Water Act data, we are developing a PCS modernization project. Our hope at this point, and I think we have a pretty solid commitment from the states, is that when that modernization is completed, we will continue to get all the majors' discharge reports, from which we'll calculate a compliance determination. But, we're hoping that we're going to get all the minors in as well, and the reason why we think we can do that is because we're moving toward electronic reporting of that data. The biggest barrier to getting that data in is state staff having to keypunch every little thing every month. So, if we can get electronic reporting of those DMRs right from the facility into a central receiving database, then there's a good chance that we might go from the current situation of about 7,000 facilities with good data up to close to 100,000 in the water program. It's not going to happen overnight, but hopefully we'll get there soon.

Matt Clark
Pete—any suggestions on this—what you would like to see?

Pete Andrews (University of North Carolina at Chapel Hill)
I'm the first of the academic eggheads up here, so I'll try to be as hard-boiled as everybody else.

As a researcher trying to use these data, let me first comment on some of the things that have been really helpful. I want to really thank the gentleman at my left here, Mike Barrette, who has been tremendously helpful with our project, both in getting the data we needed and learning to use it and so forth, and working through the portion of our grant that it took to get these data into usable shape for what we were trying to do with them.

EPA has been working on making all the data more user friendly, and this is a great help. Simple things, like single identifiers, keeping the address and contact information up to date. This comment that was made about which ones have gone out of business—one of the greatest unexpected learning experiences we've dealt with just in the process of our project is discovering how much of our own sample turns over just in the period of the project. So, that is very helpful.

The other thing that I think would be extremely helpful would be just relatively simple things, like more-user-friendly guides to the data sources—what *were* they collected for?—so that on the web, if you're using this for the first time, they're just easy buttons to click for so you understand how these data were collected, for what purposes, what their updating cycles are, if that's something that can be put up there. That will save *some* costs at the user end; it will certainly save a lot of costs at the EPA end of hand holding all of us individually on those kinds of questions which we've had to ask in the past. Those things are *really* helpful.

I'm more of a skeptic also—I wasn't expecting, after your comment about the nodding heads in 2003 that everybody was going to sound skeptical of the panel data project, but I *am* a skeptic of it. I think it could be a very useful thing to do for some purposes, but I don't think it would solve the problem you're trying to solve with it. There are obviously some areas of research that could come from it and that could be strengthened by it, but one of the basic problems I think it would run into is "bucket size" for doing statistical analysis—how many facilities you've got in each cell. There are so many different kinds of research that cry out to be done in this area, and when we start figuring how many facilities there are in a given sector, in a given state, of a given size, I worry about the *bias* of a panel like that towards: once you've created the panel, you want researchers to use it, *rather* than them looking at some of the new and emerging sectors. You know, we ought to have more people looking at agriculture today, but this is largely a manufacturing facilities and utilities and POTWs database. So, I worry about the bias—I worry about your putting *so much* money into building and maintaining and feeding a database like this that it would be *less* productive of the kind of research that, even with the rough kinds of issues we're having to deal with, *could* be improved by putting the money into *some* things that you're already starting to do and really helping us a lot by doing. And then, let researchers keep having their own head about the kind of questions that look important and how we work with that.

Dietrich Earnhart (University of Kansas)
I will echo most of these points. Going back to the presentation I made remotely September 3rd of last year, what I would want would be a nice, clean, unique identifier across all the databases. If that is already in place, as I understand what Mr. Garvey said, then I have what I want, in general. If 99 percent of the time it's a nice clean identifier, then I'm done—you don't need to integrate anything more for me—I'll gladly run through 1.8 million observations to match up what I need. Now, if that's the case, that's great, and I think it would be helpful to advertise that more, because actually it wasn't until I talked to Sarah Stafford in January of this year that I realized that that had been done.

I, like Ron, have hired research assistants who painstakingly tried to match facility name, facility zip code, etc., so I *don't* want to go back to that. I would echo the point that Pete just brought up in terms of going back to natural underlying databases—it would be helpful to have more accurate information on contact information. In our survey we distributed to every single last chemical manufacturing facility across the entire U.S., and we found that 35 percent of the data that EPA listed was wrong, *way* wrong, not even *close* to being right. We searched *numerous* databases to try to find the people who supposedly were *active* discharging facilities—we could not find them after months and months—we called state regulators—we called the EPA Regional offices—they were no where to be found. In addition to that, the *active* status was way wrong, even for some of the major polluters. So, in some ways, possibly, it would be helpful to clean up the data before you actually integrate it. (Sorry about that.)

Documentation would be really helpful. I will add that the people at EPA have been very helpful—I'll put my plug in for Steven Rubin, a fantastic man who has provided me with the Permit and Compliance System database on an ongoing basis. It would be nice if there actually might be a workshop of this sort to teach us, or teach us in combination with our research assistants—I know Madhu Khanna has an army of RAs working with her. If you could come and say this is how we use databases, especially if we had a database that is really powerful but a bugger to use, then I know I'll never touch it.

All of these things would be helpful as part of this integration/modernization process.

One minor point about the Dun and Bradstreet: I'm wondering how or why that was chosen as the way of connecting things—most people who are looking for financially related data use the Compustat Research Insight Database, which I know definitely does *not* have the Dun and Bradstreet number. So, it would be really nice to find somebody that is *not proprietary*. Once again, maybe there's some great logic behind how it was chosen, and maybe there's a different database that people can match to—I know Michael Lennox made a reference to that—so maybe we all can learn from his previous research.

Michael Lennox (Duke University)
As a doctoral student, I actually *did* that process of matching facilities to Dun and Bradstreet data, then matching to Compustat—the Compustat data, though, *doesn't* give you the structural trees of ownership, and Dun and Bradstreet *does*—and Dun and Bradstreet *has* facility-level data, which Compustat *does not*, so that's why you have to use Dun and Bradstreet.

Michael (Barrette), to make your job even *more* difficult, I just want to throw out another recommendation: It would be *great* to have these over time—affiliations-longitudinally—which I know is *incredibly* difficult but something that we've worked really hard on trying to capture—but it gives you some incredibly powerful statistical powers there by looking at facilities that have changed ownership and how that might affect behavioral performance. [Matt Clark interjection: You're speaking temporally rather than geographically.] Yes. So, in other words, as Pete was suggesting, corporate affiliation and ownership change more rapidly than you would think across these samples, so you would *almost* have to have a corporate affiliation *per year* and have it reflecting how that changes over time. I know that's a *very tall* order—we've talked to Dun and Bradstreet, and they're not thrilled about dealing with past data—they just want to deal with it here and now. But, that would be *incredibly* valuable for a researcher.

Pat Garvey
We've looked at that a half dozen times and there's no regulatory statute that EPA can sort of "hang its hat on" to do that information collection. We've heard that over and over again—it's just that there's an issue of reporting burden by the regulated community to a regulatory agency, and there's always a *tension* there, as you can imagine.

Michael Lennox
I know that the TRI fields—that's what people were saying—are notoriously ill-reported: The Dun and Bradstreet Number is the wrong one or they get the wrong firm or its subsidiaries—I know it's incredibly difficult to get.

Matt Clark
I have a question: Is there a business service like Lexus-Nexus? I would think that a lot of the sales and changes of ownership would be recorded in the Wall Street Journal or things like that, so that would *not* be an information collection problem. I was just wondering: Is there a service out there, that particularly you business professors have used, that would allow us to go back in time and see what these changes have done?

Pat Garvey
We deal with the number of firms and stuff, and D & B sort of raises its hand highest among those service agents.

Dinah Koehler (University of Pennsylvania)
Wharton has this WRDS database—I don't know what WRDS stands for, but I'll find out—and it's a pretty detailed database related to business-type issues. I think the way it works, and, again, I'm talking sort of "off-line" here, but something along the lines that you can request a data set to be prepared—it's for a fee—and they then prepare that data set, and they will probably match across various different individual data sets. So, we can check up on that and give you guys more information if you're interested as one potential model. Now, it *is* run by Wharton and it *is* for a fee. It's actually a pretty good business for Wharton.

I do have a question: We are in the process of trying to match the RADP Accident Database with TRI. What I'm trying to use is the Dun and Bradstreet facility ID. Now, Mike just said that that's not great with TRI. Can you give us any advice, or is this in the FRS already so I can go use that—or do we have to go this D & B facility ID path, which seems to be the only link that we can find between these two databases?

Pat Garvey
The Department of Homeland Security does not allow me to provide Risk Management (Audit) Program, or RMP, linkages to any FRS data. That was specifically locked down on September 22, 2001, and that's not publicly available. It *is* available to EPA staff.

Dinah Koehler
So, just to qualify, Wharton is in a cooperative agreement with the EPA to work on it, given all the confidentiality issues. So, we *do* have that database and we want to work with it and try to link it with TRI, so I guess we're going to have to do that on our own.

Pat Garvey
The TRI and RMP were our very first two databases that we linked together in 1999. On the Dun and Bradstreet side, we just finished a matching with D & B, and they did match, through an automated process, 65 percent of the 1.8 million facilities to a D & B number. As Mike said, the percentage of the 80,000-84,000 "majors" that we've designated in the database even had a *higher* matching. One could, of course, extrapolate that RMP facilities normally are pretty large, or a certain threshold probably qualified as the "majors" category, but it's not available—we're not allowed to provide that information.

Pete Andrews
Let me just add another comment—maybe this is something else that ought to go into your notes, Matt, as something to work on. Certainly with the Census data, dealing with the IRS, we've had to deal with confidentiality problems and so forth. Particularly with the Department of Homeland Security taking the position it's taking in some places, it may be important to start working on the question of having a validated method for researcher access to this information. It may not be available on the internet to the general public, but certainly EPA researchers and others have got to be able to have access to these data if EPA and the country are going to get the information they need. Maybe they won't get the individual facility coordinates that a terrorist might find useful, but they certainly need to be able to use these data to do valid and useful studies.

Michael Barrette
It's been probably four years since I've even really looked at the RMP database, but from what I remember, the reporting form requires an EPA ID to be provided, and I think it isn't really specified exactly which ID needs to be provided, but I think we recommended in the instructions that you would start with the TRI, so I'm not sure in the RMP program itself what they provide out of their own database. But, if they do provide any of that data and you can get that one field that has the EPA identifier that was self reported, you may be able to construct some of that—I'm guessing.

Pat Garvey
I was in conversation with Homeland just three months ago, and they just made another absolute comment about lockdown on RMP.

Michael Barrette

I believe my comment is related more generally, I think—it might be worthwhile thinking about this in terms of putting this database together, because it's not only researchers who are going to be concerned about this, but there's, I think, some sort of a partnership directly with DHS on this problem of information provision. Letting RMP [data out] is not the only kind of issue—in most of the very important environmental risks that many researchers are concerned about, whether it's nuclear or chemical facilities, oil refineries, water utilities, a lot of these are really potential targets from a Homeland Security point of view. Therefore, it makes sense at the beginning, as you're putting this together, to maybe find some common ground or groups.

I think, also, maybe broadening it to provide incentives rather than only looking at it as an obstacle to research—because I really think there could be some connections on the informational regulation theme, where there have been some potential benefits of broader public information from the environmental protection point of view. The same might be the case from a domestic protection point of view. Some of this information could be put together rather than being at cross purposes. I think otherwise you're really going to run into very serious problems in other fields when you start to put a lot of detailed information together, you start running off facilities, specific locations, and things like that—my guess is that that's when our friends in the anti-terrorism world are, for good reasons, going to sort of become concerned about it.

Matt Clark
I know from working with DHS that our STAR grant researchers actually *do* have to get clearance on some of these things. RFS has also done some research looking at issues about the risk of having too much information available, so that might be able to be continued.

Eric Orts (University of Pennsylvania)
A short story: Just three weeks ago, we had a number of letters come into EPA from local government and county government that said your public website had the words "water tower, water intake, water processing, water association" and they asked that you please strike off facilities that have those combinations. There's a *tremendous* pressure out there—from governors, mayors, county commissioners—to take a lot of information down from public access.

Matt Clark
Maybe research access should be different than public access, and having gone through a screening process, maybe that would work. The Census has a process.

Joel Garner (Joint Centers for Justice Studies, Inc.)
I'm working with Sally Simpson at the University of Maryland on a Justice Department study using the PCS data. I want to re-emphasize that a *big* problem is connecting facilities to firms. Any help we can get on that would be greatly appreciated.

I'd like to suggest a *small* solution as opposed to a "big guns" solution: I think it would be useful if all the projects funded under this program were required to place their data set at the end of their project in the public archives. Wayne Gray's particular project—those data—publicly funded data—should be sent to the University of Michigan or some other public archive so that others can use that. You can get *more* research per dollar spent—other researchers can use it. Researchers *don't like* giving up "their children" like this. It's just good science—it's good public policy.

Matt Clark
We require it. There are going to be limits to that, of course, with the Census data.

Joel Garner
And there are *other* public archives—Michigan also has mechanisms whereby confidential information is resided there, and it's available only when the original investigator approves researchers using it. The point is there are other places and mechanisms to do that, and it's a . . .

Randy Becker
But there *are* such mechanisms here as well. These data are archived and there *is* a process for getting at it.

Joel Garner
If I wanted to come and use the previous data, I could call you and I could use those data?

Randy Becker
Well, you have to submit a proposal to actually use those data.

Joel Garner
Right. I just think that's a very important thing to do with existing projects. The second thing I would suggest is bringing professional data archivists to the task. There are people who *know* the data and work generating it—it's a *very* different profession, and they like doing this! And they're *good* at it. And the staff *pays* them to do it. They do *good* documentation—we don't have to do that work—they can do it for us.

And then the last suggestion is: Maybe working with the states, generate the data originally, and you talked about doing some of that. If *that* work could be done *originally*, then you don't have to do it in the archives.

Pat Garvey
Matt, I'd be remiss not to tell you that at the facility level there's another large program at EPA called the exchange network. It's got about $20 million a year behind it that we give to States and Tribes. We've made arrangements already with *20 states* to, on a regular basis—as Mike was saying, every two weeks to a month—exchange their master facility record with EPA's master. In that exchange effort, we have a goal of 35 states by the end of this calendar year, so that exchange network . . . is *aggressively* moving forward.

Sarah Stafford (College of William and Mary)

I heard this comment from a couple people—this is straight to the EPA folks: I find mistakes all the time and I don't report them. Do you want me to report them, and if so, how? If I'm trying to do the linkage, and I find a matching that's not there, should I report that? Should I just use the report function in Envirofacts? Is there a better way—to do it as a batch? I'm also concerned, because, you know, it's a 95 percent hunch, because I've done a *lot* of connections, but I could be wrong too. So, what type of information do you want from us to help get these databases better? I think probably everyone in this room has found a number of mistakes—has anyone ever reported them? I find a lot, every day, so any information you have to help me help you would be great.

Pat Garvey
I'll let Mike answer, but I think we had 17,000 reported error notifications on the first year of release of ECHO, and Envirofacts gets about 310-325 per month. We don't see a lot, so *anybody* who finds especially issues of linkage IDs that are poorly done or wrong lat-longs or wrong names of facilities because they've gone out of business, *please, please, please* report. As Mike said, I run Error Tracker *and* I run Facility Registry System, and I'm also the staff director of the exchange network, so I'm in a pretty much unique position.

Michael Barrette
Just quickly on that, in terms of the practicality of reporting errors, first of all, the web site makes it very easy one at a time. So, if you're actually just playing around on the web site—ECHO, Envirofacts, or whatever—and you see an error, hit the button, and if it's a linkage issue it's going to go to Pat's staff, and they're going to figure it out. What I found is when I do a detailed targeting project and I'm looking at, let'say, comparing air releases in one system to TRI air releases or permit data, and I'll look at almost 700 facilities and maybe 200 of them or 100 of them or whatever aren't lining up right. I'll kind of scrub those down, and I'll send a batch file over to Pat and say, "These things look suspect—they're reporting TRI releases to water but they don't have a water permit attached to it, or whatever it is. Normally, he fixes it within 2-3 weeks. If you're dealing with a large data set—I don't know if Pat's willing to do this—but it's easier to send him the file than to key punch them [errors] in one at a time to the web site.

Pat Garvey
I'll take it *any* way—whenever you have a large data set at this level, information and feedback is the most important thing.

Lori Snyder (Harvard University)
This is another solution—I almost think that this already exists—a list-serve, where researchers who are using these databases could subscribe, and then we could post when we discover something—perhaps not every single error we find, but general things that we find that might be of interest to the broader research community could be shared that way, because I know a lot of us are in different fields—we don't always go to the same conferences—we're not always talking to one another—so that might be a way to facilitate communication.

Deanna Matthews (Carnegie Mellon University)
Something that would be helpful—I now know Michael Barrette's name, so I know where to go to for help with these data sets. Perhaps as a Project Officer, something that could be done is assigning somebody who does have control within the database area to each of the new projects, so they have a contact to go to rather than just the link on the bottom of the data page—so that they can say, "I'm looking for this specific data. Who should I go to to find help on that?"

Irene Xiarchos (West Virginia University)
One comment I wanted to make just because it's related to the idea that maybe we should have different access for the research community and for the public. The research community is very broad, and sometimes it includes students that may not be able to be in direct communication with data links, so they are pretty much between the public and the research community, but a lot of research is going to come out from them. I wanted to come out and say that because I am a graduate student.

Another question I have, a personal question if anybody can answer—I don't know *who* could answer, so that's why I'm posing it here—is there any data that you know of on recycling, but for the industry—for facilities—not municipal?

[There was no response from the panelists or the audience, and Matt Clark closed the session.]

Corporate Environmental Behavior and the Effectiveness of Government Interventions

PROCEEDINGS OF

SESSION V: ENVIRONMENTAL MANAGEMENT SYSTEMS

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Session V: Environmental Management Systems

Institutional Pressure and Environmental Management Practices:

An Empirical Analysis

Magali A. Delmas
University of California, Santa Barbara
and Michael W. Toffel
University of California, Berkeley

May 2004

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ABSTRACT

Despite burgeoning research on companies' environmental strategies and environmental management practices, it remains unclear why some firms adopt environmental management practices beyond regulatory compliance. This paper leverages institutional theory by proposing that stakeholders—including governments, customers, activists, local communities, environmental interest groups, and industry associations—impose coercive and normative pressures on firms. However, the way in which managers perceive and act upon these pressures at the facility level depends upon facility- and parent company-specific factors, including their track record of environmental performance, the competitive position of the parent company and the organizational structure of the facility. Beyond providing a framework of how institutional pressures influence facility's environmental management practices, we provide preliminary results based on the empirical analysis of a survey of 3160 environmental managers in the United States.

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INTRODUCTION

Why do some firms adopt environmental management practices that go beyond regulatory compliance? Is the adoption of these practices driven by potential performance outcomes or by institutional pressures? Some research has analyzed specific factors external to the firm that drive the adoption of environmental strategies such as regulation and competitive forces (Aragón-Correa, 1998; Christmann, 2000; Dean & Brown, 1995; Hart, 1995; Nehrt, 1996; Nehrt, 1998; Russo & Fouts, 1997; Sharma & Vredenburg, 1998), and pressure from non-governmental organizations (Lawrence & Morell, 1995). Other research has looked at the role of the characteristics of the firm to explain the adoption of "beyond compliance" strategies. This includes the influence of organizational context and design (Ramus & Steger, 2000; Sharma, 2000; Sharma, Pablo, & Vredenburg, 1999) and organizational learning (Marcus & Nichols, 1999). Other analyses have focused on the individual or managerial level, examining the role of leadership values (Egri & Herman, 2000), and managerial attitudes (Cordano & Frieze, 2000; Sharma, 2000; Sharma et al., 1999). While each has provided a piece of the puzzle, there is still a lack of understanding of the conditions under which these various rationales matter to explain the adoption of practices beyond regulatory compliance at the facility level. In a rare exception, Gunningham, Kagan, and Thornton (2003) examined the external and internal pressures that drive firms to improve their environmental performance beyond regulatory compliance in the pulp and paper industry. As others recently pointed out, 'our understanding of factors that foster strong environmental management practices within a firm, particularly with operations at the facility level, still remains limited' (Klassen, 2001, p. 257). This paper offers a perspective that not only evaluates the relative influences of external stakeholders exerting institutional pressures on firms, but also depicts how firm characteristics and organizational structure moderate these pressures. Beyond providing a framework of how institutional pressures influence facility's environmental management practices, we provide preliminary results based on the empirical analysis of a survey of 3160 environmental managers in the United States.

The institutional sociology framework emphasizes the importance of regulatory, normative and cognitive factors that affect firms' decisions to adopt a specific organizational practice, above and beyond the practice's technical efficiency. Institutional theory emphasizes legitimation processes and the tendency for institutionalized organizational structures and procedures to be taken for granted, regardless of their efficiency implications (Hoffman & Ventresca, 2002). However, the institutional perspective does not address the fundamental issue of business strategy: why do organizations subject to the same level of institutional pressure pursue different strategies? Building on the institutional framework, we argue that firms adopt heterogeneous sets of environmental management practices because they interpret these pressures differently due to facility and parent company characteristics. In our model, managers of different facilities are subject to the same level of institutional pressures but they are expected to perceive these pressures differently due to disparities in their parent companies' organizational structure, strategic position, and financial and environmental performance. This difference between 'objective' and 'perceived' pressure leads to different calculations and responses. The adoption of environmental management practices by firms varies therefore not only due to different levels of institutional pressures but also because of the organizational process that transforms objective pressures into perceived pressures.

To be tested empirically, this comprehensive framework of the drivers of the adoption of environmental management practices necessitates an empirical approach that combines both existing publicly available databases, as well as original data from a survey questionnaire at the facility level. Publicly available databases can provide information on "objective pressures" while the survey questionnaire can give information about the perception of pressure and the actions taken in response. The combination of these sources of information allows the evaluation of the difference between objective and perceived pressures and the resulting adoption of environmental management practices.

INSTITUTIONAL THEORY

Institutional theory emphasizes the role of social and cultural pressures imposed on organizations that influence organizational practices and structures (Scott, 1992). DiMaggio and Powell (1983) argue that managerial decisions are strongly influenced by three institutional mechanisms—coercive, mimetic and normative isomorphism—that create and diffuse a common set of values, norms and rules to produce similar practices and structures across organizations that share a common organizational field. An organizational field is defined as "those organizations that…constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products (DiMaggio & Powell, 1983: 148).

Jennings & Zandbergen (1995) were amongst the first to apply institutional theory to explain firms' adoption of environmental management practices. They argue that because coercive forces—primarily in the form of regulations and regulatory enforcement—have been the main impetus of environmental management practices, firms throughout each industry have implemented similar practices. Consistent with most institutional theorists, Jennings & Zandbergen claim that firms that share the same organizational field are affected in similar ways by institutional forces that emanate from them. They cite the examples of how the Three Mile Island crisis undermined the legitimacy of all firms in the US nuclear power industry, and how the discovery that chlorofluorocarbons (CFCs) depleted stratospheric ozone undermined the legitimacy of manufacturing and using those products, and quickly led to institutional coercive forces via the establishment of the Montreal Protocol to phase out the manufacture of CFCs. Delmas (2002) proposed an institutional perspective to analyze the drivers of the adoption of the ISO 14001 Environmental Management System (EMS) international standard in Europe and in the United States. She described how the regulatory, normative and cognitive aspects of the institutional environment within a specific country affect the costs and potential benefits of ISO 14001 adoption, and therefore explain differences in adoption rates across countries. Other researchers have explored how companies operating in different organizational fields are subject to different institutional pressures. As a result, different practices become commonplace. For example, distinct levels of coercive pressures are exerted upon different industries, which may lead to different environmental strategies (Milstein, Hart, & York, 2002).

While such studies examine dynamic and cross-industry institutional forces, they avoid the question more fundamental to strategic management: why do organizations within the same organizational field pursue different strategies, despite experiencing isomorphic institutional pressures? In other words, how might institutional forces lead to heterogeneity, rather than homogeneity, within an industry? Hoffman (2001) argues that while organizations do not simply react to the pressures dictated by the organizational field, they also do not act completely autonomously without the influence of external bounds. Institutional and organizational dynamics are tightly linked. A few researchers have begun to investigate this question empirically (D'Aunno, Succi, & Alexander, 2000; Levy & Rothenberg, 2002).

Levy & Rothenberg (2002) describe several mechanisms by which institutionalism can encourage heterogeneity. First, they argue that institutional forces are transformed as they permeate an organization's boundaries because they are filtered and interpreted by managers according to the firm's unique history and culture. Second, they describe how an institutional field may contain conflicting institutional pressures that require prioritization by managers. Third, they describe how multinational and diversified organizations operate within several institutional fields—both at the societal and organizational levels—which expose them to different sets of institutionalized practices and norms.

D'Aunno et al. (2000) explore the circumstances under which organizations are more likely to abandon institutionalized structures or practices in favor of new ones, such as by diversifying into new services. They find that market forces (proximity to competitors), institutional forces (poor compliance with government regulations, being a member of a multidivisional firm), and mimicry of changes observed in other organizational fields each encourage strategic change that diverges from institutional norms.

We hypothesize that organizational structure, strategic positioning, and performance will affect how firms perceive institutional pressures and how they decide to respond. Individuals in organizations focus on different aspects of the firm's external and internal environments, depending on the cognitive frame through which they view the world (Hoffman, 2001). Cognitive frames are mental representations individuals use to interpret and make sense of their world. Frames can come to be collectively held within organizations, especially through the influence of the organizational leader (Barr, Stimpert, & Huff, 1992; Weick & Roberts, 1993).

Institutional pressures

In this section, we describe a model that links institutional pressures to organizational characteristics to explain the adoption of environmental management practices at the facility level. Figure 1 illustrates our model.

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[Insert Figure 1. about here]

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This figure shows that facility-level managers' perceptions of institutional pressures are a function of stakeholders' actions but are moderated by the organizational characteristics of the facility and the parent company as well as the strategic positioning of the parent company. We describe how these coercive and normative pressures can affect the adoption of environmental management practices by facilities. We focus on a subset of the institutional actors identified by Hoffman (2001) who we believe are most likely to directly influence environmental practices at the facility level: governments, customers, competitors, community and environmental interest groups, and industry associations. The actors we focus upon are important to consider when assessing a firm's environmental performance (Lober, 1996).

Government pressure

Perhaps the most obvious stakeholders that influence firms' adoption of environmental practices are various government bodies. Legislation authorizes agencies to promulgate and enforce regulations, a form of coercive power. Many researchers have focused on the influence of enforced legislation and regulations on firms' environmental practices (Carraro, Katsoulacos, & Xepapadeas, 1996; Delmas, 2002; Majumdar & Marcus, 2001; Rugman & Verbeke, 1998). In particular, Delmas (2002) found that governments play an important role in firms' decision to adopt ISO 14001. First, governments can act as a coercive force by sending a clear signal of their endorsement of ISO 14001 by, for example, enhancing the reputation of adopters. Second, government can facilitate adoption by reducing information and search costs linked to the adoption of the standard by providing technical assistance to potential adopters. In this paper, we refer to political pressure as the level of political support for broader or more stringent regulations. Regulatory pressure represents the extent to which regulators threaten to or actually impede a company's operations based on their environmental performance.

Customer and competitive pressures

In addition to government actors, firms may facilitate coercive and mimetic isomorphism. For example, multinationals are widely recognized as key agents in the diffusion of practices across national borders by transmitting organizational techniques to subsidiaries and other organizations in the host country (Arias & Guillen, 1998). Firms may also mimic practices that successful leading firms have adopted. In addition, firms respond to customer requirements. The customer-supplier relationship is perhaps the primary mechanism through which quality management standards have diffused (Anderson, Daly, & Johnson, 1999). Several studies have found that firms that adopted environmental management practices were motivated by customer concerns. A survey of the largest Canadian firms showed that customer pressure was the second most cited source of pressure to adopt an environmental management plan, after government pressure (Henriques & Sadorsky, 1996). Khanna and Anton (2002) found that U.S. companies that sell final goods adopt more comprehensive EMSs than companies that sell intermediate goods. This suggests that retail consumers exert more pressure on companies to adopt environmental management practices than commercial and industrial customers. Christmann and Taylor (2001) showed that customers in developed countries have influenced companies in China to improve their environmental compliance and adopt the ISO 14001 EMS standard.

Community and environmental interest group pressures

Local communities can also impose coercive pressure on companies through their vote in local and national elections, via environmental activism within environmental non-government organizations (NGOs), and by filing citizen lawsuits. Several studies have found that company decisions to adopt environmental management practices are influenced by the desire to improve or maintain relations with their communities. Henriques and Sadorsky (1996) surveyed 700 firms in 1992. These firms indicated that community group pressure influenced them to adopt an environmental plan. Florida and Davison (2001) investigated why facilities had adopted EMS's and instituted pollution prevention programs. They found that the adoption of these programs was positively correlated with firms' active engagement with community stakeholders (Florida & Davison, 2001). Another study based on a survey of ISO 14001 certified companies across 15 countries found that one of the strongest motivating factors to pursue certification was the desire to be a good neighbor (Raines, 2002).

Some communities may be better able than others to encourage facilities to adopt environmental practices. Communities with larger minority populations, lower incomes and less education have greater exposure to toxic emissions (Arora & Cason, 1999; Brooks & Sethi, 1997; Khanna & Vidovic, 2001). Some researchers have begun examining whether socioeconomic community characteristics are associated with facilities' decisions to adopt environmental management practices. One study examined facility-level adoption of a United States Environmental

Protection Agency (US EPA) voluntary program, and found that adoption was more likely in communities with higher median household income (Khanna & Vidovic, 2001).

Greater declines in toxic emissions have been observed among facilities located in communities with higher voting rates (Hamilton, 1999) and in states with higher membership in environmental interest groups (Maxwell, Lyon, & Hackett, 2000). Maxwell et al. (2000) assert that higher environmental interest group membership levels indicate a community's pro-environmental stance and greater propensity to use these organizations to lobby for more stringent regulation. As such, the authors conclude that higher membership rates provide a credible threat of increased regulation, which in turn drives firms to self-regulate.

Many of the firms studied by Lawrence & Morell (1995), especially the larger ones, were motivated to improve their environmental performance by their concern over 'environmental organizations that had aggressively publicized firms' lapses in environmental responsibility' (Lawrence & Morell, 1995, p. 111). There are many examples where companies have amended their environmental practices in response to environmental group pressures (Baron, 2003). For instance, after Mitsubishi Corporation was subject to a protracted consumer boycott led by the Rainforest Action Network (RAN), Mitsubishi announced it would no longer use old-growth forest products (World Rainforest Movement, 1998).

Industry pressure

Institutional researchers have argued that organizations are more likely to mimic the behavior of other organizations that are tied to them through networks (Guler, Guillen, & MacPherson, 2002). Several studies have found that industry associations have motivated firms to adopt environmental management practices. Kollman & Prakash (2002) examined why the United Kingdom, Germany and the United States have such different rates of EMS certification. They found that the decision of whether to pursue certification, and which standard to certify against (ISO 14001 or the European Union's Eco-Audit and Management Scheme) was strongly influenced by stakeholder pressures from industry associations in addition to regional chambers of commerce, suppliers and regulators.

Market concentration within an industry may also affect the rate of diffusion of environmental management practices. If an industry is dominated by a few big players that require their suppliers to adopt particular environmental management practices, this is likely to lead to a greater diffusion of these practices than if the industry were more fragmented. This is a major reason why automotive suppliers in the United States have adopted similar quality and environmental practices.

Interactions

The interaction between these institutional pressures is likely to moderate their individual influence on company practices. For example, the pressure from environmental groups may encourage the formulation of more stringent regulations. This, in turn, can induce industry leaders to encourage laggard firms to adopt environmental practices. Similarly, following its chemical disaster in Bhopal in 1984, Union Carbide along with other large chemical companies faced mounting public pressure for more stringent safety and environmental regulations. In response, the chemical industry developed and promoted a set of environment, health and safety (EHS) management practices—the Responsible Care program—to chemical industry associations in Canada and the United States (King & Lenox, 2000; Prakash, 2000).

The moderating effects of firm characteristics

Within the same industry, firms may be subjected to different levels of institutional pressures. For example, multinational corporations are often held to higher standards for social and environmental responsibility than national companies because they are subject to the additional pressure of stakeholders from foreign countries (Zyglidopoulos, 2002). Furthermore, the visibility of leading firms often subjects them to more pressure. For example, social and environmental activists have targeted Nike, McDonald's, Starbucks and Home Depot in part because of their market leadership position (Roberts, 2003; Rowley & Berman, 2000). Furthermore, firms with historically poor environmental records are often subjected to more scrutiny by their local communities and regulators. Thus, multinational companies, market leaders, and firms with poor environmental records may have more to gain by developing sophisticated mechanisms to anticipate and manage external pressures.

PERCEPTION OF PRESSURE

Firm and facility characteristics can affect not only the level of institutional pressure exerted on a facility, but also how facility managers perceive institutional pressures. This is important because, even if institutional pressures were exerted at the same level on two facilities, these two facilities may well perceive and respond differently.

First, institutional pressures are exerted at various levels of a firm. For example, community pressures are often directly targeted at a particular facility, while shareholder pressures target the corporate level. Second, organizations channel these institutional pressures to different subunits, each of which frames these pressures according to their typical functional routines (Hoffman, 2001). For example, legal departments interpret pressures in terms of risk and liability, public affairs does so in terms of company reputation, environmental affairs in terms of ecosystem damage and regulatory compliance, and sales departments in terms of potential lost revenues. Consequently, the pressure is managed according to the cultural frame of the unit that receives it: either as an issue of regulatory compliance, human resource management, operational efficiency, risk management, market demand, or social responsibility (Hoffman, 2001). One implication of this process is that the internal organization of the firm matters because it influences how institutional pressures are perceived. Facility managers may perceive these external pressures more intensively (and respond to them accordingly) in firms where they have more open channels of communications with the immediate receptor of pressures (corporate functional areas responsible for finance, law, strategy, communication, and the environment).

Information sources may also play a role in cultural framing. Environmental managers may learn about management practices from a variety of sources. For example, a facility may learn in an industry association meeting about a pending boycott of a competitor because of its environmental performance. The source from which managers get their information on existing environmental management practices can also influence their decision to adopt environmental management practices.

A firm’s historical environmental performance may also influence both how managers perceive stakeholder pressures and how they respond to them. Managers in firms whose reputations have suffered from pollution accidents may be more sensitive to environmental issues than those in other companies (Prakash, 2000). After major accidents, firms may rearrange their organizational structure to prevent recurrences and to facilitate more rapid responses. Such reorganizations may also begin actively engaging with those stakeholders from whom the firm expects more scrutiny (e.g., regulators, environmental activities). These reorganizations may also occur within competing firms if heightened institutional pressures spill beyond the firm that experienced the accident. For example, the disclosure of environmental information in the annual reports of oil companies increased significantly in the years following the Exxon Valdez oil spill (Patten, 1992).

FIRM RESPONSES TO INSTITUTIONAL PRESSURES

Firms can adopt various types of environmental management practices in response to institutional pressures. These can be based on (1) environmental strategies of conformance that focus on complying with regulations and adopting standard industry practices, or (2) voluntary environmental strategies that seek to reduce the environmental impacts of operations beyond regulatory requirements (Sharma, 2000). Voluntary strategies involve creative problem solving and collaborative interactions with stakeholders (Sharma & Vredenburg, 1998). For example, firms adopting voluntary approaches can implement EMS elements by creating an environmental policy, developing a formal training program, or instigating routine environmental auditing. In addition, management can choose to have the comprehensiveness of their EMS validated by a third party by pursuing ISO 14001 certification. Management can also convey the importance of environmental management by including it as a criterion in employee performance evaluations (Nelson, 2002).

Companies can also seek to improve relations with regulators and signal a proactive environmental stance by participating in government or industry sponsored voluntary programs. Indeed, the US EPA, some industry associations, and several NGOs have recently created voluntary standards to provide incentives for firms to go beyond minimal regulatory requirements. For example, the US EPA has developed several voluntary agreements between governmental agencies and firms to encourage technological innovation or reduce pollution while providing relief from particular procedural requirements (Delmas & Terlaak, 2001). Industry programs include Responsible Care and Sustainable Slopes (King & Lenox, 2000;

Rivera & de Leon, 2003). NGO programs include the Natural Step and the Global Reporting Initiative Guidelines (Bradbury & Clair, 1999; Hedberg & von Malmborg, 2003).

Companies can also work directly with customers and suppliers to improve their environmental performance. Furthermore, they may engage in "systematic communication, consultation and collaboration with their key stakeholders...(and) host stakeholder forums and establish permanent stakeholder advisory panels at either the corporate level, the facility level, or to address a specific issue" (Nelson, 2002, p. 18).

METHODOLOGY

Data for this study are derived from two main sources: (i) a survey questionnaire sent to 3160 facilities in the fall of 2003; and (ii) publicly available databases. The survey provided information about the management practices each facility has adopted (our dependent variable) as well as the number of environmental staff, the types of environmental auditing conducted, and perceptions of institutional pressures. Various "objective" institutional pressures as well as firm and facility level characteristics were obtained from existing databases.

Sample

Our sample focuses on heavily polluting industrial sectors, which we identified based on their share of toxic chemical emissions reported to the US EPA's Toxic Release Inventory (TRI) program. The following sectors were selected: electric utilities (SIC 49), electrical/electronics (SIC 36), petroleum refining (SIC 29), chemical and allied products (SIC 28), automotive (SIC 37), machinery manufacturing (SIC 35), primary metals manufacturing (SIC 33), and pulp, paper and paperboard mills (SIC 26). In 2001, the 11,622 facilities from these industries represent 47% of the total number of facilities that reported data to TRI and 78% of the total TRI toxic air emissions reported.[1] To ensure we would have access to recent environmental performance data, we restricted our sample to facilities that reported air emissions to the TRI program in at least 3 years within 1996 – 2000. These facilities must report TRI data annually when they employ 10 or more individuals and manufacture, import, process, or use more than designated minimum

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EPA 260-S-03-001. July. www.epa.gov/tri/tridata/tri01 thresholds (typically 10,000–25,000 pounds) of any of 650 toxic chemicals.[2] To ensure the availability of financial data, we further restricted our sample to facilities owned by publicly traded companies. These restrictions reduced our sample to 3160 facilities.

Survey questionnaire

Little detailed information about environmental management practices (EMPs) is publicly available at the facility level. Consequently, we conducted a survey to gather this information as well as managers' perceptions of the factors that influenced their facility to adopting EMPs. Our survey also asked about how the facility's environmental management was structured organizationally. The survey questionnaire instrument is included in the Appendix.

Pre-testing. To ensure that our survey questions were clearly understood and easily answerable by our respondents, we pre-tested our survey instrument by having a panel of experts complete the survey. These experts included environmental managers and environmental, health and safety (EHS) managers from twelve large companies in our sample's industries, a few environmental management consultants, and several faculty members whose research interests include environmental management. We then interviewed these individuals to probe their interpretation of each question and to solicit suggestions to clarify them. This process resulted in refinements to several survey questions and response anchors.

Survey respondents. The ideal survey respondent must be knowledgeable about the facility's EMPs and have informed perceptions about the drivers of its environmental management efforts. As such, we targeted the survey toward the facility's environmental manager or EHS manager. The Survey Research Center (SRC) at the University of California at Santa Barbara called each facility to obtain the name of this individual.

Survey administration. The survey was sent to the respondents in three waves. The survey was sent to the entire sample twice, on October 13 and November 4, 2003. The cover letter that accompanied the survey provided a unique login identification number to enable respondents to complete the survey online via a secure website if they preferred that to the enclosed paper

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[2] US Environmental Protection Agency. 2001. The Emergency Planning and Community Right-to-Know Act: Section 313 Release and Other Waste Management Reporting Requirements. EPA 260/K-01-001. February. http://www.epa.gov/tri/guide_docs/index.htm

version. To encourage responses, the SRC placed calls to 2312 facilities (73% of the sample) between October 23 and November 12. In addition, postcards were sent in January 2004 to those who had not yet replied.

Response rate. In total, we received 303 responses by mail and 233 by web for a total of 536. Of our total sample of 3160, this represents a response rate of 17%, which is considered as an acceptable response rate for a sample of that size. The response rate among the 2312 facilities that received a follow-up call from SRC was 20.3%, significantly higher than the 7.2% response rate of the other 930 facilities. Sample representativeness was tested in three ways. First, we compared the size of respondent and non-respondent facilities using facility-level employment data obtained from D&B. Respondent and non-respondent facilities employed, on average, 479 and 422 employees respectively, but this distinction is not statistically significant ($p=0.19$). We then examined the response rates across industries and found they were quite similar, ranging from 13% (Refining and Electric utilities) to 17% (Machinery, Electrical/electronics) to 19% (Automotive, Primary metals). We also compared the pollution levels of the respondents to the non-respondents. The two groups' total annual toxic emissions released to air, logged and then averaged over 2000 and 2001, were statistically indistinguishable (p=.41). In addition, we compared the two groups' average environmental harm by weighting each chemical by the US EPA's TRACI scheme and then aggregating annual totals (Toffel & Marshall, 2004) and logging the result. By this measure, the two groups were also statistically indistinguishable (p=0.80). This provides further assurance that respondents are representative of the entire sample.

Dependent variable

The dependent variable represents the comprehensiveness of environmental management practices at the facility level. We proxy this unobserved quality by aggregating the observed environmental practices adopted by a facility. Our measure includes the extent to which: (1) the facility adopts and communicates an environmental policy; (2) employees receive environmental training; (3) employee performance reviews incorporate environmental performance; (4) procurement decisions incorporate environmental concerns; and (5) the facility participates in government and industry-initiated voluntary environmental programs. In addition, internal and external audit frequency and whether ISO 14001 certification were included.

There are several methods to aggregate these management practices and create the dependent variable. One method is simply to sum up the number of practices that each facility has adopted and the level of implementation of each adopted practice (Khanna & Anton, 2002). This method implicitly weights each practice equally.

A second method is to run a factor analysis on the original variables within each category (e.g., training) and then add the category totals to generate the final dependent variable. The main applications of factor analytic techniques are: (1) to reduce the number of variables and (2) to detect structure in the relationships between variables. Klassen used this method in his study of environmental management practices in the furniture industry (Klassen, 2001).

EMS comprehensiveness via summing variables

Table 1a describes the methodology to derive each category of environmental management practice. We focus on the following categories: environmental policy promotion (POLICY_D); audit frequency (AUDITS_D); training comprehensiveness (TRAIN_D); environmental performance review (REVIEW_D); environmental procurement policy (PROCUR_D); participation in voluntary programs (VOLPRG_D); and ISO certification (ISO_D). Each category is the sum of the variables composing it. For example, the category representing environmental policy is the sum of four variables, each coded 0 (“no”) or 1 (“yes”), constructed from the following survey questions: Is your environmental policy distributed to employees? (POLICYD) Is your environmental policy posted on the Internet? (POLICYI) Is your environmental policy discussed with managers or supervisors? (POLICYM) Is your environmental policy posted at the facility? (POLICYP) We then normalized each category sum to a maximum score of 1, and he added these normalized category totals to create the dependent variable (EMP_SUM).

Comprehensiveness of environmental management practices (EMP_SUM)= POLICY_D + AUDITS_D + TRAIN_D + REVIEW_D + PROCUR_D + VOLPRG_D+ ISO_D

As depicted in Figure 2, this variable has a normal distribution, a condition that facilitates the use of ordinary least squares (OLS) regression.

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[Insert figure 2. about here]

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EMS comprehensiveness via factor analysis

A specific category of factor analysis is called Principal Component Analysis (PCA). We used PCA to investigate whether we could consolidate some of our variables within a specific category. PCA is an eigenanalysis technique that extracts a set of eigenvectors and their associated Eigenvalues by a step-wise procedure. The first eigenvector is extracted in a manner that causes it to account for a maximum amount of variance in the data. After each eigenvector is extracted a residual data matrix is calculated and the procedure is repeated until there are no significant eigenvectors left. The variance accounted for by each eigenvector is measured by its Eigenvalue. The variance is equal to the square of the Eigenvalue. Examination of the Eigenvalues and their relative magnitudes allows an estimation of the number of significant 'factors' or components in the matrix. We retain only factors with Eigenvalues greater than 1, a very common criterion (Kaiser, 1960).

Not all of the environmental management practices variables could be subject to PCA due to the coding of some variables.[3] We use PCA with the following categories: environmental training; employee performance reviews; procurement; audit frequency; and voluntary environmental program participation. Table 1b describes the PCA analyses and results, including the original variables, the number of factors with Eigenvalues above 1 and their Eigenvalues of these factors, the percentage of variance explained by the factors, and the name of the new variable(s) created.

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[Insert Table 1b about here]

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[3] For example, our variable assessing the existence and communication of an environmental policy consist of dummy variables on which it is not possible to run a PCA.

We add the categories created with PCA to the variable representing environmental policy (POLICY_D) to create the second measure of the comprehensiveness of environmental management practices (EMP_PCA).

Comprehensiveness of environmental management practices using PCA (EMP_PCA) = POLICY_D + AUDITS_C + TRAIN_C + REVIEW_C + PROCUR_C + VOLPRG_C + ISO_C

EMP_PCA is normally distributed, as illustrated in Figure 3.

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[Insert figure 3. about here]

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The two dependent variables that we created (EMP_SUM and EMP_PCA) are highly correlated (0.985) but EMP_SUM (541) has more observations than EMP_PCA (480) due to the difference in methodology used to create the variables.

Independent variables

Many stakeholder pressures can be measured through publicly available data sources, though in a few cases internal company information may be significantly more accurate (e.g., customer pressure). The perception of stakeholder pressure can also be assessed through a survey questionnaire addressed to managers (Henriques & Sadorsky, 1996). Relying on both publicly available databases and a survey enable us to assess differences between "objective pressures" (measured by the former) and "perceived pressures" (measured by the latter).

Political and regulatory pressure

Political and regulatory pressure is measured in several ways. First, we include Congressional members' "National Environmental Scorecard" values published annually by the League of Conservation Voters, a measure that has been widely used for this purpose (Hamilton, 1997; Kassinis & Vafeas, 2002; Viscusi & Hamilton, 1999; Welch, Mazur, & Bretschneider, 2000). The average of the League of Conservation Voters' 1996 scores for the state's US Senate and House delegations to Congress was calculated (LCV96CON). Second, we include the number of state-level environmental policy initiatives (toxic waste, air pollution and recycling programs) each state has implemented (GINDEX50) (Hall & Kerr, 1991: 142), a measure recently been used by Welch et al. (2000). Third, we incorporate Renew America's assessment of how comprehensively each state's policies have addressed 17 environmental domains (e.g., air pollution, groundwater, soil conservation) (GINDEX17) (Hall & Kerr, 1991: 146). Fourth, we include a variable representing the state's average inverse of pollution intensity over the years 1995-2001 (PII9501). Each year's figure is the ratio of the state's gross product (million current US $) to the unweighted sum of the state's Toxic Release Inventory emissions (lbs).

Competitive pressure

Pressure toward mimetic isomorphism exerted on a facility is measured by the extent to which the facility perceives that its competitors have adopted an EMS (COMPEMS). Survey respondents could choose from five categories representing percentage ranges from 0-20% to 80-100%. We also included an additional "don't know" category that was subsequently recoded as the average response of facilities within in the same industry.

Community and environmental interest group pressure

Community pressure is measured using several indicators, including propensity for collective action, environmental attitudes and demographics. Because communities with a higher propensity for collective action are likely to be capable of exerting greater institutional pressure on local facilities, various proxies for a community's propensity for collective action are employed. First, community environmental activism is measured using the proportion of the population within the facility's state that are members of major environmental and conservation organizations, an approach used in several other studies (Maxwell et al., 2000; Welch et al., 2000; Wikle, 1995). These data were collected through a survey of 80 main environmental and conservation NGOs in 2003 (Delmas, 2004). The number of environmental NGO members per state was normalized by dividing it by thousands of state residents in 2000 (NGOPCS00).

Second, a community's propensity to file lawsuits against facilities based on environmental issues is estimated based on the proportion of a facility's state's population who are environmental lawyers (Delmas, 2003). The number of environmental lawyers per state, obtained from the Martindale Law Directory, was normalized by dividing it by each state's population (LAWYERST).

Third, community demographics may also matter. The fact that communities with lower income, less education, and greater proportions of minorities are often exposed to more pollution may be due to facilities' perceiving such communities as possessing less institutional power. Community demographics data including income, race, education, and population density in the United States are available from US Census Bureau and have been used in several studies to examine the influence of communities on organizations' environmental practices (e.g., Arora & Cason, 1999; Hamilton, 1993). We include the following variables from the US Census: median per capita income (MDINCT); percentage of the population over 25 years that attended college (EDUCCOL); percentage of population whose race was reported "white" (WHITEPOP); percentage of housing units that are owner-occupied (OWNED); and percentage of urban population (URBAN). Each of these measures represents the average US Census values pertaining to the zip codes within a five-mile radius of each facility.

Perception of pressures

In addition to using objective measures of these stakeholder pressures, we also assess how managers perceived these pressures. Survey respondents reported the extent to which they perceived various stakeholders influencing their facility to improve environmental performance. The list of stakeholders included customers, suppliers, competitors, trade associations, local community, environmental organizations, regulators/legislators, the media, corporate management, employees, other facilities within the company, socially responsible investment funds, and shareholders. Respondents ranked each stakeholder influence on a five-point scale from "no influence" to a "very strong influence." Many of these variables are highly correlated. As with environmental management practices, we conducted a principle components factor analysis with "varimax" rotation to combine these variables into a few factors. Missing observations were excluded listwise. The underlying variables loaded onto three factors: COMMERCIAL PRESSURE (pressure from customers, suppliers, competitors, trade associations), NON-MARKET PRESSURE (pressure from local community, environmental organizations, regulators, media), and FIRM INTERNAL PRESSURE (pressure from corporate management, employees, other facilities within the company). The loading of these underlying variables on the three factors is reported in Table 5. These three factors explained 58% of the variance. Only two underlying variables (socially responsible investment funds and shareholders) loaded evenly across factors and had lower coefficients (< .50). We ran additional PCA without these two variables. The resulting factors of this subsequent analysis were strongly correlated to the three initial factors (correlations > 0.980 and significant at the 0.01 level).

The moderating effects of firm and facility characteristics

We identify each facility's main business strategy by asking survey respondents to rate, on a 7-point scale, the extent to which their company "provides low cost products or services" versus seeks to "differentiate [their] products" (BIZSTRAT). Facility size is measured through its employee headcount, in thousands (EMPLHERE), which we obtained from Dun and Bradstreet.

A firm's historical environmental record could be measured using the sum of environmental compliance violations and resulting penalties accrued over the preceding years at all of its facilities (Kassinis & Vafeas, 2002; Khanna & Anton, 2002; Russo & Fouts, 1997). We use the plant's logged toxic releases averaged over 2000 to 2001 as a proxy of the attention that the media and community are paying to the performance of the facility (UNW0001L).

RESULTS

Tables 2 and 3 provide descriptive statistics. We run two sets of models. Environmental management practice comprehensiveness, constructed using the two approaches described above (sum and PCA), were regressed on various measures of institutional pressures as well as facility characteristics and industry dummy variables.

- The first set of models includes the "objective" measures of institutional pressure. Results are reported in Table 4.
- The second set of models includes the "subjective" measures of institutional pressures. Results are reported in Table 6.

In the first set of models, few "objective" measures of institutional pressure are significant. None of the regulatory or legislative pressure variables appears to significantly influence the adoption of environmental management practices. Two variables that measure community activism—

median 1999 household income and percentage of white population—are significant and negative. Their significance confirms prior research that finds correlations between community demographic indicators and pollution, though the negative relationship identified here is in sharp contrast to prior findings that poorer communities with more racial minorities are subjected to more pollution. Our findings suggest that companies located in such communities adopt *more* environmental management practices. We also find that competitor pressure, measured by the proportion of competitors a firm believes has implemented an EMS, is positively and significantly related to the number of environmental management practices the firm adopts. This direct relationship suggests that firms may mimic their peer groups in terms of how many environmental management practices to implement, whether this be a lot or few. The variable representing pollution spotlight (average unweighed TRI air releases, 2000-01) is also significant and positive, suggesting that facilities that may attract more media and regulatory attention because of their relatively high mass of emissions have implemented more environmental management practices. Finally, more environmental management practices have been adopted by facilities that are part of an organization with operations across more continents and whose headquarters is outside the US. All of these findings are robust to two alternative ways we measure EMS comprehensiveness (EMP_SUM or EMP_PCA).

In the second set of models, we initially individually included each original "perceived stakeholder pressure" survey variable and found all of them to be significant and positive except the variable representing the perceived influence of regulators/legislators (not shown). Next, we instead included the three-factor solution to the principle component analysis to evaluate the impact of commercial, non-market, and internal pressures. Perceived commercial and internal pressures to improve environmental performance are both positive and significant determinants of adopting environmental management practices. Non-market pressures to improve environmental performance appear to have no influence on the adoption of environmental management practices. Consistent with the previous objective pressure models, firms with their headquarters based in the US adopted significantly fewer environmental management practices, and firms that had a wider geographic scope and more competitor pressure adopted more environmental management practices. In contrast to the objective pressure models, neither community demographic measure is significant here, nor is the variable representing pollution spotlight (average unweighted sum of TRI air releases, 2000-01). All of these findings are robust to two alternative ways we measure EMS comprehensiveness (EMP_SUM or EMP_PCA).

In view of these results it is interesting to note that 'perceived' pressures have a better explanatory power than 'objective' pressures to predict the adoption of environmental management practices at the facility level. Some of these findings may result from the limitation of the proxy of our 'objective' pressures. It would be interesting to get a better understanding of the regulatory pressure exerted at the facility level by assessing the number of times regulatory agencies have actually contacted, visited or fined the facility. In addition, we still have yet to investigate the relationship between objective and perceived pressures, including when their levels are aligned and, perhaps more importantly, when their levels substantially differ. These findings have potentially important policy implications. Indeed understanding how facilities perceive pressures will help policy makers focus their efforts on the appropriate channels.

Our finding that regulators and other non-market actors apparently do not significantly impact the adoption of comprehensive environmental management practices suggests that other stakeholders are more effective in exerting direct influence. Policy makers can take advantage of these stakeholders to enhance the level of adoption of environmental management practices at the facility level.

CONCLUSION

This paper provides a model that describes how stakeholders including regulators, customers, activists, local communities and industry associations impose institutional pressures on facilities and their parent companies. We also suggest how a variety of facility- and parent company factors moderate how managers perceive and act upon these pressures. Moderating factors include historical environmental performance, the competitive position of the parent company and the organizational structure of the facility.

Our approach complements institutional theory as it suggests that both institutional pressures and organizational characteristics influence organizations to adopt environmental management practices. Firm and facility characteristics are viewed as moderating factors because they are expected to magnify or diminish the influence of institutional pressures.

Our results show that the most important factors explaining the adoption of environmental management practices are how environmental managers perceive the institutional pressures. In particular, we find that stakeholder pressures from the private sector influence facilities' adoption of environmental management practices. We also find that the corporation has a strong influence on facilities' decisions to adopt environmental management practices. The characteristics of the facility and the firm also matter. In particular, large facilities, facilities that are part of firms that operate internationally, and facilities whose headquarters are outside the US tend to adopt more environmental management practices. We plan to further investigate the relationship between objective and perceived institutional pressures, and how various institutional pressures influence the adoption of specific environmental management practices.

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Figure 1. A model of institutional pressures moderated by parent company and facility characteristics

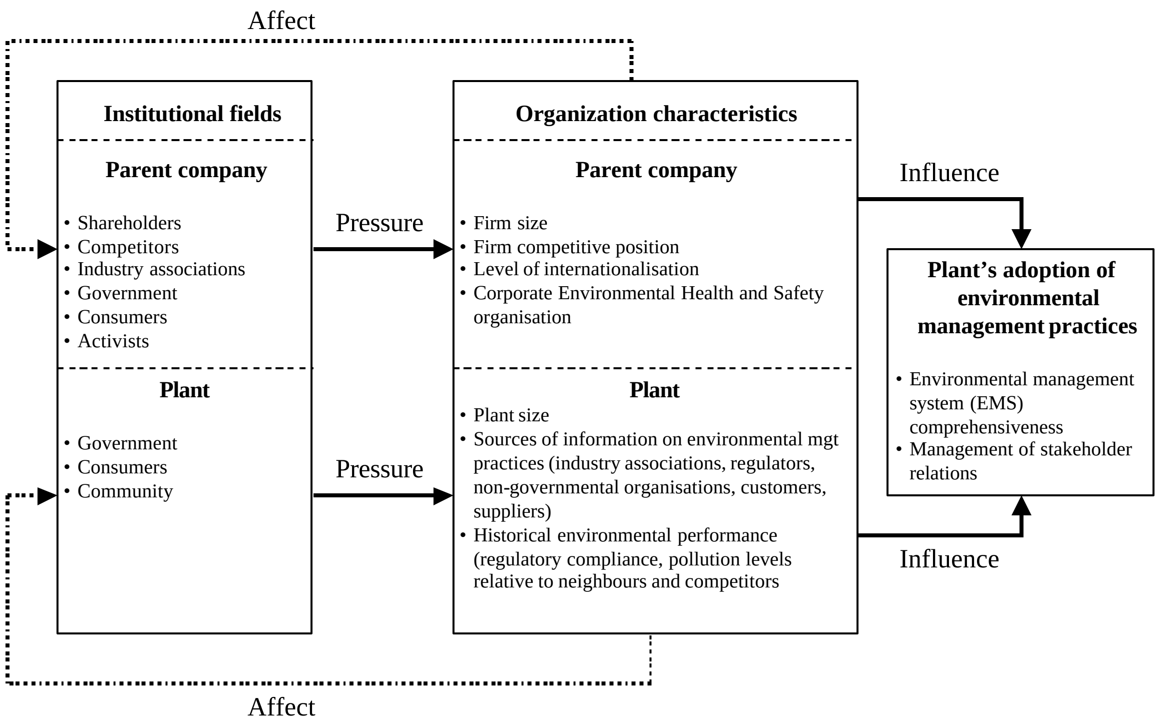

Table 1a. Construction of environmental management practices categories (sum of variables)

Variable name	Construction
Environmental policy promotion (POLICY_D)	S (POLICYD Env policy distributed to employees (0/1); POLICYI; Env policy posted on internet (0/1); POLICYM Env policy discussed with mgr/supervisor (0/1); POLICYP Env policy posted at facility (0/1))/4.
Annual audits (AUDITS_D)	S (AUDITEXT External audits last 3 yrs; AUDITINT Internal audits last 3 yrs)/3
Training comprehensiveness (TRAIN_D)	S (TRAINDES Proportion of engineering/r&d/design dept receive env. Training; TRAINEHS Proportion of EHS dept receive env. Training; TRAINMGT Proportion of management receive env. Training; TRAINMNT Proportion of maintenance dept receive env. Training; TRAINOPS Proportion of operations dept receive env. Training; TRAINPUR Proportion of purchasing dept receive env. Training; TRAINSAL Proportion of sales dept receive env. Training) /number of departments for which responses were given.
Environmental performance review (REVIEW_D)	S (REVDES Env Review of engineering/r&d/design staff; REVEHS Env Review of EHS staff; REVMGT Review of management include env. Performance; REVMNT Review of maintenance staff include env. Performance; REVOPS Review of operations staff include env. Performance; REVPUR Review of purchasing staff include env. Performance; REVSAL Review of sales staff include env. Performance) /number of departments for which responses were given
Environmental procurement policy (PROCUR_D)	S (PURPOL Extent to which purchasing uses green policy; PURISO Extent to which purchasing requests ISO 14001 of suppliers; PURINFO Extent to which purchasing requests env. info of suppliers)/3
Voluntary programs. Extent to which the facility adopts government and industry voluntary (VOLPRG_D)	S (GOVVOL Status of implementing govt voluntary programs; INDVOL Status of implementing industry voluntary programs)/8
ISO certification (ISO_D)	S (ISO9 ISO 9000 status + Iso14 ISO 14001 status)

Table 1b. PCA analyses of environmental management practice categories

Category	**Variables included**	**Eigenvalues > 1**	**Variance explained**	**Variable created**
Annual audits	External and internal audit frequency	1.99	99%	GEN AUDITS_C
Training comprehensiveness	Comprehensiveness of environmental training across seven departments	3.21	54%	TRAIN_C
Environmental performance review	Extent to which performance reviews incorporate environmental management tasks across seven departments	4.36	62%	REVIEW_D
Environmental procurement	Extent to which purchasing decisions incorporate environmental criteria	1.95	65%	PROCUR_C
Participation in voluntary programs	Participation in government- and industry-initiated voluntary environmental programs	1.37	69%	VOLPRG_C
ISO certification	Status of adopting ISO 9000 and ISO 14001	1.47	74%	ISO_C

Figure 2. EMS comprehensiveness based on sum of original variables (EMP_SUM)

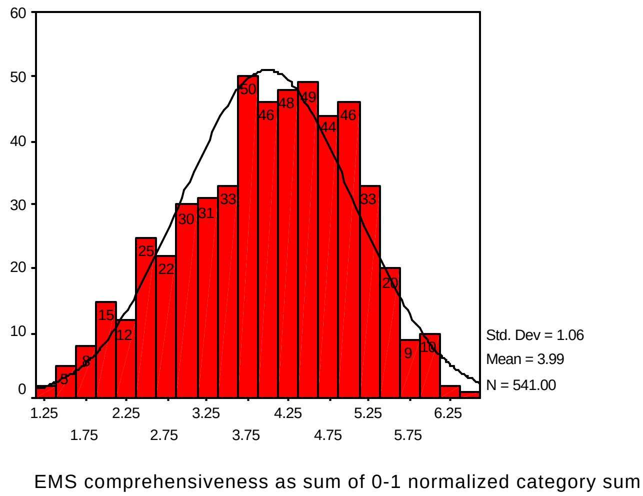

Figure 3. EMS comprehensiveness based on PCA of original variables (EMP_PCA)

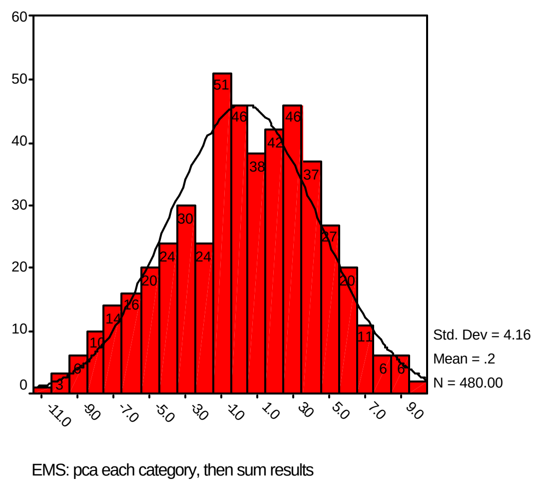

Table 2. Descriptive statistics: objective pressures

	Variable	Description	Obs	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9
1	STGRN_C5	PCA (lcv96con gindex50 gindex17 pii9501 ngopcs03)	526	-0.02	0.97	-1	2	1.00								
2	LAWPCS03	Environmental lawyers	533	6.39	2.60	2	19	0.45	1.00							
3	LCV96CON	League of Conservation Voters	526	43.61	21.05	0	91	0.75	0.25	1.00						
4	GINDEX50	Number of state env policies of 50 by Hall & Kerr	526	22.17	7.36	5	38	0.92	0.41	0.57	1.00					
5	GINDEX17	Rating of 17 state policies by Renew America	526	90.27	24.23	46	134	0.92	0.26	0.67	0.90	1.00				
6	PII9501	State's average inverse of pollution intensity, 1995-2001	526	0.01	0.01	0	0.1	0.72	0.51	0.40	0.54	0.49	1.00			
7	NGOPCS03	Environmental NGO members per 1000 state residents, 2003	533	2.91	1.71	0.02	8	0.88	0.52	0.52	0.77	0.74	0.70	1.00		
8	COMPEMS	Proportion of competitors with EMS	571	2.97	1.15	1	5	0.03	0.04	-0.02	0.06	0.06	-0.01	0.00	1.00	
9	BIZSTRAT	Company's main business strategy (low cost vs differentiation)	535	4.42	1.87	1	7	0.10	0.00	0.10	0.12	0.16	-0.04	0.06	0.07	1.00
10	MDINCT	Median 1999 household income within 5 miles, in thousands	524	41.45	12.37	9	94	0.41	0.25	0.35	0.35	0.40	0.24	0.38	0.06	0.03
11	WHITEPOP	Percentage population <White alone> race within 5 miles	524	0.79	0.18	0.2	1	-0.04	-0.10	0.03	-0.05	0.02	-0.17	-0.06	0.00	-0.09
12	EDUCCOL	Pct pop 25+ years within 5 miles	524	0.48	0.12	0.2	0.8	0.23	0.17	0.09	0.17	0.24	0.18	0.29	-0.04	-0.01
13	EMPLHRT	Plant employees	421	0.48	0.70	0	6	0.01	-0.13	0.04	0.06	0.10	-0.12	-0.06	-0.01	0.13
14	UNW0001L	Log of Average unweighted TRI air releases, 2000-01	501	8.76	3.47	-4	16	-0.08	-0.19	0.01	-0.07	-0.07	-0.12	-0.09	-0.07	-0.06
15	TRC0001L	Log of Average TRACI-weighted TRI air releases, 2000-01	325	5.00	5.76	-9	19	-0.02	-0.11	0.05	0.01	-0.01	-0.08	-0.06	-0.05	-0.24
16	INTL_D	Geographic breadth of operations	575	0.59	0.41	0	1	0.11	-0.02	0.11	0.16	0.16	-0.07	0.04	0.24	0.21
17	HQUS	HQ located in US	575	0.86	0.34	0	1	0.00	0.00	0.02	-0.02	-0.01	0.02	-0.01	-0.13	0.02
18	INDSTRY1	Automotive industry	575	0.10	0.29	0	1	-0.09	-0.10	-0.08	-0.07	-0.06	-0.09	-0.09	0.21	0.01
19	INDSTRY2	Electrical/Electronics industry	575	0.18	0.39	0	1	0.10	0.04	0.06	0.09	0.10	0.09	0.07	0.12	0.05
20	INDSTRY3	Machinery industry	575	0.10	0.30	0	1	-0.01	-0.12	-0.02	0.03	0.06	-0.07	-0.05	-0.13	0.11
21	INDSTRY4	Primary Metals industry	575	0.14	0.35	0	1	0.12	0.04	0.06	0.14	0.13	0.03	0.11	-0.17	0.08
22	INDSTRY5	Refining industry	575	0.24	0.43	0	1	-0.05	0.20	-0.09	-0.04	-0.09	0.05	-0.02	0.16	0.06
23	INDSTRY6	Utilities industry	575	0.08	0.27	0	1	-0.03	-0.12	0.13	-0.13	-0.11	0.04	-0.03	-0.30	-0.43

Table 2. Descriptive statistics: objective pressures (continued)

	Variable	Description	10	11	12	13	14	15	16	17	18	19	20	21	22	23
10	MDINCT	Median 1999 household income within 5 miles	1.00													
11	WHITEPOP	Percentage population <White alone> within 5 miles	0.16	1.00												
12	EDUCCOL	Pct pop 25+ years within 5 miles	0.65	0.13	1.00											
13	EMPLHRT	Plant employees	0.00	-0.02	0.01	1.00										
14	UNW0001L	Log of Average unweighted TRI air releases, 2000-01	-0.08	-0.11	-0.09	0.11	1.00									
15	TRC0001L	Log of Average TRACI-weighted TRI air releases, 2000-01	-0.08	-0.01	-0.11	-0.11	-0.01	1.00								
16	INTL_D	Geographic breadth of operations	0.11	0.01	0.03	0.16	-0.15	-0.03	1.00							
17	HQUS	HQ located in US (dummy)	-0.09	-0.06	-0.03	-0.06	-0.07	0.08	-0.05	1.00						
18	INDSTRY1	Automotive industry	-0.02	0.12	-0.02	0.22	-0.07	-0.06	0.15	0.02	1.00					
19	INDSTRY2	Electrical/Electronics industry	0.19	0.10	0.09	0.04	-0.20	-0.06	0.17	-0.16	-0.14	1.00				
20	INDSTRY3	Machinery industry	-0.01	0.08	0.11	0.21	-0.22	0.02	0.10	0.07	-0.12	-0.13	1.00			
21	INDSTRY4	Primary Metals industry	-0.07	-0.02	-0.05	-0.10	-0.27	0.24	-0.08	0.10	-0.17	-0.18	-0.16	1.00		
22	INDSTRY5	Refining industry	-0.01	-0.21	0.00	-0.17	0.21	-0.32	0.03	-0.03	-0.24	-0.25	-0.22	-0.31	1.00	
23	INDSTRY6	Utilities industry	0.03	0.07	-0.01	-0.10	0.28	0.22	-0.32	0.07	-0.12	-0.12	-0.11	-0.15	-0.21	1.00

Table 3a. Descriptive statistics: perceived pressures

Variable	Description	Obs	Mean	SD	Min	Max
EMP_SUM	Comprehensiveness of environmental management practices (sum of normalized category sums)	319	3.95	1.02	1.50	6.10
EMP_PCA	Comprehensiveness of environmental management practices (sum of category-level principle-component factors)	283	0.10	4.00	-9.95	9.37
INFLUPRI	perceived influence of commercial pressures (comp, cust, suppl, trade assoc)	319	-0.02	1.01	-2.46	2.48
INFLUCOM	perceived influence of non-market pressures (community, ngos, regulators, media)	319	0.04	1.00	-2.88	2.65
INFLUFIR	perceived influence of internal pressures (corp mgt, employee, other facilities)	319	-0.04	1.01	-2.79	2.47
COMPEMS	Competitors with EMS	319	2.92	1.14	1	5
MDINCT	Median household income	319	40.28	11.61	9.4	94.2
WHITEPOP	Percentage population white	319	0.79	0.20	0.2	1.0
EMPLHRT	plant employees	319	0.48	0.67	0.001	5.5
UNW0001L	TRI air releases	319	8.72	3.33	0	15.8
INTL_D	Geographic breadth of operations	319	0.60	0.40	0	1
HQUS	HQ located in US	319	0.93	0.26	0	1
BIZSTRAT	Company's main business strategy	319	4.33	1.88	1	7
INDSTRY1	Automotive industry	319	0.12	0.33	0	1
INDSTRY2	Electrical/Electronics industry	319	0.18	0.38	0	1
INDSTRY3	Machinery industry	319	0.11	0.31	0	1
INDSTRY4	Primary Metals industry	319	0.17	0.37	0	1
INDSTRY5	Refining industry	319	0.28	0.45	0	1
INDSTRY6	Utilities industry	319	0.09	0.29	0	1

Table 3b. Correlations: perceived pressures

	Variable	Description	1	2	3	4	5	6	7	8	9	10	11
1	INFLUPRI	perceived influence of commercial pressures (comp, cust, suppl, trade assoc)	1.00										
2	INFLUCOM	perceived influence of non-market pressures (community, ngos, regulators, media)	-0.03	1.00									
3	INFLUFIR	perceived influence of internal pressures (corp mgt, employee, other facilities)	0.04	0.03	1.00								
4	COMPEMS	Competitors with EMS	0.23	-0.12	0.04	1.00							
5	MDINCT	Median household income	0.01	-0.04	-0.13	-0.03	1.00						
6	WHITEPOP	Percentage population white	0.01	-0.16	-0.18	0.03	0.09	1.00					
7	EMPLHRT	Plant employees	0.19	-0.06	0.00	0.04	-0.01	0.03	1.00				
8	UNW0001L	TRI air releases, 2000-01	0.03	0.17	0.10	-0.10	-0.06	-0.07	0.12	1.00			
9	INTL_D	Geographic breadth of operations	0.09	-0.21	0.13	0.24	0.12	0.03	0.17	-0.11	1.00		
10	HQUS	HQ located in US	-0.14	-0.04	0.02	-0.15	-0.09	-0.02	-0.07	-0.05	-0.03	1.00	
11	BIZSTRAT	Company's main business strategy	0.07	-0.06	0.23	0.02	0.04	-0.06	0.14	-0.05	0.25	-0.05	1.00

Table 4 Regression results: Objective institutional pressure. Dependent variable comprehensiveness of Env. Mgt Practices[4]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	PCF
state greenness=PCA	0.07													
	[0.06]													
Environmental lawyers		0.00												
		[0.02]												
League of Conservation Voters			0.00											
			[0.00]											
Number of state env policies				0.01										
				[0.01]+										
Rating of 17 state policies					0.00									
					[0.00]									
State's inverse pollution intensity						1.57								
						[3.76]								
Environmental NGO members							0.05							
							[0.03]							
Competitors with EMS	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.24	0.93
	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.05]**	[0.06]**	[0.21]**
Company's business strategy (	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.03	0.05	0.17
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.04]	[0.13]
Median 1999 household income	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01			-0.01		-0.01	-0.05
	[0.00]*	[0.00]*	[0.00]+	[0.00]*	[0.00]*	[0.00]+	[0.00]*	[0.00]*			[0.00]+		[0.01]+	[0.02]*
Percentage population White									-0.60		-0.55	-0.57	-0.21	-2.35
									[0.27]*		[0.27]*	[0.27]*	[0.34]	[1.11]*
Pct pop 25+ years college										-0.66		-0.60		
										[0.43]		[0.43]		
Unweighted TRI air releases	0.05	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04		0.15
	[0.02]**	[0.02]*	[0.02]**	[0.02]**	[0.02]**	[0.02]**	[0.02]*	[0.02]*	[0.02]*	[0.02]*	[0.02]*	[0.02]*		[0.07]*
TRACI-weighted TRI air													0.00	
													[0.01]	
plant employees,	0.16	0.18	0.17	0.16	0.16	0.17	0.18	0.18	0.18	0.18	0.17	0.18	0.21	0.59
	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.08]*	[0.09]*	[0.34]+
Breadth of oper	0.41	0.40	0.41	0.40	0.41	0.42	0.40	0.40	0.38	0.37	0.40	0.38	0.47	1.32
	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.14]**	[0.17]**	[0.57]*
HQ located in US	-0.50	-0.40	-0.50	-0.50	-0.50	-0.49	-0.41	-0.41	-0.42	-0.41	-0.42	-0.43	-0.15	-2.45
	[0.20]*	[0.20]*	[0.21]*	[0.20]*	[0.21]*	[0.21]*	[0.20]*	[0.20]*	[0.20]*	[0.20]*	[0.20]*	[0.20]*	[0.32]	[0.84]**
Industry dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant	3.12	2.98	2.98	2.87	2.93	2.99	2.96	3.00	3.14	2.97	3.41	3.40	3.45	-0.85
	[0.47]**	[0.48]**	[0.46]**	[0.46]**	[0.47]**	[0.46]**	[0.46]**	[0.46]**	[0.48]**	[0.47]**	[0.50]**	[0.51]**	[0.59]**	[2.09]
Observations	354	360	354	354	354	354	360	360	360	360	360	360	236	314
R-squared	0.22	0.21	0.21	0.22	0.21	0.21	0.21	0.21	0.21	0.2	0.22	0.21	0.2	0.22

Standard errors in brackets + significant at 10%; * significant at 5%; ** significant at 1%

[4] Dependent variables: Sum = EMP_SUM; PCA= EMP_PCA

Table 5. PCA Institutional Pressures (Rotated Component Matrix)

		Component		
		1	**2**	**3**
COMMERCIAL PRESSURE	Influence of competitors	.805	.154	.129
	Influence of customers	.784		.165
	Influence of suppliers	.696	.285	.166
	Influence of trade associations	.506	.383	.238
	Influence of SRI funds	.488	.470	.102
NON-MARKET PRESSURE	Influence of media	.278	.758	.133
	Influence of environmental organizations	.296	.699	.161
	Influence of local community	.201	.669	.286
	Influence of regulators/legislators	-.146	.660	.173
FIRM INTERNA L PRESSURE	Influence of corp mgmt	.117		.759
	Influence of other facilities in firm	.206	.172	.721
	Influence of employees		.319	.683
	Influence of shareholders	.420	.298	.509

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Table 6. Regression results of perceived institutional pressures

Dependent variable: Comprehensiveness of environmental management practices[5]

	(1) Sum	(2) PCF
Perceived influence of commercial pressure	0.31	1.25
	[0.05]**	[0.20]**
Perceived influence of non-market pressure	-0.01	0.06
	[0.05]	[0.20]
Perceived influence of firm internal pressure	0.37	1.37
	[0.05]**	[0.20]**
Competitors with EMS	0.20	0.70
	[0.04]**	[0.19]**
Median 1999 household income	0.00	-0.02
	[0.00]	[0.02]
Percentage population White	-0.31	-1.63
	[0.24]	[0.99]
TRI air releases, 2000-01	0.01	0.05
	[0.02]	[0.07]
Plant employees	0.13	0.42
	[0.07]+	[0.31]
Geographic breadth of operations	0.33	1.03
	[0.13]**	[0.53]+
HQ located in US	-0.44	-2.27
	[0.18]*	[0.74]**
Company's business strategy	-0.01	0.05
	[0.03]	[0.12]
Industry dummies	Y	Y
Constant	3.86	0.2
	[0.46]**	[1.93]
Observations	319	283
R-squared	0.43	0.42

Standard errors in brackets + significant at 10%; * significant at 5%; ** significant at 1%

[5] Dependent variables: Sum = EMP_SUM; PCA= EMP_PCA

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SURVEY ON ENVIRONMENTAL MANAGEMENT PRACTICES

Thank you for agreeing to take part of this benchmarking exercise on environmental management practices.

- All individual responses will be kept strictly confidential
- Please try to answer every question, even though you may not be 100% sure of your answer.

If you have any questions, please feel free to contact Paolo Gardinali, Associate Director of the Social Science Survey Center (SSSC) at (805) 893-3887 or paolo@survey.ucsb.edu

Project Principal Investigators:

Professor Magali Delmas

Professor Dennis Aigner, Dean

Donald Bren School of Environmental Science and Management
University of California, Santa Barbara

Graduate Research Assistant: Mike Toffel, Haas School of Business.
University of California, Berkeley

Please return this questionnaire to:
Social Science Survey Center
ISBER, 2201 North Hall
University of California
Santa Barbara, CA 93106
Fax: (805) 893-7995

You can also fill the questionnaire online at http://www.survey.ucsb.edu/env
with the code:

Section 1. General information

1. Parent company information

   Parent company name: ____

   Location of parent headquarters (country): ___________________________________

2. Does your company operate facilities outside of the United States? ❑ Yes ❑ No

   If YES, where are they located? (check all that apply): ❑ Europe ❑ Asia ❑ Elsewhere

In this questionnaire, we are asking questions about your facility: a facility includes buildings that are on a contiguous site and under common control by a company.

Section 2. Environmental management organization

3. Which of the following most closely reflects your position? Please check one:
   - ❑ EHS manager or specialist
   - ❑ Environmental manager or specialist
   - ❑ Plant manager
   - ❑ Other, please describe_____________________________

4. Approximately how many full time equivalent employees (FTEs) are working on environment, health and safety issues for your facility?

   EHS / Environmental department ______

   Other departments ______

   Total ______

Section 3. Environmental management practices

5. If your facility or company has an environmental policy, how is it communicated? Please check all that apply

❑ We do not have an environmental policy

We have an environmental policy and:

- ❑ post the policy around our facility
- ❑ post it on the internet
- ❑ distribute it to all facility employees
- ❑ most employees have discussed the policy with a manager/supervisor

6. Over the past 3 years, how many times has your facility had an **internal** environmental audit conducted by your facility staff and/or corporate staff? _________ (If none, please enter zero)

7. Over the past 3 years, how many times has your facility had an **external** environmental audit conducted by third-parties such as consultants, not including regulators or corporate staff? _________

8. Approximately, what proportion of your employees at your facility have received environmental training over the past 12 months in the following departments?
Environmental training includes coursework or team meetings where environmental policies, procedures and impacts are discussed or disseminated.

Please check one for each department.

	0-20%	21-40%	41-60%	61-80%	81-100%	No such department at my facility
Management	❑	❑	❑	❑	❑	❑
Operations	❑	❑	❑	❑	❑	❑
Maintenance	❑	❑	❑	❑	❑	❑
Engineering/ R&D, Design	❑	❑	❑	❑	❑	❑
Sales	❑	❑	❑	❑	❑	❑
Purchasing / Procurement	❑	❑	❑	❑	❑	❑

9. In job performance reviews for employees at your facility, how important do you consider the contribution of your employees to environmental performance?

Please check one for each department. Use your best estimate if you are unsure.

	Not part of review	Low importance	Moderate importance	Important	Very important	No such department at my facility
General management	❑	❑	❑	❑	❑	❑
Operations	❑	❑	❑	❑	❑	❑
Maintenance	❑	❑	❑	❑	❑	❑
Engineering/ R&D, Design	❑	❑	❑	❑	❑	❑
Environment, health & safety	❑	❑	❑	❑	❑	❑
Sales	❑	❑	❑	❑	❑	❑
Purchasing / Procurement	❑	❑	❑	❑	❑	❑

Section 4. Relations with stakeholders

	Never	Occasionally	Frequently	All the time
10. To what extent does your purchasing department use a green purchasing policy?	❑	❑	❑	❑
11. To what extent does your purchasing department request your suppliers to be ISO 14001 certified?	❑	❑	❑	❑
12. To what extent does your purchasing department ask suppliers to provide information about their environmental management practices?	❑	❑	❑	❑

	0-20%	21-40%	41-60%	61-80%	81-100%	Don't know
13. Approximately what proportion of your competitors have adopted an environmental management system (EMS)? (Certified or non-certified).	❑	❑	❑	❑	❑	❑

	Not being considered	Future consideration	Planning to participate	Currently participating
14. What is the status of your participation in voluntary US EPA or state programs such as Energy Star, Wastewise, Environmental Performance Track, etc.	❑	❑	❑	❑
15. What is the status of your participation in industry-led environmental programs such as Responsible Care, industry climate challenge programs, etc.	❑	❑	❑	❑

	Never	Rarely	Sometimes	Often	Very often	All the time
16. How often does your facility solicit opinions from environmental non-profit organizations, such as involving them in site planning or in identifying environmental impacts?	❑	❑	❑	❑	❑	❑

17. What is the status of the following certifications at your facility?

	Not being considered	Future consideration	Planning to implement	Currently implementing	Successfully implemented
ISO 9000 certification	❑	❑	❑	❑	❑
ISO 14001 certification	❑	❑	❑	❑	❑

18. Approximately how many complaints has your facility received from the surrounding community about odors, noise, smoke, dust, effluents, water pollution, or aesthetic appearance in the last three years? __________

19. To what extent have each of the following groups influenced your facility to improve its environmental performance?

	No influence	Little influence	Some influence	Strong influence	Very strong influence
Customers	❑	❑	❑	❑	❑
Suppliers	❑	❑	❑	❑	❑
Competitors	❑	❑	❑	❑	❑
Trade associations	❑	❑	❑	❑	❑
Local community	❑	❑	❑	❑	❑
Socially responsible investment funds	❑	❑	❑	❑	❑
Environmental organizations	❑	❑	❑	❑	❑
Media	❑	❑	❑	❑	❑
Shareholders	❑	❑	❑	❑	❑
Corporate management	❑	❑	❑	❑	❑
Employees	❑	❑	❑	❑	❑
Other facilities within company	❑	❑	❑	❑	❑
Regulators/legislators	❑	❑	❑	❑	❑

20. To what extent have the following corporate departments influenced your facility to improve its environmental performance? Please check one for each department:

	No influence	Little influence	Some influence	Strong influence	Very strong influence	Our corporation does not have such department
Corporate environmental management	❑	❑	❑	❑	❑	❑
Corporate legal & regulatory affairs	❑	❑	❑	❑	❑	❑
Corporate public relations	❑	❑	❑	❑	❑	❑
Corporate strategy	❑	❑	❑	❑	❑	❑
Corporate marketing	❑	❑	❑	❑	❑	❑
Corporate product design	❑	❑	❑	❑	❑	❑
Other (please specify): ____________________________	❑	❑	❑	❑	❑	❑

Section 5. Measuring and reporting environmental performance

21. To what extent are your facility's environmental costs identified in cost accounting?

Not at all	To a limited extent	To some extent	To a large extent	To a great extent
❑	❑	❑	❑	❑

22. Which of the following issues are significant environmental issues at your facility?

❑ Air emissions
❑ Water pollution
❑ Solid Waste
❑ Hazardous Waste
❑ Noise
❑ Other, please describe_______________________________

23. For which of these environmental issues do you have objectives and targets?

❑ Air emissions
❑ Water pollution
❑ Solid Waste
❑ Hazardous Waste
❑ Noise
❑ Other, please describe_______________________________

24. Do you disseminate your facility Toxic Release Inventory (TRI) data to the public in an easily accessible format (beyond reporting this data to the US EPA)? ❑ Yes ❑ No

Section 6. Motivations for environmental management practices

25. In addition to improving environmental performance, how important are the factors listed below in motivating your facility to implement environmental management practices?

	Not important	Somewhat important	Important	Very important
Increase customer loyalty	❑	❑	❑	❑
Reach new customers	❑	❑	❑	❑
Improve employee motivation or morale	❑	❑	❑	❑
Help generate new products or services	❑	❑	❑	❑
Improve regulatory compliance	❑	❑	❑	❑
Influence pending legislation or regulations	❑	❑	❑	❑
Improve relations with environmental non-profit organizations	❑	❑	❑	❑
Improve relations with our local community	❑	❑	❑	❑

26. Please describe your company's main business strategy using the following scale, from "provide low cost products or services" (1) to "differentiate our products" (7)?

	1	2	3	4	5	6	7	
Provide low cost products or services	❑	❑	❑	❑	❑	❑	❑	Differentiate our products on the market

27. Please check the following box if you would like to receive a copy of the final report in the future.

❑ Yes, I would like to receive a copy of the report.

Name: ____________________

E-mail: ____________________

Facility name: ____________________

Street address: ____________________

City: ____________________

State and Zip code: ____________________

❑ No, I am not interested.

28. Please provide any comments and suggestions here:

Thank you!

Environmental Management Systems: Informing Organizational Decisions

Chris T. Hendrickson, Deanna H. Matthews, and Lester B. Lave
Carnegie Mellon University
Pittsburgh, PA

Abstract

Approaches to improve environmental performance have expanded to include voluntary programs that encourage organizations to go beyond regulatory compliance. Environmental management systems (EMS) are a recent type of voluntary initiative expected to produce general reductions in pollution discharges. Unlike voluntary programs such as Green Lights or 33/50, the specific goals and benefits of EMS implementation to participating organizations and government regulators has not been defined. Participating companies expect to lower environmental costs or to improve performance. Society should benefit from reduced energy consumption, pollution, and waste generation. However, not all EMS will be equally effective. For example, a process-oriented EMS, such as ISO 14000, may not provide a comprehensive view of environmental issues across an organization or develop the data needed to assess environmental improvements and cost savings. We examined existing EMS at various levels. First, at a macro-level, we assessed the change in environmental performance as a result of adopting an EMS. Second, at a micro-level, we examined the existing EMS in a number of organizations and the extent to which the system provides relevant data and analysis to inform company decisions. The data provide a basis for identifying the EMS attributes that are useful and necessary for decision-making. Organizational leaders can use the results to improve the effectiveness of existing or new EMS. Policy makers can use the results to determine requirements for a potential voluntary program for implementation of environmental management systems.

Introduction
U. S. Environmental Protection Agency actions to improve companies' environmental performance have expanded to include voluntary programs that encourage organizations to go beyond regulatory compliance. Environmental management systems (EMS) are a recent type of voluntary initiative expected to produce general reductions in pollution discharges. At the same time, environmental issues are becoming more strategic to business, so firms are implementing EMSs as a means to capture and assess environmental issues across operations. Participating companies expect to lower environmental costs or to improve performance. Society should benefit from reduced energy consumption, pollution, and waste generation. However, not all EMS will be equally effective at achieving these goals. The research presented here examines existing EMSs to help address the future role of environmental management systems in environmental policy and organizational decision-making. The research recognizes the need for evaluating individual components of environmental management systems, as well as whole systems. If EMSs are effective, then fewer problems from regulatory compliance may occur and the burden of regulation may be reduced. It is essential for both government agencies and firms to know what components and ways of operating the system are most effective in improving environmental performance. This research investigates how EMSs and environmental information in general are used by organizations and, in turn, proposes a design for an EMS that provides the information needed for better decisions.

The research examines EMSs at two distinct levels. First, at the macro-level, we assess facility performance in relation to ISO 14001 EMS adoption and certification. The macro-level analysis uses publicly available information, most of which is collected by government agencies via regulatory requirements, in order to assess overall patterns in environmental performance. The analysis provides a picture of what can be learned from existing data about environmental performance. Specifically, the analysis assesses the ISO 14001 environmental management system standard in relation to these data providing policy makers with information on how the standard currently integrates with other environmental initiatives. The results show little difference between the environmental performance of facilities. These results have serious implications for policy makers in how certified environmental management systems should be used to evaluate facility environmental performance.

Once we know generally how firms with a formal EMS compare to those without, the micro-level analysis allows us to find out why. By investigating the environmental information available internally to an organization, we learn what data are used merely for regulatory reporting and which are used to guide decision makers. An effective EMS is expected to include information collection and dissemination of useful, relevant, and timely data to inform company decisions. Results show that most data are regulatory based, reported outside environmental groups infrequently, and thus limit their use in decision-making toward improvements in environmental performance. This detailed inquiry into data availability and use can help businesses and policy makers choose measures that reflect environmental performance, can be understood by various stakeholders, and lead to improvements across industry.

The overall results of the research lead to suggestions for improving environmental management systems for organizational decision-making and policy development. First, EMSs must stretch beyond the current regulatory issues to be effective in long-term improvement. Unlike other voluntary programs, EMSs do not require organizations to operate outside the boundary of current regulatory issues. Second, EMS goals, targets, and resulting performance must be made more transparent. The link between efforts to reduce environmental problems via an EMS and reported environmental performance metrics is tenuous. Finally, as various environmental issues continue to shift in importance, EMSs must adapt to changing organizational focus and monitor potential future regulatory issues. For example, corporate social responsibility and calls for sustainability (incorporating social and economic factors, as well as environmental factors) and the global importance of carbon emissions (currently unregulated in the U.S.) are influencing corporate strategy. An EMS should support decision-making on these pressing issues, especially for multinational companies operating under different regulatory schemes.

Macro-Level Analysis – Facility Environmental Performance In Relation to ISO 14001 Certification

The ISO 14000 series for environmental management systems continues to grow in popularity as a means for organizations to address environmental issues in their facilities across operations. Approximately 62,000 organizations worldwide have been certified as following the ISO 14001 EMS standard as of December 2003, but only about 3,500 in the U.S. (1). Since participation is voluntary, certification to ISO 14001 is regarded as an indication of a firm's interest in environmental improvement and going "beyond compliance" to address environmental problems. This research investigates the level of environmental performance in facilities in relation to certification to the ISO 14001 EMS standard. The analysis focuses on automobile assembly facilities in the U.S. consisting of approximately 50 facilities in 20 states producing a variety of cars, vans, trucks, and SUVs. The sector has a history of dealing with environmental issues. Both the emissions and wastes from manufacturing operations as well as from the use-phase of the final product have resulted in public and regulatory attention to the industry. In addition, the automotive industry has been a leading sector in ISO 14001 EMS certification. Ford Motor Company initiated a commitment to establishing EMSs and certifying its facilities to the ISO 14001 EMS in the early stages of the standard. All of Ford's U.S. facilities were certified by early 1999. The other two major U.S. firms as well as foreign-owned firms followed this lead and began to implement the standard in their own facilities. To further reinforce their commitment to environmental management systems, the major U.S. firms announced that suppliers would be required to implement and certify to the standard as well, with deadlines for certifying in late-2002 or mid-2003 (2, 3). Approximately one-fifth of all U.S. certifications are held by facilities with business related to the automotive sector (4).

The study examines four different measures of environmental performance over the period from 1993 to 2003. The measures include toxic chemical releases, criteria air pollutant emissions, hazardous waste generation, and compliance to regulatory requirements. Most performance measures have been normalized to production, allowing a comparison of facilities on a per-vehicle basis. During the time period, all facilities, regardless of EMS status, made steady progress in reducing their environmental burdens. The analysis shows that in later years, certified facilities are not performing better than facilities that chose to certify their EMS later. In addition, the results give no indication that the facilities are achieving an increase in the rate of improvement that was seen prior to adopting and certifying to the standard. In some cases, certified facilities are more likely to have worse performance once the EMS is operating.

The ISO 14001 EMS standard defines an EMS as "that part of the overall management system which includes organizational structure, planning, activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing, and maintaining the environmental policy" (5). The intent of the standard is to provide a structured framework for an EMS that is based on a commitment to continual improvement in overall environmental performance. By periodically reviewing and evaluating the environmental management system, the organization will identify opportunities for improvement.

These implications of the standard lead to two main hypotheses. First, facilities that have established and implemented an ISO 14001 EMS and now have a system for and commitment to environmental performance improvement should have better environmental performance than those facilities without such a system in place. A structured EMS gives a facility the ability to systematically identify and address environmental problems, which presumably leads to reduced environmental discharges.

Second, facilities that have established and implemented an ISO 14001 EMS have undergone a change in operations. In theory, the system provides them with a tool to reduce environmental impacts that was previously unavailable. Once the standard is in place and operations are regularly being assessed and evaluated, the facilities should continually improve on the past performance levels and likely at a greater rate of improvement. From year to year after certification, one would expect a facility with a certified ISO 14001 EMS to make additional reductions in overall environmental impact than had been achieved previously.

Research Method

The sample includes approximately 50 automobile assembly facilities in the U.S. across the time period from 1993-2003. The number of facilities in each analysis varies depending on data availability. The Automotive News Market Databook provides parent company, facility location, vehicle descriptions, and production information. Company websites or correspondence supplied some data and helped to validate existing data. The World Preferred Registry provides a list of entities holding registrations to the ISO 14001 EMS standard and the date of certification. Three variables were constructed from the information on ISO certification. First, we separate the facilities into two groups, defined as "early adopters" if certification occurred in 1998 or 1999 and "late adopters" if certification occurred in 2000 or after (adoption status). Second, the date of certification establishes the stage of implementation of the ISO 14001 EMS in a facility (ISO Stage). The variable is a counter variable that increases by one as a facility moved through different stages – from no system (0), implementing (1), certifying (2), and operating under the EMS (3 and up). A third variable represents the status of the EMS as either certified or not certified in a given year (ISO status).

Environmental performance data were collected from the U.S. Environmental Protection Agency public databases. The Toxics Release Inventory (TRI) (1993-2001), AirData on criteria air pollutant emissions (1996 and 1999), National Biennial RCRA Hazardous Waste Report (1993-2001, odd-numbered years), and the Enforcement and Compliance History On-line (ECHO) (1996-2003) provide data. We construct the final sample for each metric by matching entries in the various databases by the name of the facility, address information, and EPA facility information which includes identification numbers for the facilities under various programs.

Results

Table 1 shows the average total toxic chemical releases and average total toxic chemical waste managed per vehicle for the facilities from 1993 to 2001. The number of facilities in the Certified Facilities group increases each year as facilities certify their EMSs. Overall, the facilities show a decreasing level of chemical releases and wastes per vehicle as expected. From 1997 to 2001, the non-certified facilities show a much larger improvement in total toxic chemical releases and amount of toxic chemical waste managed – almost twice that of the certified firms. It should also be noted that the variance in releases per vehicle is large for the group of facilities, ranging from a low of ~0.0 pounds/vehicle to a high of 8.0 pounds/vehicle in 2001.

Table 1: Trend in Average Toxic Chemical Releases and Waste Management.

	Total Releases (pounds per vehicle)		**Total Waste Management (pounds per vehicle)**	
	All Facilities		**All Facilities**	
1993	6.19		13.18	
1994	5.10		10.74	
1995	4.80		11.26	
1996	4.63		10.96	
1997	4.01		9.85	
	Certified Facilities	**Non-certified Facilities**	**Certified Facilities**	**Non-certified Facilities**
1998	3.64	3.87	9.24	8.11
1999	3.64	3.66	8.66	7.92
2000	3.36	3.30	8.28	8.11
2001	3.32	2.77	8.40	6.03
% Change 1997-2001	-17%	-31%	-15%	-39%

Using standard OLS multiple regression analysis to determine if any difference exists between facilities once certification has been achieved produced no significant statistical support for the two proposed hypotheses.

Table 2 shows the results of three different regression models. For each regression model, the dependent variable is pounds of toxic releases per vehicle. As expected, coefficients for time and production are negative, suggesting improvement over time and some scale efficiency. Facilities that assemble trucks produce only about 0.5 pound more toxic chemicals per vehicle than those facilities that assemble cars. Facilities in the DaimlerChrysler company have lower emissions than average, compared to both Ford and General Motors facilities which have higher emissions of the same magnitude. Foreign or multiple-owner facilities are the base case. Each of these seven parameter coefficients are significant ($p\text{-value} < 0.05$). Adoption status, differentiating between early and late adopters, has a negative coefficient indicating that early adopters generally have lower toxic wastes per vehicle than later adopters. Likewise, the longer the ISO 14001 EMS is in place the lower toxic wastes per vehicle, as noted by the negative coefficient of the ISO stage variable. The ISO Status variable, indicating whether a facility has a certified ISO 14001 EMS in place in a given year, has a positive coefficient indicating increased toxic wastes for these facilities. However, none of these three coefficients is statistically significant ($p\text{-values} > 0.4$) and the estimated magnitude of the effect is small. Similar results are achieved for the other TRI variables investigated. No difference is seen across facilities in each group for total waste managed, waste that is recycled, recovered, or treated, or when weighting the chemicals for toxicity prior to analysis. In addition, no statistical significance is found for other model specifications considering such variables as change in TRI pounds and change in production from the previous year

Table 2: Results of OLS Regression for Toxic Chemical Releases.

	Model 1	Model 2	Model 3
Constant	4.43 (0.737)	4.470 (0.769)	4.457 (0.758)
Time (years since 1993)	-0.35 (0.043)	-0.357 (0.064)	-0.354 (0.057)
Production (1000's of vehicles)	-0.0083 (0.0011)	-0.0083 (0.0011)	-0.0083 (0.0011)
Car	2.50 (0.443)	2.498 (0.444)	2.498 (0.444)
Truck	3.03 (0.417)	3.032 (0.418)	3.031 (0.418)
DaimlerChrysler	-1.08 (0.525)	-1.075 (0.526)	-1.076 (0.525)
Ford	1.12 (0.396)	1.116 (0.398)	1.118 (0.397)
GM	0.94 (0.466)	0.935 (0.467)	0.935 (0.467)
Adoption Status (early vs. late)	-0.33 (0.469)	-0.353 (0.492)	-0.345 (0.485)
ISO Stage (years with certified EMS in place)		-0.024 (0.128)	
ISO Status (certified EMS in place)			0.060 (0.371)

p-values all less than 0.05 except for adoption status (Model 1: p-value = 0.48, Model 2: p-value = 0.47, Model 3: p-value=0.47), ISO stage (Model 2: p-value = 0.85), and ISO Status (Model 3: p-value= 0.87).

Table 3Table 3 and Table 4 show the average tons of criteria air pollutant emissions per 1000 vehicles from 1996 and 1999. Nineteen facilities are in the group of early adopters certified by 1999, while 27 facilities are in the group of late adopters certified after 1999. First, consider the comparison of the "average" facility in 1996 – when no facilities were certified – to the two groups of facilities in 1999 – certified and non-certified (Table 3). Both groups of facilities achieved reductions in criteria air emissions over the average 1996 levels despite increases in production, with facilities with a certified EMS having an overall lower level of emissions per vehicle in 1999 than facilities without a certified EMS. In fact, facilities without certified EMS had an increase in particulate matter emissions.

Table 3: Average emissions of criteria air pollutants (tons/1000 vehicles).

	1996	**1999**	
	Average Facility	**ISO-Certified**	**Not ISO-Certified**
Production	207,000	246,000	217,000
CO	0.371	0.231	0.309
NOx	0.882	0.341	0.679
VOC	6.311	4.348	4.890
SO2	0.618	0.043	0.513
PM25	0.088	0.025	0.120
PM10	0.117	0.082	0.163
Total	8.301	5.047	6.556

Table 4Table 4T indicates, however, that the facilities which certified an EMS by 1999 (the early adopters), did not attain reductions in criteria air pollutant emissions to the extent that facilities which did not certify an EMS (late adopters) were able to attain. Overall, late adopters show a greater reduction in air emissions – a 37% decrease, versus a 5% decrease for the early adopters who were implementing and certifying their EMSs in the interim years. During this time, the late adopters also increased production considerably. The largest absolute improvements came in VOC emissions which account for 75% of all emissions. The early adopters made large relative improvements in emissions of sulfur dioxide compared to the late adopters; however, the total reduction of sulfur dioxide by late adopters was more than three times the amount. Regression analysis using OLS methods again did not indicate any statistical significance in the ISO certification variables. Statistical analysis to determine if a difference exists between the mean values for the different groups of facilities did not show significance.

Table 4: Average emissions of criteria air pollutants (tons/1000 vehicles).

	1996		**1999**	
	ISO-Certified by 1999	**ISO-Certified after 1999**	**ISO-Certified by 1999**	**ISO-Certified after 1999**
Production	240,000	183,000	246,000	217,000
CO	0.126	0.543	0.231	0.309
NOx	0.489	1.158	0.341	0.679
VOC	4.468	7.608	4.348	4.890
SO2	0.112	0.974	0.043	0.513
PM25	0.080	0.094	0.025	0.120
PM10	0.103	0.127	0.082	0.163
Total	5.299	10.413	5.047	6.556

For hazardous wastes, again a general trend of improvement is seen across all facilities, although no difference is apparent between facilities with certification and those without certification of an EMS. Table 5 shows the trend in hazardous waste generation from 1993 to 2001. Both groups of facilities experienced similar generation rates in the latter years as some facilities were undergoing implementation and certification of an EMS. In comparing the initial 1993 figures to the final 2001 figures, facilities that had certified the EMS to ISO 14001 had a higher percentage of reductions – a 27% decrease over the 8 years, versus 19% decrease for those without certification. In a statistical comparison of the mean tons per 1000 vehicles for each year, no significant difference exists between the two groups of facilities, indicating that time of adoption does not have a greater influence on hazardous waste generation. Again, OLS regression shows no statistical significance in the ISO-certification variables in relation to waste generation per vehicle.

Table 5: Trend in Hazardous Waste Generation.

	Hazardous Waste Generation (tons per vehicle)	
	All Facilities	
1993	7.15	
1995	6.03	
1997	5.78	
	Certified Facilities	**Non-certified Facilities**
1999	4.82	4.33
2001	4.22	4.67
% Change 1997-2001	-27%	-19%

The data for regulatory compliance appear in Table 6. Note that the data represent information for a two-year period inclusive; inspections, violations, penalties or corrective action could have occurred at any point in the two-year period. The first column represents a period when no facilities had an EMS certified to the ISO 14001 standard, although several facilities were in the implementation phase. The second column represents 1998-2000 and the facilities are separated into two groups – those which certified an EMS during the time and those which did not (effectively early adopters and late adopters). The third column represents 2001-2003 and again the facilities are separated into two groups – those with EMSs which had been certified and in operation during the time period and those which were implementing an EMS for certification (again, effectively early adopters and late adopters). Inspection rates across the first two time periods are consistent, as are rates between the groups in the final year. This provides a baseline that compliance issues are not biased by a change in inspection activity from regulators.

The data reveal several differences between the groups of facilities. First, facilities that are in the implementation phase prior to certification show higher occurrences of violations or noncompliance events. This is true for the early adopters in the 1998-2000 period, and the late adopters in 2001-2003, although it is more pronounced for the early adopters. Perhaps more importantly, 77% of facilities with an established EMS had a regulatory compliance issue, indicating that the EMS is not entirely successful in allowing facilities to maintain compliance. The overall rate of violations or noncompliance events for all facilities in 2001-2003 is 78%, similar to the rate in 1996-1998 without any certification. On average, facilities were out of compliance for 6 of the 8 quarterly periods over each time frame. It is possible that violations and non-compliance events are likely getting resolved more quickly over time. The number of continuing events (those with 8 quarters of continuous noncompliance) decreased from 66% in the first period to about 40% in the last period.

Table 7: Regulatory compliance of firms from 1996-2003 in relation to ISO 14001 EMS certification.

	1996-1998	1998-2000		2001-2003	
	No facilities with EMS certified	Facilities with EMS certified during time period	Facilities with no EMS certified during the time period	Facilities with EMS certified prior to time period	Facilities with EMS certified during time period
Total number of facilities	50	22	28	30	20
Facilities that have been inspected	46	20	26	26	17
Total number of inspections	186	71	99	75	42
Percent of facilities inspected	92%	91%	93%	87%	85%
Average number of inspections per facility	4.0	3.6	3.8	2.9	2.5
Facilities with violation or noncompliance event	38	20	19	23	16
Percent of facilities with violation or noncompliance event	76%	91%	68%	77%	80%
Quarterly periods with 1 or more violation or noncompliance event	240	115	112	159	96
Average periods with violation or noncompliance event per facility	6	6	6	7	6
Continuing noncompliance/violations	25	11	10	9	7
Percent of facilities with continuing noncompliance or violations	66%	55%	53%	39%	44%
Facilities with significant noncompliance	13	4	1	12	10
Percent of facilities with significant noncompliance event	34%	20%	5%	52%	63%
Facilities with pollutant release exceedances	9	4	3	6	4
Number of parameters over limit	18	6	4	8	5
Average number of parameters over limit per facility	2	1.5	1.3	1.3	1.3
Percent of facilities with pollutant exceedances	18%	18%	11%	20%	20%
Number of reports over limit	92	28	21	26	14
Number of reports submitted	9843	6116	3246	5495	1429
Facilities with pollutant spills	10	3	0	10	9
Total number of pollutant spills	13	5	0	15	19
Average number of pollutant spills per facility	1.3	1.7	0	1.5	2.1
Percent of facilities with pollutant spills	20%	14%	0%	33%	45%
Facilities where enforcement actions were taken	9	9	3	18	5
Number of Facilities assessed penalties	4	5	1	17	5
Total penalties assessed	$144,000	$490,000	$56,000	$1,650,000	$176,000
Total number of enforcement actions taken	15	14	5	24	6
Average number of enforcement actions taken per facility	1.7	1.6	1.7	1.3	1.2
Percent of facilities where enforcement actions taken	18%	41%	11%	60%	25%

In the latter time period, of the 39 facilities which had a violation or noncompliance event, 22 had events with significant noncompliance ratings corresponding to 52% of facilities with EMS certified prior to the time period, and 63% of facilities in the implementation stage. These percentages are a large increase from the baseline year (34%) or the middle period (20% and 5%). Facilities with no certified EMS had fewer pollutant release exceedances. More pollutant spills are occurring in the facilities over time. During the last period, almost 40 spills occurred at 20 facilities, about twice that of the initial period. Facilities with an operating EMS received far more enforcement actions (18 out of 30 facilities) and faced more fines ($1.7 million) than the other groups of companies despite having a comparable number of enforcement actions per facility.

Discussion of Results

The results do not support either hypothesis formulated about the relationship between facility environmental performance and ISO 14001 certification. The first hypothesis proposed that facilities that have established and implemented an ISO 14001 EMS and now have a system for and commitment to environmental performance improvement should have better environmental performance than those facilities without such a system in place. Overall, the U.S. automobile assembly facilities exhibit no substantial difference in environmental performance in relation to the implementation and operation of an EMS certified to ISO 14001. The total emissions and wastes from all facilities decreased over the 1993-2001 period which is to be expected. Emissions and wastes for individual facilities trend downward, although fluctuations both up and down are widespread. Similarly, the wide variance in performance for any metric in any year indicates that some facilities have large volumes of waste or emissions that have been eliminated by other facilities with low volumes. Regulatory compliance has not changed considerably over the time period, for better or for worse.

The second hypothesis proposed that facilities with a certified ISO 14001 EMS should continually improve on past performance levels and likely at a greater rate of improvement. However, once a facility had certified an EMS to the ISO 14001 standard, improvements in environmental performance did not accelerate from past performance. In some cases, facility performance was actually worse after an EMS was implemented and certified to the ISO 14001 standard.

One important consideration is whether the performance measures chosen for the analysis match areas where the facilities put efforts for improving performance. Within the ISO 14001 EMS framework, each facility may choose specific impacts to target for reduction or improvement. These goals and targets are not made public and may not correspond to the environmental performance measures represented by the public data used in the analysis. However, as the ISO 14001 EMS standard claims to provide a framework for overall improvement in environmental performance, some relationship would be expected. As the facilities move to organized methods of documenting impacts, assigning responsibilities, and incorporating a general awareness of environmental issues, all environmental impact areas should see some improvement.

The firms in the automobile assembly industry publicize their performance in environmental areas using a variety of metrics. Most common for facility performance are measures of energy use and carbon dioxide emissions, measures of materials consumption and waste generation, and water consumption. None of these data are public at the facility level, except hazardous waste data which is only a small portion of waste generation (on the order of 1% of total waste). So, a relationship would be expected, and this is the area where we see the strongest support of performance in relation to ISO 14001 certification. Early adopters decreased hazardous waste generation by 27% while late adopters only decreased generation by 19% from 1993 to 2001. Still, no statistically significant difference in the groups exists. In addition, the early adopters experience a 24% increase in hazardous waste generation from 1999 to 2001 when the facilities would have had an ISO 14001 EMSs in operation approximately 3 years. Clearly not continued improvement in environmental performance.

One aspect outside the scope of this research is how cost influences changes in environmental performance. It is possible that through implementing and certifying an EMS to the ISO 14001 standard that facilities achieved reduction in waste or emissions, which may be equal to reductions at facilities which did not initiate ISO 14001 implementation, at a lower cost. The standard may allow facilities to identify more cost-effective methods of improving performance. Organizations would then have to consider if these cost savings match the costs of implementing and maintaining the EMS to the ISO 14001 standard.

Two factors of how the ISO 14001 EMS standard is structured may explain to the results and, after a longer time period, may lead to better performance. First, given the work related to implementing the standard, facilities undergoing certification may have a better grasp of environmental impacts existing at the facility. From a thorough audit and investigation of facilities operations for creation of an EMS, facilities may identify sources of waste and emissions, do a better inventory of wastes and emissions, or become aware of or more diligent of compliance issues. This would increase the figures used to measure performance in comparison to earlier years without the standard. Yet, these figures would be a more accurate depiction of actual performance. If this is true, longer time periods of analysis would identify improvements once the baseline for emissions and waste generation had been shifted to these new levels. However, the data for toxic releases and hazardous wastes, which provide measures for about 20 facilities after 3 years of implementation do not show significant improvements with time. Similarly, the number of violations and noncompliance events for these facilities with well-established ISO 14001 EMSs are similar to those prior to implementation.

A second factor of the ISO 14001 EMS standard that may not be reflected in the performance data is the potential impact of better general management of environmental issues once a facility implements ISO 14001. The standard requires facilities to identify responsibilities and initiate a cycle of audit and review of operations of the EMS. These requirements, while not necessarily having a direct impact on day-to-day performance of operations, may in the long run assist in reducing environmental impacts, especially one-time problematic events. For example, if an employee with environmental oversight leaves the position, the duties and concerns of the position are documented and more easily transferred to other personnel. This ensures continuity of operations and reduces the chance that certain activities, such as monitoring an effluent or annual training, will go unchecked. Better overall management of environmental issues would not be directly translated to environmental performance improvements. This then identifies a shortcoming in the ISO standard for achieving improvements.

Micro-Level Analysis – EMS Structure and Information Systems

An EMS is intended to address all activities related to environmental issues, including such activities as monitoring wastes and emissions, complying with regulatory requirements, developing new products, and providing service to customers. In many cases, organizations gather existing environmental activities under a single framework to establish a formal EMS. The ISO 14001 EMS is becoming the de facto model for EMS. The standard provides a structure to EMS by outlining specific elements that must be included, but is non-prescriptive in how the elements might be fulfilled, allowing for flexibility among users.

The basic components of an EMS include: a mission statement, documented environmental policy, goals, timelines, data collection and organization, information systems, identification of environmental impacts, regulatory requirements, personnel responsibility and task list, training and awareness, management review, organizational decision process, audits, annual reports, security measures, and emergency plans (6-9). The general process for developing an EMS is to document how tasks with an environmental impact are to be done, complete the tasks as documented, and check periodically to verify that the tasks are being done as intended and, if not, correct the problem. Implementation includes obtaining commitment from top management, communicating the importance of environmental efforts, establishing environmental policy and objectives, assessing current impacts, developing a plan for improvement, assigning responsibilities, recording achievements, auditing results, and reviewing the system.

Given this wide consensus in content and implementation, one might expect that all EMS would be similar, regardless of the type of the organization. To test this claim, we investigated the EMSs of nine companies via structured and open-question interviews, a likert-scale survey, facility visits, and a review of publicly available information. The case studies involved both EHS and non-EHS personnel and inquired about both the EMS and environmental management information systems (EMIS) used to support EMS. In the area of EMS generally, the research considered the components and structure of the EMS and the value the EMS had provided to the organization. The intent of the research was to determine if a consensus EMS existed, and to identify components, if any, that were unique. One particular interest was the integration of environmental, health, and safety (EHS) issues at some companies, and the influence it has on EMSs. The research on EMIS considered the data use and availability within the organization for decision-making. The intent was to determine if common data were available, if unique data existed, and how the data were utilized across the firm.

Case Study Methods

Nine companies agreed to participate in the case study research. The companies' names have been withheld to maintain anonymity. The companies that participated are from a variety of industry sectors in the United States including leaders in the fields of electronics, transportation, chemicals, and construction. Eight of the nine companies fall within the North American Industry Classification System (NAICS) manufacturing sectors (32 and 33). The other company is from the construction industry (NAICS 23). All companies are multinational corporations with operating sites around the world, resulting in a complex array of environmental requirements that must be followed. With a range of employees from 10,000 to 100,000, the range of environmental issues is wide.

For each company, we conducted the investigation at one representative location, and in some cases interviewed corporate environmental staff as well. The facilities were typical sites of the firms. Corporate staff provided a broader picture of the EMS function across the firm. The companies represent an opportunity sample selected from contacts of the researchers. Selection resulted in many of the participants being known environmental leaders in their fields, although among the nine companies environmental performance varies widely. The status of EMSs at each company varied as well, with some having mature EMSs to some only beginning to implement formal EMSs. All of the companies that participated had at least a few facilities (ranging from 5% of facilities to

100% of facilities) that were ISO 14001-certified. Six of the nine facilities visited were ISO 14001-certified. Further certification of facilities will depend on the demands of the customers as well as corporate policy decisions. Seven of the nine companies have integrated the functions of environment, health, and safety issues. This integration of function influences the make up of the EMS. Safety and health information was identified by most participants as part of the EMS information.

Each case study consisted of an initial conversation detailing the project and verifying a company's willingness and interest in participating, an exchange of information on the company's EMS or environmental programs, a site visit with a tour of the facility, a structured survey, a set of open-ended questions, additional questions that arose during the visit, and then follow-up contacts to fill in data gaps and verify information. The information exchanged by the company with the researchers on their EMS or environmental programs ranged from entire EMS manuals to corporate presentations. The information for each case study was augmented with publicly available environmental information for both the company and the facility available through company websites, press releases, and government databases. Due to the small sample size, complex statistical analyses of the data do not produce reliable conclusions. However, qualitative information and simple statistics were used to summarize the data collected. A summary of the responses from some questions results in statements on general trends and the beginning of a contingent typology of EMS and EMIS within corporations.

Comparison of EMS Components

Based on the nine companies that participated, the major components of the EMSs were the same. The reliance on common components suggests that a "consensus" EMS has been established across many industries. Each company had a corporate-wide environmental policy recognizing responsibility in environmental matters (and in health and safety matters in some cases). Policies pledged various activities, usually compliance with regulations, communication with stakeholders, and continuous improvement of performance. Often, companies included establishing an EMS as part of its policy or pledge.

Each company has established goals for its environmental performance to be monitored and measured by its EMS. Four of the nine companies use the strategic plan of the corporation to develop strategic environmental goals. Once corporate goals are established, the goals are handed down to divisions and business units, which in turn pass them down to individual facilities for achieving them. Seven companies reevaluate goals annually, one semi-annually, and one company reevaluates goals "as needed" to maintain improvements. Various tools and techniques are used to identify environmental issues that the EMS monitors. Four of the companies use cross-functional teams to assess operations. These teams involve environment, health, and safety staff, business division staff, and research and development personnel. Three of these teams use formal tools – an assessment matrix, a checklist, and a product characterization process – in their evaluation. Other companies look only toward their EHS staff to identify issues. Past audit results are the main source of information, while brainstorming exercises or offering employee incentives are also used to identify environmental issues.

All of the companies conduct internal environmental audits at each site with at a frequency ranging from 2 to 5 years. Audits require a few days to two weeks. Often these audits consist of employees, particularly environmental professionals, from many different facilities who are able to share their expertise. Some of the companies have developed self-auditing tools which can be used to prepare for audits or do internal audits more frequently. These tools include checklists, electronic tracking systems, email reminders, and guidance documents. External audits occur as specified by any certifications.

Each company did have unique characteristics of its EMS. Some companies have developed extensive process maps or mass balances of their facilities in order to identify all inputs and outputs as well as environmental impacts that should be covered by the EMS. Some companies have incorporated a means to track, identify, and prioritize future risks to their business and facilities into the EMS. Many have produced EMS skeletons to help ease the implementation burden as the EMS is initiated at different facilities. A few companies have seen a benefit from industry-wide groups that bring environmental professionals together to share successes and challenges in EMS activities. Within some industry sectors, e.g., the chemicals sector, sharing of EHS strategy occurs. In other sectors, each company independently deals with these issues. The EMSs are similar across all sectors, however. Finally, while most companies have a procedure to determine if capital expenditures have any environmental consequences as part of the EMS, few have procedures to involve EHS staff early in product development

EMS Structure

While the organization's EMS had similar components, the management structure of the various EMSs was different across firms. By structure, we mean how the EMS is arranged and operated within the organizational layout of the firm. For example, some systems are centralized at the corporate level while others operate independently at the business unit or facility level. One company has a corporate certification to ISO 14001 where all manufacturing facilities are covered and audited for conformance on a rotating basis. Two other companies have a corporate-wide EMS protocol (not ISO 14001) which covers (or will cover once fully implemented) all facilities. Some facilities within one of those organizations are certified to ISO 14001, however. The other companies, while maintaining a central, corporate EHS function, have facility-level environmental management systems. Many of these facility EMSs conform to the ISO 14001 standard. The structure of an EMS depends on whether a company repeatedly produces the same product year-to-year, changes the product continuously, provides a service rather than a product, or has a few large manufacturing facilities versus many, small manufacturing facilities. These variations affect the complexity as well as the core of the EMS in terms of personnel, documentation, responsibilities, and information systems.

Six of the companies shared their EMS manuals with the researchers of this study. Although two of these were not ISO 14001 certified, all of these manuals aligned with the ISO 14001 suggested structure and contained detailed information about procedures and responsibilities. Most environmental personnel commented on the large amount of time and work required to compile these manuals, but they also acknowledged the benefits in employee training, knowledge transfer, and overall organization when complete. All of the companies identified customers or suppliers as influences on their EMS. Several facilities within the organizations in the case study had implemented EMSs according to the ISO 14001 standard based on customer demands. But this customer demand had not influenced corporate mandates for EMS development. Individual facilities took the initiative to implement the standard. Two companies had incorporated product information (not simply process or operating information) into their EMSs based on requests for product standards from customers.

Value of the EMS

We asked participants to rate the value of their environmental management system in different areas. Most respondents consider the EMS to provide the most value to the EHS department itself, rather than outside the department. There could be some bias here as environmental staff answered the question. Thus, this is how the environmental staff perceives non-environmental staff to view the EMS. Each facility was asked to evaluate on a scale of 0 to 5 ("not valuable" to "extremely valuable") how the EMS contributed to the following eight business opportunities as shown in Table 7. Companies may not perceive the valuation scales exactly the same.

Table 7: Valuation of environmental management systems

EMS Characteristics	Company									
	A	B	C	D	E	F	G	H	J	average
Improved Environmental Impact	5	5	5	3	*	5	3	*	5	4.43
Performance Enhancement of Products or Processes	4	4	5	4		4	4		3	4.00
Managing Regulatory Requirements	4	5	2	3		4	3		4	3.57
Communicating with Management	5	3	4	4		2	1		4	3.29
Communicating with Employees	3	4	4	4		2	4		3	3.43
Financial Savings	3	3	5	2		3	3		3	3.14
Time Savings	4	5	1	1		2	4		3	2.86
Communicating with External Stakeholders	2	1	3	2		2			2	2.00
Overall value average	3.75	3.75	3.63	2.88		3.00	3.14		3.38	

Respondents were asked to rate the value of the EMS with regard to the activities on a scale of 0 to 5 from not valuable to extremely valuable. *Companies E and H not included because they either do not have formal EMSs or their EMS is still in the implementation phase and are unable to rate their EMS.

An EMS provides the least value to communicating with external stakeholders. All of the participants had information regarding their environmental programs on the corporate website, yet the information did not correspond with components of the EMS. All companies publicized the environmental policy and commitments to monitoring environmental issues. Only one company stated their actual EMS goals. Some companies either on the website or within a published report on environmental or corporate responsibility communicate performance metrics, but these are often data already public. These data include safety accident data, toxic release inventory releases, and total waste generation. Other information included status of ISO 14001 certification and environmental awards presented or earned by the company or individual facilities and personnel. While this information is beneficial to community stakeholders, it does not reflect the efforts and activities of the companies' environmental management systems.

Comparison of Environmental Management Information Systems

Information systems are used to manage regulatory requirements, compare facilities to one another, and monitor time trends. Table 8 lists the types of data available in environmental, health, and safety information systems at the facilities. Note that the categories do not reflect individual software tools, only that information of a given type is available via electronic form. Most data are collected for regulatory purposes; some other data that have internal value are also collected. The most common data in information systems collected by at least two-thirds of the companies include: air emissions management, injury and illness incident statistics, key performance indicators, non-conformance statistics, chemical inventory and management, EHS auditing, and notice of violation tracking. Examples of data collected for non-regulatory use include greenhouse gas emissions, waste minimization efforts such as recycling, energy consumption, and non-reportable injury and illness statistics. Most of the companies in the study have adopted corporate-wide environmental information systems within the past three years.

Table 8: Environment, Health, and Safety Data Available in Company Information Systems

Data Category	**Company**								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**
Injury & Illness Incident Statistics	X	X	X	X	X		X	X	X
Air Emissions Management	X	X	X	X	X			X	X
Key Performance Indicators	X	X	X	X	X			X	X
Non-Conformance Statistics	X	X	X	X	X			X	X
Chemical Inventory/Management	X		X	X	X			X	X
EHS Auditing	X			X	X	X		X	X
Notice of Violation Tracking		X	X	X	X			X	X
Waste Management	X				X	X	X	X	X
Computer Based Training for Environmental	X			X	X	X			X
MSDS's - Incoming from vendors	X			X	X			X	X
Spill Tracking and Notification			X	X	X	X			X
Computer Based Training for Health & Safety	X			X	X				X
EHS Documents/Knowledge Base			X	X	X				X
Energy Consumption/ Energy Management	X		X				X		X
ISO 14001 Management System	X	X		X					X
MSDS's - On the Web for Customers		X	X		X			X	
Pollution Prevention	X			X	X			X	
Toxic Release Inventory	X		X		X			X	
MSDS Creation - Outbound for Customers		X		X	X				
Other				X				X	X
Regulatory Tracking Calendar		X		X				X	
Wastewater Management		X						X	X
EHS Project Management				X	X				
Product Liability/Product Stewardship		X			X				
Regulatory Interpretation Library				X		X			
Stormwater Management						X		X	
Toxicology Information				X	X				
EHS Cost Analysis					X				
Voluntary Program Participant Requirements									

As information systems have become more common-place, companies have begun to migrate to formal databases or web-based systems. Companies are beginning to establish intranet systems to accommodate multiple site data requests, such as waste generation from all facilities within a single business unit. Often these systems utilize workers outside of EHS personnel to input and track data. However, some data remains segregated in non-networked systems, limiting availability of the data for decision-making.

Companies were asked about the level of integration of their EMIS. The level of integration reflects the linkage of the environmental management information system with other business information systems. The level of integration can be determined by the number of other business information systems that are linked with the environmental information systems. The survey options for systems that may be integrated included: accounting/ financial, business development, human resources, inventory control, maintenance, manufacturing, and purchasing. Each of these systems can be considered a level of integration. Few of the case study companies had integrated the EMS data with more than 2 other business information systems. Most commonly integrated was inventory control, reflecting a need to monitor chemicals.

Each company was asked how frequently environmental data are requested with the following seven choices: daily, weekly, monthly, quarterly, annually, infrequently, never as well as the option of "all that apply." The question was answered for three parts of the company: management outside the EHS function at the facility, EHS management at the corporate level, and management outside the EHS function at the corporate level. Table 9 shows the frequency of data requested by each company. Management within the EHS divisions at the corporate level usually requests information more frequently than management within the non-EHS divisions of the facility and always requests information more frequently than management within the non-EHS divisions of management at the corporate level.

Table 9: Data Requests by Management

	A	**B**	**C**	**E**	**F**	**G**	**H**	**J**
Management within the EHS Function of the Company								
Daily	X						*	
Weekly	X	X			X			
Monthly		X		X				X
Quarterly			X	X				
Annually			X	X				
Infrequently								
Management outside the EHS function of the Company								
Daily							X	
Weekly								
Monthly	X				X		X	
Quarterly		X	X	X			X	X
Annually				X			X	
Infrequently						X		
Management outside the EHS function of the Facility								
Daily							X	
Weekly	X			X				X
Monthly	X	X	X	X	X		X	
Quarterly				X			X	
Annually				X		X	X	
Infrequently						X		

* Company D did not answer this question because they said that using the data is an ongoing process and that the frequency of data requests varies. Company H did not answer the question for EHS staff because they continually have access to this data - so they do not ever have to request it

An intensity value was assigned to the frequency from infrequently (1) to daily (6). Table 10 shows the average data request frequency across companies. Management within the EHS divisions at the corporate level requests data weekly (average of 4.75), management within the non-EHS divisions of the facility company requests data more than once a month (average of 4.1), and non-EHS divisions of management at the corporate level requests data more than once a quarter (average of 3.1). The total intensity index averages the intensity value for each level of management per company. Table 10 also shows the total intensity index by company. Across levels of management, Company A requests data most frequently, and Company G requests data the least frequently.

Table 10: Data Request Frequency and Intensity

	A	B	C	E	F	G	H	J	average
Management within the EHS Function of the Company	6	5	3	4	5	5	*	4	4.75
Management outside the EHS function of the Company	4	3	3	3	4	1	4	3	3.1
Management outside the EHS function of the Facility	5	4	4	5	4	2	4	5	4.1
Total Intensity Index	5	4	3.33	4	4.33	2.67	4	4	

The total intensity index averages the intensity value for each level of management per company.

In addition to the frequency of data requested, there are differences in which types of data are requested and which parts of the company request the data. In at least 6 of the 9 companies, management within the EHS divisions of the company request data from: waste management, injury and illness incident statistics, air emissions management, chemical inventory/ management, EHS auditing, and MSDS's - incoming from vendors. The only information requested by more than half of the management with the non-EHS divisions of the company was the injury and illness incident statistics, which technically is not even an environmental item. The next most requested items (by 4 of the 9 companies) included waste management and EHS auditing. Management within non-EHS divisions of the facility most commonly (by 5 of 9 companies) requests information on waste management and injury and illness incident statistics. The interest in these two items probably occurs because both are easy to define, easy to measure, and linked directly to costs.

Value of EMIS

The EHS information systems are considered to be valuable in many areas. Each facility was asked to evaluate (on a scale of 0 to 5 from “not valuable” to “extremely valuable”) how the EHS information system contributed to eight business opportunities. The valuations by each company are listed in Table 11. Companies may not perceive the valuation scales exactly the same. An average was taken across the nine companies to prioritize the areas. From the averages, these companies receive the most value from information systems in managing regulatory requirements and improving environmental impact. Note that the range of value for the categories is lower than the valuation given previously for EMSs. More value is perceived from the overall management system than from the information system used in conjunction with the EMS. Communicating with external stakeholders remains the lowest category for gaining value.

Table 11: Valuation of environmental information systems

	A	B	C	D	E	F	G	H	J	average
Improved Environmental Impact	5	3	5	3	3	3	3	5	3	3.67
Managing Regulatory Requirements	5	2	4	4	3	2	3	5	5	3.67
Communicating with Management	4	2	5	3	3	3	3	5	3	3.44
Communicating with Employees	3	2	5	3	3	4	2	4	3	3.22
Time Savings	4	3	1	1	1	5	4	5	5	3.22
Performance Enhancement of Products or Processes	4	3	3	3	0	4	3	3	2	2.78
Financial Savings	3	3	2	1	1	3	4	3	2	2.44
Communicating with External Stakeholders	2	1	5	2	0	1	3	4	1	2.11
Overall value average	3.75	2.38	3.75	2.5	1.75	3.13	3.13	4.25	3.0	

Respondents were asked to rate the value of the EHS information system with regard to the activities on a scale of 0 to 5 from not valuable to extremely valuable.

Discussion

The micro-level analysis demonstrates the commonalities among EMS and information systems in various organizations. The components within an EMS typically relate to existing regulatory requirements. Thus, EMSs are likely to be helpful in identifying compliance issues as these issues are targeted for action and personnel can access data readily. Each of the companies participating in the case studies had violations against environmental permits and had received enforcement action for environmental compliance issues in the past two years (10).

Given the commonalities in environmental management systems across corporations of various industries, sizes, and locations, managers can take advantage of the experience from individual facilities to build up new EMS or strengthen existing ones. The unique collaboration among environmental professionals that some of the participants had initiated is an aspect that facilitates learning.

In this study, management within the EHS divisions at the corporate level usually requests information more frequently than management outside the EHS function of the facility and always requests information more frequently than the management outside the EHS function at the corporate level. These results indicate that environmental data may not be utilized throughout all areas of an organization. Business managers should realize that decision-makers in all areas should be able to access environmental data. One potential aid to exchange is integration of the EMS information into other management information systems. Few companies had links between the environmental data and the data in the traditional business systems, although data from these systems is crucial to decisions. Without this integration, the EMSs are limited in how they might assist decision makers.

Respondents in the study evaluated where environmental information systems contributed to business opportunities. Environmental information systems provide the most value in improving environmental impact and managing regulatory requirements. The environmental information systems provide the least value in communicating with external stakeholders. Similarly, environmental management systems provided the most value in improved environmental impact and performance enhancement of products or processes. Like the environmental information systems, the environmental management systems provided the least value in communicating with external stakeholders.

Implications for Policy Makers, Organizations, and the Public

The results of the analyses have important implications for policy makers, organizational managers, and the public. From the macro-level analysis, certification of an EMS to the ISO 14001 standard cannot be used as a proxy for improved environmental performance, and possibly more importantly, cannot be used as a proxy for regulatory compliance. As the data indicate, facilities with a certified EMS continue to struggle with violations and noncompliance of environmental regulations. Regulators cannot assume that presence of a certified EMS guarantees against infringement and resulting environmental impacts. Since no difference in operating performance is evident, policy makers must not consider EMS certification to be a means to an end. Continued reductions in currently regulated wastes and emissions are not assured. Any policy which gives regulatory preference to a facility on the basis of implementing and certifying an EMS to ISO 14001 should be considered only with additional transparency of the underlying goals and targets of the EMS. Additional transparency allows for a more robust analysis of efforts and accomplishments made by facilities in relation to the EMS.

Likewise, from the micro-level analysis, both EMS and EMIS revolve around regulatory compliance issues, the systems may be less useful in allowing companies to go beyond compliance. Unlike other voluntary programs intended to improve environmental performance by targeting issues outside the regulations, EMSs may only assure that firms are aware and improving areas already under scrutiny. Without additional data reporting (either internally to a firm, or externally) on non-regulated issues or integration with non-environmental data, using the systems continues to address only impacts with compliance aspects. At the same time, use of the data outside EHS management is also essential in having EMS become part of the decision-making processes in an organization.

One must consider, however, if *how* a facility is dealing with environmental issues is more important that what the performance is. The ISO 14001 EMS structure emphasizes continuity and consistency in addressing environmental impacts. As noted above, do the management aspects of the standard have benefits outside of general environmental performance over time which serve to improve operations? Benefits such as codifying responsibilities, establishing protocols, increasing awareness of environmental issues, and documenting these items, albeit cumbersome, may be shown to improve management of environmental issues overall. These factors may benefit organizations and encourage continued use and implementation of EMSs.
But since improving environmental performance in ways that are clearly identifiable to policy makers, local citizens, and the general public is the main goal of regulation, then the existing ISO 14001 standard is not sufficient. The fact that a consensus EMS exists can support regulators as policies and programs develop around the concept of EMSs. Regulators can determine which elements are essential for improving performance and concentrate on strengthening those components within facilities, and focusing on those elements during audits. Assistance programs can be generalized to promote further adoptions of EMS that allows for the company to have flexibility in establishing a corporate-level or facility-level EMS.

The results of the two analyses, along with discussion from a workshop on environmental management for multinational corporations attended by corporate-level environmental, health, and safety executives, led to the development of five essential elements of an EMS to aid environmental decision-making. The five elements, shown in Table 12, provide decision makers with key information on how environmental issues influence day-to-day and long-term operations of the firm. The scope of issues confronted on a daily basis in multinational firms requires a broad EMS that captures more than just regulatory requirements.

Table 12: Five elements for environmental management systems to aid organizational decision-making.

1. Process diagrams identifying material and energy inputs and outputs
2. Quantifiable goals for both short- and long-term performance consistent with the organization's strategic plan
3. Reliable methods of collecting and disseminating environmental data
4. Risk assessment tools for current and emerging environmental issues for operations and products
5. Collaboration and education of environmental personnel both within the organization and outside

These EMS elements are not universal, even among ISO 14001 certified EMS. Other than establishing goals and targets (element 2), these elements are not required for ISO 14001 certification, although at various levels a certified system may have these attributes. The five elements do not focus on regulatory issues or compliance. Most organizations (with or without an ISO-certified EMS) have existing systems to address regulatory requirements. Instead, the elements center on the goal of the EMS to provide timely, relevant information for decision-making on environmental issues that may occur across the organization.

The overall results of the research lead to suggestions for improving environmental management systems for organizational decision-making and policy development. First, EMS must stretch beyond the current regulatory issues to be effective in long-term improvement. Unlike other voluntary programs, EMS do not push organizations to concentrate efforts on addressing impacts outside the regulatory issues. Second, EMS goals, targets, and resulting performance must be made more transparent. The link between efforts to reduce environmental problems via an EMS and reported environmental performance metrics is tenuous. Finally, as environmental issues continue to shift in importance, EMS and must adapt to changing organizational focus and monitor potential future regulatory issues. For example, corporate social responsibility and calls for sustainability (incorporating social and economic factors, as well as environmental factors) and the global importance of carbon emissions (currently unregulated) are influencing corporate strategy. An EMS should support decision-making on these pressing issues.

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FORMALIZED ENVIRONMENTAL MANAGEMENT PROCEDURES: WHAT DRIVES PERFORMANCE IMPROVEMENTS? EVIDENCE FROM FOUR U.S. INDUSTRIES

ANDREW M. HUTSON
DANIEL EDWARDS, JR.
RICHARD N. L. ANDREWS[1]

ABSTRACT

This paper examines changes in environmental performance and management benefits associated with the introduction of environmental management systems (EMSs), and factors influencing these outcomes. Specifically, we sought to determine whether there are systematic differences, in EMSs themselves and in resulting environmental performance, between organizations that adopt EMSs for their own organizational reasons ("self-initiated"), or under coercion from corporate or customer mandates, and those that have not adopted such systems at all. Data included a survey of 3,200 plant managers in four sectors that include many suppliers to the automotive industry, which has mandated EMS adoption by its subsidiaries and suppliers, plus data from EPA's IDEAS database. The results suggest important findings concerning the roles of specific objectives for performance improvement, as opposed to adoption of an EMS per se; the limited effects of business-to-business EMS mandates; the perceived benefits of environmental performance improvement to business objectives; and the continued importance of governmental regulation and inspection to environmental performance on some key indicators.

KEYWORDS: EMS, environmental management systems, ISO 14000, compliance, pollution prevention, eco-efficiency, product stewardship, environmental performance, voluntary standards

INTRODUCTION

The adoption of formalized sets of environmental management practices by manufacturing facilities has proliferated over the past decade, but the efficacy of such practices in promoting environmental performance improvements remains uncertain. Over 50,000 organizations worldwide, including approximately 3,000 in the United States, have certified to the ISO 14001 environmental management system (EMS) standard, and more are currently in the process of registration.[2] Many other businesses have adopted formalized sets of environmental management practices, but have not officially registered to the ISO 14001 standard. While some may have adopted EMSs equivalent to the ISO 14001 standard and chosen not to formally register, others have adopted systems which fall short of ISO requirements. Nonetheless, efforts to install

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[1] Corresponding author. Address: Department of Public Policy, CB#3435, Abernethy Hall, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-3435. Tel. 919-843-5011, Fax 919-962-5824. Emails: hutson@unc.edu, deg@email.unc.edu, pete_andrews@unc.edu

[2] See http://www.ecology.or.jp/isoworld/english/analy14k.htm. Note that some ISO 14001 certificates may cover multiple facilities of the same parent organization, while others may cover only a specified subset of functions even at a single facility site.

systematic procedures for environmental management are becoming increasingly common, and in some cases a de facto condition for operating in certain industries and markets.

It is plausible to expect that the actual efficacy of an EMS in promoting environmental performance improvements may vary depending on the motivation of the business in introducing it. An EMS might be introduced, for instance, to improve compliance with environmental regulations, or to improve pollution prevention and increase "eco-efficiency" in the use of materials and energy in production processes (Coglianese and Nash 2001), or to improve the environmental performance of a company's products all the way from raw materials through recycling or waste management ("product stewardship") (Gallagher 2002). Alternatively, it might be introduced with an eye to improving overall plant management, whether or not it achieved significant improvements in environmental performance per se (Florida and Davison 2002). Or it might be introduced simply as a paper process, either to promote the business's "green" image (Darnall 2002) or merely to satisfy a mandate from corporate headquarters or a major customer.

Many facilities are increasingly under pressure from corporate parents and major customers to adopt formal environmental management practices. A number of major businesses have recently mandated introduction of environmental management systems (EMSs) by their subsidiaries and suppliers, particularly in the automotive and electronics industries: prominent among these are recent mandates from Ford and General Motors that all company facilities, as well as facilities of their first tier suppliers, must adopt and register an EMS in conformance with the ISO 14001 standard (Hutson 2001). Government agencies also have begun to promote such systems with public recognition and incentives, such as EPA's National Performance Track and similar state-level initiatives.[3]

A key unanswered question is what differences in actual environmental performance are associated with the introduction of such systems, and particularly, whether such systems produce positive changes in performance and other benefits when they are mandated or encouraged by external incentives.

The objective of this research project was to determine what changes in environmental performance result from the implementation of environmental management systems (EMSs), and what differences in organizational characteristics, motivations, and decision making are associated with these changes. Specifically, we sought to determine whether there are systematic differences, in EMSs themselves and in resulting environmental performance, between organizations that adopt EMSs for their own organizational reasons ("self-initiated"), or under coercion from corporate or customer mandates, and those that have not adopted such systems at all. Both public policymakers and businesses themselves will benefit from better information on the consequences of EMSs for environmental performance, and on their associated benefits and costs.

The research addressed a series of more specific questions concerning the impact of EMS adoption:

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[3] http://www.epa.gov/performancetrack/, and state initiatives e.g. in Colorado, Illinois, Indiana, Maine, North Carolina, Oregon, Texas, Virginia, Wisconsin and others.

- First, is the adoption of a formal environmental management system a good predictor of environmental performance improvement? Do facilities that have introduced ISO-certified EMSs – or comparably formalized EMSs – improve their environmental performance more than other facilities in the same industrial sector?
- Second, if so, are some environmental performance indicators (EPIs) more likely to improve than others? Do they improve across the board, or merely in some more limited set of performance indicators – and if the latter, what lessons might be drawn for understanding the strengths and limitations of EMS impacts on environmental performance?
- Third, are such improvements associated with EMS adoption per se, or with more specific characteristics of the EMS such as the particular types of goals and performance objectives adopted? One required characteristic of an ISO-equivalent EMS is the adoption of explicit objectives for performance improvement, but the nature and stringency of these objectives is left to the discretion of the adopter. Do facilities experience greater environmental performance improvement for outcomes that are targeted by their EMS performance objectives?
- Fourth, do facilities that adopt a formalized set of environmental management practices reap business benefits as well? That is, do they experience improved management efficiencies, improved positioning in the market place, or other business benefits in addition to (or even independent of) their actual environmental performance changes?
- Finally, do facilities that are subject to explicit requirements from corporate parents or customers to adopt environmental management practices perform differently than facilities that are not subject to such pressures, and that presumably therefore implement environmental management practices – whatever ones they do implement – under their own initiative?

Data sources included a survey of plant managers from a stratified random sample of facilities in four industrial sectors, as well as publicly available data for those facilities from EPA's IDEAS regulatory compliance database and its Toxics Release Inventory.[4]

FORMALIZED ENVIRONMENTAL MANAGEMENT SYSTEMS AND BENEFITS

To answer these questions, one must consider three bodies of theory and evidence: what impacts does an EMS have on environmental performance, what impacts might one expect it to have on business outcomes such as management and market benefits, and what expectations of business benefits might explain the imposition of business-to-business mandates for EMS adoption on subsidiaries and suppliers?

Environmental Performance

To date, studies that have attempted to determine the effects of EMSs on environmental performance have shed some light on the issue, but have not produced systematic or consistent answers. Case studies of facilities that have adopted EMSs point to a myriad of environmental improvements associated with the management systems, but have not produced systematic or reliable results (Berry and Rondinelli 2000; Rondinelli and Vastag 2000; Ammenberg 2001).

[4] Analysis of the TRI data is still in progress.

Several survey-based studies also have reported the impacts of EMSs on environmental performance, some too early after ISO 14001 adoption (in 1996) to produce compelling results (Melnyk et al. 1999; Hamschmidt 2000), and others with improved reliability but limited generalizability (Florida and Davison 2001; Mohammed 2000; Anton 2002; Andrews et al. 2003). Two studies have sought to measure performance outcomes using EPA's Toxics Release Inventory (TRI) database, with conflicting results: Matthews (2001) found that facilities in the auto industry with EMSs did not perform better than those without them, while Russo (2001) found that ISO 14001 was a significant predictor of reduced toxic emissions in the electronics industry. The findings of these latter studies may have differed due to differing methodological approaches and/or sectoral variance. In any case, the results focused only on toxic emissions rather than on a broader array of environmental performance indicators.

Additionally, most existing studies do not address the great range of discretionary variation that exists among the EMSs that facilities adopt. ISO 14001 provides a standard template for the process elements of an EMS – identifying environmental aspects and impacts, setting goals and objectives, assigning responsibilities, training, corrective and preventive actions, periodic review, and so forth – and it specifies three overarching goals for that process (compliance, pollution prevention, and continual improvement). But all the specific content – what environmental aspects and impacts will be considered, what environmental performance objectives will be priorities and how rapidly they are to be achieved, and others – are left entirely to the choices of the adopter, and businesses that do not seek ISO 14001 certification are not bound even to the ISO template. One previous study found great variation in practice both among aspects and impacts considered, and in the determination of which of these impacts were considered significant and targeted as priorities for improvement (Andrews et al. 2003). An important question for further inquiry is what impact the facility's choice of objectives – not just its decision to adopt a formal EMS – has on environmental performance and other outcomes.

Management and Market Benefits

The implementation of a formal EMS can be an expensive and time consuming endeavor (Darnall and Edwards *forthcoming*). Several theoretical justifications have been offered as to why an EMS might produce benefits both to environmental performance and to business outcomes. First, systematic management of functions with negative environmental consequences, rather than haphazard and inconsistent methods for addressing them, is more likely to produce outcomes that have both environmental and business benefits, such as minimizing costs, environmental liabilities, regulatory penalties, and risks to the firm's image and associated brand value (Coglianese and Nash 2001). Second, managers who address environmental problems with formal management systems may also reap improvements in product quality and process efficiencies that lead to positive financial outcomes (see also Porter and van der Linde 1995; Hart and Ahuja 1996; Klassen and McLaughlin 1996; Sharma and Vredenburg 1998; Dowell, Hart and Yeung 2000; Christmann 2000).

Third, an EMS can contribute to broader patterns of beneficial management and cultural changes within a business organization, such as integrating environmental management with other primary management functions and with organization-wide quality management procedures (Florida and Davison 2001, Coglianese and Nash 2001). Additionally, management-based approaches may be less costly and more effective than government imposed regulation, may lead to greater buy-in from management due to a greater sense of legitimacy, ownership and control, and may promote innovation and social learning (Coglianese and Lazar 2003). However, some suggest that claims about the ability of EMS to lead to performance improvements may be overstated, and must be empirically tested (Walley and Whitehead 1994).

Business-to-Business Mandates

It is becoming increasingly common for business decision makers to include comprehensive environmental management plans as part of a broader corporate strategy. Such strategies may include strong encouragement, as in the case of IBM, or explicit requirements, such as those mandated by Ford, General Motors and others, for subsidiaries and suppliers to adopt formal environmental management systems.

A corporation may require that its own facilities adopt EMSs for at least three reasons (Andrews, Hutson, and Edwards, *forthcoming*). One is to minimize legal and financial liabilities associated with poor environmental performance by its subsidiaries: through more explicit procedures for environmental management and associated accountability, firms may prevent accidents and better understand the potential legal risks they face. A firm may be harmed by poor environmental behavior of its subsidiaries and may therefore seek a unified strategy to reduce current and potential risks. Second, a company may mandate EMSs by its subsidiaries in order to protect or improve its image, reputation, and brand value. Adoption and certification of EMSs may be a means for presenting an image to the external world of the company's commitment to good environmental management practices, whether or not this image in fact represents better performance than that of other comparable firms (Darnall 2002). Third, the increasingly widespread geographic distribution of manufacturing sites, which has coincided with the globalization of manufacturing, has increased the need for greater standardization of practices. Firms that use standard operating procedures throughout their global operations – including standardization of environmental management practices – may improve both communication and overall efficiency, both of which may improve financial performance by reducing costs and minimizing waste.

Firms may extend such requirements to suppliers and business partners for similar reasons. In an increasingly global economy, where firms often subcontract manufacturing functions to a geographically disperse network of suppliers, firms face a host of challenges. First, corporations in some sectors face shared threats to their reputations, which are addressed by creating sector-wide standards to which members must adhere (Kollman and Prakash 2002), or "lead industry regulation" to influence the practices of suppliers or customers whose behavior may affect their own reputations or liabilities (Nash 2002). Second, large brand-visible firms may choose to have their more anonymous suppliers adopt formal sets of practices and/or codes of conduct in an effort to protect their brand image and reputation from harm caused by potential environmental or human rights abuses down the value chain (Gereffi et al. 2001, Klein 1999). Finally, the adoption of standardized practices by suppliers may result in increased efficiencies, cost reductions, and even innovations whose benefits which can then be shared with lead firms (Geffen and Rothenberg 2000, Corbett 2002). In essence, firms seek to reap the same benefits from their suppliers as they expect from their own subsidiaries.

How effectively those who are subject to requirements from corporate parents and customers respond to mandates is still untested. While some evidence suggests that mandates are motivating suppliers to adopt formal EMSs, many for the first time (Hutson 2001), no systematic studies have been conducted on mandates to adopt EMS, nor on the resulting effectiveness of such mandates in inducing environmental performance improvements. The possibility exists that EMSs, which are touted as efforts to "regulate from the inside," may in practice be perceived more like traditional regulatory mandates by governments (which "regulate from the outside") when they are imposed on suppliers and business partners. Even though facilities can choose how to adopt the systems, and are not constrained by strict performance targets, they may choose to adopt the system simply as a paperwork burden, or do so in the most limited form necessary to meet the requirements. Alternatively, it is also possible that facilities which adopt environmental management practices under pressure may do a more thorough job of implementation, as they perceive that doing so is a precondition of their contractual relationships; or that having initially adopted the EMS only because of a mandate, they may subsequently discover that it has unanticipated benefits to them.

DATA AND MEASURES

Data

The data used in this analysis were collected through a survey of plant managers from a random sample of manufacturing facilities in four U.S. industrial sectors: Motor Vehicles Parts and Accessories (SIC 3714), Chemicals and Chemical Preparations (SIC 2899), Plastic Products (SIC 3089) and Coating, Engraving, and Allied Services (SIC 3479). These sectors were chosen to include a high number of certified environmental management systems, strong supplier relationships to the automotive sector (which has mandated supplier EMSs), and significant environmental impacts based on EPA's Toxics Release Inventory (TRI) data. The sample included facilities that had adopted EMSs with and without external pressures or incentives to do so, as well as controls that had not adopted formal EMSs at all. From our original sample we discarded approximately 500 due to facility closures, re-location and incorrect mailing addresses, and sent the survey to plant managers of over 3,200 facilities. From these we received 617 responses, a response rate of 20%, well distributed among the industries sampled.[6] For each facility, the survey requested information on current environmental management objectives and activities, specific motivations or requirements to develop an EMS, and changes in environmental performance indicators (EPIs) and other benefits that the respondents had observed as a result of environmental management activities. Plant managers were the target respondents.

Dependent Variables

The study used two primary groups of dependent variables, as reported by the respondents: changes in seventeen environmental performance indicators, and ten categories of management and market benefits (figure 1). Facility responses indicated whether environmental indicators increased, decreased or were unchanged during the past three years, corresponding roughly to

[6] A response rate of 19.56% was achieved after accounting for facility closures, re-location and incorrect mailing addresses.

2000 thru 2002.[7] The respondents similarly indicated the significance of management and market benefits realized due to the adoption of environmental management activities, on a scale ranging from 'no benefits' to 'high benefits.' [8]

Figure 1: EPI and Management Benefits Examined

EPIs	Management Benefits
• Water use	• Cost savings in terms of inputs or taxes
• Energy use	• Avoidance of non-compliance penalties
• Recycled inputs	• Increase in productivity
• Recycling of waste	• Increase in market share
• Chemical inputs per unit output	• Ability to reach new markets
• Total material inputs	• Product differentiation
• Hazardous waste generation	• Improved company/plant image
• Non-hazardous solid waste generation	• Improved access to capital markets
• Wastewater effluent	• Improved competitive advantage
• Air pollution emissions	• Improved management efficiencies
• Greenhouse gas emissions	
• Noise generation	
• Smell generation	
• Disruption of the natural landscape	
• Soil contamination	
• Severe leaks or spills	
• Legal violations or potential violations	

Independent Variables

Three primary independent variables were used to explain environmental performance outcomes and management benefits: the degree to which environmental practices and activities were formalized at the facility level, the relative priorities each facility placed on particular objectives for their environmental practices, and the existence of external market pressures to adopt an environmental management system. (For a detailed description of measures see Appendix I).

Control Variables

The study also included two types of control variables in the analysis to account for other sources of variability in performance outcomes. The first included *endogenous* resources and capabilities that might influence environmental performance outcomes, such as prior management systems or cultural norms of the organization. The second category included *exogenous* factors, such as industrial sector and regulatory pressures, which have the potential to alter environmental results at the facility level. (For detail on control variables see Appendix II).

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[7] Facilities were given the option to indicate that the listed indicator either was not tracked by the facility or was not applicable to site operations.

[8] Additional tests using TRI data as dependent variables measuring environmental performance change are still in progress.

METHODS AND RESULTS

Models

This study used a binomial logistic regression model to investigate the effects of the variables of interest on resulting environmental performance and management benefits. This model applies a maximum likelihood estimation technique to estimate the likelihood of a certain outcome.

The model takes the linear form:

$$z = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k$$

While the parameter estimates produced by this method are not necessarily intuitively meaningful, the regression coefficients can be transformed to show either the percent change in the odds of the outcome's occurrence per a one unit change in the independent variable or the percent change in probability in the outcome's occurrence at the margin for the mean probability given a one unit change in the independent variable. Both transformations are useful in understanding the effects of our independent variables on environmental performance and management benefit outcomes. However, the former transformation allows us to generalize the impact of the independent variables on the likelihood that improved environmental performance is reported without assumptions about mean probability that such improvements will occur. In contrast, the latter transformation is dependent on the sample mean for each dependent variable of interest.

For the seventeen EPIs and ten management benefits as well as a comparison of overall benefit or cost of environmental practices, the models take the following general form: [9]

$$\text{Log } p(epi_k) = \alpha + \beta_1(\text{EMS formalization}) + \beta_2(\text{system objectives})_i + \beta_3(\text{business mandate})_i + \beta_4(\text{attitude}) + \beta_5(\text{involvement}) + \beta_5(\text{time}) + \beta_6(\text{size}) + \beta_7(\text{industry})_i + \beta_8(\text{ownership}) + \beta_9(\text{resources}) + \beta_{10}(\text{capabilities})_i + \beta_{11}(\text{location})_i + \beta_{12}(\text{regulatory pressure})_i$$

$$\text{Log } p(benefit_k) = \alpha + \beta_1(\text{EMS formalization}) + \beta_2(\text{system objectives})_i + \beta_3(\text{business mandate})_i + \beta_4(\text{attitude}) + \beta_5(\text{involvement}) + \beta_5(\text{time}) + \beta_6(\text{size}) + \beta_7(\text{industry})_i + \beta_8(\text{ownership}) + \beta_9(\text{resources}) + \beta_{10}(\text{capabilities})_i + \beta_{11}(\text{environmental performance})_i$$

The model results for each of the seventeen (17) self-reported EPIs are shown in Tables 1 and 2.[10] The model results for each of the ten management benefits are shown in Tables 3 and 4. The Wald chi-square statistic is presented for each model along with a Max-rescaled R-Square statistic. The parameter coefficient is reported along with a point estimate of its effect on the odds that improved environmental performance was reported along with the standard error of the parameter coefficient.

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[9] The model presented below is a generalized model. Slightly different specifications were used for some classes of management benefits. See Tables 3 and 4 as well as Figure 5 in Appendix II for more detail.

[10] The models for four EPIs – greenhouse gas emissions, disruption of the natural landscape, soil contamination and noise generation – did not produce statistically significant results and are not included in the referenced tables.

Table 1: Logistic Regression Results for Self-Reported Environmental Performance Changes: Regulated and Quasi-Regulated Indicators

EPI Model	Hazardous Waste			Air Pollution			Wastewtr Effluent			Spills			Violations		
Chi Square		50.84**			52.65**			48.37**			47.66**			46.70**	
R2		0.19			0.27			0.19			0.25			0.16	
n		429			348			393			344			376	
	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.
Variables of Interest															
EMS Practices Formalization													0.30**	1.35	0.16
Customer Mandate															
Corporate Mandate															
Both B2B Mandates															
Compliance Goals	-0.32**	0.73	0.14							0.31*	1.36	0.18	0.32**	1.38	0.16
Pollution Prevention Goals													0.23*	1.26	0.12
Eco-Efficiency Goals	0.20*	1.22	0.11												
Product Stewardship Goals	0.27**	1.31	0.12	0.22*	1.25	0.13									
Endogenous Controls															
Other Plans															
Quality Management Systems							0.60*	1.82	0.34						
Attitude Toward Env. Mgmt															
Employee Involvement				0.17*	1.11	0.07									
Time with Formal EMS	0.14*	1.13	0.07												
Exogenous Controls															
Auto Supply Sector				0.91*	2.49	0.42									
Plastics Sector				1.02**	2.77	0.40	-0.71*	0.49	0.37	-1.01***	0.36	0.38			
Coatings Sector										-1.56***	0.21	0.41			
Private Ownership				-0.76**	0.47	0.31	-.055**	0.58	0.28						
Recent Inspections+				0.31***	1.36	0.09	0.02*	1.02	0.01						
Recent Non-Compliance+	0.03*	1.03	0.02										0.04***	1.04	0.01
Recent Fines+															
Region 1															
Region 2															
Region 3							-1.08*	0.34	0.56	-1.20**	0.30	0.61			
Region 4	-1.25***	0.29	0.47	-0.92*	0.40	0.54									
Region 5	0.89**	0.41	0.46												
Region 7	-1.60***	0.20	0.58												
Region 8															
Region 9										1.20**	3.31	0.62			
Region 10															
Facility Size+															

*$p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$, + see Appendix II for discussion of variable construction

Table 2: Regression Results for Self-Reported Environmental Performance Changes: Non-Regulated Indicators

EPI Model	Water			Energy			Recycled Inputs			Recycled Waste			Chemical Use			Material Use			Smell			Non-Hazardous Waste		
Chi Square		**58.85*** **			**52.13** **			**61.56*** **			**57.97*** **			**44.17** **			**47.78** **			**46.25** **			**59.12*** **	
R2		**0.22**			**0.17**			**0.27**			**0.20**			**0.17**			**0.16**			**0.28**			**0.20**	
n		**445**			**462**			**382**			**449**			**399**			**415**			**279**			**465**	
	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Paramete r Estimate	Point Estimate	S.E.	Paramete r Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.
Variables of Interest																								
EMS Practices Formalization							0.36**	1.43	0.16	0.34**	1.40	0.15												
Customer Mandate																								
Corporate Mandate	-0.61*	0.54	0.36																					
Both B2B Mandates													-0.85**	0.43	0.35									
Compliance Goals							-0.37**	0.69	0.17	-0.31**	0.73	0.15							0.44*	1.55	0.26	-0.36***	0.70	0.14
Pollution Prevention Goals																								
Eco-Efficiency Goals				0.34**	1.41	0.11	0.40***	1.49	0.13	0.32***	1.38	0.12				0.22*	1.25	0.13				0.29***	1.34	0.11
Product Stewardship Goals																			0.31**	1.37	0.16			
Endogenous Controls																								
Other Plans	0.78*	2.17	0.37				1.17***	3.22	0.45	1.12***	3.07	0.36										0.70*	2.02	0.37
Quality Management Systems	0.63**	1.88	0.33	0.57*	1.77	0.31							0.60*	1.82	0.32									
Attitude Toward Env. Mgmt																								
Employee Involvement													0.10*	1.11	0.06	0.16**	1.17	0.06						
Time with Formal EMS																			0.17*	1.19	0.10			
Exogenous Controls																								
Auto Supply Sector	0.81**	2.25	0.36	0.81**	2.25	0.35	-0.78**	0.46	0.46				1.12***	3.06	0.37	1.34***	3.82	0.39	-1.08**	0.34	0.52			
Plastics Sector	-0.57*	0.56	0.35				-0.79**	0.46	0.37															
Coatings Sector							-1.00***	0.36	0.36				0.92***	2.51	0.36							-0.71**	0.49	0.32
Private Ownership																								
Recent Inspections+				0.26**	1.01	0.01										0.04*	1.04	0.02						
Recent Non-Compliance+																						0.04***	1.04	0.01
Recent Fines+																0.00*	1.00	0.00						
Region 1				1.22*	3.39	0.66																		
Region 2	1.44**	4.21	0.63																					
Region 3																								
Region 4							1.03**	2.81	0.48	0.98**	2.67	0.43				-0.82*	0.44	0.47						
Region 5	0.97**	2.56	0.43																			0.67*	1.96	0.40
Region 7																								
Region 8																								
Region 9													0.88*	2.40	0.52									
Region 10													1.62**	5.07	0.77				1.96*	7.08	1.16	1.84**	6.30	0.77
Facility Size+							0.39***	1.48	0.11							-0.26**	0.77	0.11	0.33**	1.39	0.14			

*p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01, + see Appendix II for discussion of variable construction

Table 3: Regression Results for Self-Reported *Internal* Management Benefits[11]

Management Benefits Model	Cost-Benefit			Inputs			Penalities			Productivity			Mgmt Efficiency			Comp Advantage		
Chi Square		**35.20****			**49.67*****			**31.09***			**52.71*****			**59.09*****			**88.75*****	
R2		**0.10**			**0.18**			**0.27**			**0.17**			**0.21**			**0.32**	
n		**491**			**434**			**293**			**485**			**465**			**480**	
	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.
Variables of Interest																		
EMS Practices Formalization	0.29**	1.33	0.14										0.37**	1.45	0.18	1.05***	2.85	0.27
Customer Mandate				1.23***	3.44	0.42				0.65*	1.92	0.40				0.86**	2.37	0.42
Corporate Mandate																		
Both B2B Mandates				0.70**	2.02	0.33												
Compliance Goals																		
Pollution Prevention Goals				0.19**	1.24	0.11												
Eco-Efficiency Goals				0.27**	1.30	0.11							0.23**	1.26	0.12	0.25**	1.28	0.11
Product Stewardship Goals										0.27***	1.31	0.11				0.62***	1.85	0.12
Endogenous Controls																		
Other Plans																		
Quality Management Systems	0.65**	1.91	0.27															
Attitude Toward Env. Mgmt																		
Employee Involvement										0.17***	1.19	0.05						
Existence of Parent Org.	0.58**	1.79	0.27										0.58*	1.79	0.34			
Time with Formal EMS																		
Environmental Performance+				1.27***	3.57	0.37	1.37***	3.92	0.55									
Exogenous Controls																		
Auto Supply Sector				-0.59*	0.55	0.33	1.03*	2.80	0.62									
Plastics Sector							2.35	10.45	0.87	-0.53*	0.59	0.31						
Coatings Sector							1.43	4.17	0.69									
Private Ownership																0.60**	1.82	0.27
Recent Inspections+																		
Recent Non-Compliance+																		
Recent Fines+																		
Region 1																		
Region 2																		
Region 3																		
Region 4																		
Region 5																		
Region 7																		
Region 8																		
Region 9																		
Region 10																		
Facility Size+							-0.39**	0.68	0.18									

*p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01, + see Appendix II for discussion of variable construction

[11] Individual variables that were not included within each respective model are marked in solid black.

Table 4: Regression Results for Self-Reported *External* Management Benefits[12]

Management Benefits Model	Market Share			New Markets			Product Differentation			Plant Image			Capital Access		
Chi Square		79.58***			89.43***			70.74***			39.14**			44.78***	
R2		0.28			0.32			0.26			0.38			0.23	
n		463			468			439			177			306	
	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.	Parameter Estimate	Point Estimate	S.E.
Variables of Interest															
EMS Practices Formalization				0.54**	1.72	0.27									
Customer Mandate	1.21***	3.37	0.44	0.77*	2.16	0.42									
Corporate Mandate				-0.96**	0.38	0.41									
Both B2B Mandates	0.86**	2.36	0.36	0.61*	1.84	0.34									
Compliance Goals				-0.29**	0.75	0.14									
Pollution Prevention Goals	0.40***	1.49	0.12	0.31***	1.36	0.12	0.30***	1.35	0.12						
Eco-Efficiency Goals															
Product Stewardship Goals	0.43***	1.53	0.12	0.44***	1.55	0.11	0.58***	1.80	0.12				0.63***	1.88	0.15
Endogenous Controls															
Other Plans							0.71*	2.04	0.41	1.97**	7.16	0.84			
Quality Management Systems													0.84**	2.32	0.44
Attitude Toward Env. Mgmt															
Employee Involvement															
Existence of Parent Org.										2.02*	7.58	1.07			
Time with Formal EMS	-0.16**	0.85	0.07	-0.14*	0.87	0.07									
Environmental Performance+										2.17**	8.75	0.95			
Exogenous Controls															
Auto Supply Sector															
Plastics Sector				0.59*	1.81	0.33									
Coatings Sector	0.71**	2.03	0.35	1.05***	2.86	0.34							0.71*	2.03	0.39
Private Ownership															
Recent Inspections+															
Recent Non-Compliance+															
Recent Fines+															
Region 1															
Region 2															
Region 3															
Region 4															
Region 5															
Region 7															
Region 8															
Region 9															
Region 10															
Facility Size+															

*p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01, + see Appendix II for discussion of variable construction

[12] Individual variables that were not included within each respective model are marked in solid black.

Results

Environmental Performance

The formalization of EMS practices was a significant predictor of improved environmental performance for only three of thirteen environmental indicators. Facilities that had adopted a *formal EMS* or *ISO 14001 equivalent EMS* were significantly more likely to report increases in recycling of waste (86 percent), in use of recycled inputs (80 percent), and in reductions in regulatory violations (70 percent), than were those with less formalized environmental management practices. However, the formalization of environmental management practices had no significant associations with other important environmental performance indicators, such as air and water quality, hazardous and non-hazardous waste generation, material and energy inputs, or even control of spills. The proportions of facilities reporting improvement in each EPI are presented in Table 5.

The presence or absence of a formal mandate to adopt an EMS, either from a facility's corporate headquarters or from a customer, did not appear to have any significant influence on its environmental performance. The only indicator for which a mandate variable appeared to predict a change in environmental performance was chemical use, for which facilities with both a customer and corporate mandate were less likely (57 percent) to report improvement. Without any plausible rationale or additional evidence to explain this result, we are inclined to dismiss it as spurious.

However, the priority each facility placed on particular goals of their environmental management activities (compliance, eco-efficiency, or product stewardship) was a broadly significant indicator of performance improvements. Facilities that placed emphasis on <u>compliance</u>-centered goals were significantly <u>more</u> likely to report improvements in reducing violations (38 percent), spills (36 percent), and smells (55 percent), but were significantly <u>less</u> likely to report improvements in hazardous and non-hazardous waste management (27 and 30 percent, respectively), recycling of wastes (27 percent) and use of recycled inputs (31 percent). Conversely, facilities that placed emphasis on <u>eco-efficiency</u> goals were significantly <u>more</u> likely to report improvements in recycling and use of recycled inputs (38 and 49 percent, respectively), in energy and materials use (41 and 25 percent, respectively), and in hazardous and non-hazardous waste generation (22 and 34 percent, respectively). However, similar improvements were not reported for water or chemicals use. Finally, facilities that placed emphasis on <u>product stewardship</u> were significantly more likely than others to report improvements in hazardous waste generation (31 percent), in air quality (25 percent), and in smells (37 percent), though not in other indicators.

A second variable that was broadly and significantly associated with patterns of environmental performance improvement was the presence of a formal pollution-prevention or waste-minimization plan. Facilities that had such plans were significantly more likely to report improvements in recycling (207 percent), in use of recycled inputs (222 percent), in water use (117 percent), and in non-hazardous waste generation (102 percent).

Table 5: Reporting of Improved EPI Performance

Environmental Performance Indicator	Improved	Not Improved	Not Applicable	No Response	Total	n
» Water use	0.38	0.49	0.12	0.01	100%	617
» Energy use	0.37	0.53	0.08	0.02	100%	617
» Recycled inputs	0.37	0.35	0.24	0.03	100%	617
» Recycling of waste	0.35	0.51	0.12	0.02	100%	617
» Chemical inputs per unit output	0.36	0.41	0.20	0.03	100%	617
» Total material inputs	0.28	0.52	0.15	0.05	100%	617
» Hazardous waste generation	0.58	0.33	0.08	0.02	100%	617
» Non-hazardous solid waste generation	0.43	0.48	0.07	0.02	100%	617
» Wastewater effluent	0.35	0.41	0.21	0.02	100%	617
» Air pollution emissions	0.49	0.42	0.07	0.02	100%	617
» Smell generation	0.20	0.35	0.43	0.02	100%	617
» Severe leaks or spills	0.32	0.33	0.33	0.01	100%	617
» Legal violations or potential violations	0.30	0.41	0.27	0.02	100%	617

Recent inspections and non-compliances appeared to have a positive impact on environmental performance for the most heavily regulated indicators, though not for others. For example, facilities that had experienced recent inspections were significantly more likely to report improvements in air pollutant emissions (36 percent), energy use (1 percent), reductions in materials use (4 percent), and wastewater effluent (2 percent). Facilities that had recently identified non-compliances were significantly more likely to report improvements in non-hazardous waste generation (4 percent), in reducing violations (4 percent), and in hazardous waste generation (3 percent).

Several other factors appeared to be associated with performance changes as well. The greater the involvement of a broad range of employees in environmental management activities, the more likely it was that changes would be reported in some of the outcomes that were harder to achieve, such as reduction of material use, reduction of chemical use, and air quality. For example, we could predict that if a facility involved all site employees and other interested parties the likelihood of reducing materials used in production might increase by 270 percent. However, because these findings lacked consistent statistical support across other logically similar input variables, we are inclined not to place too much emphasis on this finding.

Interestingly, the attitudes of the responding managers toward environmental issues appeared to have no significant effects on any of the environmental performance indicators. This finding stands in contrast to other studies that have found positive attitudes about environmental management to be significant drivers of environmental performance improvements (see e.g. Kagan, 2004 *forthcoming*).

The presence of formal quality management systems was significantly associated with an increased likelihood of reducing wastewater effluent (82 percent), as well as water use (88 percent), chemical use (82 percent) and energy use (77 percent). However, in most of these cases (with water use as the exception) such findings were present only at the significance level of p=0.10. While these effects are not statistically striking, the convergence is worthy of comment. Input variables such as chemical, water and material use may be affected by quality management initiatives that seek to limit waste and increase efficiency.

The single most systematically influential predictor seen in the data was the greater improvement of firms in the auto supply sector compared to the chemicals sector. Facilities in the auto supply industry were nearly 150 percent more likely to report improvements in air pollutant emissions than were chemicals firms and 100-200 percent more likely to report improvements in use of most production inputs including material inputs, chemical, water, and energy use. Only in the use of recycled inputs and in smell generation were auto supply firms significantly less likely than chemical plants to have improved (54 and 66 percent, respectively). Facilities in the plastics industry were also more likely than the chemical industry during the period of this study to improve their air pollution emissions (177 percent), although they were less likely than chemical firms to reduce spills (64 percent) and to increase the use of recycled inputs (54 percent).

Finally, we note several strong regional associations that deserve further investigation and explanation. Facilities in EPA Region 10 (Pacific Northwest) were more than 500 percent more likely to reduce non-hazardous waste generation and over 400 percent more likely to reduce chemical use than did firms in the base region (Region 6, the south central states). Facilities in Region 5 (Great Lakes) and those in Region 2 (New York/New Jersey) showed disproportional improvement in water use (156 and 321 percent, respectively), and those in Region 4 (Southeast) showed disproportional improvement in recycling (167 percent) and use of recycled inputs (181 percent). Several other regions showed significantly less improvement in some outcomes than the base region. Whether these differences reflect differences in regional policies and priorities of EPA itself, or in the industrial mix or other exogenous influences in those regions, they suggest regional patterns or influences that deserve further investigation.

Management Benefits

The formalization of environmental management activities by facilities also appeared to be a significant predictor of some management benefits. Overall, facilities with formalized environmental management practices in place were more likely to report the benefits of those activities as greater than the costs (33 percent) than those with less formalized activities. These facilities also were more likely to report increased management efficiencies (45 percent) and improved access to new markets (72 percent), and were much more likely to report improved competitive advantage (285 percent) associated with their environmental management activities. Table 6 shows the proportion of facilities reporting some benefits for each investigated activity.

The presence of business-to-business mandates also appeared to be a significant predictor of some management outcomes. However, some important distinctions must be made regarding the *type* of business-to-business mandate to which a facility is subject. Facilities subject to an EMS mandate from their corporate parent were not more likely to report any management benefits, and in fact were less likely (62 percent) to report improved access to new markets. Conversely, facilities subject to a customer requirement to adopt a formal EMS were not only more likely to report several management benefits, but were *much* more likely to do so for some such benefits. For example, facilities subject to a customer mandate were more likely to report increased savings from inputs and taxes (244 percent), increased productivity (92 percent), increased market share (237 percent), improved competitive advantage (137 percent), and improved access to new markets (116 percent).

Table 6: Reporting of Management Benefits

Management Activity	Benefit	No Benefit	Not Applicable	No Response	Total	n
» Cost savings in terms of inputs or taxes	0.40	0.40	0.16	0.04	100%	617
» Avoidance of non-compliance penalties	0.77	0.12	0.08	0.03	100%	617
» Increase in productivity	0.51	0.37	0.09	0.03	100%	617
» Increase in market share	0.32	0.51	0.13	0.03	100%	617
» Ability to reach new markets	0.37	0.47	0.12	0.04	100%	617
» Product differentiation	0.28	0.51	0.18	0.03	100%	617
» Improved company/plant image	0.79	0.13	0.05	0.03	100%	617
» Improved access to capital markets	0.26	0.51	0.19	0.03	100%	617
» Improved competitive advantage	0.47	0.40	0.10	0.03	100%	617
» Improved management efficiencies	0.68	0.22	0.07	0.03	100%	617

As with environmental performance, the priority each facility placed on specific goals of their environmental management activities (compliance, pollution prevention, eco-efficiency or product stewardship) was a significant predictor of the management benefits facilities reported. Facilities whose activities focused on <u>pollution prevention</u> activities were more likely to report cost savings in terms of inputs and taxes (24 percent), increased market share (49 percent), improved access to new markets (36 percent), and product differentiation (35 percent). Facilities whose activities centered on <u>eco-efficiency</u> goals were more likely to report cost savings from inputs and taxes (30 percent), improved management efficiency (26 percent), and improved competitive advantage (28 percent) stemming from their environmental management activities. Facilities that focused on <u>product stewardship</u> goals reported the widest range of benefits, with such facilities more likely to report benefits from increased productivity (31 percent), increased market share (53 percent), access to new markets (55 percent), product differentiation (80 percent), access to capital (88 percent), and competitive advantage (85 percent). The only management benefits that such facilities were not more likely to report were cost savings from inputs and taxes, avoidance of non-compliance penalties, and improved image.

While the goal of a facility's EMS was an important predictor of an increased likelihood of reporting management benefits, the value of focusing specifically on a regulatory <u>compliance</u> goal was less impressive. Facilities that emphasized regulatory compliance as their EMS goal were no more likely than others to report *any* management benefits from their environmental management activities. In fact, such facilities were *less* likely to report improved access to new markets (25 percent). However, facilities that had a recent legal violation were more likely to report benefits from avoidance of non-compliance penalties (292 percent) and improved company or plant image (775 percent). Additionally, facilities with a parent organization, and those with a waste minimization or pollution prevention plan in place, were much more likely to report improved image benefits from their environmental management activities (658 percent and 616 percent, respectively).

FINDINGS AND IMPLICATIONS

The results of this study offer new insights into the roles that environmental management systems play in improving environmental performance, and into their potential for management benefits to facilities that adopt them.

Finding: One should not expect to see substantial changes in environmental performance simply because a facility adopts a formal EMS.

The most evident changes in environmental performance associated with EMS adoption were changes in relatively marginal practices at the day-to-day operating level. These changes did not extend to other impacts, such as air and water pollution, that might require more significant changes in technologies and capital investments. In short, it appears that the kinds of improvements that were most often reported in association with formalized EMSs were those that were easiest and cheapest to improve at the margin in day-to-day operations at the facility level ("better housekeeping," for instance), whereas those less often reported as improved were those that would require more significant changes in actual production technologies and processes (and perhaps, therefore, more significant capital investments, and approval from decision makers located outside the individual manufacturing facility).

Finding: Specific goals for improvement, rather than simple EMS adoption, appear to be a better predictor of the success of environmental management activities.

The specific goals of environmental management practices appear to be much better predictors of performance improvements than mere presence of a formalized environmental management system. Our results suggest strongly that improvements in environmental performance indicators stem not from adoption of environmental management systems per se, but instead from adoption of specific objectives aimed at correcting impacts of particular manufacturing processes or products. Facilities that focused their environmental management efforts on areas such as eco-efficiency and pollution prevention tended to report improvements in EPIs which reflected those goals. Improvements reported by facilities with formal pollution prevention and waste minimization plans in place (in addition to EMSs) add further support for this conclusion, as such facilities were much more likely to report improvements in EPIs that these plans targeted. For environmental regulatory agencies and the interested public as well as other potential adopters, these findings suggest strongly that attention and any rewards or recognition should focus on the specific environmental performance improvements targeted as priority objectives in the EMS, and on the facility's success in achieving them, not merely on the adoption of an EMS per se.

Finding: Environmental regulation plays an important role in promoting improved environmental performance.

Whatever the benefits of voluntary initiatives such as adoption of an environmental management system, government regulation continues to play an important role in environmental performance improvements. Indicators that were regulated and inspected regularly showed greater improvements than those that were not. For instance, recent inspections were strongly associated with improvements in air pollution; this association was expectable and even reassuring, since air pollutant emissions are arguably the most systematically monitored and inspected indicator of environmental performance (water pollution is monitored more variably, and primarily by the states rather than EPA). Facilities with recent non-compliances, or potential non-compliances, were also more likely to report improvements in hazardous waste generation and reduced violations: these too are understandable and reassuring results, since hazardous waste management is an area of high potential economic liability to the facility if non-compliances should be discovered on inspection and cited as formal violations.

Reductions in regulatory violations and non-compliances are not by themselves a surprising result, given prior research on the impact of formalized environmental management techniques (Andrews et al. 2003), and they reinforce the importance of regulation in promoting environmental performance improvements when used in conjunction with voluntary "beyond compliance" measures such as EMS adoption. But perhaps paradoxically, facilities that emphasized compliance as a primary goal of their environmental management activities were less likely to report either the additional environmental performance improvements or the management benefits that facilities with other goals reported. While a compliance-focused EMS may well have helped to reduce regulatory violations, it did not appear to promote improvements in beyond-compliance environmental performance measures such as eco-efficiency or product stewardship. Further, facilities that designed their EMSs with multiple environmental performance objectives that spanned all four areas (compliance, pollution prevention, eco-efficiency and product stewardship) had greater potential to accrue a suite of separate benefits associated with each category.

Finding: The accumulation of management-related benefits also is associated more with specific management goals than with EMS adoption.

Facilities with formal EMSs in place were more likely to report a number of management benefits, but the specific goal of a facility's environmental activities was a much better predictor of what kinds of management benefits a facility could expect to achieve than was the mere presence of an EMS. Those facilities that focused their activities on pollution prevention goals were more likely to report more *external* benefits (such as market share, access to new markets, and product differentiation) than *internal* benefits (such as cost savings from inputs and taxes). Conversely, facilities with a focus on eco-efficiency were more likely to report more *internal* benefits (including cost savings and improved management efficiencies) than *external* benefits (though such facilities were more likely to report increased competitive advantage, which can be thought of as both an internal and external benefit). Facilities with a focus on product stewardship were more likely to report a broad array of both internal and external benefits, and more likely in general to report a greater number of management benefits, than facilities with other priorities for their environmental activities. Such findings suggest that facilities with "higher-order" environmental objectives, such as product stewardship, may achieve greater management benefits as well (see Appendix I for discussion of "higher-order" environmental objectives).

The finding that facilities with a compliance focus were less likely to report management benefits reveals an important additional point. Facilities that limit themselves to achieving legal compliance, instead of broadening the scope of their activities to include more advanced practices and to integrate environmental management with other management practices and objectives, may be missing fundamental opportunities to extract additional value from their investments in such activities.

Sectoral differences, where automotive parts manufacturers were more likely to report environmental performance improvements compared with the chemical industry, may reflect technological and historical differences that deserve further investigation and comparative study. In the chemical industry, end products are highly resource dependent: nearly all inputs (chemical and otherwise) are potential product. Over the past two decades, the chemical industry has been much more proactive in the adoption of systematic environmental management practices. Since the Bhopal disaster of the mid-1980s and the subsequent introduction of the Responsible Care© initiative a decade ago, many within the chemical sector may already have gone through a period of intensive environmental management improvement, a process which auto supply facilities are just now beginning to experience.

Finding: Business-to-business mandates offer limited potential to promote environmental protection.

Facilities that were required to adopt environmental management activities by a customer, corporate parent, or both, were no more likely to report performance changes than those who were not subject to such requirements. On its face, this result appears to lend little support to advocates of systematic efforts by the private sector to issue mandates in order to promote environmental protection. However, if these mandates serve as an impetus for EMS adoption by facilities that otherwise would have no such formalized practices in place, they may nonetheless spur performance improvements if the resulting systems are designed correctly. That is, if the EMSs that emerge in these facilities place emphasis on specific performance-related goals such as eco-efficiency, pollution prevention, and product stewardship, and not simply on adoption of EMS procedures, then explicit requirements may nonetheless lead to eventual performance improvements.

Finding: Private sector mandates may lead to management benefits, depending on who issues the mandate.

While mandates did not appear to affect environmental performance, customer mandates, at least, did appear to affect management benefits. Facilities subject to corporate mandates were not more likely to report management benefits in any category, but those subject to customer mandates were more likely to report benefits, of multiple types.

Two possible reasons might account for the absence of reported management benefits associated with corporate mandates. First, facilities subject to corporate mandates might have been subject to stricter environmental management regimes prior to the mandate, as larger corporations have been ahead of the curve in this regard, and may thus have been less likely to experience additional improvements in internal management benefits. In checking this possibility, however, we determined that while facilities with corporate mandates were more likely to have a pollution prevention plan already in place – thus suggesting the existence of a previously-developed environmental management regime – they were no more likely to have a pre-existing waste management plan, total quality management plan, or ISO 9000 certification, and when these proxies were combined there was no difference. Second, it is possible that corporate subsidiaries market their products primarily through their parent corporations (or through higher-level business units within them) rather than directly to outside markets, and thus may be less likely than non-subsidiaries to experience changes in external benefits such as increased market share or access to new markets, which are primarily the concern of those at the corporate level. The corporation as a whole may well receive benefits from company-wide adoption, but these may not be as directly salient at the facility level. This possibility requires further investigation of the extent of subsidiary independence in marketing and other decision-making.

Facilities subject to customer mandates, conversely, might perceive internal benefits as being greater because for many these efforts might be their first foray into formal environmental management, or might at least represent a greater step forward. Many auto suppliers subject to automotive mandates to adopt ISO 14001, for instance, have had no formal system in place prior to those mandates (Hutson 2001). However, our data do not appear to show that facilities with customer mandates were less likely to have had pre-existing pollution-prevention or waste management plans, which could provide proxies for the presence of prior environmental management activities. Customer-mandated facilities might also report external benefits more frequently because unlike their counterparts who are corporate subsidiaries, they may be more likely to market their products to a variety of customers. In such cases, concerns about market share, competitive advantage, and plant/company image may be more salient at the facility level. This possibility also deserves further investigation.

CONCLUSION

Taken together, the findings we have presented in this paper point to three main conclusions for policy makers and business leaders.

First, broad environmental improvements should not be expected from the simple adoption of an EMS, either voluntarily or as a result of a business-to-business mandate (nor probably, by extension, in response to government rewards or other incentives). While adoption may be valuable as a tool for helping facilities to reduce regulatory violations, to better manage day-to-day activities such as recycling, and more generally to instill more explicit environmental management procedures and accountability, EMS adoption does not by itself lead to environmental performance improvements across a broader spectrum of performance indicators. Those interested in EMS as a tool for substantive improvement in environmental performance, such as reduced natural resource use or pollutant emissions, should concentrate instead on promoting specific performance improvements as EMS goals, and ensuring that these targets are achieved.

Second, the management benefits that facilities may gain from EMS adoption appear commensurate with their efforts to move beyond compliance and focus on "higher order" environmental goals such as eco-efficiency and product stewardship. For the business community, such results suggest that a serious commitment to environmental performance improvements may have economic rewards. Moreover, facilities whose environmental objectives represent a broad array of performance goals may achieve a wider array of benefits, both environmental and management, than facilities whose objectives are more narrowly tailored.

Finally, voluntary efforts at self-regulation should be complements to, not substitutes for, more traditional environmental regulation and enforcement by state and federal agencies. While environmental management practices may in fact deliver environmental performance improvements, particularly toward goals that are specifically targeted for improvement, facilities that were subject to recent inspections were more likely to report such improvements in performance indicators that are subject to inspection. The persistence of traditional regulation may therefore facilitate the effectiveness of self-regulatory efforts.

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APPENDIX I: PRIMARY VARIABLES OF INTEREST

EMS Formalization

In order to determine the degree to which a formalized environmental management system (EMS) was in place, respondents were asked to identify specific practices in place at their facility. Responses were evaluated and coded on a three point scale to measure the degree of environmental activity formalization. Environmental management activity formalization is summarized in figure 2.

Figure 2: Environmental Management Activity Formalization

Environmental Activity:	**Formal EMS**	**ISO Equivalent EMS**
adopted a written statement of environmental policy goals.	✓	✓
set specific environmental performance objectives.	✓	✓
planned specific, measurable steps to meet environmental performance objectives.	✓	✓
has a single manager who has primary responsibility for environmental management activities.		✓
trains employees in specific activities related to environmental aspects of their jobs.	✓	✓
has a procedure in place for identifying legal requirements.	✓	✓
regularly tracks and manages environmental **compliance** indicators.	✓	✓
regularly tracks and manages environmental indicators **other than compliance.**		✓
makes some environmental performance data available to the public.		✓
makes results of environmental performance available to employees.	✓	✓
has a formal procedure for documenting environmental management practices.	✓	✓
has procedures in place for responding to environmental spills or accidents.	✓	✓
periodically conducts top management reviews of environmental performance.	✓	✓
conducts regular **internal** audits of environmental procedures or conducts regular **external** (3rd party) audits of environmental procedures	✓	✓

System Objectives

Facilities were asked to describe the priority placed on written objectives at the site in order to gain insight into what impact specific goals of environmental activities might have on subsequent environmental performance. Facilities rated twelve statements on a scale of 0 (no objective) to 4 (high priority), and were grouped into four categories of potential EMS focus based on their responses (Gallagher, 2002).[13] Figure 3 illustrates the relationships between these constructs and the survey questions.

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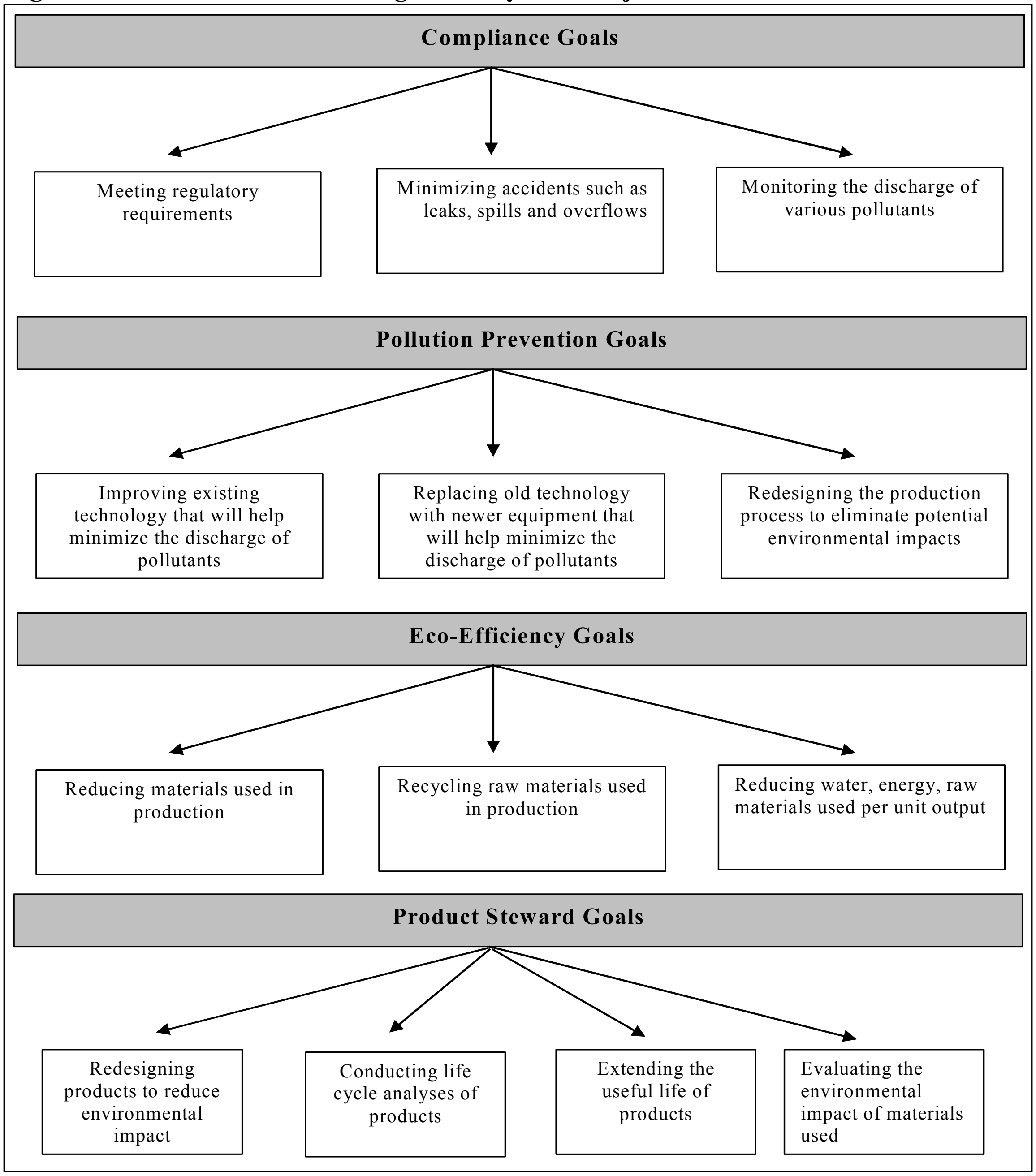
[13] Gallagher (2002) argues that a facility's EMS goals move along a continuum from regulatory compliance toward environmental sustainability. Within this paradigm, facilities with less aggressive goals place a narrow focus on achieving compliance goals while more enterprising facilities place an emphasis on goals that are progressively centered on pollution prevention, conservation of raw materials (eco-efficiency), product design (product stewardship), and ultimately consideration of the facility's impact on environmental quality for future generations (sustainability). While our data cannot confirm or refute a nested, directional, and cumulative relationship among the concepts in this typology, this categorization of facility EMS goals appears consistent with our observations.

Figure 3: Environmental Management System Objective Constructs



Business to Business Mandates

Because many manufacturing facilities have recently made the decision to adopt a formal EMS in the context of industry pressures, respondents were asked to rate the impact of customer and/or corporate pressures on the decision of whether or not to adopt an EMS. Facilities were coded into four mutually exclusive categories based on the presence of specific pressures from customers or corporate parents: no mandate, customer mandate, corporate mandate, and customer and corporate mandate. Dummy variables were created for each mandate category.

APPENDIX II: CONTROL VARIABLES

Endogenous Controls

Facilities that have developed a broad array of management competencies often extend these competencies to include the adoption of environmental management practices (Christmann 2000; Florida and Davison 2001; Darnall 2002; Andrews et al 2003). Specifically, firms that have previously acquired systematic knowledge in quality management and pollution prevention are better able to leverage these internal capabilities toward development of environmental management activities (Melnyk et al 1999; Corbett and Kirsch 2000; King and Lenox 2001). Accordingly, this study has included several control variables that take such management capabilities into consideration.

With respect to other specific management plans or systems, the survey asked respondents whether or not the facility had formal pollution or waste minimization plans in place. Facilities with either a formal pollution prevention or waste minimization plan were code 1, facilities with neither plan were coded 0. Similarly, facilities with a Total Quality Management (TQM) system in place were coded 1, facilities with no TQM system were coded 0. Whether or not the facility belonged to a larger organization was also considered. Facilities with a parent organization were coded 1, independent facilities were coded 0.

The length of time a facility has engaged in environmental activities may be an important consideration in environmental performance changes at the facility level. For instance, the "80-20 rule" argues that as a rule of thumb, 80% of environmental benefits can be reaped with 20% of the costs: generally the first environmental problems to be solved are the easiest and most visible. Such activities include recycling or pollution prevention practices, where facilities may be able to garner impressive improvements over a short period of time. Over time, however, the additional marginal benefits gained by reducing environmental impacts may be less than the costs of more fundamental changes that sustain prior environmental improvements. To control for the potential effect of time on environmental performance, facilities were asked how long the environmental management system had been in operation. Facility responses were evaluated and coded on a 0 to 4 scale where 0=no management system, 1=less than one year, 2=one to two years, 3=two to three years and 4=more than three years.

At the pre-testing phase of research, environmental professionals reported (through anecdotal observation) two additional factors that deserved attention. Both the general attitude a facility manager has towards environmental practices in place, and the degree to which employees of all levels are committed to them, may influence the effect of environmental management activities on performance outcomes. Accordingly, we included two additional control variables to account for the influence of managerial attitudes about, and employee involvement in the facility's environmental activities. Respondents were asked to rate five statements related to experience with environmental activities on a 0 (strongly disagree) to 6 (strongly agree) scale (Figure 4). The median response was used to measure the facility attitude toward its environmental management activities. The survey instrument also asked respondents to describe the degree to which five categories of employees and stakeholders were involved with environmental management activities. Respondents rated the involvement of the environmental manager/engineer, plant manager, non-management employees, contract service providers and interested parties/citizen groups on a 0 (not involved) to 3 (highly involved) scale. Facility responses were evaluated and the rating for each category of interested party was summed. The total score for each facility (0-15) measured the overall level of involvement.

Figure 4: Statements of General Attitude Toward Environmental Activities

Overall, environmental management activities have resulted in better risk management, improved company image, cost savings, and other benefits.
Overall, environmental management activities have added extra costs and consumed scarce resources without adding much value to our operations.
Overall, the more experience we have with our environmental management activities, the more opportunities we find for cost-effective improvements.
Overall, the more experience we have with our environmental management activities, the more it becomes just a paperwork routine.
Overall, the more experience we have with our environmental management activities, the more it becomes a strategic driver in our overall business management decisions.

Exogenous Controls

Factors outside the direct control of facility management may also affect environmental performance. The industry within which a facility operates is perhaps one of the most important such factors. Facilities operating in different sectors often have dissimilar impacts on the natural environment, face distinctive regulatory pressures, and have unique opportunities for environmental improvement. Industry dummies were constructed for each of the four sectors examined in this study.[14] Facilities in the chemical industry were used as the base category in this analysis.

Facilities that are owned by large, publicly traded corporations often consider environmental performance measures in corporate reports and assume pro-active environmental strategies due to pressure from shareholders and environmental groups. The analyses used dummy variables (ownership as publicly traded or privately held) to control for the potential effect of ownership status on environmental performance.

Backed by the power of state and federal governments, regulators have the power to command changes in environmental performance at the facility level. To control for the effect of regulatory pressure on facility environmental performance, we constructed three variables using data from EPA's IDEAS database. The number of inspections, number of non-compliances and the amount of fines at each facility during the three years prior to the study period were modeled. Two separate variables were used in the analyses depending on the indicator being modeled; for air pollution emissions only data from the AIRS database were considered, for hazardous waste generation only data from the RCRA database were considered. For all other indicators, each variable was summed across the AIRS, RCRA and NPDES databases.

[14] Facilities were grouped by four-digit SIC codes as reported in the EPA TRI database.

Within the United States, the degree of regulatory pressure to which manufacturing facilities are subject may vary due to differing state laws, rigidity of enforcement, industrial composition, and public attitudes towards environmental protection. To control for potential regional differences, we constructed dummy variables based on the EPA region (1-10) in which these facilities are located. EPA Region 6 (south central) was used as the base category in this analysis.

Finally, the complexity of facility operations may impact its environmental performance. Large, multi-faceted facilities may experience greater challenges in controlling the number and magnitude of their environmental impacts due to complex or diverse production processes. As a proxy for this aspect of facility operations, respondents were asked to report the total number of full-time employees at their site. Facility responses were evaluated and coded on a seven-point scale consistent with the U.S. Census Bureau's classifications for the 1997 U.S. Economic Census. The following scale was used for number of full-time employees reported by the facility: 1=less than 20, 2=20-99, 3=100-249, 4=250-499, 5=500-999, 6=1000-2499, 7=more than 2500.

Facility environmental performance was also considered within the management models since many of the hypothesized efficiencies are expected to accrue to the facility from an increased management of their impacts on the natural environment. More specifically, self-reported environmental data were included in four of the eleven benefit models. Figure 5 shows which variables were included within the specific models.

Figure 5: Inclusion of Environmental Performance Outcomes in Management Benefit Models

Model	Self-Reported EPI Included
Cost savings in terms of inputs or taxes	Water Use
	Energy Use
	Recycled Inputs
	Chemical Inputs
	Material Inputs
Avoidance of Non-Compliance Penalties	Legal Violations or Potential Violations
	Severe Leaks or Spills
Improved Company/Plant Image	Legal Violations or Potential Violations
	Severe Leaks or Spills
	Noise Generation
	Smell Generation
Improved Access to Capital Markets	Legal Violations or Potential Violations

Transcription of Session V Discussant Comments by Chuck Kent (U.S. EPA, Office of Policy, Economics, and Innovation)

Thank you very much. First of all let me say that all three of these papers I find fascinating and of great interest to my work. Let me describe a little bit about *what* that work is and *why* I'm so interested.

As part of the Office of Policy, Economics, and Innovation we attempt to—we try new ideas, we pilot projects, we pilot all kinds of proposals with companies, with states, and at the federal level. For example, we have a National Performance Track Program that incorporates some of the ideas that you are hearing here today in terms of focusing on performance, trying to get companies to articulate what they would try to improve over a period of time, and in what categories are they willing to measure their accomplishments against those items and share that information with the public and with the government, and so on and so forth.

We also decided to make that program partly dependent on having an EMS in place—an EMS not being the most important element of that program but a necessary condition to being a member, and the idea there was that it might provide a better sense of sustainability, of dependability, whether that company would continue to perform at a higher level. But, the kinds of things that we hear from the literature continue to raise questions for us in terms of: Is that program design the best that we can make it, and what does it have to say for future programs of this type?

Let me talk for a few minutes about each of the papers and then come back and talk about some broader policy initiatives that are under way and how this research might help us even further.

With regard to the first paper, I am fascinated by the look into the difference between perception and objective pressures on corporate decision making. Since my business is trying to influence the behavior of corporate decision makers, it's very interesting to me to understand better how they think and what causes them to do what they do. It looks like an enormously complicated enterprise, and I'm looking forward to the future iterations of this work. I am fascinated that there's apparently stronger pressure from private sector sources and corporate sources than even the community. That's a bit counter-intuitive to me, but in one respect consistent with the notion that what we're seeing, for example in Performance Track, is that where you have a corporate executive who chooses to go a certain direction with the firm, chooses to change the reputation of the firm and to do it in a visible way, *amazing* things can happen. In fact, it's so prominent a feature of the behavior that we're seeing that we are adding a component to Performance Track this year that will recognize the corporate level of commitment. Heretofore, the program has been designed at a facility level, just looking at performance and commitments at a facility level, and now we're actually going to recognize corporations that have chosen to do something at a corporate level and are pushing hard.

A couple of sort of minor comments, and I'm by no means the right person to comment on the methodologies and the elaborate statistical manipulations that are going on here. I've been out of graduate school since 1975, and I don't know most of these terms, but in terms of your Figure 1, Magali, on the right-hand side where you're talking about sort of the outcome that you're trying to monitor, your paper talks a lot about the emphasis on performance, but that figure only refers to whether there is an EMS in place. So, you might try to reflect the performance element on the right-hand side as the desired outcome. Also, I think it's generally acknowledged that TRI data don't always match up very well with some of the things that we're actually trying to—both what companies are trying to do with an EMS as well as the kinds of things we're trying to measure overall, but I don't think I need to dwell on that.

One other minor point is that as we look at what you call the *"proxies"* for something like community pressure, it seems to me that the ones that you ended up choosing are a bit remote. I know it's very difficult to find good measures of things like that, but counting the number of environmental lawyers in a community almost sounds like the beginning of a good joke, no offense to the study. I would hope that maybe there are more-direct measures of pressure that we could find ultimately—perhaps counting legal actions, complaints, hearings, --who knows? I'm also reminded that Bob Kagan's work has talked about the concept of social licensing, and I'm intrigued by that in relationship to this paper, and I'm actually surprised not to see a reference, since you're both from the University of California. So, you might want to think about whether that's relevant.

As the proud co-founder of the Environmental Studies Program at Santa Cruz in 1969, I'm pleased to see Santa Barbara and Berkeley and others all working together on these things.

So much for attempting to focus on data and methods, because I recognize that this is a very difficult task. I noticed in your histogram on stakeholders, Magali, "corporate management" seemed to be the highest influence; "regulators" was the second highest—you didn't talk about it, but the third highest was "employees." That caught my eye, because one of things I'm seeing—at this point, it's more anecdotal, but I've heard it referenced in certain literature and from corporate executives who use EMS's—and what they're finding is that one of the most interesting impacts of environmental management systems is the impact they have on employees' motivation, and thinking, and acceptance, sort of the legitimacy of the environmental agenda within a corporation. That's an interesting dynamic that I think deserves more attention, because it can be sort of a hidden force within a corporation, or even a small business, in terms of *how* the work gets done and the sense of *ownership* of environmental values.

But clearly your work at this point is showing strong business motivation as drivers for behavior, and, as I said before, the corporate pressure is something that I'm beginning to see and we're recognizing it in the design of Performance Track. So, I look forward to seeing future iterations of this work, and I commend you for handling such a large data set. I wish you the best of luck.

With regard to Deanna's work, I recall the first iteration of this a couple of years ago. In fact, as I recall, when you were presenting it, you were about to give birth as well, right? I'm wondering if Pete has something equally productive to show for his . . . [Pete Andrews interjected: "My first grandchild next month!"] There we go—there's another pattern we should take into consideration here.

I must say that the overall conclusion that there's no substantial difference in performance in this particular sector in response to an industry mandate is not a *huge* surprise to me. I've been personally skeptical about Ford Motors telling their suppliers, "you've gotta have this piece of paper by a certain date; otherwise, we won't buy your stuff," and what kind of behavioral modification that might bring about. Similarly, I have concerns about the role of government in terms of requiring that firms have that piece of paper and what kind of behavior *that* would induce. As you may know, EPA has been very cautious about requiring EMS's as part of our regulatory policy, and I'll talk more about that in a moment.

I am interested, as you pursue your work, Deanna, whether you intend to gather more information on the motivations of the individual companies as they apply the EMS in their own context—motivation other than the customer requirement—because I think that does have a lot to do with what *gets done* with the EMS. In fact, I kind of wish the microanalysis that you did, which I guess was of other companies, could have been focused on the same sector, because it would have helped us learn a great deal more about how they think. But, obviously, there were probably methodological reasons for that.

Minor points: I would ask you all to be careful about the language you use when you talk about EPA's voluntary programs. I think it's probably an exaggeration to suggest that voluntary programs are somehow *taking the place* of regulatory programs at EPA. They are certainly prominent and there are bunches of them. They're a little bit sloppy—as Jay may have talked about earlier today, we're launching a major initiative to try to add some considerable discipline to the design and management of voluntary programs at EPA. But, try to avoid the suggestion that voluntary programs are sort of taking over the world, because I don't see it that way.

In summary, I would say that we have a great interest in the motivational factors that drive a sector like the auto assembly sector. Particularly, we're interested in the effect of mandates. We, as an *agency*, are certainly *not* comfortable in focusing on the *how* over the *what*, because ultimately we think that, as tax payers, you're more interested in the *what*.

With regard to Pete's work, this is the second major piece of work from this study. We've followed Pete's work with great interest, and it has informed our thinking, as well, as we've designed programs at the Agency. We're particularly interested in his probing into the difference between a self-initiated EMS and a required EMS. I'm a little disappointed that so far the data really don't show much difference—that's just me wishing for something more useful out of that particular probe. But, I would hope that each of you would think about that and see whether there's more that you can draw out of your research and what you can tell us at EPA.

I *did* notice that the presence of a formal mandate, although it didn't appear to influence performance, generally, *where specific goals were set*, appeared to make a difference. This is a really important theme that I think we'll be hearing more and more about, and that is—and you've said this before, Pete—an EMS maybe serves better as a *window into* an organization, how they think and how they operate, than almost anything else. *If* you have a clear vision about what you want to accomplish, an EMS may, in fact, be a very useful tool for getting you there, but in and of itself, there's no magic in an EMS that's going to get you what you want. That ties into the major point that Pete made that *goals matter*. When you set out to do a compliance-focused EMS, what you get is better compliance, usually. When you set out to do eco-efficiency, you tend to get some of that a little better, and so on and so forth. And when you tackle something *big*, like stewardship, *surprise*—you get something bigger than you otherwise would. I find that very encouraging. To me, it should be part of the message to *all* of us, in government and in the private sector, who try to *use* these systems: let's not be bashful—let's go for something more dramatic.

Let me shift then to just a quick description of recent policy initiatives at EPA that relate to this work that you would want to know about and that you, in turn, can inform. On April 12th the Deputy Administrator signed a major new EMS strategy. It doesn't change our *policy*, but what it does is articulate first of all the set of principles that are pretty well stated already in EPA's position statements. But then we lay out, I think, six major policy ideas to *test*, and what we're responding to is a great deal of interest, particularly in several states around the nation, to try to incorporate EMS ideas and concepts into permits and regulations—and even at the federal level there's been quite a bit of discussion of this. So, what we're doing is trying to *channel* the thinking and the analysis along the lines of at least these six broad area policy ideas to test. I would have you at least be aware of those in your work and see whether you can help inform that debate as well. I won't read them all; Jon Silberman is here in the audience, and he was one of the major authors of this document, as well as George Wyeth and many other people at EPA. We will have that document on the web within days, I'm told. We do have one copy here, and Jon is willing to be the contact point for copies of this document. I would have you take a look at that—it helps clarify both the Agency's position and the things that we want to learn.

Finally, I just want to say that I'm the chair of an Agency-wide policy group on EMS, and we're trying to establish a *learning* kind of climate within the organization so that it's clear *what* questions we're trying to *answer*, it's clear what we would *do* with those answers, and try to incorporate those into the regulatory design of our programs.

Thank you.

Session V: Discussant Comments
Patrick R. Atkins, Alcoa

Introduction

Alcoa is a large company with over 385 manufacturing sites in 40 countries throughout the world. We have determined that an effective management system is a requirement for driving the appropriate systems and behaviors throughout our company to achieve our goals of excellent environmental performance and continual improvement. We have 160 companies certified to the ISO 14001 Standard and have a Global Certificate from BSI that recognizes that our corporate management systems conforms to ISO 14001. Locations can be certified to ISO 14001 under that global certificate.

We find that environmental performance does improve through the application of the principles of the 14001 EMS, and that our locations demonstrate continual improvement when the management system is utilized. The ISO process requires the locations to identify the activities at the facility that can impact the environment, prioritize those impacts and establish a plan and process to address the critical issues on a priority basis. Legal and other (corporate, community, customer, etc.) requirements also have to be identified and used in the risk matrix that establishes the priorities for the issues.

I believe it boils down this, (perhaps too simplistic a view): Businesses with good Business Management Systems and practices are able to leverage the ISO 14001 structure and get additional value from the process. Businesses that are weak in other Management areas have difficult with ISO 14001. GE and Toyota have found value from ISO 14001 because the whole organization understands the value of a proper executed management system.

With this background in mind, I offer the following comments:

Formalized Environmental Management Procedures: What Drives Performance Improvements? Andrews, et al.

Andrews concludes:

> First, broad environmental improvements should not be expected from the simple adoption of an EMS, either voluntarily or as a result of a business-to-business mandate (nor probably, by extension, in response to government rewards or other incentives). While adoption may be valuable as a tool for helping facilities to reduce regulatory violations, to better manage day-today activities such as recycling, and more generally to instill more explicit environmental management procedures and accountability, EMS adoption does not by itself lead to environmental performance improvements across a broader spectrum of performance indicators. Those interested in EMS as a tool for substantive improvement in environmental performance, such as reduced natural resource use

> or pollutant emissions, should concentrate instead on promoting specific performance improvements as EMS goals, and ensuring that these targets are achieved.

This seems to be a misunderstanding of the intent of ISO. The system itself is not the end product, the end product and value is the execution of the Objectives and Targets defined by the system. An organization should not put all their energy in the system but in the making the management activity work. This conclusion should be restated to emphasize that value is obtained when the intent of the standard is met. (This is more clearly defined in the ISO 14001:2004 revisions.)

He then concludes:

> Second, the management benefits that facilities may gain from EMS adoption appear commensurate with their efforts to move beyond compliance and focus on "higher order" environmental goals such as eco-efficiency and product stewardship. For the business community, such results suggest that a serious commitment to environmental performance improvements may have economic rewards. Moreover, facilities whose environmental objectives represent a broad array of performance goals may achieve a wider array of benefits, both environmental and management, than facilities whose objectives are more narrowly tailored.

I tend to agree. The goals and objectives have to have a long-range strategic component or the organization will lack direction and will make not make leaps of progress. However, this means that all stakeholders' definition of environmental performance improvement cannot be satisfied at once.

His third conclusion:

> Finally, voluntary efforts at self-regulation should be complements to, not substitutes for, more traditional environmental regulation and enforcement by state and federal agencies. While environmental management practices may in fact deliver environmental performance improvements, particularly toward goals that are specifically targeted for improvement, facilities that were subject to recent inspections were more likely to report such improvements in performance indicators that are subject to inspection. The persistence of traditional regulation may therefore facilitate the effectiveness of self-regulatory efforts.

I think an important point that is missing in this conclusion is the following: Significant aspects are controlled in the management system because they have a higher risk. A business focuses resources and attention voluntarily on ISO 14001 system objectives, which frequently supports compliance. State and Federal regulation of a site is not always risk based. Regulatory agencies and Business should align their efforts to ensure compliance. This can be address from both sides: State and Federal regulation should become more risk based, and Business should be able to obtain regulatory relief for well functioning management system.

Environmental Management Systems: Informing Organizational Decisions: Matthews and Lave

This is an ambitious effort to use several sets of data to measure environmental performance changes in facilities that have ISO certification as compared to the performance of facilities that have not been certified to ISO 14001. The researcher then attempt to use a survey technique to better understand why environmental performance improvement is not being seen

A major problem with this work in my opinion is it attempts to use nationally published goals as measures of EMS success…is this appropriate? Can it even be done, given the wide range of variables in such data, the recognized poor quality of the data in such data sets, and the many other variables that impact plant performances such as product mix changes, investment strategies by the corporation, process changes within the plant, etc?

Another problem appears to be a lack of understanding about how an ISO EMS is supposed to operate. The paper notes that each facility may choose the areas for reduction or improvement, but then claims that since EMS should provide for overall improvement in environmental performance, some relationship should be expected, and the timing of the work suggests to me that they expect this improvement in any and all environmental improvement parameters to be immediate (within a year of certification). This is certainly a high (and rapid) hurdle for measuring success, especially when the ISO system is not designed to perform this way. The results seem inconclusive, as I would suspect from the flawed study design.

The case study approach resulted in the conclusion that an ISO EMS may not be focused on the areas that are important to all the stakeholders…especially regulators. I agree with this conclusion. The authors then proposed that there are five elements that should be used to all environmental decision making:

- Process diagrams and material flows
- Quantifiable goals and targets
- Reliable data
- Risk assessment tools
- Environmental personnel collaboration and education

I contend that a good EMS will include these elements and much much more.
EMS must recognize how an organization operates and how best to achieve the goals and targets within the organizational systems that exist.
All stakeholders must be included in the management process…including communities, customers, suppliers, regulators, investors, employees and even the public at large.

Perhaps a more useful approach for the next effort would be to work directly with the auto company that were the subject of the first part of the paper to determine the true impacts of EMS on the business and the company's environmental performance

Institutional Pressure and Environmental Management Practice: Delmas and Toffel

This research relies on a questionnaire approach to gather information on the drivers behind environmental management practices. I am pleased to see that a great deal of effort was invested in the form of the questionnaire and the processes to extract and analyze the data. Such steps are critical in studies like this. I was disappointed in the return rate, given the degree of effort expended by the researchers. I think a higher response rate would make the data set more robust.

The study indicates that corporate and private pressures are more important than community/regulator pressures or customer supplier pressures. I am not in full agreement with this conclusion, and suspect that the data may have been biased by the level of people in the organizations that responded to the questionnaires. Often a person "in the trenches" at an operating location will have a view of the world that is a bit too narrow, and will provide responses that can place the focus on the clear signals from a corporate directive, when actually there are strong community and regulatory pressures that are also influencing the entire management structure of the location and hence the management system.

I suggest there be more focus on case studies as this work goes forward. Issues with the complexity of the question of performance drivers cannot be adequately addressed via questionnaires.

Summary of the Q&A Discussion Following Session V

Matt Clark (U.S. EPA, Office of Research and Development)
(relaying a question from William D'Alessandro, one of the remote participants, who addresses this question to the entire panel, but specifically to Dr. Andrews)
Stipulate for a moment that the following statement is a fact: ISO 14001 was battled over ferociously and ultimately approved to require companies headquartered in the U.S. to do *absolutely nothing* they were not already required to do by law and nothing they *chose* not to address. How well would this explain the findings of your work?

Pete Andrews (University of North Carolina, Chapel Hill)
Dr. Andrews said he did not dispute the point, but he also did not think it affects the usefulness of what companies are doing with EMS's or the work he and his colleagues are doing to try to clarify that. He stated, "A lot of the firms *are* choosing to do this, and so it becomes relevant and interesting and quite *important* for us to examine what, in fact, they do when they're doing it. Particularly where public agencies are now offering benefits for it, or encouraging it, our point is to point out that, depending on what goals companies choose to adopt, they can really get some *good* results—so they can get something that just, maybe, achieves better compliance but gets them *no* other business benefits, or if they focus on compliance, it may not get them better performance in other ways, or vice versa."

Jon Silberman (U.S. EPA, Office of Enforcement and Compliance Assurance)
Directing his comments to Dr. Andrews, Mr. Silberman said, "I couldn't help but think of Maslow's hierarchy of needs and his behavioral research for individuals when we were talking about compliance-based EMS's, and product stewardship, and e-Gov efficiencies, etc. I guess my question for you is: Do you think there's some kind of similar effect like that for EMS's, for example for companies that are unlikely to be able to reach higher levels of higher order goals until they first satisfy their lowest order goals, and maybe that's why some of these companies are getting compliance-focused EMS's? Would it be a natural progression, do you think, that they would move up along the continuum more towards the higher order goals over time?"

Mr. Silberman closed by stating that EPA believes "it's *much* better for EMS's to focus on higher order goals," and as evidence he cited the fact that the Office of Enforcement and Compliance Assurance has required only "26 total compliance-focused EMS's as adjunctive relief in settlements since 1993 in literally thousands of cases. We *really* try to save them for the companies that really are not able at all to manage their compliance."

Pete Andrews
Dr. Andrews responded, "In answer to your question, we've puzzled a lot about this and you may know the work of one of my former colleagues who is now teaching at Duke, Deb Gallagher, who has done some of the most detailed efforts to try to figure out whether these are, in effect, *nested* goals—if you'd start with compliance and move on."

He also said he'd be interested in hearing Pat's [Pat Atkins, Alcoa] reaction to the question, as "a voice from the industry sector itself." He added, "Certainly for the existing facilities we've looked at, it looks like some of that may be going on, but it may be historical," and he pointed out that claiming that an initial focus on compliance is a "necessity" for progressing to higher-order goals "would leave out the whole category of unregulated industries."

Pat Atkins (Alcoa)
Mr. Atkins commented, "I think one of the big issues is metrics, and compliance is a pretty good yes/no kind of metric and everyone can follow it, and I would equate it with safety and public-reportable injuries, a pretty good metric that everybody can understand, and it's easy to track and to report on. But, once you get that metric in place and begin to move beyond it, and start looking at healthy workforce or off-site accidents or the education of people on how to be safe in their own lives, it takes on a much broader impact on the company. I think that's what will happen with the environmental management systems—perhaps your first steps and objectives will be those that you can easily measure, and compliance may be one of those, particularly if you're in a highly regulated environment like the United States. And once you show progress in those areas, you will begin to grow your list of aspects and things will migrate upward in terms of impacts and risks of your business. So I think you're right—it will grow."

Michael Lenox (Duke University)
Dr. Lenox voiced his concern about the causality issue in Dr. Andrews' work, saying, "I'm a little worried—could it be that firms are in *ex-post*, justifying their objectives based on the benefits that they received or the behavior that they have created? But more importantly, are there some other kind of underlying factors that are driving both the objectives and then ultimately what happens at the end of the day, *or* is it a recommendation that we can give to other firms to simply adopt these types of objectives and then the outcomes will follow? Those could be very different prescriptions."

Dr. Lenox also commented on Dr. Andrews' suggestion that it would be great if all the firms with EMS's would disclose the data they are collecting to the general public. Dr. Lenox said that at first the idea sounded reasonable to him, also, but then he realized that companies required to disclose the internal data they collect for their EMS's might simply choose not to write EMS's, thereby defeating the whole purpose.

Pete Andrews
Dr. Andrews responded to the causality question by saying, "Remember, we didn't just ask them what their goal was—we constructed those from what they told us about actual changes they've made. So, I don't *think* that we're just getting an artifact in that sense. There may well be underlying factors of some sort. Clearly, there are a lot of other relationships we didn't talk about, such as, like others, we do see it affect prior practices like ISO 9000 and so forth. Clearly, companies that already have that management framework in place find it easier to piggyback and to model this into that larger integrative framework. Cary Coglianese and Jennifer Nash have done a lot of thinking

about the root underlying factors behind all of this, and I think there probably *are* some. But I *do* think that what we're trying to do—finding out "What effect *does* it make what people choose to focus on?"—in a sense, shouldn't be rocket science. The things they focus on are the things that improve—what gets measured gets managed—what gets chosen as objectives gets managed. That, to me, is simply reinforcing the point that it is what companies *choose* to do—what they prioritize and what they choose to really make the management system *work* for—that matters rather than just that they have this labeled management system in place. That's *reassuring* in a sense, but it also says, "Okay, so let's talk about performance and not just about using the EMS or the certification for *public* purposes as a proxy for good performance."

Regarding the second point that was raised, about disclosure, Dr. Andrews pointed out, "I'm trying to make a point that I wanted to really make a difference between what companies choose to do for their own purposes and what they choose to do for public benefits . . . There's a larger interesting conversation going about: many companies now *do* produce environmental reports, but there's no comparability, there are no standards for them, and so forth, so they become, basically, PR exercises. There is an attempt, the Global Reporting Initiative—there may be some other attempts as well—to create a more standardized basis, partly on the grounds that it may be in the company's own interests to do that. As you get more folks—you know, social-screening funds—barraging you with questionnaires every year, all different, and so forth, it might even be beneficial to them. But it *certainly* would be beneficial to the *leaders* to have a common set of data. It may not do everything, but let's have common, comparable kinds of data that would be worth having. In that sense, disclosure is a larger conversation than EMS. I certainly wouldn't say that we ought to drive them away from doing EMS by requiring them to disclose everything in the EMS. But, if they're trying to come to EPA or to a state agency and say, "I'm a good environmental steward, so I want flexibility or I want a prize for it, such as a governor's recognition award," I'm saying let's not just talk about whether you have an EMS. If you say you have an EMS, it means that you've thought about this—you're achieving these performance changes—let's talk about what you're achieving and focus on the performance."

Dinah Koehler (University of Pennsylvania)
Dr. Koehler commented that she thought Dr. Andrews had concluded "somewhat wistfully" that "Gee, wouldn't it be great if they were to make serious capital investments in product changes and process changes." She said that led her to "think that perhaps we're expecting too much of an ISO standard." She challenged the entire panel to consider what exactly can be expected from ISO 14000 and she wondered what has been learned from ISO 9000 that might help. She closed by asking, "Are we to expect these leaps or will we just see incremental, tiny changes in whatever outcome measure we think we're looking at, as a function of some quality management system?"

Magali Delmas
Citing her experience, Dr. Delmas said, "When you talk to environmental managers, they will tell you that it takes several years before they see any improvement, and that actually

was the case with 9000—it would sometimes take 4 years. At first you would get more information, actually, about how much emissions . . . and then they make progress 4 to 5 years down the road, so maybe what we are observing right now is that it's just too early to say *anything.* Facilities started adopting ISO 14000 here in the U.S. in 1999, and the majority—the big wave—was in 2000. So, it's really early to say anything. We should just be more positive and wait a little bit more before drawing negative conclusions."

Deanna Matthews (Carnegie-Mellon University)
Dr. Matthews stated, "I think your comment that maybe we're expecting too much from ISO 14000 might be a good way to phrase it, but perhaps some on the management side have looked at this as—going back to the signaling issues—this is something that we just need to do for business, and, thus, we're not really going to see any change in performance. If that's so, then policy makers and business managers do need to look at it from a different perspective and figure out what they need to do to make the big changes. As Pat says, ISO 14000 is *not* the end product—it is trying to get it into that strategic element of business strategy that's going to give the capital projects that are going to change the processes that are going to make the *big* steps in how facilities improve. I could reflect on some of Alcoa's goals for their 20/20 Vision that *are* technology dependent, that are built into the long-term strategy and not simply based on an individual plant having ISO 14000 or an EMS."

Pete Andrews
Dr. Andrews gave "a couple of quick responses," saying, "I think that's right. First of all, ISO 14001 was one of the largest suite of ISO 14000 guidelines, guidance documents, and so forth for business. I don't know if anybody's ever even looked at the question: Do companies that have ISO 14000 *care* at all about the other ISO documents. Do they use the other documents to inform this toward a larger strategic process? I haven't seen it, and I'd be interested but surprised if it were happening. I think so much attention has been focused on 14001, because it's *certifiable* and so forth, that that's happening. It *might b*e that it just takes longer, but more likely, I think, is that we've all been looking at the facility level, and it may be that the real changes don't happen [at that level]. What happens is one facility, at some point, gets out-competed or outmoded and gets closed down and the production goes to some more-modern facility somewhere else. That's not something that the facility manager is going to tell you about at that facility, and it's either happened or not."

He concluded by saying, "So, I think ISO 14001 *is* valuable for mainstreaming environmental considerations—again, you may be right, Deanna, that it's not happening at the facilities you looked at, but I think it is happening at some others, and to the extent that it *does* mainstream these considerations . . . into the job description of other managers, it *can* help at the margin, with managing a particular facility, but I do think it is process-based and we need to look to some larger processes as public policy experts or people who care about actual environmental performance outcomes . . . how do we *really* reduce large-scale environmental impacts?"

Monica Araya (Yale University)
Dr. Araya directed her comments to Dr. Delmas, saying, "We all agree that it's difficult to capture that action [i.e., the role of activists] in an empirical picture. My impression is that monitors are saying that those activists in communities are not the reason they are doing this. . . . My question is: Do you think that their perceived reasons for engaging in environmental management systems should be taken as the reason why they do it? The reason why I'm asking this is because in the area I work in, which is corporate environmental reporting, companies sometimes say they are reporting because of internal reasons, but, in practice, they are doing it because of actions that are coming against them. So, the fact that they don't mention that in a survey doesn't mean that it is not happening. So, could you in your study come up with a way of capturing this by taking companies that have a corporate mandate and companies that do not and see how they react to external pressures?

Magali Delmas
Dr. Delmas asserted that she thinks "it's really important to have objective measures and survey measures *together*, so here what we are trying to do is to see how can you assess community pressure objectively and how do environmental managers perceive this pressure, so we will be able to look at the difference with this. . . . So we will be able actually to compare both to be able to see the distance between perceived and objective pressure.

Glenn Farber (U.S. EPA, Office of Solid Waste and Emergency Response)
Dr. Farber stated, "My office often maintains that minimizing waste or other kinds of environmental compliance or performance improvements provide business benefits, even if it's only reducing the burden that we ourselves have imposed in the first place, but I've never heard that associated with product stewardship, and I was *surprised* by your result, Pete, that showed business benefits deriving from EMS's that had product stewardship as an objective. I was wondering if you found that surprising as well."

Pete Andrews
Dr. Andrews responded, "We're interested in it, too. We'll try to figure it out."

Corporate Environmental Behavior and the Effectiveness of Government Interventions

PROCEEDINGS OF

SESSION VI: INFORMATION DISCLOSURE

A WORKSHOP SPONSORED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY'S NATIONAL CENTER FOR ENVIRONMENTAL ECONOMICS (NCEE), NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH (NCER)

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4700 Falls of Neuse Road, Suite 350, Raleigh, NC 27609

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DISCLAIMER

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Information Disclosure and Risk Reduction: The Sources of Varying State Performance in Control of Toxic Chemical Emissions

Michael E. Kraft
kraftm@uwgb.edu

Troy D. Abel
abelt@uwgb.edu

University of Wisconsin-Green Bay
Green Bay, WI 54311

and

Mark Stephan
stephanm@vancouver.wsu.edu
Washington State University, Vancouver
Vancouver, WA 98686

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Abstract

This paper reports on initial findings of a research project that examines the effects of information disclosure policies on environmental decisionmaking, specifically, actions related to control of toxic chemical emissions in the United States. The project seeks to determine why some companies do more to reduce toxic chemical pollution than others and why some communities encourage such pollution reduction more than others. Ultimately, we will try to identity the variables that most directly affect pollution reduction and by implication improvements in public health.

Theory: We examine state trends in reduction of toxic chemical emissions through two theoretical frameworks: the lens of comparative state environmental policy and a perspective derived from the politics of information disclosure. We hypothesize that state environmental release and waste reductions are a function of: (1) population size and economic prosperity; (2) state policy resources; (3) the structure of environmental and industrial interests; and (4) state political liberalism. Method: Ordinary Least Squares regression is used on data representing trends in reported releases and production-related waste of 11,353 facilities between 1991 and 1997. Results: Consistent with theories of information disclosure politics, the level of conservation group membership is the most influential factor influencing a state's ratio of firms reducing toxic releases to firms increasing them. States with less ideologically polarized politics also tend to host more release reducers than increasers. However, multiple regression models could only weakly account for trends in production-related waste. These findings reinforce our longer-term goal of incorporating sub-state level analysis (quantitative and qualitative) in an effort to explain the patterns of toxic chemical releases and the effect of information disclosure policies.

Since the 1980s, information disclosure policies have emerged as one of the more promising alternatives in the public policy repertoire. Considerable confidence has been expressed in their utility and potential impact in achieving diverse societal goals: corporate financial responsibility, food safety and nutrition awareness, drug safety, auto safety and fuel economy, accountable campaign financing, and environmental protection, among others (Graham 2002; Weiss and Tschirhart 1994). As a policy approach, information disclosure represents what Schneider and Ingram (1990, 1997) refer to as capacity building tools, that is, policies or programs that aim to inform or enlighten and thus to empower people to act on their concerns. These tools are attractive in part because they may complement or replace government regulation, thereby reducing the costs and burdens often imposed by enforcement of regulatory standards. They also are consistent with widely held values promoting citizen access to information in a democracy, captured in the phrase "right-to-know" (Hadden 1989). In addition, they reflect conviction on the part of many analysts that new policy strategies may improve both public and private sector performance, particularly in areas such as environmental protection, where emphasis is placed increasingly on community-level action to promote public and environmental health (Mazmanian and Kraft 1999; National Academy of Public Administration 2000; Portney 2003; Sexton et al. 1999; Tietenberg and Wheeler 1998).

Despite their widespread use, there has been little systematic inquiry into how information disclosure policies actually affect corporate or community decisionmaking, and how they might be designed to maximize their effectiveness—for example, in the way information is communicated to the public and actions that could improve the public's capacity to understand and use the information. The development of training programs in use of such data is one example.[1] As one prominent illustration, the federal Toxics Release Inventory (TRI) program authorized by a provision of the Superfund Amendments and Reauthorization Act (SARA) of 1986 often has been cited as a success story in dissemination of information about releases of toxic chemicals by industrial facilities. Title III of SARA created the Emergency Planning and Community Right-to-Know Act (EPCRA), section 313 of which mandates that manufacturing facilities report their annual releases of listed toxic chemicals to the EPA; the agency in turn makes the information public.[2] The information is available in an online database that can be accessed by the public and stakeholders, and summary statistics are provided in a TRI Public Data Release report each year. In addition, some environmental groups, most notably Environmental Defense, make the data available online in a variety of graphic formats that allow community residents to assess what each industrial facility in their communities is emitting (www.scorecard.org).

The TRI program has been evaluated positively because of its appearance of effectiveness. Indeed, the EPA itself calls it a "tremendously successful program," the results of which "speak loudly for themselves" (U.S. EPA 2002a).[3] The agency comments refer to the dramatic reduction since the late 1980s in the volume of toxic chemicals released by manufacturing facilities reporting under the program. Positive conclusions about the program's utility are reached even when observers acknowledge that most of the reductions in chemical releases occurred during the first five years of the program and that current volumes of releases remain quite large and continue to pose a significant risk to public and environmental health (Press and Mazmanian 2003). Still, it is easier to document reductions in the release of such chemicals than it is to explain the mechanism by which these reductions have occurred since the late 1980s, or to anticipate how future reductions in emissions might occur if such disclosure policies remain a major component of federal and state environmental protection efforts (Stephan 2002).

As Graham and Miller (2001), among others, argue, the overall reductions in release of toxic chemicals reported in the TRI require careful interpretation in light of the complexity of the reporting system, major changes made to it over time, and the multiplicity of variables that can affect corporate environmental decisions. They note, for example, that reported decreases in chemical releases "mask widely varying trends in major manufacturing industries" (15). It is apparent that economic factors affecting particular industries, new regulations or enforcement actions by federal and state regulators, and decisions made by managers of particular facilities with large releases can significantly affect the national trends on which analysts usually focus (see also Natan and Miller 1998).[4] The EPA itself regularly includes comparable warnings in its annual TRI report on the "limitations that must be considered when using the data"; these include the widespread use of estimated rather than actual data on chemical releases and significant variation among companies in the way they estimate such releases (U.S. EPA 2002a, ES-13).

One conclusion is that to understand the way such information disclosure works, why it is successful (or not), and its potential for the future requires analysis that is directed at state-level trends and especially at decisions made in specific communities that are located near facilities producing large quantities of toxic emissions or emissions with high risk levels. Even here, however, interpretations of the data differ. The EPA has been quite optimistic about the way the TRI data are likely to be used by governments and citizens at these levels, as indicated in the following statement from the press overview that accompanied its 2002 TRI report:

> Governments—federal, state, and local—have used the TRI to set priorities, measure progress, and target areas of special and immediate concern. The public, our most important customer, has used the TRI data to understand their local environment, to participate in local and national debates about the choices being made that may affect their health and the health of their children and, ultimately, to exert their influence on the outcomes of these debates (U.S. EPA 2002a, 1).

Many analysts seem to agree with the EPA's assessments. They argue that use of the TRI information has "contributed significantly to community organizing efforts to change facility emission behavior" (Bouwes, Hassur, and Shapiro 2001, 2). Similarly, a survey of corporate leaders found that over half acknowledged that "pressure from community activists" has affected their companies' behavior, sometimes leading to a reduction in chemical pollution (cited in Bouwes, Hassur, and Shapiro 2001).

A common argument, captured in a recent report by EPA analysts, is that public access to information "can drive change more effectively than regulations alone," and that the release of such information "can help to empower community residents, heighten industry accountability to the citizenry, and support efforts to ensure environmental justice" (Bouwes, Hassur, and Shapiro 2001, 1). The authors do state clearly that availability of data is a necessary but not sufficient condition to achieve such goals. Beyond use by such activists, state and local agencies use TRI data in developing emergency planning procedures, formulating legislation, and monitoring toxic waste. Many states also have supplemented EPCRA with their own right-to-know legislation and regulations, and some mandate reduction in a facility's toxic emissions.

Even with such qualifications, we wonder whether the confidence in the use of TRI data expressed by the EPA and others is fully warranted, particularly as such use applies to citizens and stakeholder groups at the community level. For most of the life of the TRI program, these citizens and groups worked with data that reflected only the total pounds of chemical releases, not a more meaningful indicator of public or environmental health risks (that is, information about exposure and toxicity). Some scholars have expressed somewhat similar reservations about the effectiveness of voluntary pollution reduction measures adopted as an alternative to conventional regulation, where companies may lack the incentives to do as much as they would under a regulatory regime with consistent enforcement of the law (e.g., Harrison and Antweiler 2003). Only empirical research can adequately address these concerns.

These observations lead us to some basic questions that need to be asked about information disclosure policies of this kind. We focus on environmental policies, but the questions are equally applicable to other forms of information disclosure. How does the collection and dissemination of such information bring about a change in corporate behavior that leads to a reduction in the amount of toxic chemicals released to the local environment? What specific changes in incentives occur as a result of such policies that might lead corporate officials to alter manufacturing processes or take other actions to reduce releases of toxic chemicals?[5] What are the effects of information disclosure on communities themselves, specifically on the level of attention paid to and concern over chemical risks in a local area? What efforts do public officials, community leaders, environmental and health groups, and others make to try to reduce emissions by local industry, and how effective are those efforts?

Our larger research agenda includes the building of a framework for understanding the effects of environmental information disclosure on corporations and communities, using the case of the federal TRI program. The research seeks to answer two major questions: What effect does the release of information about pollution output have on decisionmaking by corporate officials, community leaders, and representatives of local and regional nongovernmental organizations, and on environmental quality outcomes? What factors mediate the use of such information and thus condition behavioral changes and the environmental outcomes they produce?[6] If those questions can be answered, we hope to be able to determine which components of the TRI are most likely to affect behavior, in what ways, and why. That knowledge should add to our understanding of how the processes of environmental information disclosure work within both a corporate and community setting, and how they result in improved environmental outcomes. There are important implications for the design and implementation of information disclosure policies, and for the TRI program in particular.[7]

The Analytic Framework

A rich body of work exists on the emergence of non-regulatory measures for businesses and communities that are aimed at increasing public involvement as well as the dissemination of information (Dietz and Stern 2003). However, these studies give little attention to factors normally considered from a political science perspective that can help to explain the relationship between environmental performance in industrial facilities and decisionmaking within surrounding communities (Stephan 2002). We hope the project will help to fill that void by integrating a number of different theoretical perspectives that bear on non-regulatory environmental decisionmaking into a useful analytic framework.

These perspectives are drawn from studies of (1) risk perception and communication (where variables such as trust in the source of information, a capacity to understand it, and surprise or shock upon release are important); (2) organizational behavior (for example, corporate embarrassment or shame when emissions data are released, and internal firm characteristics that affect action on chemical risks); (3) transaction costs in acquiring and using information (disclosure policies may reduce the cost of information for citizens and thereby encourage a higher level of participation); (4) environmental justice (inequities in the distribution of chemical risks and economic benefits, the likelihood of variable levels of citizen action in communities with different racial and economic profiles); (5) political agenda setting (new information may alter the way problems and potential solutions are viewed as well as their saliency); and (6) policymaking processes at state and local levels (such as different capacities among states and communities to take action on environmental risks).

For the present paper we outline the framework only briefly because we focus below on one component of firm environmental performance in the fifty states. One dependent variable is a state's ratio of TRI facilities that reduce production related waste to the number of TRI facilities that expand production related waste. Another is the ratio of TRI facilities that reduce their total releases to the number of TRI facilities that expand their total releases.[8] A third is the ratio of facilities that decrease both releases and production related waste to those that increase both. We seek to explain variation among the fifty states in these measures of environmental performance. We do so partly because theory suggests that state variations do matter and reflect relevant differences across states (see the literature review below). In later papers, we will examine the related dependent variable of actual reduction in health risk to exposed populations using the U.S. EPA's RSEI model discussed in note 1.

The key assumption in our working model is that TRI information disclosures affect community and corporate decisionmaking through an alteration in risk perception and a change in environmental beliefs and values. That is, the release of such information is likely to affect the way corporate officials and community residents think about environmental and public health and the value they attach to them. It may be that the information enhances knowledge of previously uncertain health risks, that it conflicts with established expectations of industry behavior or community health, or that it raises the saliency of these issues. The new knowledge and attention given to it within both the corporation and community may also raise levels of concern, propel the issues to a higher status on corporate and community agendas, mobilize community leaders and activists, and as a result spur action to reduce emissions. How the information releases, the environmental risks themselves, and the associated corporate and community actions are covered by local media should be a significant variable as well.

Decisionmaking within a corporate setting and within a community obviously is complex and is affected by many factors (including, as reported here, state differences). For example, pollution reduction by companies may come about because of the actions of green investors and consumers who cajole them to change their ways, pressures from the local community and interest groups, competitive business practices (including perception of liability), shared learning within the industrial sector, the development of new technologies, efforts to forestall anticipated regulation through voluntary action, or calculations that the benefits of reducing releases of toxic chemicals exceed the costs (Harrison and Antweiler 2003; Press and Mazmanian 2003). Some companies may engage in what appears to be voluntary reduction in release of toxic chemicals but which in reality is part of the firm's compliance with what it believes to be (or soon will be) required by federal or state law.[9]

We will explore many of these possibilities during the field work stage of the project when interviews will be conducted with corporate officials and community leaders and activists. For this paper, as noted, we focus on variation in facility performance across the fifty states. We distinguish facilities that decrease production-related waste and toxic chemical emissions (and thus risk) from those that show an increase in either and we look for patterns across the states to help explain these variations.

As indicated in Table 1, this dimension is one of two that can be used to distinguish the states by placing them into four categories: greening, browning, safer but still dirty, and cleaner but riskier. The x-axis represents a continuum of production-related waste where facilities on the left-hand side increase waste. If they decrease waste, they progress to the right side of the axis, towards cleaner production. A continuum of risk runs along the y-axis, with facilities that increase pollution risks on the bottom. If they reduce risk, they progress upwards towards safer production. When facilities reduce both production-related waste and pollution risk, they move from the lower-left to the upper-right, reflecting an ideal case of cleaner and safer production. As discussed above, we will fill out the typology in a related paper that will include estimates of actual risk reduction using EPA's RSEI model.

Industrial Pollution and Environmental Decisionmaking Within and Across States

That states vary in pollution production, management, and reduction, is not really in doubt. However, scholars have tried to explain why some states do more than others to manage or reduce their toxic pollution levels (including hazardous waste production), and why some states see marked improvement in pollution control, while other states do not exhibit the same success (Bacot and Dawes 1997; Grant 1997; Lester 1983; Lester and Lombard 1990; Potoski and Woods 2002; Ringquist 1993; Williams and Matheny 1984; Yu et al. 1998). Some common themes have emerged over decades of work.

Research that seeks to improve understanding of *state-level policy choices or priorities* (as defined by regulatory decisions or budget expenditures) has focused mainly on whether policy has more to do with political factors (such as interest group strength), administrative capacities (both in terms of fiscal health and organizational capacities), or the severity of the pollution problem. Results have varied, suggesting at the least that multiple factors help to shape the choices made by states. For example, some studies have found that pollution severity is itself a significant influence on state choices (Bacot and Dawes 1997; Lester et al. 1983; Ringquist 1994), while others have had mixed results (Potoski and Woods 2002) or found no such evidence (Lombard 1993; Williams and Matheny 1984). A variety of studies have suggested that administrative or state capacity is critical, whether the factor is measured by a consolidated environmental bureaucracy (Lester et al. 1983), state size (Potoski and Woods 2002), or the level of professionalism of state legislatures (Lester et al. 1983; Ringquist 1994). In contrast, Lombard (1993) suggests that federal actions may be more critical to state decisionmaking than state capacity factors. In particular, state enforcement activity may follow closely in the wake of federal enforcement action, regardless of other state-level factors.

The most contradictory results relate to political factors, with some research suggesting that the strength of interest groups or political parties is critical (Bacot and Dawes 1997; Ringquist 1994; Sigman 2003; Williams and Matheny 1984), while others present findings that undermine this thesis (Davis and Feiock 1992; Lester et al. 1983; Lombard 1993). In one of the most interesting studies to date, Potoski and Wood (2002) find evidence that suggests political factors influence some state policy choices, but not all, and that different types of environmental programs will have different sets of drivers. They conclude that programs "that allocate resources may be influenced primarily by the interplay of affected interests within the larger political environment"(211). Because different environmental arenas tend to draw different interests, we should not be surprised that the significant factors vary. Another potential political variable is state opinion liberalism which may have an indirect affect on state choices by influencing the strength of interest group and party behavior (Erikson, Wright, and McIver 1989; Ringquist 1994; Wright, Erickson, and McIver 1987).

Research focused on understandings *changes in industrial pollution levels over time* has tended to focus on factors such as regulatory pressures, non-regulatory pressures (e.g., information disclosure programs), and industrial practices. Ringquist (1993) finds that the stringency of regulation has a significant and negative relationship to sulfur oxide (SO_2) and nitrogen oxide (NO_x) emissions. In a related vein, Yu et al. (1998) find that as the direct regulation of pollution emissions increases, the levels of emissions fall over time. Research also suggests that variations in state-level information disclosure programs are related to changes in emissions. States that fund information disclosure programs (Grant 1997) and extend their outreach to affected communities (Yu et al.1998) are able to reduce toxic emissions, even when controlling for factors such as industry production levels, state wealth, and enforcement activities.

Regulatory and non-regulatory actions can also move in tandem and interact in important ways (Yu et al. 1998). To use Schneider and Ingram's (1997) "policy tool" terminology, it may not be a question of whether "informational tools" are better or worse than "authoritative tools," but rather the extent to which both may together have an impact on pollution levels. Though shifts in industrial practices attributable to technological updates or economic changes undoubtedly have an affect on pollution levels (Stephan 2003; Yu et al. 1998), the extent to which these occur as exogenous pressures remains unclear. Arguably improvements in pollution levels may in turn help to spur the spread of technological practices and may help revive states dealing with economic downturns.

In sum, previous research suggests a multi-faceted examination of the policy relevant factors which may influence changes in industrial pollution over time. Key categories of variables include both political and administrative factors. Regulatory and non-regulatory variations across states are potentially critical and cannot be ignored. Finally, control variables--such as the severity of the problem--must be included in order to better assess whether policy choices are proactive or reactive.

Data and Methods

EPA's online TRI Explorer (www.epa.gov/triexplorer) provided facility-level data for this study's dependent measures. To characterize state-level TRI trends, the study analyzed a sample of facilities (11,353) reporting in both 1991 and 1997 and their changes in reported releases of toxic chemical pollutants as well as production-related-waste (PRW). The PRW is the sum of all toxic wastes generated across a firm's production processes that a facility reports as recycled, recovered for energy, treated on and off-site, or released on and off-site. The year 1991 was selected because it was the first year in which PRW was reported in response to the 1990 Pollution Prevention Act. We end with 1997 because it was the last year for which the EPA's first version of the RSEI model included facility-level data. We will extend the period covered in later work. The sample included only the 1991 core chemicals to assure consistent comparisons of facility-level toxic chemical management across the two years.[10] These facility characteristics were then aggregated to explore state-level factors related to environmental waste management changes. However, ten states were excluded from the analysis because their relative smaller concentrations of TRI facilities distorted statistical comparisons.[11]

Candidate independent variables encompassed state measures of *policy*, *politics*, and *resources* (see Table 4). No single variable was critical in our initial data gathering. Rather, we sought to identify a set of interrelated clusters of variables that captured our understanding of what the literature suggests are the compelling factors in driving state differences.

A set of state *policy* measures were obtained from Bob Hall and Mary Lee Kerr's *1991-1992 Green Index*. Their index of "state policy initiatives" encompassed 73 different policies, and we included this broad measure while also breaking out some of its subcomponents that addressed toxic waste. Specific policy measures included the presence or absence of a state program promoting access to information about toxic chemical usage and releases, the imposition of fees that support community right-to-know (RTK), and laws requiring toxics reduction plans and reporting. Another variable was included: a measure for state spending on air pollution per capita. The policy measures were intended to capture the extent to which states have policies, programs, and budgeted funds in place to deal with pollution.

Political variables included several measures from Erikson, Wright, and McIver's (1993) work. Their composite index of policy liberalism was included, as were measures for state partisan identification (whether citizens lean Democratic or Republican) and ideological identification (whether citizens lean conservative or liberal). Further variables included a measure of mass ideological polarization (the extent to which party members in a state contrast ideologically with the members from the opposing party) and measures for Democratic/Republican elite ideology (the average ideological stance for party leaders in the state). Beyond these "statehouse democracy" variables, separate measures were used for the number of members of conservation groups, community improvement or capacity-building groups, and philanthropic groups (all per 1,000 population) to further understand the role of interest groups, both state-level and local. In sum, the variables were meant to capture the extent to which political forces both within and outside of state governments might either directly or indirectly influence pollution reduction.

Our *resource* variables were meant to serve as controls. Our intent was to avoid attributing to policy or politics what may have more to do with demographic or economic differences across states (although the three categories of variables are intertwined to some degree). Population, poverty, unemployment, and income measures all came from the U.S. Census**.** Following Potoski and Woods (2002) and Ringquist (1993, 1994), we included measures of industry group strength, such as the value added by manufacturing (as a percentage of the state's gross product) associated with state firms most responsible for air pollution.

Results

Forty-one percent of facilities (4,655) reported reductions in chemical releases and reductions in production related waste, while thirty-four percent of sampled facilities increased both (see Table 1). On average, 41% of a state's facilities achieved both pollution and waste reductions, with the top percentile occupied by North Carolina, Maine, and Connecticut, which had more than 48% of their TRIs moving towards safer and cleaner production.[12] A second group of state performers included New Hampshire, Delaware, New York, Virginia, New Jersey, Massachusetts and Rhode Island, which saw more greening TRIs than 75% of their peers. Lagging states, where less than 37% of TRI facilities achieved pollution and waste reductions, included Kentucky, Georgia, Utah, Michigan, Louisiana, and Maryland. Arizona and Tennessee hosted the fewest TRIs moving towards greener production, with less than 32% reducing waste and releases (See Table 2 and Figure 1). Table 3 presents state TRI aggregations for total facilities, the percentage reducing both waste and pollution releases, and the ratio of waste and release reducers to increasers.

While states, on average, saw more firms reducing releases than increasing them (134 to 99, respectively, or a ratio of 1.41), the opposite was true for production-relate waste trends. An average of 126 firms per state were managing more hazardous waste in 1997 than in 1991, while 119 saw, on average, less PRW (see Table 4). These figures suggest that the TRI program is perhaps not as successful as many have assumed it to be. Much depends on which indicator one selects for analysis. As we show here, substantial decreases in overall emissions can occur at the same time that many firms are increasing production-related waste. More recycling or energy recovery may be occurring but firms can move closer to clean production with source reduction.

Bivariate correlations for a variety of socioeconomic, policy, and political measures (listed in Table 4) on two sets of dependent variables (state concentrations of release and waste reducer facilities) yielded a diversity of expected and unexpected patterns (see Table 5). As previous research would suggest (Yu et al., 1998), informational tools in the form of state Right-to-Know (RTK) initiatives produced a moderate correlation with the ratio of firms in a state reducing production-related waste (PRW). However, an unexpected negative correlation appeared between PRW reduction ratios and an index of state environmental policy initiatives. The percentage of a state's firms reducing PRW also produced a negative correlation with unemployment trends. However, because the variable was operationalized as the difference in unemployment percentages from 1990 to 1996, higher positive values meant more job losses and the negative correlation meant reductions were associated with unemployment decreases.

Similarly, a state's concentration of firms reducing toxic chemical releases also yielded a negative correlation with unemployment increases and the index of state environmental policy effort. Additional positive correlations between release reducer concentrations appeared with environmental conservation membership levels, state ideological identification, a composite index of policy liberalism, and, unexpectedly, with Republican elite ideology. These patterns are somewhat consistent with findings in the comparative state policy literature. A slight variation appeared when the release variable was operationalized in percentage terms instead of a ratio. State partisan identification emerged with a significant correlation while no significant relationships emerged for policy liberalism or Republican elite ideology.

When our comparison measure was the sheer amount of toxic releases, bivariate correlation patterns mirrored relationships indicative of the states' size, and therefore their pollution levels (see Table 5). The strongest correlations appeared between 1991 release levels and population, Manufacturing Gross State Product, and Air Polluters Gross State Product, while moderate relationships appeared with state poverty levels and the number of community and foundation groups. Conservation group membership density, on the other hand, produced a negative correlation with total release levels. On a measure of release trends, the correlations again produced a pattern reflecting the influence of state size, with positive relationships appearing with population, manufacturing GSP, and air polluters GSP. Finally, when the percent change relative to a state's 1991 release amount base was examined, only the index of state pollution prevention effort and conservation membership density produced significant negative correlations.

In the next phase of the study, the correlation analysis and our theoretical framework guided the exploration of multiple regression models of environmental waste and release reductions using ordinary least squares (OLS). Since our key dependent variables are interval measurements, OLS is an appropriate statistical estimation technique. An initial analysis was performed with all of our candidate predictors, although it was clear that issues of multicollinearity made this model inappropriate.[13] Candidate predictors were eliminated if they presented multicollinearity problems or they were dropped through a series of likelihood ratio tests for variables that had a consistently low impact on the model. Combinations of independent variables from each theoretical grouping (policy, politics, and resources) were followed with the calculation of a Variance Inflation Factor (VIF).When predictors are highly correlated, standard errors of fitted coefficients are inflated and commonly diagnosed with the VIF procedure in statistical software packages. Independent variable combinations were excluded if items exceeded a VIF of three. Finally, adjusted R-squared were compared across models in order to better understand what variables seemed to consistently hold up under multiple specifications.[14]

Although concerns about endogeneity were considered, we were unable to perform comprehensive tests to cover this contingent. Our main concern was whether our policy factors might be explained partly by our political or resource variables. Initial analyses suggest that there is little or no direct relationship between variables such as "citizen right-to-know laws" and our key political and resource measures.[15] Part of the problem is that our measure for pollution releases (TRI data) is truncated. We do not have good information before 1989, and therefore we cannot check to see whether changes in pollution output have driven the creation of policies, the nature of politics, or the quality of resources before the late 1980s. Future research will address these concerns in more depth.

These iterations left just six independent variables in our models of toxic chemical trends among facilities aggregated across the states. In the first model of the percentage of firms reducing releases, conservation group membership produced the largest standardized coefficient estimate. Ideological polarization was the second largest coefficient, but in a negative direction, while state initiatives on citizen right-to-know produced a third significant and positive coefficient. Insignificant factors included population, a pollution prevention index, and an index of policy liberalism. The adjusted R^2 indicated that over 30% of the variance in the dependent variable could be explained by the model's combination of independent variables (see Table 6). Model 2 displayed a higher R^2 (45.6%) and showed that both conservation group membership and ideological polarization relate to a state's ratio of release reducer facilities to increasers. In both models, the statistically significant F-test demonstrated that rejection of the null hypothesis that each independent variable except the constant are equal to zero could be rejected with 99% confidence.

The same multiple regression model faired much worse when the dependent variable encompassed Production-Related Waste (PRW) trends in percentage or ratio form. In model 3, a state's percentage of facilities reducing PRW did not produce a commonly accepted level of statistical significance on the F-ratio (see Table 7). However, in bivariate regressions, the citizen right-to-know measure did produce a statistically significant model with an adjusted R^2 of 0.232 and 0.117 (see Table 8).

In three final models, we performed multiple regressions on three dependent variables that combined facility-level waste and release performance: (1) a ratio measure of facilities reducing both toxic waste and releases to facilities increasing them; (2) the percentage of toxic waste and release reducers; and (3) the percentage of toxic waste and release increasers. The model of our sample's ratio of toxic reducers displayed an adjusted R^2 indicating that the combination of independent variables accounted for nearly half (48.8%) of the variance in the dependent variable (see Table 9). Conservation group membership again achieved the largest standardized and significant coefficient, followed by ideological polarization in the negative direction and value added by air polluters with a positive correlation.

When the percentage of toxic reducers (both waste and releases) became the dependent variable, the regression's performance dropped substantially and achieved an adjusted R^2 accounting for less that 18% of the variance. Conversely, our explanatory model of toxic increasers accounted for almost half of the dependent variable's variance (the adjusted $R^2 = 0.494$) with significant but negative coefficients on conservation group membership and value added by air polluters and a positive coefficient for ideological polarization.

Discussion

The results, taken in their entirety, are suggestive rather than conclusive. There are at least three conclusions we take away from them.

The first is that policy factors and political factors may both play a role in driving state differences. For example, policy liberalism correlates positively with the number of facilities making release reductions between 1991 and 1997 (see Table 5) while ideological polarization seems to have a negative influence on a number of the dependent variables, including the percentage of firms reducing releases and the ratio of toxic reducers to increasers (see Table 6). Interestingly enough, the same cannot be said of reductions in PRW when observed in isolation (see Table 7). This actually makes sense given the nature of the TRI as a form of information disclosure. Pollution releases have a much greater salience in the media and in communities than does PRW. Moreover, the results relating to ideological polarization may suggest that politically liberal groups are having more of an impact in less polarized states, or facilities may be more sensitive to this threat and more likely to be reducing release levels. Though PRW data are publicly available, it is the subset of pollution releases that gets greater attention from interest groups and average citizens. Other PRW besides releases are "off the radar" for all but the closest of examiners of TRI information.

The consistency of statistical significance in our measure of environmental group membership levels further reinforces the influence of a state's political environment (see Tables 6 through 9). Two interpretations are possible. First, facility pollution reductions in states with more conservation group participation may be evidence that companies are facing more pressure from organized environmentalists in some states and not others. Or, companies may be anticipating pressure from a more vigorous environmentalism and be making efforts to forestall unwanted attention by reducing emissions. A definitive conclusion one way or another must await more focused research.

There is some evidence to suggest that the presence of state-level citizens right-to-know programs helps to increase the percentage of TRI facility reducers in a given state across both PRW and total releases (see Tables 6 to 8). This is not surprising, given that others have found related results (Grant 1997; Yu et al. 1998). At the same time, we can only speculate why this is true. One possibility is that state level right-to-know programs may actually enhance the abilities of facilities to measure their own performance, which in turn may be driving them to reduce their overall waste production. Facilities in the 1990s were measuring aspects of their production processes that they were not measuring ten years previously. Alternatively, state level programs may increase the salience of both total releases and PRW for citizens outside of these firms, which in turn motivates them to put pressure on the facilities for change. These results raise further questions about the extent to which information disclosure programs are driving firm behavior from within rather than firms responding to external demands for change.

The second major conclusion is that results in the correlation matrix suggest the possibility of an interesting dynamic that defies straightforward explanation (see Table 5). When comparing results for the ratio or percentage of reducers in total releases to the results for changes to total pounds of pollution reduced in each state, the findings suggest that two separate processes may be going on. It is conceivable that key political factors, such as policy liberalism within a state, improve the likelihood that facilities will move towards pollution reductions rather than expansions, while at the same time macro-level variables such as population and manufacturing gross state product are driving the amount of change in pollution output overall. The former suggests that political factors can influence the *direction* of change, while non-political factors may influence the *intensity* of change.

In the context of theory about the function of information disclosure policies, it may be that such programs can help to motivate companies to improve their environmental practices, but the robustness of those improvements may be constrained by factors that no level of information transfer can influence. Relatedly, the dynamic here may be similar to the findings of Potoski and Woods (2002), in which different environmental issues draw different sets of interests to them.

The third major finding, the lack of significant results across most of our independent variables, is itself telling. Arguably, our broad argument about the influence of information disclosure programs remains viable: decision-making is most critically influenced closer to the source—either through interactions with the community or within facilities (and companies) themselves. State differences can mediate some of what happens at the local level, but only partially.

Future Directions

Measuring and modeling the factors that influence innovative environmental decisions and outcomes will significantly advance our understanding of their relationship to information disclosure policies. However, we also intend to augment this modeling with qualitative analysis through the use of questionnaires, interviews, and case studies. Such a precedent was outlined by Meier and Kaiser (1996) when they leveled a provocative criticism of traditional regression techniques. They point out that these focus on average cases when more interest may lie in unusual cases. For the research under way, this would be communities with high concentrations of facilities that have undertaken source reduction or have decreased pollution levels beyond what would have been expected (performers). If the most ideal presumptions about information disclosure are right, we would expect to find performing firms to indicate that their environmental management choices were partially or even fully influenced by community factors. On the other hand, much can be learned from communities hosting facilities that struggle to change (or regress on) their environmental management and/or their pollution levels (strugglers).

We can offer a few comments about the direction in which our research efforts are heading. As noted, these kinds of initial results will guide our sampling of leading and lagging facilities and the communities in which they are located**.** We will use a survey questionnaire to be sent to corporate officials, administrative agency officials, environmental group leaders, and community leaders in 30 communities. The questionnaire will focus on how environmental decisions have been affected by TRI information disclosures, with attention to the range of variables identified earlier in the paper. Special consideration will be given to opportunities for communication between communities and industrial facilities. As noted above, we will also gather information on corporate environmental commitment, environmental expertise, and management structure.

Following analysis of the data from the questionnaires, we will select ten communities for in-depth field research. This effort will involve interviews with corporate officials as well as environmental agency administrators, environmental group leaders, and community leaders, and will focus on the effects of information disclosure on decisionmaking. We will match five communities with leading industrial facilities and five with laggard facilities in terms of TRI reductions and toxics management. The flexibility inherent in interviews will allow us to probe more effectively on issues raised by our respondents that expand our understanding of information disclosure programs and give us some indication of possible reforms or policy changes.

Our research strategy is to compare leading and lagging firms and the communities in which those firms are located. Selecting firms from the greening and browning categories should facilitate this comparative case study approach, and the qualitative phase of our research should enable us to learn much about why these firms make the kinds of decisions they do about toxic chemical pollution.

As suggested early in the paper, there are policy implications to work of this kind. Until we know more about the effect of information disclosure programs we cannot speak with confidence about either their previous success or what changes in policy design or implementation might make them more effective in the future. In later reports we hope to be able to address how the TRI program might be redesigned to provide greater incentives to industrial facilities to reduce both production-related waste and the volume of high-risk chemicals released to the environment. We also expect to say more about how communities can use TRI data (including new data coming from the RSEI model) to become better informed about health and environmental risks and help to influence corporate environmental decisions that can have a substantial effect on those risks.

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Table 1. Firm Environmental Performance Associated with Increasing or Decreasing Waste Production and Risk

Risk	Production-Related Waste: Increasing (Dirtier)	Production-Related Waste: Decreasing (Cleaner)
Decreasing (Safer)	**Safer, but Still Dirty** 1,898 (16.7%) Example: a firm could substitute a more benign chemical for one of its most toxic air releases but still generate and even release large quantities of less toxic pollutants.	**Greening Firms** 4,655 (41.0%) Example: a firm installs new pollution control equipment that decreases the volume of its more toxic air releases and initiates source reduction activity that reduces its production-related waste.
Increasing (Riskier)	**Browning Firms** 3,911 (34.4%) Example: a firm increases production but takes no steps to control the higher volume of toxic air releases and production-related waste.	**Cleaner, but Riskier** 889 (7.8%) Examples: a firm targets its biggest waste streams for reductions while maintaining or even increasing a low volume, but highly toxic air release.

Note: Production-related waste is the sum of all toxic wastes generated across a firm's production processes that a facility reports as recycled, recovered for energy, treated on and off – site, or released on and off-site. For this paper we use TRI total releases as a surrogate for risk. In future papers we will apply the U.S. EPA's RSEI model to toxic air emissions to gain a more useful measure of actual risk to exposed populations.

Table 2. State Performance in Hosting TRI Facilities That Reduce Both Production-Related Waste and Pollution Releases

Brownest Less Than 37%	Browns 37% to 40%	Yellows 40% to 43%	Greens 43% to 46%	Greenest More Than 46%
Tennessee Arizona Maryland Louisiana Michigan Utah Georgia Kentucky	Nebraska West Virginia Oregon Pennsylvania Missouri	Iowa South Carolina Washington California Illinois Kansas Oklahoma Ohio Mississippi Minnesota Indiana Wisconsin Alabama Texas Florida Colorado Arkansas	New Hampshire Delaware New York Virginia New Jersey Massachusetts Rhode Island	North Carolina Maine Connecticut

Note: Ten states were dropped from the analysis because they had too few facilities to permit comparative statistical analysis without distorting the results: Alaska, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Vermont, and Wyoming.

Table 3. Trends in Toxic Chemical Waste and Release Reductions for the Fifty States

State	Reporting TRIs 1991, 97	% Waste & Release Reducers	Ratio of Reducers to Increasers	State	Reporting TRIs 1991, 97	% Waste & Release Reducers	Ratio of Reducers to Increasers
Alabama	270	40 %	0.99	Montana	15	33 %	1.00
Alaska	4	25 %	.50	Nebraska	72	38 %	0.96
Arizona	89	31 %	0.67	Nevada	17	38 %	1.29
Arkansas	219	40 %	1.05	New Hampshire	61	46 %	1.40
California	662	43 %	1.57	New Jersey	335	44 %	1.63
Colorado	78	40 %	1.24	New Mexico	22	41 %	1.29
Connecticut	201	48 %	1.81	New York	371	45 %	1.62
Delaware	42	45 %	2.38	North Carolina	471	51 %	1.71
Florida	226	40 %	0.85	North Dakota	10	20 %	0.33
Georgia	347	37 %	0.90	Ohio	931	42 %	1.27
Hawaii[a]	5	----	------	Oklahoma	138	42 %	1.21
Idaho	18	39 %	1.40	Oregon	135	39 %	0.95
Illinois	702	43 %	1.30	Pennsylvania	681	39 %	1.11
Indiana	565	40 %	1.02	Rhode Island	71	44 %	1.41
Iowa	201	43 %	1.16	South Carolina	293	43 %	1.25
Kansas	139	42 %	1.05	South Dakota	29	41 %	1.09
Kentucky	240	37 %	1.14	Tennessee	306	31 %	0.69
Louisiana	177	36 %	1.25	Texas	657	40 %	1.22
Maine	52	48 %	2.08	Utah	63	37 %	0.85
Maryland	88	35 %	1.03	Vermont	21	48 %	2.00
Massachusetts	279	44 %	1.63	Virginia	262	44 %	1.19
Michigan	497	36 %	0.96	Washington	153	43 %	1.38
Minnesota	252	40 %	1.10	West Virginia	90	38 %	1.26
Mississippi	170	41 %	1.13	Wisconsin	478	40 %	1.12
Missouri	289	39 %	0.96	Wyoming	10	30 %	0.60

[a] No percentage is entered for Hawaii because the state has too few cases to permit comparison with the other states.

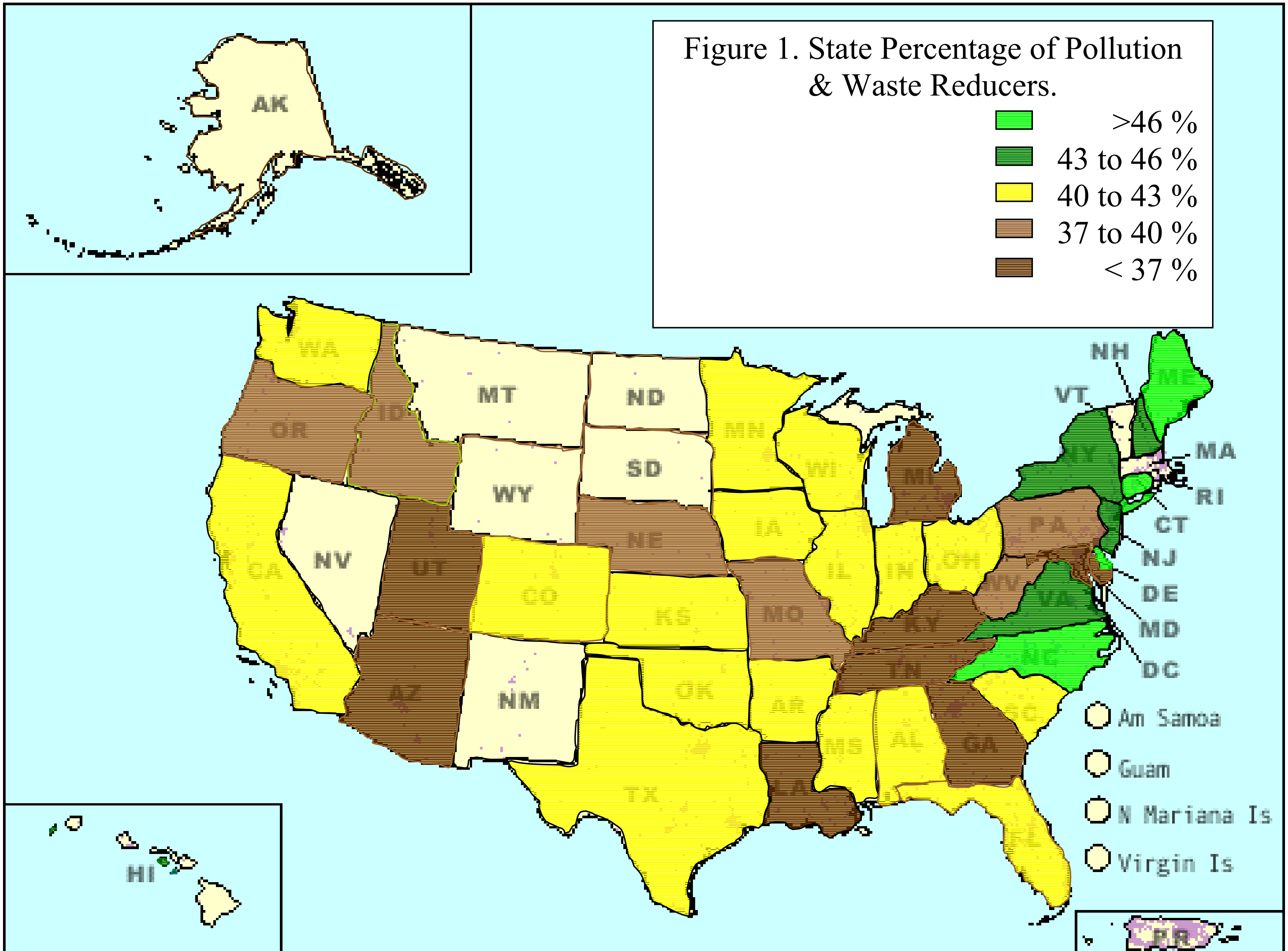
Figure 1. State Percentage of Pollution & Waste Reducers.
>46 %
43 to 46 %
40 to 43 %
37 to 40 %
< 37 %
AK
HI
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
OH
KY
TN
MS
AL
GA
FL
SC
NC
VA
WV
PA
NY
VT
NH
ME
MA
RI
CT
NJ
DE
MD
DC
Am Samoa
Guam
N Mariana Is
Virgin Is
PR

Table 4. Descriptive Statistics for Variables

	N	Mean	Std. Deviation	Minimum	Maximum	Skewness		Kurtosis	
Independent Variables						*Statistic*	*Std. Error*	*Statistic*	*Std. Error*
State census population (90)[a]	50	4963.14	5462.411	454	29786	2.55	0.337	8.301	0.662
Conservation Members[b]	50	8.544	3.58467	2.5	20.2	0.64	0.337	0.831	0.662
Manufacturing GSP[c]	50	20324.38	22457.41	486	113253	1.98	0.337	5.004	0.662
Air Polluters' GSP[c]	50	6791.14	7470.428	120	33794	1.80	0.337	3.515	0.662
Value Added by Air Polluters[c]	50	0.33584	0.140083	0.105	0.751	1.01	0.337	1.139	0.662
State Spending on Air Pollution (per capita)	50	0.629	0.498317	0.14	3.26	3.24	0.337	15.256	0.662
Comm. Improvement Groups[d]	50	159.3	165.6466	18	770	1.94	0.337	3.916	0.662
Foundations (1988)[d]	50	789.58	1096.155	30	6417	3.33	0.337	14.133	0.662
Median household income[c]	50	29102.82	5560.394	20136	41721	0.64	0.337	-0.151	0.662
Per capita income in 1989	50	13658.58	2347.937	9648	20189	0.62	0.337	0.057	0.662
State Pollution Prevention[e]	50	1.80006	1.529701	0	6	1.06	0.337	0.768	0.662
State Policy Initiatives[e]	50	25.5	14.57738	1	50	0.00	0.337	-1.200	0.662
Green Policies rank[e]	50	2200.64	670.2726	764	3230	-0.31	0.337	-1.101	0.662
Citizen's Right to Know[f]	50	0.4	0.494872	0	1	0.42	0.337	-1.900	0.662
Aid for Right to Know[f]	50	0.42	0.498569	0	1	0.33	0.337	-1.969	0.662
Toxic Cuts Law[f]	50	0.32	0.471212	0	1	0.80	0.337	-1.425	0.662
Plan and Report Cuts[f]	50	0.26	0.443087	0	1	1.13	0.337	-0.759	0.662
Focus: Reduce Toxics[f]	50	0.06	0.239898	0	1	3.82	0.337	13.124	0.662
Partisan identification[h]	48	7.110417	11.38368	-17.4	35.3	0.16	0.343	-0.125	0.674
Ideological identification[h]	48	-14.3	7.514525	-28	-0.2	-0.05	0.343	-0.748	0.674
Ideological polarization[i]	48	35.46458	9.118359	18.6	54	-0.08	0.343	-0.684	0.674
Policy liberalism[j]	48	-0.006875	0.986043	-1.54	2.12	0.19	0.343	-1.093	0.674
Dem. elite ideology[h]	46	3.176957	2.045752	-0.71	7.47	-0.19	0.350	-0.806	0.688
Rep. elite ideology[h]	46	-3.176087	1.754952	-6.05	-0.4	0.13	0.350	-1.251	0.688
Total TRIs reporting in 1991 and 1997[g]	50	284.12	273.4119	5	1117	1.23	0.337	0.956	0.662
Dependent Variables									
PRW Increasers[g]	50	125.92	120.7923	0	492	1.22	0.337	0.881	0.662
PRW Decreasers[g]	50	118.84	116.9886	1	483	1.30	0.337	1.188	0.662
PRW Unchanged[g]	50	2.18	2.869189	0	13	2.00	0.337	4.351	0.662
PRW Unreported[g]	50	37.18	35.62084	1	131	1.11	0.337	0.476	0.662
Percent of State TRIs reducing PRW[g]	50	0.416179	0.083539	0.2	0.83	2.19	0.337	12.598	0.662
PRW Ratio[g]	49	0.928571	0.207385	0.33	1.63	0.54	0.340	3.100	0.668
REL Increasers[g]	50	99.98	95.26536	1	388	1.17	0.337	0.769	0.662
REL Decreasers[g]	50	133.68	131.0151	2	551	1.30	0.337	1.246	0.662
REL Unchanged[g]	50	14.34	17.78627	0	96	2.52	0.337	8.467	0.662
REL Unreported[g]	50	36.04	34.63274	0	131	1.12	0.337	0.555	0.662
REL Ratio[g]	50	1.408107	0.589504	0.22	4	2.07	0.337	7.268	0.662

a. 1990 census, in thousands.
b. Membership in three environmental groups (Sierra Club, Greenpeace, and the National Wildlife Federation) per 1,000 in population.
c. As of 1989. Value added by air polluters refers to the percentage of a state's gross product added by manufacturing industries most responsible for air pollution. The Manufacturing GSP refers to the manufacturing share of the Gross State Product, expressed in millions of dollars, as of 1989. Following Ringquist (1993), the Air Polluters GSP refers to the sum of contributions to the Gross State Product contributed by seven key manufacturing sectors: paper and allied products; chemicals and allied products; petroleum and coal products; rubber and miscellaneous plastics products; stone, clay and glass products; primary metal industries; and other transportation equipment (not including vehicles). The data are taken from a Commerce Department Web site: www.bea.doc.gov/bea/regional/gsp.
d. As of 1988. The measure of community improvement groups is the number of community improvement or capacity building groups per 1,000 population. The foundations variable refers to the number of philanthropic groups per 1,000 population.
e. Indices are taken from the 1991-1992 Green Index (Hall and Kerr 1991).
f. Dichotomous (1=yes, 2=no) measure taken from 1991-1992 Green Index (Hall and Kerr 1991). The toxic cuts law variable refers to state policies intended to reduce toxic chemical emissions. The citizen right-to-know variable refers to whether a state promotes public access to information about toxic chemical usage and emissions. Aid for right-to-know refers to whether a state provides funding for right-to-know programs. The plan and report cuts variable refers to state policies that require facilities to plan and report on toxic chemical use and emissions. The focus: reduce toxics variable refers to state policies that go beyond the planning and reporting requirements to require source reduction.
g. State aggregations from EPA's TRI Explorer. The PRW measures used in the paper are not normalized for production because we did not have access to production data. However, we did control in multiple regressions models for total state releases in 1991, which is a surrogate of a facility's production level.
h. These measures all use a mean score for the period 1976 to 1988, and are taken from Erickson, Wright, McIver (1993). Partisan identification and ideological identification are aggregate measures based on *New York Times/CBS* surveys of registered voters in each state over this time period. Democratic elite ideology and Republican elite ideology are measures built with factor analysis from surveys of county party chairpersons, state legislators, convention delegates, and congressional candidates by different researchers, most of which are from the same time period. They also are drawn from Erickson, Wright, and McIver (1993, pp. 98-99)).
i. Ideological polarization refers to the differences in mean ideology scores between registered voters within the state who identified themselves as Democrats or Republicans (but not independents) in surveys conducted during the 1976 to 1988 period (from Erickson, Wright, McIver 1993).
j. Standardized composite index of state policy measures on eight issues, including education funding, Medicaid coverage, welfare eligibility, consumer protection enactments, criminal justice liberalism (victim compensation, absence of death penalty, etc.), legalized gambling, women's rights, and tax progressivity, taken from Erickson, Wright, McIver (1993).

Table 5. Selected Pearson Correlations

	State Facility PRW Reducer Ratio	State Facility Release Reducer Ratio	State Facility PRW Reducers (%)	State Facility Release Reducers (%)	Total State Releases (91)	Total State Releases (97)	State Release Difference (91-97)	Release Change (% of 91 base)
State population	0.113	-0.0032	0.0041	0.0442	**0.5526***	**0.3943**	**0.3476**	0.0022
ST Poverty Percent	-0.167	-0.2184	-0.0700	-0.0473	**0.3192***	**0.2814***	0.1154	0.0138
ST Unemp Change	**-0.337***	**-0.4763***	**-0.4899***	**-0.3377**	0.2011	**0.3045***	-0.1298	-0.2004
Median House Inc	0.287	0.4142	0.2031	0.2676	-0.1865	-0.1445	-0.0991	-0.0921
Per capita income	0.0945	0.3543	0.1402	0.2629	-0.1764	-0.1430	-0.0838	-0.1112
Manufacturing GSP	0.1849	0.0184	0.0542	0.0960	**0.6211***	**0.4774***	**0.3362***	-0.0298
Air Pol Val Add	0.0440	0.0412	0.0688	0.2270	0.2396	0.1910	0.1189	0.0850
ST Air Pol Spend	-0.0356	0.1953	0.0592	0.1305	0.0203	-0.1461	0.2685	0.1732
ST Pollute Prevent	0.1343	0.2127	0.0242	0.1613	0.1369	0.2167	-0.1033	**-0.3153***
ST Policy Initiatives	**-0.2802***	**-0.3661**	-0.2261	**-0.2917***	0.0462	0.0491	0.0035	0.0808
ST Green Plcy Rank	**-0.2786***	**-0.3590**	-0.2042	**-0.2734***	0.0714	0.0768	0.0038	0.0877
Citizen's RTK	**0.4346***	0.2046	0.2613	0.2634	-0.0586	-0.0188	-0.0736	-0.1451
Aid for RTK	-0.0402	0.1263	-0.0106	0.2465	0.1912	0.0816	0.2076	0.1510
Toxic Cuts Law	0.2041	0.1317	0.0803	0.1390	0.2223	0.2610	-0.0230	-0.1768
Plan/Report Cuts	0.2361	0.1839	0.0963	0.1604	0.0478	0.1035	-0.0805	-0.1990
Reduce Toxics	0.0267	0.0367	0.0150	0.0654	-0.1360	0.1862	**-0.5364***	**-0.5900***
Cons. Members	0.1286	**0.4560***	0.1187	**0.2893***	**-0.4102**	**-0.357**	-0.1544	-0.0378
Air Polluters GSP	0.1661	0.0130	0.0578	0.1281	**0.7330***	**0.5670***	**0.3911**	0.0250
Comm. Groups	0.1357	0.0401	0.0278	0.0934	**0.5327***	**0.4393***	0.2410	-0.0788
Foundations	0.1314	0.0983	0.0343	0.1040	**0.362**	**0.3029***	0.1583	-0.1095
Partisan ID	-0.0002	0.1005	0.1369	**0.3043***	0.2140	0.2754	-0.0594	-0.1764
Ideological ID	0.0975	**0.4253***	0.1946	**0.3596**	-0.2152	-0.1228	-0.1811	-0.2006
Ideol Polarization	-0.0352	0.0522	-0.0226	-0.0284	-0.0928	-0.1178	0.0232	0.0175
Policy liberalism	0.1167	**0.4125**	0.1349	0.2292	-0.1833	-0.1275	-0.1185	-0.1544
Dem. elite ideology	-0.0601	0.1598	-0.1105	-0.0466	-0.1828	-0.1804	-0.0345	-0.0631
Rep. elite ideology	0.0300	**0.4247***	0.1223	0.2264	-0.2795	-0.1685	-0.2179	-0.1490

Correlation is significant at the 0.001 level (2-tailed) ***; at the 0.01 level (2-tailed)**; or at the 0.05 level*.

The "reducer" ratios above are simple ratios of reducing facilities to increasing facilities, where any value over 1.0 means a state has more reducers than increasers, and vice versa for all values below 1.0. The "percent reducers" is a measure of the number of reducing facilities divided by total number of facilities.

Table 6. Ordinary Least Squares Regression on Toxics Release Inventory (TRI) Trends

Independent Variables	State Percentage of Release Reducers Estimate[a] (Standard Error)		State Ratio of Release Reducers Estimate (Standard Error)	
Socioeconomic Factors				
Population	-0.019	(0.000)	-0.021	(0.000)
State Policy Factors				
Pollution Prevention	0.068	(0.007)	0.170	(0.040)
Citizen Right To Know	0.374**	(0.020)	0.164	(0.110)
State Political Factors				
Conservation Group Membership	0.717**	(0.004)	0.884***	(0.240)
Ideological Polarization	-0.576**	(0.001)	-0.628***	(0.007)
Index of Policy Liberalism	-0.213	(0.014)	-0.086	(0.078)
Adjusted R^2		0.3118		0.456
Standard Error		0.0532		0.2935
F		4.0207		6.588
Significance of F		0.004		0.000
(N)		40		40

[a] All of the regression coefficients reported here are standardized coefficients.

Table 7. Ordinary Least Squares Regression on Production-Related Waste (PRW) Trends

Independent Variables	State Percentage of PRW Reducers Estimate[a] (Standard Error)		State Ratio of PRW Reducers Estimate (Standard Error)	
Socioeconomic Factors				
Population	0.075	(0.000)	0.138	(0.000)
State Policy Factors				
Pollution Prevention	-0.023	(0.005)	0.013	(0.020)
Citizen Right To Know	0.547**	(0.015)	0.349	(0.056)
State Political Factors				
Conservation Group Membership	0.184	(0.003)	0.201	(0.012)
Ideological Polarization	-0.239	(0.001)	-0.267	(0.004)
Index of Policy Liberalism	-0.071	(0.011)	0.024	(0.040)
Adjusted R^2		0.165		0.046
Standard Error		0.0039		0.1494
F		2.314		1.320
Significance of F		0.056		0.275
(N)		40		40

[a] All of the regression coefficients reported here are standardized coefficients.

Table 8. Bivariate Regression on Production-Related Waste (PRW) Trends

Independent Variable	State Percentage of PRW Reducers Estimate[a] (Standard Error)		State Ratio of PRW Reducers Estimate (Standard Error)	
State Policy Factors				
Citizen Right to Know	0.501**	(0.012)	0.373*	(0.047)
Adjusted R^2		0.232		0.117
Standard Error		0.0039		0.1455
F		12.768		6.155
Significance of *F*		0.001		0.018
(*N*)		40		40

[a] All of the regression coefficients reported here are standardized coefficients.

Table 9. Ordinary Least Squares Regression on Toxic Reducers and Increasers

Independent Variables	Ratio of Toxic Reducers to Increasers Estimate[a] (Standard Error)		Percentage of Toxic Reducers Estimate (Standard Error)		Percentage of Toxic Increasers Estimate (Standard Error)	
Socioeconomic Factors						
Manufacturing GSP	0.151	(0.240)	0.111	(0.000)	-0.232	(0.000)
State Policy Factors						
Value added by air polluters	0.339**	(0.337)	0.024	(0.050)	-0.388**	(0.059)
Citizen Right to Know	0.155	(0.015)	0.161	(0.014)	-0.161	(0.016)
State Political Factors						
Conservation Group Membership	0.852***	(0.017)	0.599**	(0.003)	-0.798***	(0.003)
Ideological Polarization	-0.473**	(0.001)	-0.344	(0.000)	0.475**	(0.001)
Adjusted R^2		0.488		0.175		0.494
Standard Error		0.253		0.038		0.045
F		8.42		2.66		8.62
Significance of *F*		0.000		0.039		0.000
(*N*)		40		40		40

[a] All of the regression coefficients reported here are standardized coefficients.

Notes

[1] In 2003, the U.S. EPA's Office of Pollution Prevention and Toxics released for public comment a draft version of a *Community Air Screening How to Manual* that carried the subtitle "A Step-by-Step Guide to Using a Risk-Based Approach to Identify Priorities for Improving Outdoor Air Quality." The manual illustrates well how government agencies might take action to improve the

public's capacity to understand and use data, in this case Toxics Release Inventory data. The manual strongly endorses the establishment of partnerships between communities and local industry, with broad stakeholder involvement, as the best way to establish local priorities and promote their achievement.

The agency's educational effort focuses on the Risk-Screening Environmental Indicators (RSEI) model that we used in a paper presented at the annual meeting of the American Political Science Association in August 2003 that covered only EPA Region V. We will use the model again but for the entire nation in a paper to be presented at the 2004 annual meeting of the American Political Science Association. The history of the model's development and its use to date is described in Schmidt (2003) and in Bouwes, Hassur, and Shapiro (2001). Further information is available at EPA's RSEI Web site: www.epa.gov/opptintr/rsei.

[2] TRI facilities include all industrial firms that are required by the EPA to self-report the release of any toxic chemical into the environment. The federal guidelines stipulate that a facility must file a report for the TRI program if it conducts manufacturing operations within Standard Industrial Classification codes 20 through 39 (with a broader set of categories applicable after 1998, such as metal mining, coal mining, and electric utilities that burn coal); has ten or more full-time employees; and manufactures or processes more than 25,000 pounds or otherwise uses more than 10,000 pounds of any listed chemical during the year. For 2000, the TRI was expanded to include new persistent bioaccumulative toxic (PBT) chemicals, with lower reporting thresholds. The full TRI list now includes over 650 chemicals.

[3] The quote comes from the "overview" section of "The Toxics Release Inventory (TRI) and Factors to Consider When Using TRI Data": www.epa.gov/tri/tridata/tri00/press/overview.pdf.

[4] One striking figure drives home the importance of large manufacturing facilities. In 1999, just 50 facilities out of the 21,000 reporting that year accounted for 31 percent of all the TRI releases nationwide (cited in Graham and Miller 2001). It also is apparent that larger facilities have been more successful on the whole in reducing toxic releases than have smaller facilities.

[5] One interesting finding is that subsidiaries of major corporations apparently have "significantly higher emissions rates"; that is, they release a greater percentage of on-site TRI chemicals to the environment. The study reporting this finding used data for 1990, and many changes in the TRI program have been made since then. However, if the findings hold up over time, they suggest that firms with less visibility have fewer incentives to reduce toxic chemical pollution. See Grant and Jones (2003).

Given the design of the TRI program, a long-time concern is that facility managers have an incentive to reduce the emission of listed chemicals and thereby to avoid or limit undesired media attention and public pressures to alter business practices. But they might choose to do so in a way that merely shifts use of unlisted chemicals for those on the list, or they might seek a cheap and quick way to reduce the volume of emissions that does not reduce the risks to public health as much as might be achieved through a more thorough alteration in production processes.

[6] In a paper delivered at the 2003 annual meeting of the American Political Science Association, we identified five mediating factors as likely to be most important in shaping the way in which information disclosure affects community and corporate risk perceptions and environmental beliefs and values: community social capital, local and state political system characteristics (including regulatory stringency), local social and economic conditions, firm or facility characteristics (such as size, age of facility, and profitability), and the nature of media coverage of the information released as well as coverage of corporate actions.

[7] The research reported in this paper is supported by the National Science Foundation under Grant No. 0306492, Information Disclosure and Environmental Decision Making. Michael Kraft and Troy Abel are co-principal investigators, and part of the research is being conducted by Mark Stephan. Any opinions, findings, and conclusions or recommendations expressed in the paper are those of the authors and do not necessarily reflect the views of the National Science Foundation.

[8] As reported below, "total releases" can be understood as a subset of "production-related waste." Total releases are simply the releases to land, water, and air, while production related wastes also include produces that are recycled, recovered for energy, and treated either on or off-site.

[9] In a survey conducted in the early 1990s, Santos, Covello, and McCallum (1996) found that regulatory compliance was one of the two reasons that facilities cited most frequently for reduction of their TRI releases and transfers. The other was employee health. That is, where many observers assume that TRI reductions are made voluntarily because the program is non-regulatory in nature, this kind of evidence suggests a more realistic explanation would acknowledge the incentives created by the larger regulatory environment, including company concern over civil liability and state regulatory action. Without the requirements imposed by such federal and state environmental regulation, information disclosure programs might be considerably less effective.

[10] EPA doubled the reportable chemical list in 1996 that potentially distorts longitudinal analyses.

[11] A total of 151 TRI facilities were excluded.

[12] We use the term "TRIs" here as a shorthand for "TRI reporting facilities."

[13] Results are available from the authors upon request.

[14] Full results are available upon request.

[15] There was some slight evidence that policy liberalism within a given state might influence the likelihood of citizen right-to-know laws, but the results were not stable across multiple specifications. Results are available upon request.

The Effect of Reporting Thresholds on the Validity of TRI Data as Measures of Environmental Performance: Evidence from Massachusetts

by:

Lori D. Snyder
John F. Kennedy School of Government
Harvard University
lori_snyder@ksg.harvard.edu

1 Introduction

The old adage, "You can't manage what you don't measure," is the primary rationale for conducting systematic evaluations of the effectiveness of various environmental policy initiatives. Only if governments, non-profits, industries, and communities have good measures of environmental outcomes (changes in pollution levels, risk levels, etc.) can they evaluate what policies work, how well they work, and how to improve their effectiveness. If the metrics are not valid, then neither are the policy inferences drawn from these metrics. This paper examines one aspect of the validity of a frequently used measure of environmental performance—pollution releases reported under the federal Toxics Release Inventory (TRI) program.

The TRI data are the most comprehensive data available on facility-level releases of toxic chemicals. Facilities are required to disclose publicly their releases to all media—air, water, land, and underground injection (on-site releases) —as well as their transfers of chemicals off-site for recycling or disposal (off-site releases), for over 600 toxic chemicals. Because the TRI data capture releases to all media and include measures of the environmental impact of a facility's activities beyond the facility's fence (off-site releases), many have argued that the TRI data provide a more complete picture of facility-level environmental performance than other available metrics (Karkkainen, 2001).

In fact, the TRI data are used frequently for the purposes of comparing environmental performance across geographic areas and over time by government agencies, non-profits, and academic researchers. Environmental Defense uses the TRI data as one of the indicators of environmental performance in its Scorecard, an online database that allows the public to compare counties on a number of environmental metrics.[1] The Public Interest Research Group (PIRG) and its state affiliates frequently compile lists of the worst polluters in a state or region based on releases reported to the Toxics Release Inventory.[2] Similarly, EPA ranks states and industries by their total releases as reported in the TRI (U.S. EPA, 2002a). State environmental agencies also publish annual progress reports that measure changes in environmental performance based on changes in releases to the TRI, and label particular industries and facilities as the top polluters based on these releases.[3] Academic researchers have used the TRI data as outcome variables in evaluations designed to determine what factors affect environmental performance (Arora and Cason 1998; Grant and Jones 2003; Helland and Whitford 2003; Khanna and Anton 2002; King and Lenox 2000). Researchers have also used TRI data to evaluate whether requiring facilities to publicly disclose pollution leads facilities to decrease pollution. Fung and O'Rourke (2000) and Wolf (1996)

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[1] The Environmental Defense scorecard can be accessed at www.scorecard.org.

[2] See, for example, U.S. Public Interest Research Group 1998.

[3] A full list of state TRI programs with links to the state annual reports can be found at www.epa.gov/tri/programs/state_programs.htm.

argue that the observed 45 percent decline in overall TRI releases from 1988 to 1995 indicates that information disclosure is a valuable regulatory tool for reducing pollution.[4]

Despite the frequent use of TRI data for policy analyses, there are several known concerns about the validity of these data as measures of environmental performance. This paper defines the characteristics of a valid measure of environmental performance and outlines several known threats to the validity of the TRI data. The paper then focuses on estimating the magnitude of the measurement error created by the existence of arbitrary reporting thresholds. The potential for measurement error exists because facilities are only required to report *releases* to TRI if their *use* of a chemical exceeds some threshold. This creates an incentive for facilities to reduce their use of a listed chemical to a level just below the reporting threshold. However, this does not necessarily represent a real improvement in environmental performance, as the facility's release level may remain largely unchanged (or potentially could even increase). As a result, observed decreases in reported releases might overstate the true change in environmental performance. This paper asks the question: How much of any observed decline in reported releases could be artificially created by the existence of the reporting thresholds?

The TRI data are also used to rank facilities based on their pollution levels. Truncation at the reporting threshold may also have an effect of the validity of these cross-sectional rankings. This paper also asks the question: How much would our rankings of facilities change if we could account for releases by facilities that are below the reporting threshold?

[4] See U.S. EPA 2003 for a list of detailed discussion of how TRI data have been used by government, business, academics, and citizen groups.

While the potential for bias introduced by reporting thresholds is well known, there has previously been little that users of the data could do to ascertain the magnitude of this bias. The TRI data provide scant information that would allow a user of the data to ascertain whether a facility that ceases reporting did so because it went below the reporting threshold. However, the State of Massachusetts has expanded the disclosure requirements under TRI in ways that better allow for assessment of the reasons facilities cease reporting. This paper utilizes data from the Massachusetts Toxics Use Reduction Act (TURA) to estimate, for facilities in Massachusetts, bounds on the degree of bias introduced by the reporting thresholds in both time series and cross-sectional analyses.

The TURA data are similar to the TRI data. Indeed for Massachusetts facilities, data reported to TRI is a subset of the data reported to TURA. However, the TURA data include two additional features missing from the national data that make possible estimation of bounds on the truncation bias. First, the TURA reporting forms contain an optional question on why facilities are no longer reporting a chemical they had previously reported. Second, the TURA program requires facilities to report their chemical *use* in addition to their chemical *releases.* These two features of the data for Massachusetts allow estimation of the number of facilities that cease to report because they reduced use below the reporting threshold, but still use the chemical in positive quantities. These data are also used to estimate bounds on the amount of "missing" releases that result. Because the TURA data are in other ways identical to the TRI data, analysis of the TURA data provides some preliminary evidence on whether truncation bias is likely to be a large or small problem for the national TRI data.

The paper begins in Section 2.2, by describing the TRI and TURA data. Section 2.3 articulates a specific definition of "validity" of an environmental performance metric and highlights several threats to the validity of the TRI/TURA data as measures of environmental performance under this definition. This section defines truncation bias at the reporting thresholds and details how this bias may invalidate both time-series and cross-sectional comparisons. Section 2.4 estimates the magnitude of the truncation bias created by the existence of the reporting thresholds using the TURA data. The results suggest that truncation bias is indeed a serious threat to the validity of these data as measures of environmental performance, particularly in cross-sectional comparisons. Time-series estimates are off by roughly 40 percent in Massachusetts in the worst-case scenario. That is, 40 percent of the observed decrease in releases in Massachusetts may be artificial declines created by the reporting thresholds. For cross-sectional comparisons the results for Massachusetts indicate that quartile rankings of facilities may be wrong as often as 45 percent of the time when truncation bias is not accounted for. Section 2.4 ends with a discussion of the implications of the Massachusetts findings for the use of nationwide TRI data. Given the potential importance of these effects for policy analysis, Section 2.5 presents suggestions for adjusting policy analysis to account for truncation bias.

2 The U.S. Toxics Release Inventory and the Massachusetts Toxics Use Reduction Act

In December 1984, a Union Carbide pesticide plant in Bhopal, India accidentally released 40 metric tons of methyl isocyanate, killing an estimated 2,000 people and injuring 100,000 others. Shortly thereafter, a pesticide release in West Virginia hospitalized 150 people. Partly in response to concerns raised by these high-profile accidental releases, Congress passed the Emergency Planning and Community Right to Know Act (EPCRA) in

1986. EPCRA requires manufacturing firms to report releases of specific toxic chemicals on an annual basis, and to make these reports available to the public. The U.S. Environmental Protection Agency's (EPA) implementation of EPCRA resulted in the creation of the Toxic Release Inventory (TRI), which requires large manufacturing facilities publicly disclose total releases of listed toxic chemicals to all media on an annual basis.

There are three factors that determine whether a facility is subject to the disclosure requirements. The first is industrial sector. Originally, only manufacturing facilities were subject to the TRI reporting requirements. Subsequently, several other industrial sectors were added including: federal facilities, metal and coal mining, electrical generating facilities that combust coal or oil, chemical wholesale distributors, petroleum terminals and bulk storage facilities, and hazardous waste treatment storage and disposal facilities. The final two determinants of regulatory eligibility concern facility size. Only facilities with 10 or more full-time equivalent employees are required to report pollution levels. In addition, facilities are only required to disclose releases of listed chemicals for which they either: (1) manufacture or process more than 25,000 pounds or (2) otherwise use more than 10,000 pounds. Figure 2-1 provides a flow chart of TRI reporting requirements.

Several states have subsequently required additional public disclosure for plants in their jurisdictions. In 1989, Massachusetts passed the Toxics Use Reduction Act which expanded the reporting requirements for facilities in that state (Massachusetts Department of Environmental Protection 2003). There are three main differences between the TURA and the TRI requirements. First, the list of chemicals for which facilities are required to report is larger in Massachusetts. Massachusetts facilities must report releases of all chemicals required by TRI and also any chemical listed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund.

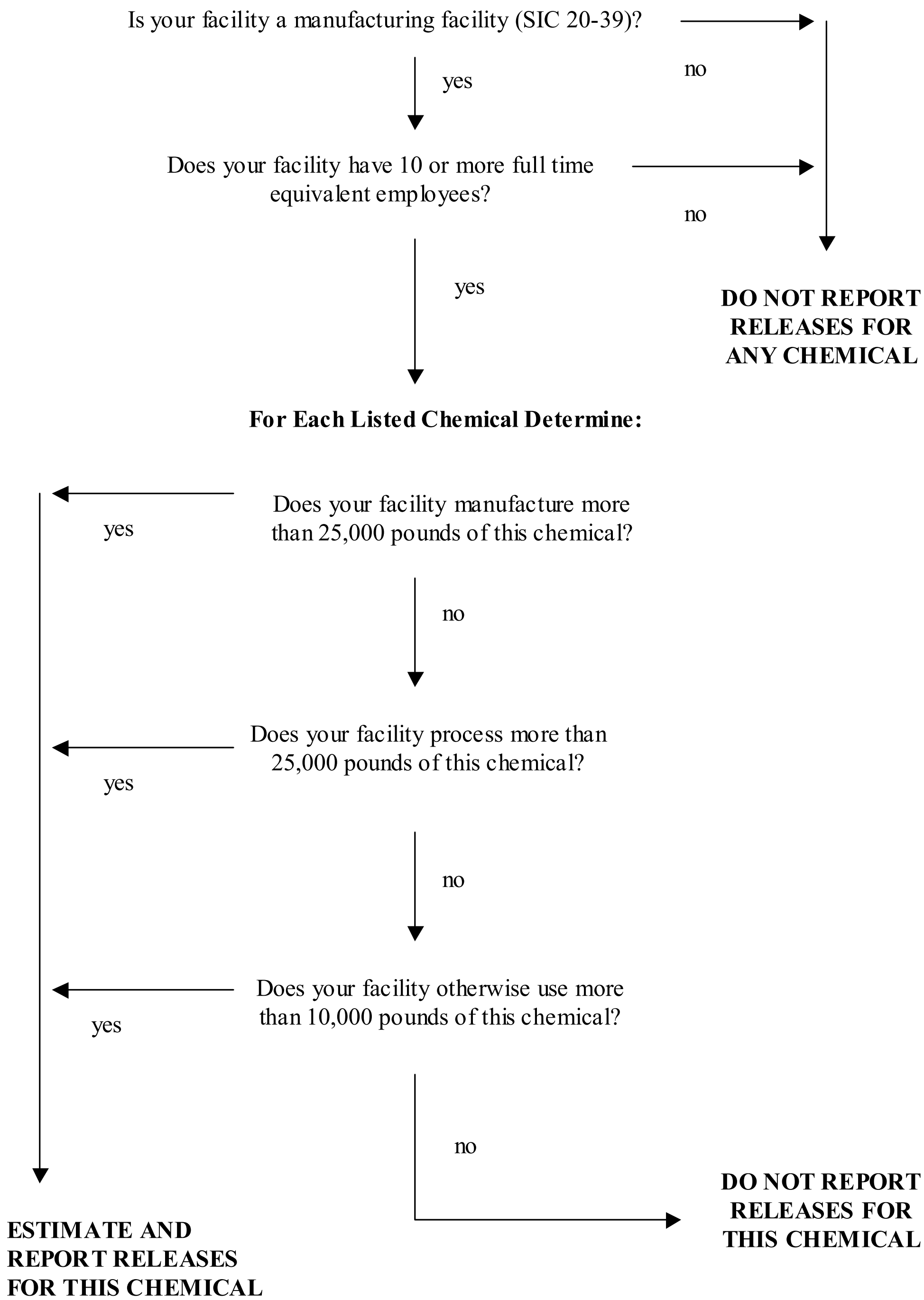

Figure 2-1: Flow Chart of TRI Reporting Requirements

The second difference is that the reporting thresholds are weakly lower in Massachusetts. If a facility triggers the federal reporting threshold for at least one listed chemical (i.e., manufacturers or processes more than 25,000 pounds or otherwise uses more than 10,000 pounds), the facility must report for all listed chemicals for which total manufacture, process, and use is greater than 10,000 pounds. Therefore, for most facilities in Massachusetts there are not three separate reporting thresholds, but one binding threshold at 10,000 pounds of total use for each listed chemical.

The final difference is that facilities in Massachusetts are required to report chemical *use* in addition to chemical *release*. The reporting thresholds are based on chemical use, but the federal program does not require public disclosure of use levels. In Massachusetts facilities must report both total use of the chemical and total releases of the chemical. Figure 2-2 provides a flow chart for the TURA reporting requirements.

This paper is concerned about the effects of the reporting thresholds present in both the TRI and the TURA designs, on the valid uses of these data for policy analysis. Before specifically examining the TRI and TURA data and determining whether or not these data are valid measures of environmental performance, it is worthwhile to articulate a definition of valid measurement of environmental performance. That is the subject of the next section.

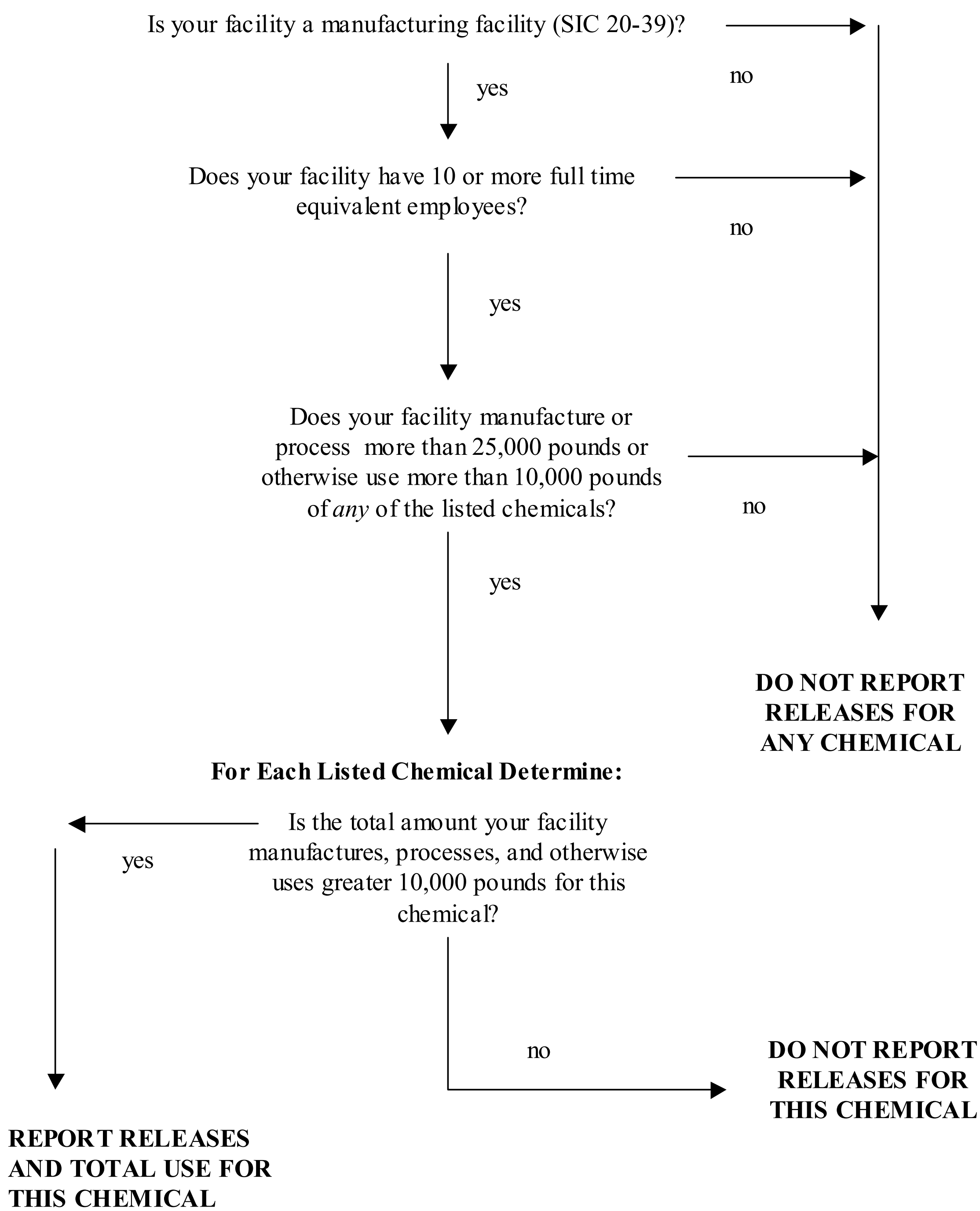

Figure 2-2: Flow Chart of TURA Reporting Requirements

3 The TRI/TURA Data as Measures of Environmental Performance

3.1 Defining a valid measure of environmental performance

There are a number of potential characteristics of a valid measure of environmental performance (National Academy of Engineering, 1999; White and Zinkl, 1997; U.S. EPA, 1992). The most frequently discussed characteristics of a valid performance metric are:

1. Significance: The measure has a clear relationship to environmental performance.
2. Precision: The stochastic component of the measure is small relative to the deterministic component.
3. Verifiability: The measure is publicly available and can be validated by a third party.
4. Comparability: The measure allows for comparisons across facilities, industries, countries, and across time.

Focusing on the last of these, comparability, there are potentially two standards of comparability that could be required--cardinal comparability or ordinal comparability. Cardinal comparability implies that the measure can be compared in magnitude across different entities. Define releases by facility *i* to be X_i. If X is cardinally comparable, $X_1>X_2$ implies that facility 1 is doing better than facility 2 and is, in fact, doing precisely X_1-X_2 better.[5]

[5] Cardinal comparability is often present in outcome measures used to evaluate program effectiveness by many other federal and state agencies such as the Department of Health and Human Services and the Labor Department. If participants in a pilot job training program earn an average of

A weaker comparability standard would be ordinal comparability. Ordinal comparability implies that if $X_1 > X_2$ then facility 1 is doing better than facility 2. However, it is not the case that the magnitude of the difference in performance is captured by the magnitude of the difference in the performance metric, X. Ordinal comparability is the minimum comparability standard for a valid performance metric. The whole point of program or policy evaluation is to ascertain whether a program or policy made society better off. If the metric used cannot be relied upon to order outcomes from better to worse, then the metric cannot be relied upon to measure whether a program resulted in a better outcome. Cardinal comparability is not necessary if the goal of the evaluation is to determine whether a specific initiative improved outcomes. However, cardinal comparability is necessary if the goal of the evaluation is to determine how much of an improvement was obtained by the firm, industry, state, or policy initiative. For example, cardinal comparability is necessary for cost-effectiveness analyses that compare policies on the basis of the amount of risk reduction per dollar spent.

The remainder of this paper evaluates the Toxics Release Inventory data as measures of plant-level environmental performance in relationship to these four characteristics of validity. In particular the paper highlights the potential threat to validity presented by the existence of minimum reporting thresholds and attempts to quantify the degree of the bias created by these thresholds.

3.2 Validity of TRI Data as a Measure of Environmental Performance

There are several known threats to the validity of the TRI data. The first is that data are only collected for certain industries and chemicals. Originally data were collected for

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$25,000 per year and non-participants earns an average of $20,000 per year, then trainees are better off than non-trainees by exactly $5,000 per year, on average.

manufacturing facilities and for approximately 300 chemicals. The fact that the TRI data are not comprehensive may reduce the *significance* of these data as a measure of environmental performance. For the measure to be significant in needs to have a clear relationship to environmental performance. If the TRI data only capture releases of a small subset of total chemicals, the significance of these data may be compromised.

This concern was recognized early in the program (U.S. Government Accounting Office 1991) and the program has since been expanded to more than double the number of chemicals and to include federal facilities, metal and coal mining facilities, electric generating facilities that combust coal or oil, chemical wholesale distributors, petroleum terminals and storage facilities, and hazardous waste treatment storage and disposal facilities. Obviously the TRI data cannot be used as a valid measure of environmental performance for plants that are not obligated to report these data. Thus, these data will necessarily by limited to use only in evaluations that affect these industrial sectors.

A second threat to the validity of the TRI data as a measure of environmental performance stems from the fact that TRI data are reported in total pounds of a chemical released, but it is widely acknowledged that pounds of different chemicals present widely different levels of risk. Similarly, a pound of a chemical released in rural Oklahoma may have a different impact than a pound of the same chemical released in downtown Manhattan. Some of the factors that determine the overall environmental risk presented by a facility's activities include the total pounds of releases, the toxicity of these releases, the exposure level in the population, the duration of exposure, and the sensitivity of the population. Simply adding up total pounds of different chemicals released and comparing across facilities may provide an incorrect ordering of facilities according to relative risk. For example, a facility that releases a few pounds of a very toxic, persistent, and bio-accumulating toxin may appear to have much better "environmental performance" than a facility that releases more pounds of a less hazardous and more degradable substance.

Even if the point estimate of environmental performance provided by TRI is biased by lack of information on toxicity, one might hope that *changes* in TRI releases still provide a measure of *changes* in environmental performance. That is, perhaps time series comparability is maintained even if cross-sectional comparability is compromised. For example, even if pounds of different chemicals are not equal in their risk profile, one might argue that fewer pounds is better than more pounds, holding all else constant. But the key is that all else must be held constant. The assumption that the trend in TRI releases is a valid indicator of the trend in environmental performance is likely to hold if, among other things, the facility consistently uses and reports on the same chemicals in every year. One change in reporting that may threaten the validity of changes in TRI releases as measures of changes in environmental performance is if a facility substitutes from a less toxic to a more toxic chemical (or vice versa). Even if the facility reduces releases by a substantial amount, the total risk presented by the facility may remain the same, decrease by less, or even increase. Thus, not adjusting for toxicity compromises the *significance* and the *comparability* of the TRI data both across facilities in a given year and within a facility over time.

EPA and academic researchers have been working to develop indicators that take the TRI data as an input, combine it with toxicity, exposure, and degradability information, and then calculate a risk-based metric. EPA has recently released its Risk Screening Environmental Indicators (RSEI) model, which combines TRI data and risk information to develop a risk-adjusted pollution measure for peer review (U.S. EPA, 2004). These changes will doubtless improve the quality of estimates of environmental performance using TRI data.

A third threat to the validity of the TRI data stems from the fact that these data are self-reported by facilities. This affects both the *precision* and the *verifiability* of the data as measures of environmental performance. Changes in how a facility estimates releases or even how it classifies releases may lead to changes in reported releases that are not reflective of real changes in environmental performance (Graham and Miller 2001). In the initial years following the establishment of TRI, the accuracy of the self-reported releases was thought to be poor (U.S. Government Accounting Office 1991); however, most observers believe it has improved over time. EPA has issued updated guidance on estimating releases both for different industries and chemicals,[6] and it audits a small number of facilities' TRI reports each year. Despite these efforts, concerns over the precision and verifiability of the self-reported data remain.

The final threat to the validity of the TRI data is due to truncation in reported releases caused by the existence of reporting thresholds. It is this threat that this paper addresses. Reporting thresholds set a minimum level of chemical use at a facility, below which the facility is not required to report releases. For the TRI data, the reporting thresholds are 25,000 pounds for manufacture and processing of a listed chemical and 10,000 pounds for any other use of the chemical. Similarly, the TURA data require reporting only if total use (manufacturing plus processing plus otherwise use) is greater than 10,000 pounds. These reporting thresholds create incidental truncation in the TRI data. This truncation threatens the *significance* and *comparability* of the TRI data for both ordinal and cardinal analyses. To illustrate the potential bias, define:

y_{ict} = actual releases of chemical c, by facility i, in time t

[6] For example, U.S. EPA (2000) provides detailed guidance for the Textile Processing Industry. The set of all industry and chemical guidance can be obtained online at www.epa.gov/tri/guided_docs.

M_{ict} = amount of chemical c manufactured by facility i in time t

P_{ict} = amount of chemical c processed by facility i in time t

U_{ict} = amount of chemical c otherwise used by facility i in time t

ς = set of all chemicals, *c*, that are reportable to TRI

For each facility there exists a true aggregate measure of releases, Y, such that

$$Y_{it} = \sum_{c \in \varsigma} y_{ict} \ .$$

However, we do not observe y_{ict} or Y_{it}. Instead, we observe:

$$\widetilde{Y}_{it} = \sum_{c \in \varsigma} y_{ict} r_{ict} \ ,$$

where

$$\begin{aligned} r_{ict} &= 1 \text{ if } (M_{ict} > 25{,}000) \text{ or } (P_{ict} > 25{,}000) \text{ or } (U_{ict} > 10{,}000) \\ &= 0 \text{ otherwise} \end{aligned} .$$

Further define:

r_{it} = vector of r_{ict} (r_{i1t}, r_{i2t}, …, r_{iCt}) for all c in ς ,

$$\begin{aligned} u_{ict} &= 1 \text{ if } (M_{ict} > 0) \text{ or } (P_{ict} > 0) \text{ or } (U_{ict} > 0) \\ &= 0 \text{ otherwise} \end{aligned} \text{, and}$$

u_{it} = vector of u_{ict} (u_{i1t}, u_{i2t}, …, u_{iCt}) for all c in ς .

Under what circumstances can we use observed data on reported releases, $\widetilde{Y}_{it}$, to make valid cross-section or time series comparisons? Begin with a cross-sectional comparison. If we observe: $\widetilde{Y}_{1t} > \widetilde{Y}_{2t}$, under what circumstances can we be confident that

$Y_{1t} > Y_{2t}$? This inference will be valid if both facilities report for all chemicals for which they use any positive quantity.[7] That is if:

$$r_{1t} = u_{1t} \text{ and } r_{2t} = u_{2t}.$$

The key point is that if there are some chemicals which a facility uses in positive quantities, that is $u_{ict}>0$, but for which the facility is not required to report because u_{ict} is below the reporting threshold, then $\widetilde{Y}_{it}$ does not necessarily equal Y_{it} and $\widetilde{Y}_{it}$ is not necessarily ordinally comparable across facilities.[8]

Turning to time-series evaluation, under what circumstances do the trends in reported releases provide valid information on the trends in actual releases? That is, under what circumstances does $\widetilde{Y}_{it} - \widetilde{Y}_{it-1} = Y_{it} - Y_{it-1}$? As with the cross-sectional comparison, time series comparisons based on reported releases will only provide valid inferences on true releases if the facility reports for every chemical that it uses in any positive quantity.[9] That is, if:

$$r_{1t} = u_{1t} \text{ and } r_{1t-1} = u_{1t-1}$$

Notice that the facility does not need to report for the same set of chemicals in both years. It just must report for all chemicals it uses in each year. If a facility stops using a chemical and, hence, stops releasing this chemical, that is a real change in environmental

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[7] This is the only condition under which this inference is generally valid. However, this inference may be valid in certain special cases. For example, if every facility does not report for a chemical, c, but releases of that chemical are the same for all facilities. There is no reason to think that this will hold.

[8] If ordinal comparability is not preserved, then cardinal comparability is also not preserved.

[9] This condition allows for valid time series inference in all cases. There may be special cases in which require less restrictive conditions. For example, if the amount of non-reported releases is constant across time, then the absence of these releases does not bias the time series comparison. However, there is no *a priori* reason for assuming non-reported releases are constant across time.

performance. But if a facility simply uses less of the chemical and is no longer required to report releases, this is not necessarily a real change in environmental performance.

The bias that results from truncation at the reporting threshold is referred to as truncation bias. The term truncation bias here has a slightly different meaning than the classic econometric definition. The truncation bias in this paper most closely resembles incidental truncation bias, which arises when facilities or individuals are observed on the basis of the outcome of another decision (Wooldridge, 2002: 552). For example, imagine one only observes wages for the employed, so observing wages is the result of another decision, in this case the labor market participation decision. The truncation bias in the TRI data is incidental truncation bias at the unit for which the data are collected, which is the facility-chemical-year level. One only observes a facility-chemical-year record if the facility triggers the reporting threshold for that chemical in that year. So observing data is the result of the chemical use decision. This incidental truncation bias is further aggravated by aggregation to other levels of analysis, such as the facility, firm, industry, or state level. The aggregation essentially treats all unobserved data as zero, which further invalidates comparisons. Perhaps a more specific name for this bias is "truncation and aggregation bias," but it will be referred to here as truncation bias for short.

While the first three threats to the validity of TRI data are well recognized and measures have been taken to address the threats, little has been done to assess or reduce the problems associated with truncation bias. This lack of attention is not the result of a lack of understanding of the problem, rather it is largely due to the fact that data have not been available that would allow analysts to estimate the extent of the problem and correct it. In contrast, the bias introduced by not weighting TRI pounds by some measure of toxicity is conceptually easier to address because risk factors can be determined with available data and the TRI data can be corrected using these risk factors. However, since facilities are generally not required to report chemical use levels, one cannot observe whether a facility is reporting for all chemicals it uses in positive quantities. Thus, the truncation bias cannot be corrected for in a systematic way using available data.

While systematic correction of the truncation bias cannot be obtained, this paper focuses on estimating bounds on the degree of bias presented by truncation of the data at the reporting thresholds. A reasonable question might be: How much of the observed decrease in TRI releases is potentially due to truncation bias? Similarly, for a cross-section one can ask how much the relative rankings of facilities could change if truncation bias were to be accounted for. A better understanding of the approximate magnitude of the bias introduced by the reporting thresholds can help ascertain whether this bias is a practical, rather than purely theoretical, threat to the validity of the TRI data as a measure of environmental performance.

4 Estimating Bounds on the Truncation Bias

There are several limitations in the TRI data that inhibit systematic estimation of the degree of potential truncation bias. First, the researcher only observes whether a facility reports releases of a chemical in a given year. If a facility does not report for a chemical in year t for which it reported in year t-1, the researcher cannot determine if the facility eliminated use of the chemical, substituted to a different chemical, or was below the reporting threshold.[10]

[10] Facilities that report in one year and then cease reporting in future years represent only a fraction of the truncated observations. There may also be facilities that use a chemical in every year below the reporting threshold, have releases of these chemicals, but are never legally required to report. This non-reporting is equally problematic for policy analysis, but little can be done to identify facilities for which this may be true.

In contrast, the TURA data provide two sources of variation that better allow for the identification of bounds on the truncation bias. First, if a facility does not report for a chemical in year *t* for which it had reported in year *t-1*, the TURA reporting forms include an optional question that asks the facility to explain the change. Approximately, one-third of facilities that cease reporting for a chemical answer the optional question. I check to see if the facilities that respond to this optional question are representative of the set of facilities that cease reporting and find evidence that responders are not systematically different from non-responders. Thus, the responses to the optional question are used to gauge the degree to which facilities are not reporting for chemicals they use in positive quantities.

The second source of variation in the TURA data that can be used to help estimate bounds on the truncation bias is that facilities are required to report how much chemical they *use* in addition to how much they *release*. The federal TRI has reporting thresholds based on use, but only requires reporting on releases. The use data combined with the responses to the optional question about why facilities ceased reporting reveal that the distance from the reporting threshold is a good predictor of whether a facility ceases reporting because it went below the reporting threshold, but still used the chemical in positive quantities. I use this relationship to predict for non-responders the reason why they ceased reporting.

For facilities that directly reveal that they ceased reporting because they went below the reporting threshold, and for facilities that are predicted to have ceased reporting because they went below the reporting threshold, I then estimate the effect of these missing releases on trends in releases over time and on cross-sectional comparisons of facilities within a given year. Missing releases are estimated using three different procedures. The first is a lower bound estimate on total releases at the facility. The lower bound estimate assumes that when a facility ceases reporting its true releases are zero. This is the implicit assumption currently made by government agencies, non-profits, and academic researchers when aggregating releases data to the facility level (or higher levels). The second estimate of missing releases can be considered an upper bound estimate. In the upper bound scenario, if a facility ceases reporting a chemical because it went below the reporting threshold, releases are set equal to the most recent level of releases reported for that chemical at that facility. Moreover, the facility is assumed to continue releasing the chemical at the same level in perpetuity. The final estimate of missing releases is one that extrapolates the value of non-reported releases based upon linear trends in reported releases. These three scenarios present an upper and lower bound and an intermediate estimate of the degree of bias introduced by the reporting thresholds.

Section 4.1 examines why facilities claim they ceased reporting in Massachusetts using the optional question from the TURA form. This section also discusses the estimation used to predict reasons for non-reporting for facilities that did not answer the optional question. Section 4.2 discusses the estimation of the magnitude of missing releases in Massachusetts based on three estimation methods. Section 4.3 discusses the implications of the Massachusetts results for national analyses.

4.1 Why do facilities cease reporting?

Facilities in Massachusetts were required to disclose pollution and chemical use data to the TURA program beginning in 1990. From 1990 to 1999 there were a total of 23,200 chemical reports filed by 1,092 facilities. During this same time period there were 3,758 cases where a facility reported for a chemical in one year, but did not report the chemical in the following year.[11] For these facilities, the TURA form provides an optional question where the facility can explain why it is no longer reporting for this chemical. The question is multiple-choice with the following six possible responses: (1) chemical use is below the reporting threshold but greater that zero, (2) chemical was not used this year, (3) substituted a different chemical, (4) chemical use eliminated without substitution, (5) decline in business, and (6) other. If the facility answers other, they are given the option to fill in a reason. This question is answered for a total of 1,271 (or 33.8 percent) of the cases where reporting ceases. Table 2-1 provides the distribution of responses.

Table 2-1: Explanation for Non-Reporting Among Respondents to the Option Question in Massachusetts

Reason for No Longer Reporting	*Number of Respondents*	*Percentage of All Non-missing Responses*
Chemical use is below the reporting threshold but greater than zero	844	66.40
Chemical was not used this year	96	7.55
Substituted a different chemical	87	6.85
Chemical use eliminated without substitution	60	4.72
Decline in business	31	2.44
Other	153	12.04

Approximately two-thirds of all respondents to the optional question answered that they were no longer reporting because their chemical use was below the reporting threshold, but greater than zero. Of the respondents that answered "other" the most

[11] It is possible that the facility reported that chemical again in future years. This occurs 379 times.

frequent explanation was that the chemical in question had been delisted by the state and reporting was no longer legally required.

The high percentage of respondents that state they ceased reporting because their chemical use was positive, but lower than the reporting threshold, raises concern that the degree of truncation bias may not be trivial. However, before estimating bounds on the truncation bias, it is necessary to determine whether the facilities that responded to the optional question are systematically different from those that did not respond. If responders are systematically different from non-responders in ways that may also be correlated with their reason for not reporting, then the sample of responders cannot be used to impute explanations for non-reporting. To see whether the responders to the optional question are a representative sample, I compare the distribution of the data for the two groups for three key variables—two-digit SIC code, year reporting stopped, and total releases to the environment in year before reporting stopped. Table 2-2 presents the distribution of SIC codes, Table 2-3 presents the distribution of years, and Table 2-4 presents the mean and standard deviation for total pounds released.

Table 2-2: Distribution of Standard Industrial Codes by Optional Question Responders and Non-Responders

	Percentage of Total	
SIC code	*Respondents to Optional Question*	*Non-Respondents to Optional Question*
17	0.24	0.04
20	1.83	1.04
22	4.54	4.23
23	0.48	0.41
24	0.08	0.29
25	1.27	1.41
26	5.74	4.39
27	1.83	1.49
28	21.83	21.72
29	0.08	0.17
30	**5.10**	**7.21**
31	**0.80**	**1.66**
32	0.88	0.99
33	6.22	7.54
34	15.30	14.17
35	**2.15**	**3.69**
36	11.24	10.48
37	3.03	2.61
38	6.06	4.77
39	3.51	2.69
45	**0.00**	**0.21**
47	0.00	0.08
49	**2.79**	**4.85**
51	**4.38**	**2.90**
72	0.56	0.70
73	0.00	0.04
75	**0.00**	**0.21**
76	0.08	0.04

Bold SIC codes indicated that the difference in percentages is statistically significant at the 5% level. The t-test assumes unequal variances across groups.

Table 2-3: Distribution of Years When Reporting Ceased by Optional Question Responders and Non-Responders

	Percent of Total	
Year Reporting Ceased	Respondents to Optional Question	Non-Respondents to Optional Question
1990	10.96	11.76
1991	**11.36**	**8.62**
1992	15.06	13.05
1993	14.67	9.51
1994	**13.56**	**15.31**
1995	8.60	10.68
1996	**8.99**	**8.90**
1997	7.57	7.98
1998	**9.23**	**14.18**

Bold SIC codes indicated that the difference in percentages is statistically significant at the 5% level. The t-test assumes unequal variances across groups.

Table 2-4: Distribution of Reported Pollution Releases by Optional Question Responders and Non-Responders

	Mean	Standard Error
Respondents to Optional Question	16,749	4,333
Non-Respondents to Optional Question	18,102	1,443
Difference between Respondents and Non-Respondents	1,353	4,567

A t-test on the difference in average pollution releases between the two groups cannot reject the null hypothesis that this difference equals zero. The t-statistic is 0.30 allowing the variance between the two groups to be unequal.

The data suggest that responders to the optional question are not systematically different from non-responders at least on total pounds of chemicals released. The difference in the average release levels is 1,353 pounds with a standard error of 4,567 pounds. There are some systematic differences in industry and year reporting stopped. Of the 28 SIC codes, the two groups—responders and non-responders—are statistically different for 7 of them.[12] There are also some differences among responders and non-responders in the years for which reported ceased. Of the nine years, the distribution of responders and non-responders differs in four years.[13] In addition, one may be concerned that there are unobservable differences between the responders and the non-responders that also are correlated with whether the facility goes below the reporting threshold but still uses the chemical in positive quantities. In the absence of a valid instrument that can explain response to the optional question, but not explain going below the threshold, specific sample selection correction models cannot be employed. Rather in this section, I impute reasons for non-reporting for those that did not answer the optional question based on data from the sample of facilities that answered the optional question assuming that responders are reasonably representative on non-responders. I then conduct sensitivity analysis on these results which is presented in Section 2.4.3.

There are several ways one might impute these data. A common method is known as "hot deck" (Ford 1983; Little and Rubin 1987). Essentially, hot deck is a matching strategy—find a facility that responded to the question that looks like a facility that did not respond and assign the matching responders value to the non-responder. A variant of hot deck is to use regression to estimate a relationship between facility characteristics and the explanation for ceasing reporting for those that respond to the optional question, and then using this regression function, predict for non-responders what their explanation would have been.[14] This regression-based imputation strategy is employed here.

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[12] A Pearson's Chi-squared test rejects equality of the industry distributions across the two groups.

[13] A Pearson's Chi-squared test rejects equality of the industry distributions across the two groups.

[14] These two strategies differ in the degree that matching is "enforced" and the functional form assumption. Hot deck is a non-parametric strategy that does not impose a specific functional form on the relationship between the covariates and the response variable. Regression is loose matching, but

To construct the prediction relationship, I first create a new dummy variable that takes a value of one if the facility ceased reporting because it went below the reporting threshold and zero otherwise. I then use this variable as the dependent variable in a logit estimation on observable facility characteristics. The task is then to compile a set of observable characteristics that explain whether a facility will go below the reporting threshold.

One characteristic that may explain the propensity to go below the reporting threshold is the facility's distance from the reporting threshold. Degeorge, Patel and Zeckhauser (1999) demonstrate that the existence of performance thresholds for managers induces specific changes in their earnings management, with managers managing to the thresholds. For example, empirically there appears to be a concentration of profits just above zero for managers that are compensated based on whether their unit earns positive profits. Degeorge, Patel and Zeckhauser refer to this as threshold-regarding behavior. Threshold-regarding behavior is particularly pronounced among units that are very close to the profit threshold. In other words, if your unit is quite far from earning positive profits, you do not try to manipulate earnings much, because no amount of manipulation will cause your unit to earn positive profits. But, if your unit is very close to the positive profit threshold, manipulation of earnings is more valuable.

In the context of the TURA reporting thresholds, we might expect to see similar threshold-regarding behavior. Facilities that are very close to reporting threshold in year *t* have a greater incentive to manage their chemical use so that they fall below the reporting threshold in *t+1*. To measure the distance from the reporting threshold, I construct a

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does impose a functional form. The regression-based matching will perform well when the assumed parametric specification is a good approximation to the average response function.

variable that measures, for each chemical, how far the facility is from each of the reporting threshold. In Massachusetts, this process is simplified by the fact that once the facility triggers the reporting threshold for one chemical, the reporting threshold for all chemicals is 10,000 pounds of combined manufacture, process, and other use amounts. So in Massachusetts there are not three separate reporting thresholds, but one binding threshold at 10,000 pounds of total use. The facility's distance from the reporting threshold is then given by total use minus 10,000 pounds. The hypothesis is that the greater the distance from the reporting threshold, the less likely a facility is to cease reporting that chemical because its use of the chemical went below the reporting threshold.

Similarly, if there is a relationship between chemical use and chemical release, then total releases of the chemical in time *t* may predict whether the facility goes below the reporting threshold in year *t+1*. Thus, total releases are also used as an explanatory variable. Other potential explanatory variables include industry dummy variables, and year dummy variables that proxy for changes in industry best practices and exogenous technological change. The relationship estimated is then given by:

$$\text{below\_threshold}\begin{pmatrix}0\\1\end{pmatrix} = \alpha + \beta_1 \text{Distance from Threshold} + \beta_2 \text{releases} + \beta_{\text{sic}} SIC + \beta_t Year + \varepsilon$$

The results of this estimation are present in Table 2-5.

Table 2-5: Results for Estimation of Threshold Logit for Respondents to Optional Question

	Coefficients	Percent Increase in Baseline Probability Resulting from a 10% Decrease from Mean
Constant	1.02 (1.19)	NA
Distance from Threshold	-0.00001 *** (0.000003)	6.5%
Releases	-0.00003 *** (0.000006)	3.1%
SIC dummies	Yes +	NA
Year dummies	Yes +	NA
Number of observations	1,251	
Pseudo R-squared	0.17	
Baseline Probability	60.0 %	

Baseline Probability is the probability evaluated at the mean value of all continuous explanatory variables and at zero for all binary variables.
*** Significant at the 1% level
+ An F-test shows variables are jointly significant at the 1% level

Because the logit estimation is non-linear, the coefficients presented do not convey information about the marginal effect of a change in one of the explanatory variables on the dependent variable. To determine what the magnitude of the effect of each explanatory variable is on the probability that a facility ceases reporting because it goes below the reporting threshold, I first calculate the baseline probability—that is the probability of going below the threshold predicted by the logit equation when all of the continuous variables are set at their mean value and all of the binary variables are set at zero. The baseline probability evaluated at the mean is 60.0%. I then decrease each covariate in turn by 10% from its mean value and report the percentage point change from the baseline. Using this method, a 10 percent decrease from the average distance from the reporting threshold results in a 6.5 percentage point increase in the probability of going below the reporting threshold. Similarly a 10 percent decrease in total releases to the environment results in a 3.1 percentage point increase in the probability of going below the reporting threshold.

This probability function can then be used to predict whether facilities that ceased reporting for a chemical, but did not explain why, were likely to have ceased reporting because they went below the reporting threshold. The above equation was used to predict the probability of going below the threshold for the 2,482 observations with no answer to the optional question. Observations with a predicted probability greater than 50 percent were coded as going below the threshold. Table 2-6 provides a breakdown of the observations that ceased reporting by explanation. Of the 2,482 observations for which no explanation for non-reporting was provided, 1,786 (72.0 percent) were predicted to have stopped reporting because the facility went below the reporting threshold for that chemical, but still use the chemical in positive quantities.

Table 2-6: Distribution of Observations (Facility-Chemical-Year) that Cease Reporting by Explanation

	Explanation Provided by Facility	Explanation Predicted	Total
Below the Reporting Threshold	844	1,786	2,630
All Other Reasons	424	696	1,120
Total	1,268	2,482	3,750

In summary, analysis of the Massachusetts TURA data indicates that a substantial percentage of facilities that cease reporting a chemical do so because they go below the reporting threshold for that chemical, but still use it and may still have positive releases of these chemicals. While this frequency of threshold-regarding behavior seems to present some concern about the validity of the TRI data for making comparisons among facilities or across time, the level of concern may still be low if the total amount of releases that disappear from the registry is small. That is, perhaps the percentage of observations affected by the reporting thresholds is large, but the total share of releases represented by these observations is small. The next section addresses the question of the likely magnitude of the truncation bias.

4.2 What is the Magnitude of Missing Releases in Massachusetts?

The difficulty in assessing the effect of truncation at the reporting thresholds on the validity of the TRI data is that it is impossible to know how large a problem non-reportable releases are, precisely because these releases are no longer reported. The best we can do is assess how large this problem might reasonably be, given observable information. To that end, this section focuses on estimating the magnitude of "missing" releases by estimating bounds on the possible size of these releases—a lower bound estimate, an upper bound estimate, and a linear projection estimate.

To make these results meaningful, I restrict the analysis to chemicals and industries that have been subject to the TURA reporting requirements since its inception—the so-called core group. This ensures that we are examining variation in reported releases due to facility behavior around the thresholds and not changes in releases due to changes in the regulatory requirements themselves. The analysis is also done for two different measures of pollution from the TRI. The first is on-site releases. On-site releases are releases of the pollutant to air, water, land, or under-ground injection that occur at the facility's location. The second measure is total on- and off-site releases. Total releases include on-site releases, but add transfers of waste to offsite locations for disposal or recycling. In general, it is thought that total releases is over-inclusive as a measure of environmental performance because some of the transfers are not pollution, but are transfers for recycling and reuse. On-site releases, however, are under-inclusive as a measure of environmental performance because some waste that is transferred off-site is pollution attributable to the facility. Researchers have used both on-site and total releases as measures of environmental performance, so it important to see if the reporting thresholds have different effects for the two measures.

The lower bound estimate of the value of non-reported releases is that these releases are zero. This assumes that once a facility drops below the reporting threshold for a given chemical, they no longer release any of that chemical. A conservative upper bound estimate of the value of non-reported releases is that they equal the last reported value of releases for that chemical at that facility. Thus, if a facility reports releases of 500 pounds of a chemical in year t and then drops below the reporting threshold, the upper bound estimate of missing releases is that this facility releases 500 pounds a year of that chemical in perpetuity.[15]

One might argue that assuming unobserved releases are either zero or set at their most recent value in perpetuity are extreme assumptions. There is some evidence that suggests that, on average, setting releases equal to the last reported value is not as extreme an assumption as it may first appear. There are 287 observations (1 percent of the total) where the facility stops reporting for a chemical in one year because it went below the reporting threshold and then in the future the facility begins reporting for that chemical again. How do releases of the chemical in future years compare to the reported releases in the last reported year? On average, the future reported releases are 796 pounds *greater* than

[15] Occasionally a facility will report for a chemical for a few years, then stop reporting for that chemical because they are below the reporting threshold, and then begin reporting for the chemical again in later years. In this case, the upper bound estimate of releases equals observed releases in any year in which the facility actually reports releases and in non-reporting years are set equal to the releases in the most recent year in the past for which the facility reported releases for that chemical.

the last reported releases for that chemical. [16] Of course, this does not rule out the possibility that assuming releases are constant for non-reporting facilities is a conservative upper bound. Facilities that waver above and below the reporting threshold are distinct from facilities that go and remain below the reporting threshold. Thus, we might not expect the release behavior of the facilities that oscillate around the reporting threshold to be indicative of the release behavior of facilities that go below the reporting threshold and stay there forever. But this evidence does suggest that using the last reported releases as an estimate of future reported releases might be a reasonable upper bound.

Providing upper and lower bounds on the potential bias in reported releases induced by truncation at the reporting thresholds provides useful information on how large the bias may be. However, it does not provide any information on the probability distribution of the true bias within that range. While this range is useful, perhaps, we would wish to also have an estimate of bias under a more probable scenario. An alternative assumption about the behavior of releases among non-reporting facilities is to assume that facilities do not fundamentally behave in different ways with respect to their release decisions based on whether they are above or below the reporting threshold. If this is the case, then the trends in non-reported releases might be expected to increase or decrease at the same rate as the trends in observed releases. Under this assumption, one can project trends in releases for non-reportable data based on observed trends in releases among reported chemicals.

How can we predict the trend in reported releases so that it can be extrapolated to non-reporting facilities? One might hypothesize that the amount of the chemical used, the

[16] The largest future drop in reported releases is by 63,571 pounds and the largest future increase in reported releases is 105,600 pounds.

type of chemical, the industrial sector, and other similar factors. would all be good predictors of how much chemical a facility will release in a given year. While all of these factors do explain chemical releases, taken together they only explain about seven percent of the variation in reported releases.[17] The best predictor of reported releases turns out to be a distributed lag of past releases. A simple one period distributed lag, where current releases of each chemical are regressed on releases of that chemical from the previous year, explains 80% of the variation in releases. Increasing the number of lags increase the predictive power slightly, but makes the equation less useful for prediction because a smaller number of observations have multiple lags. The results for one-, two-, and three-period distributed lag models are presented in Table 2-7. Using the one-period distributed lag model, current on- and off-site releases are, on average, 95 percent of previous years' releases. Similarly, using a one-period distribution lag model, current on-site releases are 80 percent of previous years' releases.

[17] This estimate comes from a regression of releases on total chemical use with two-digit SIC code, chemical, and year fixed effects. Including facility-chemical fixed effects increases the predictive power of the regression to 65 percent. However, the distributed lag model, which yields a higher predictive power, also is preferred because all of the data are observable. That is, it relies only on past releases, which we observe for all facilities that cease reporting.

Table 2-7: Distributed Lag Models of Reported Releases

	Total Releases (On- and Off-site)			On-site Releases		
Specification	1	2	3	1	2	3
1 year lag	0.947 ***	0.865 ***	0.872 ***	0.798 ***	0.740 ***	0.737 ***
	(0.054)	(0.131)	(0.149)	(0.036)	(0.084)	(0.115)
2 year lag		0.105	0.086		0.087	0.130
		(0.134)	(0.143)		(0.068)	(0.089)
3 year lag			0.017			-0.021
			(0.083)			(0.046)
Observations	8586	6572	4964	8927	6952	5330
Adjusted R-squared	0.779	0.795	0.804	0.782	0.807	0.808

*** indicates the coefficient is statistically significant at the one percent level.

Using the coefficients from the one-period distributed lag model, I predict releases for each facility that ceases reporting. This generates trends for facilities that cease reporting. These projected trends are downward sloping for all facilities that cease to report for a chemical, and the rate of decrease is larger for on-site releases than for total releases. Figure 2-3 diagrams the process of estimating lower, upper, and linear projected releases for a facility and Table 2-8 provides data on the magnitude of missing releases, both total releases (on and off-site) and on-site releases, using both the upper bound assumption and the linear projection.

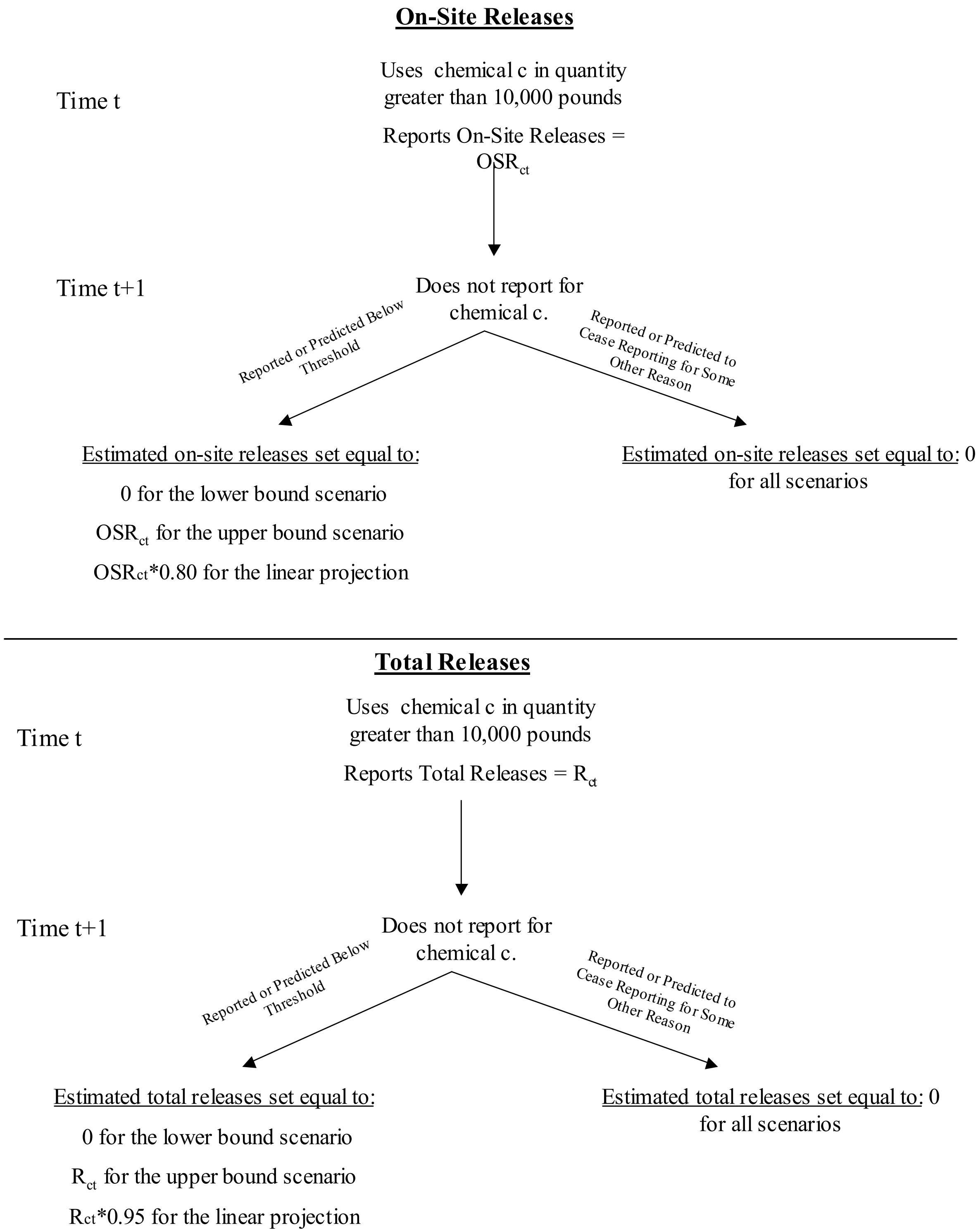

Figure 2-3: Flow Chart for Imputation of "Missing" Releases

Table 2-8: Estimates of TURA Releases in Massachusetts (in 1,000s of pounds)

	Total Reported Releases (On- and Off- Site)				On-Site Releases			
Year	Lower Bound	Linear Projection	Upper Bound	% Difference Between Lower and Upper Bounds	Lower Bound	Linear Projection	Upper Bound	Percent Difference Between Lower and Upper Bounds
1991	43,294	45,228	45,337	4.7%	17,600	18,870	19,191	9.0%
1992	44,842	48,301	48,774	8.8%	15,563	17,495	18,296	17.6%
1993	38,215	44,110	44,427	16.3%	11,857	14,640	16,060	35.4%
1994	39,052	46,131	46,345	18.7%	9,299	12,158	14,258	53.3%
1995	36,538	44,265	44,845	22.7%	8,711	11,264	13,928	59.9%
1996	36,812	44,852	45,935	24.8%	7,449	9,657	13,134	76.3%
1997	32,430	40,614	41,903	29.2%	6,357	8,337	12,318	93.8%
1998	33,026	41,623	43,495	31.7%	5,599	7,364	12,050	115.2%
1999	19,955	28,778	31,333	57.0%	5,117	6,689	11,966	113.8%

The results indicate that the degree of missing releases in the early years is relatively modest as a percentage of total releases. In 1991, missing releases are only about four percent of total (on- and off-site) releases and between seven and nine percent of reported on-site releases. However, over time, missing releases as a percentage of total reported releases rise dramatically. There are two reasons for this. First, missing releases are cumulative. In every year, about two to four percent of the previous year's releases are not reported due to facilities going below the reporting threshold. But in each year the total amount of missing releases are all those releases that are no longer being reported by all facilities, these include the releases from facilities that stopped reporting for the chemical this year, as well as the missing releases from facilities that went below the reporting threshold two years ago, three years ago, and so forth. Particularly in the upper bound scenario, when facilities that drop below the reporting threshold are assumed to continue releasing at the same level in perpetuity, the cumulative effect can be quite large.

The second explanation is that reported releases fall considerably over time, even for facilities that continue to report for all chemicals. For the upper bound case, where non-reporting facilities are assumed to continue to release at the same level forever, the relative importance of these releases increases over time—the missing releases stay the same, but the total reported releases decrease—resulting in a sharp increase in missing releases as a percentage of total reported releases. In fact, for on-site releases the difference between the upper and lower bound estimates of releases differs by 134 percent in 1999.

The data in Table 2-8 illustrate that the magnitude of missing releases generated by the existence of the reporting threshold is non-trival. But does this result in significantly biased estimates in the trend in environmental performance over time? Figures 2-4 graphs the trend in total releases over time for each of three scenarios: (1) only reported releases (lower bound estimated assumes non-reported releases equal zero), (2) reported releases plus the upper bound estimate of missing releases (sets missing releases equal to their last reported value for all years), and (3) reported releases plus linearly extrapolated estimates of missing releases.

Looking at total releases first, it is clear that the estimate of the trend in environmental performance is substantially affected by the exclusion or inclusion of the estimated releases for non-reporting facilities. Using a lower bound assumption, that all non-reported releases are zero, the change in total releases from 1990 to 1999 is 36.7 percent. However, if one instead uses the upper bound assumption, that facilities that fall below the reporting threshold continue to release the same amount forever, the change in total releases over the same ten year period was only 0.6 percent. Using the more moderate assumption that facilities that are no longer reporting continue to decrease releases over time at the same rate as the average reporting facility, the change in total releases over the ten-year period is 8.7 percent.

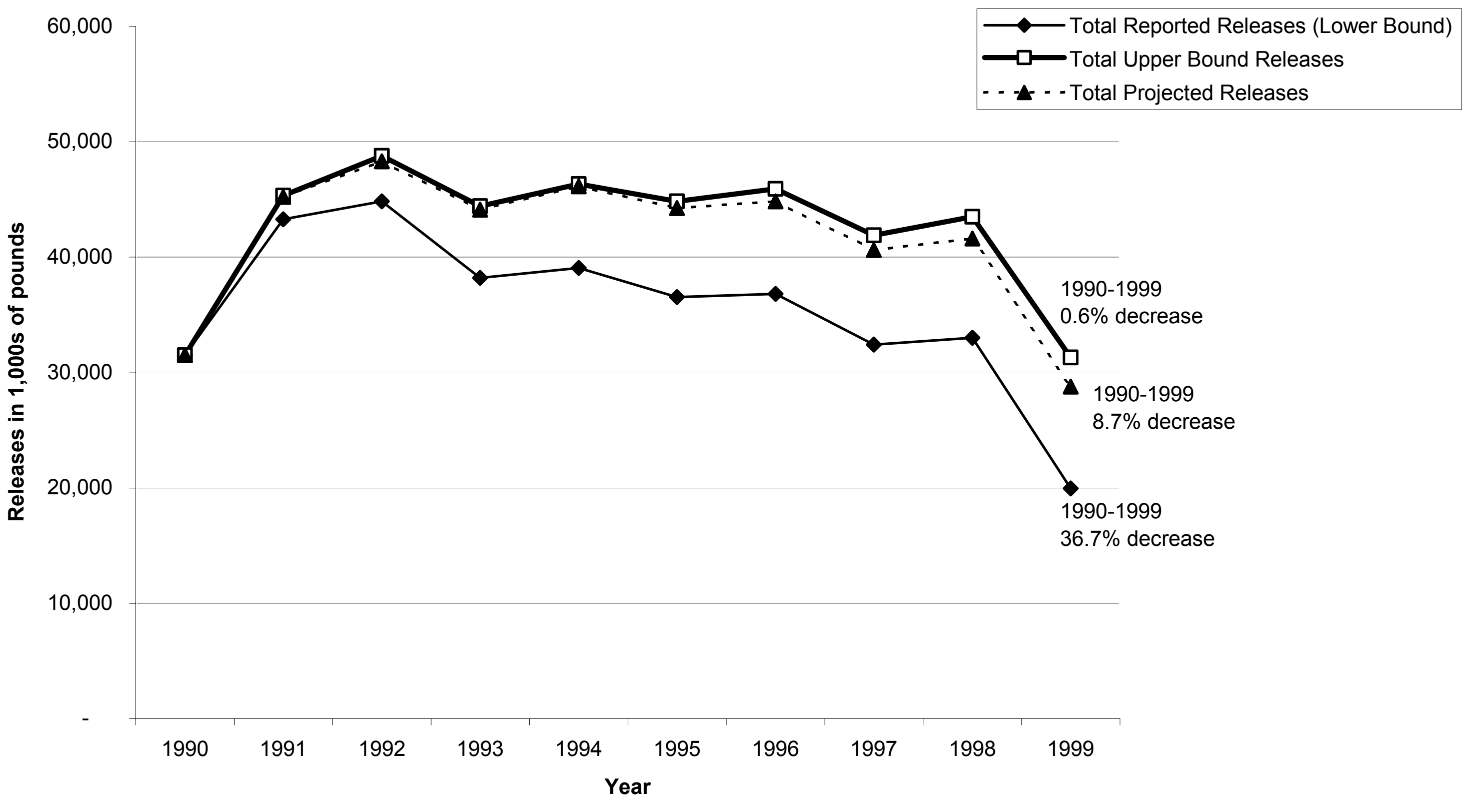

Figure 2-4: Trends in Total (On- and Off-Site) Releases in Massachusetts

The story is somewhat less stark, but still significant, if one ignores the upward trend in reported off-site releases between 1990 and 1991 and instead examines trends only for the years 1991 to 1999. For this period, the lower bound assumption leads to the conclusion that total releases have fallen by 53.9 percent, the upper bound assumption estimates the decline at 30.9 percent, and the linear projection leads to an estimate of a 36.4 percent decrease. Using the difference in trends from 1991 to 1999, it appears that in the worst case, non-reported releases by facilities that fall below the reporting threshold may account for approximately 23 percentage points of the total 54 percentage point decrease in reported releases, or roughly 40 percent.

The potential degree of bias introduced by the reporting thresholds in the trends for on-site releases is less pronounced, although still sizeable. Figure 2-5 provides the estimated trends in on-site releases. Using the lower bound assumption, the decrease in on-site releases from 1990-1999 was 75.7 percent. Using the upper bound assumption, the decrease over this period was 43.1 percent. Finally using the assumption of linearly projected decreases in non-reported releases, the change over the decade was 68.2 percent. Thus, of the observed 75 percent decline in reported releases, from 1990-1999 as much as 32.5 percentage points (or 40 percent) of this decrease may be accounted for by non-reported releases.

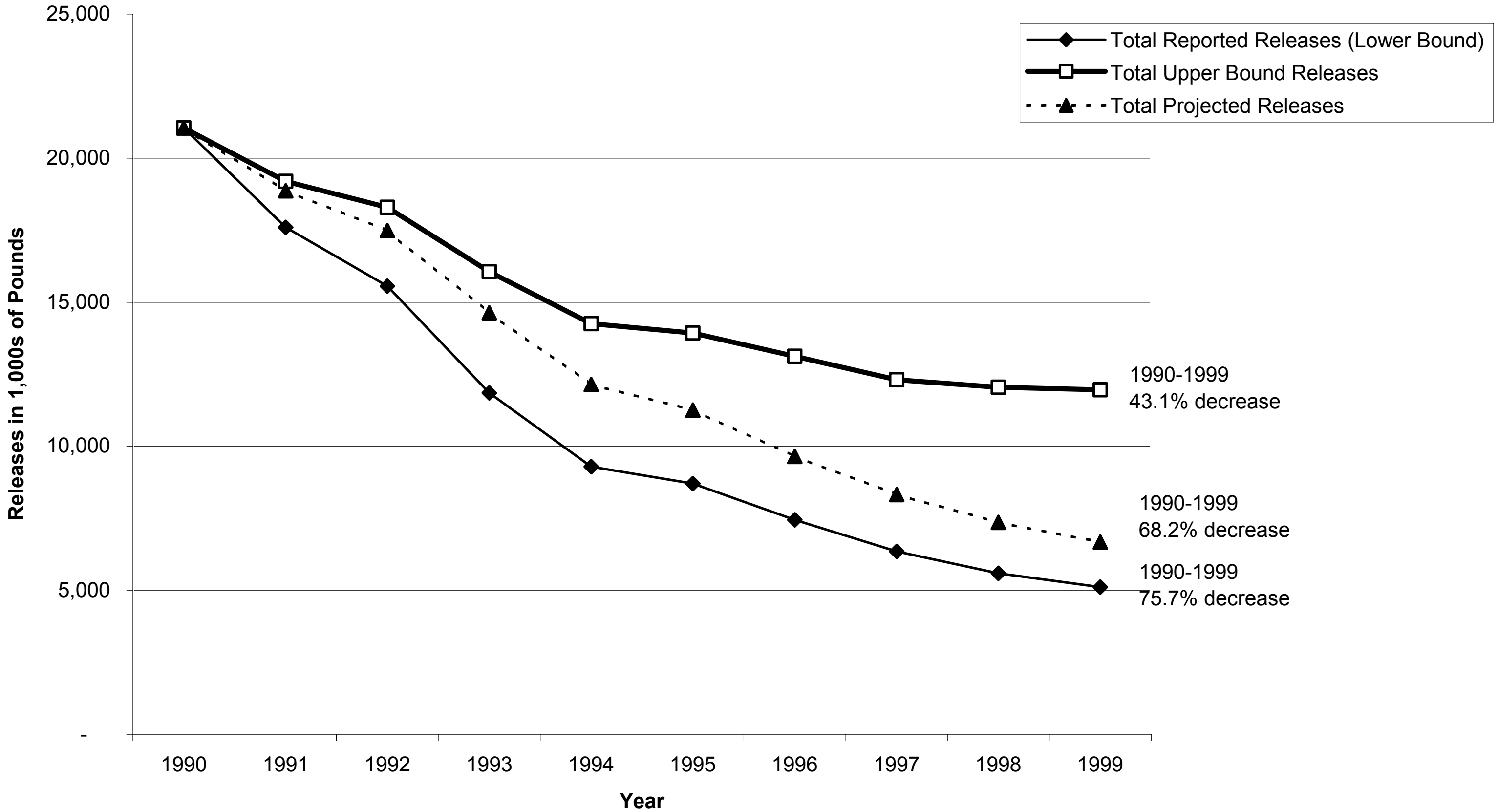

Figure 2-5: Trends in On--Site Releases in Massachusetts

As evidenced by these data, our understanding of the magnitude of the change in environmental performance is substantially affected by the truncation bias introduced by the reporting threshold. Making different assumptions about what happens to releases when facilities cease to report because they fall below the reporting threshold makes a big difference in our understanding of the level of environmental improvement. Having said that, it is somewhat reassuring that even in the upper-bound scenario, on-site releases of toxic chemicals have fallen by over 43 percent in Massachusetts. In this case, using TURA data to conduct policy analysis is very likely to result in erroneous cardinal estimates of the magnitude of improvement, but unlikely to result in erroneous ordinal estimates—things have improved by somewhere between 43 and 76 percent.

A separate concern is whether the reporting thresholds induce bias in cross-sectional comparisons of facilities. Imagine that we rank facilities from lowest releases to highest releases. If the degree of non-reported releases is small relative to any given facility's total reported releases, adjusting for these non-reported releases will change our estimate of how much a facility releases, but may not change the facility's rank much. If on the other hand, the magnitude of missing releases is large relative to total reported releases for some set of facilities, then adjusting facility totals to account for this may substantially changing the rankings of facilities.

To investigate the degree of cross-sectional bias potentially introduced by the reporting thresholds, I first divide facilities into quartiles based on their reported releases. Thus, facilities whose reported releases are in the lowest 25 percent of all facilities in that year are assigned to quartile number one. Facilities whose releases are among the highest 25 percent of all facilities are assigned to quartile number four. These are the quartile rankings associated with the lower bound assumption that all non-reported releases are equal to zero. I then recalculate the facility's quartile ranking based on the upper bound assumption and the linear projection. If the relative importance of the non-reported releases is small, we would expect to see few facility quartile rankings change. In this case we would not be terribly concerned about the potential cross-sectional bias introduced by the reporting thresholds. However, if the relative importance of missing releases is large, we might expect to see more facility quartile rankings change dramatically. An alternative way to think about this is to imagine a policy maker assigning a facility a grade based on its pollution levels relative to other facilities in a given year. A facility can get a grade of excellent, good, fair, or poor. If we adjust for missing releases resulting from facilities going below the reporting threshold, do we change our grades for only a few facilities or for a substantial number of facilities? The results of the quartile distribution comparison are provided in Tables 2-9 and 2-10 for total and on-site releases, respectively.

Table 2-9: Quartile Ranking Comparisons for Total Releases

		Upper Bound Ranking			
		1	2	3	4
Lower	1	**1,046**	960	794	277
Bound	2	349	**146**	33	6
Ranking	3	256	472	**501**	105
	4	0	67	321	**1,257**

Table 2-10: Quartile Ranking Comparisons for On-Site Releases

		Upper Bound Ranking			
		1	2	3	4
Lower	1	**1,279**	644	865	515
Bound	2	232	**173**	30	5
Ranking	3	171	624	**338**	71
	4	0	177	414	**1,054**

In each table, the diagonal elements (in bold) represent facilities whose quartile ranking is unaffected by inclusion of estimates of their missing releases. All off-diagonal entries are facilities whose quartile rankings differ under the upper and lower bound assessments. For total releases, 45 percent of facilities have different quartile rankings under the upper bound assessment than under the lower bound assessment. For on-site releases 43 percent of facilities have different quartile rankings under the two different scenarios.

For the purposes of using TURA or TRI rankings for regulatory targeting purposes, perhaps one is most concerned about errors in the top and bottom quartile. That is, one is concerned most with mislabeling a facility as "poor" or "excellent." Focusing on these quartiles, we can see from the data in Table 2-9 that 24 percent of the facilities that are labeled "poor" based on their reported releases would have been labeled either "fair" or "good" once reported releases are adjusted to include an upper bound assessment of missing releases. In addition, 66 percent of facilities that were labeled "excellent" using only reported releases would have been labeled "good," "fair," or "poor" if missing releases are included. The results for on-site releases are quite similar (Table 2-10). For on-site releases 36 percent of facilities labeled "poor" using reported releases should have received a higher grade and 61 percent of facilities labeled "excellent" should have received a lower grade.

This potential variation in ordinal rankings of facilities within a given year is large enough to be of substantial concern. Indeed, the degree of variation in the cross-section rankings of facilities seems more troubling than the variation in trends over time. In the trends, we were confident in the direction of the change (there had been an improvement), but not in the magnitude of the change. With the cross-sectional rankings we are potentially assigning the wrong grade two-thirds of the time in the best quartile and a quarter of the time within the worst quartile. If regulatory or enforcement resources are targeted based on rankings of reported releases, these resources are likely to be misallocated.

4.3 Sensitivity Analysis

One of the key components of the above analysis was imputing whether or not a facility ceased reporting because it went below the reporting threshold if the facility did not answer the optional question. As discussed in Section 2.4.1, there were some observable differences between facilities that responded to the optional question and those facilities that did not respond. How sensitive are the findings to changes in the imputation method? I try two alternative imputations and provide information on the impact of these changes on the estimates of truncation bias both for trend and cross-sectional analyses.

The first sensitivity analysis is to change the probability cutoff from the logit that determines whether a facility that does not answer the optional question stopped reporting because it went below the reporting threshold. In the main analysis, facilities with a predicted probability of going below the threshold greater than 50 percent from the logit were assumed to have ceased reporting because they went below the reporting threshold. The first test is to increase this probability cutoff to 75 percent.

The second sensitivity analysis is to only examine missing releases for facilities that actually respond to the optional question and state that they cease reporting because they went below the reporting threshold, but still use the chemical in positive quantities. No imputation is made for facilities that do not answer the optional question. This is essentially the same as increasing the probability cutoff from the logit to 100 percent.

Table 2-11 presents the results of the sensitivity analysis for estimates of the effect on the trend in total and on-site releases. For comparison, the first column contains the original estimates (where the probability cutoff equals 50 percent). Under the most conservative scenario, that only used data from facilities that actually answered the optional question, up to 15 percent of the observed decrease in total releases and up to 17 percent of the observed decrease in on-site releases from 1991-1999 could be due to missing releases.

Table 2-11: Maximum Percent of Observed Decline in Releases from 1991-1999 That Could be Explained By Threshold Regarding

	50%	75%	100% (responders only)
Total Releases	42.7	23.8	14.8
On-Site Releases	46.9	27.2	16.7

Sensitivity analysis was also done on the cross-sectional rankings. Table 2-12 presents the results for the differences between the upper bound and lower bound quartile rankings for all three modifications to the probability cutoff (75%, 100%, and expected value). The first column of the table provides the main findings based on a 50 percent cutoff for comparison. In the most conservative scenario, the quartile rankings are wrong about 25 percent of the time. The rankings are only wrong about seven percent in the bottom quartile. That is only about seven percent of facilities that would have received a label of "poor" using the reported data should have received a higher grade if missing data were incorporated. In the upper quartile the percent error is still higher than average. Approximately 33 percent of facilities that would have been labeled "excellent" based on reported releases would have received a lower ranking if missing releases had been accounted for.

Table 2-12: Maximum Potential Error in Cross-Sectional Rankings Due to Threshold Regarding

	50%	75%	100% (responders only)
Total	45%	42%	25%
Bottom Quartile	24%	7%	7%
Top Quartile	66%	56%	33%

Overall the sensitivity analysis supports the general findings presented in the main analysis. First, a potentially significant share of the decrease in observed releases may be due to facilities no longer being legally obligated to report releases because their use of the chemical is below the reporting threshold. Second, the reporting thresholds may also skew the cross-sectional rankings of facilities. In particular, facilities that appear to be low releasers or good environmental performers based on TRI releases may actually not be better than other facilities with higher releases. The error in cross-sectional ranking diminishes as one moves down the distribution. The rankings are considerably less wrong about identifying the worst facilities.

4.4 Extrapolating to the National Level

So far we have examined the degree of bias potentially introduced by the reporting thresholds into both trend and cross-sectional measures of environmental performance for Massachusetts' facilities only. The reason for focusing on Massachusetts was one of data availability. Data from TURA are critical in estimating the magnitude of the truncation bias.

Can we extrapolate the findings from Massachusetts to estimate the degree of truncation bias in national trends and cross-sectional comparisons? Unfortunately, any such precise extrapolation would be shaky, at best, and outright misleading at worst. While the results for Massachusetts do give a strong reason to be concerned about truncation bias affecting the validity of national TRI data, the actual bias at the national level could be lower or higher than in Massachusetts. The set of Massachusetts' facilities is far from a representative sample of national facilities reporting to the TRI. On average, facilities in Massachusetts have reported releases that are an order of magnitude smaller than average releases for facilities in other states. The average total releases between 1990 and 1999 for Massachusetts' facilities were 22,971 pounds while the average for all other facilities were 166,368 pounds.[18] These substantial differences

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[18] This difference is not only due to a smaller variance among Massachusetts facilities. If one graphs the distribution of both total and on-site releases for Massachusetts and all other states,

in the only observable variable that might be used to both predict which facilities cease reporting because they went below the reporting threshold and to estimate the magnitude of missing releases, make valid extrapolation infeasible.

Even on an intuitive level it is difficult to predict how the precise degree of truncation bias nationally will compare to the estimated degree of bias in Massachusetts. On the one hand, the reporting thresholds are lower in Massachusetts than for the federal TRI program. In Massachusetts, once a facility triggers a reporting threshold for a single chemical, the facility must report for all chemicals for which manufacturing plus processing plus otherwise use amounts are greater than 10,000 pounds. For the federal program reportability is calculated separately for each chemical based on the 25,000 pounds manufacture or process and 10,000 pounds otherwise use thresholds. This might imply that truncation bias is likely to be a larger problem for the federal TRI data than for the Massachusetts TURA data.

On the other hand, Massachusetts has an aggressive state-level pollution prevention and reporting program that provide additional incentives for facilities in that state to reduce use of their chemicals below the regulated level. Thus, we might expect to see more threshold-regarding behavior in Massachusetts than in the rest of the country. Similarly, Massachusetts' facilities do have lower average releases. This may also indicate that Massachusetts' facilities are, on average, closer to the reporting threshold and we would expect to see more threshold–regarding behavior in that state than in the nation as a whole.

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the entire distribution for Massachusetts' facilities is shifted to left. A Kolmogorov-Smirnov test rejects the null hypothesis of equality of the distribution at the 1% level.

While I cannot provide any specific estimate of the degree of truncation bias in the national trends or cross-section comparisons using TRI data, the experience in Massachusetts does suggest that concern over truncation bias is well-founded. In addition, some preliminary evidence from decreases in the federal reporting thresholds for lead provide further evidence that the reporting thresholds may affect inferences from the federal TRI data.

In 2001 the reporting threshold for lead was lowered to 100 pounds at the federal level. For the 2000 reporting year, there were 1,997 facilities reporting for lead and lead compounds and total reported releases of lead were 374 million pounds. In 2001, the first year of reporting under the lower threshold, there were 8,444 facilities reporting a total of 443 million pounds. This represents a net increase of 69 million pounds (19 percent). About half of this increase--33.5 million pounds--is attributable to facilities that did not report on lead and lead compounds in 2000.[19]

Given these results, what implications should we draw about how to use TRI data as a measure of environmental performance for policy analysis? That is the topic of the final section.

5 Policy Implications for Using TRI as a Measure of Environmental Performance

The above analysis indicates that the existence of the reporting thresholds may introduce substantial bias in both the trend and cross-sectional estimates of environmental performance using reported TRI releases. However, the TRI data are currently one of the best sources of facility-level pollution levels nationwide. What is the policy analyst to

[19] Personal communication, Cody Rice, Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency, April 26th, 2004.

do? The following recommendations are likely to enhance the validity of studies that use TRI data for policy analysis.

First, the number of chemicals reported by a facility should be treated as an additional policy outcome.[20] If EPA is investigating the effectiveness of a new regulation, it is not sufficient to examine only the effects on total TRI releases (even if these releases are adjusted for toxicity). If the policy also has an effect on the number of facilities that reduce chemical use below the reporting threshold, then estimates of the policy's effect on TRI releases are likely to be biased upward—that is, the effect of the policy will be overstated. If however, one estimates that the policy does not have an effect on the number of chemicals reported, but does have an effect on total releases, one can feel more confident that the policy has actually improved environmental performance and not simply reduced reporting.[21]

If one is only concerned about whether a policy had a positive effect on environmental performance, then a worst-case estimate of the effect may be appropriate. For this worst-case estimate one would assume that any facility that ceases reporting for a chemical did so because it went below the reporting threshold (as opposed to eliminating the chemical, going out of business, or so forth). The facility's releases could

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20 It may be tempting to normalize total releases by how many chemicals the facility reports. For example, one could compare facilities both cross-sectionally and over time based on their average releases per report. However, this correction does not remove the truncation bias. For example, imagine a facility releases uses three chemicals and in the first reporting years reports releases of 200 pounds of Chemical A, 200 pounds of Chemical B, and 150 pounds of Chemical C. In that year the average releases per chemical reported is 183 pounds. In the second reporting year the facility only reports for two chemicals. It still releases 200 pounds of chemical B and 150 pounds of Chemical C. Now the average releases per reporting year are lower at 175 pounds. Releases per chemical reported declined, but the releases for that facility's reported chemicals do not change across those two years.

[21] See the first chapter of this dissertation for an example of a policy analysis that estimates the effect of the policy on both releases and number of chemicals reported.

then be set to their last reported level in perpetuity. This clearly overestimates total releases, but if the policy is still found to lower releases even under this extreme assumption, then one can feel confident in the policy's effectiveness. The magnitude of the effect will be wrong, but the direction, if positive, will be correct.

One could also do sensitivity analysis on the directional effect of the policy (although again not on the magnitude of the effect) by comparing the results for the whole sample to the results for a sample only of facilities that report for the same chemicals over the relevant time frame. If one estimates positive effects of the policy in both samples, then the effects are not due only to decreases in reporting.

Such sensitivity analysis would be greatly improved by the addition of a question on the federal reporting form that asks facilities why they are not reporting for a chemical in the current year for which they reported in previous years. This question, similar to the one used on the Massachusetts TURA form, could help EPA and others assess the potential for truncation bias.

Unfortunately, the only fail-proof way to ensure that truncation bias will not affect the results, and the only way to ensure the magnitude of policy estimates is accurate, is to eliminate the reporting thresholds. EPA has the regulatory authority to change the reporting thresholds, and has done so on two occasions. In 1999, EPA reduced the reporting threshold for persistent and bio-accumulating toxins (the threshold was reduced to 10 or 100 pounds depending on the chemical). In 2000, EPA reduced the reporting threshold for lead to 100 pounds. Obviously, there are costs associated with lowering-reporting thresholds. These costs include administrative costs for promulgating a series of notice-and-comment rulemakings that are likely to be contentious. There are also substantial paperwork compliance costs for facilities that will be required to report for chemicals that were previously unreportable. These costs were estimated at 80 million dollars for the first year of reporting under the lower threshold for lead (U.S. EPA, 2001).

Despite the costs, there may be important benefits from reducing or eliminating the reporting thresholds. For example, EPA argues that responsible use of TRI data allows "Federal, state, and local governments to compare facilities or geographic areas, identify hot spots, evaluate existing environmental programs, and track pollution control and waste reduction progress" (EPA, 2002b). This statement is only correct with the caveat that analysis must also include an examination of the effect of the policy on the number of chemicals reported, or in some other way address the potentially serious issue of truncation bias. EPA has spent considerable resources developing a series of risk-based weights for the TRI data in an effort to enhance the validity of these data as a measure of environmental performance. Based on the results presented in this paper, it is worth asking whether a similar effort on reducing truncation bias is warranted.

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Transcription of Session VI Discussant Comments by John Dombrowski (U.S. EPA, Office of Environmental Information)

Thank you. I'm John Dombrowski—I'm the Associate Director of the TRI Program Division in the Office of Environmental Information. I'm really impressed by the work that Lori [Snyder] and Michael [Kraft] have done. When I read through the papers, I was actually thrilled, thinking, "Wow, people are actually using our data, and look at this!" I think you did very good work, and you should be proud of that.

Just some points of clarification that I'd like to make first, generally about the TRI Program. Then I have some thoughts, or comments, on the papers themselves and a little update to what's going on in the TRI Program, because I think some of your work is relevant to some things that we're looking at within the TRI Program.

As everyone here is aware, the EPCRA [Emergency Planning & Community Right-To-Know Act] Section 313 set the reporting thresholds; the one thing that I would encourage is [for everyone] to look at the Pollution Prevention Act [PPA], because our program is based on this act, and that's where we start encouraging facilities to go towards source reduction.

There has been a lot of reference to the risk-screening environmental indicators [tool] in [the] context of the data in risk. That's fine—we agree with that—we don't have any problem with that, except just keep in mind that the TRI Program is a *hazard*-based program. I have my hands full just *collecting* the information, getting the information out there, needless to say to worry about the *risk* of the data, but I don't think it's something that should be ignored. Again, we provide the data so that communities can make a risk determination for themselves at the community level.

There's been discussion about how the data represent just an estimate, and I assume that's meant in a broader sense, because the origin of TRI data can be based on direct monitoring. The statute does allow for direct monitoring pursuant to other laws—it doesn't *require* direct monitoring—*or* making a reasonable estimate. Then I guess if there is direct monitoring data, they can extrapolate that data over the course of a year, and that's where the estimate would come in. I just want to clarify that it *does* allow for both, and sometimes, actually, we think the engineering-estimated data are probably better than some of the direct-monitoring data that are collected out there.

There's another clarification, also, that the *total* releases—I just want people to be aware, because sometimes this is totally misunderstood—the total releases that EPA reports do *not* include transfers offsite for recycling or treatment, and the TRI Program does not include reuse in their program. "Total releases" involves either releases to environmental media onsite or transfers offsite for disposal. I just want to make sure that people are clear on the terminology that we're using for the program.

The one thing about the TRI Program, as Mike pointed out: It is a very good capacity-building tool—that's exactly the intention of the law. If you look at EPCRA Section

313h, that's what Congress intended it to be. We provide information to the public, to governments, to researchers, and yes, we think it is a *very* valuable and *very* good measurement tool. We'll stand behind a lot of those statements that are up there. However, I don't think you're going to be able to find *one* specific answer to your questions about why reductions are occurring—I think there will be *other* factors, a *lot* of factors involved in that. Yes, I think public pressure is a *big* part of that, but I think you're going to find a lot of different reasons for your answers. Don't look for just one answer is what I would suggest.

The one thing, Mike, that you pointed out in your paper (this is a *big question* for us that we always talk about, and we're starting to think about it a little bit more)—releases are going down. Why is that? Well, again, that's one of the questions that you're trying to answer, and we look forward to those answers. Part of it, also—and what I would suggest you look at, too—is the fact that we allow facilities to come in and revise their information. We don't have any set limit on that. They could also *withdraw* their information. So, as facilities gain better information about their operations and better information about how they may have estimated their releases, they may go back and revise their information using better methods. That's something that should be factored in as well, for more accurate information.

The one thing that you pointed out, Mike, in your paper is that the production-related waste is increasing. We've noticed that trend, too, but we don't really have an answer for that. Releases to the environment are going down, and that's a very good story to tell. We want to tout that story, and the media picks up on it a lot—the public picks up on it, because they understand "releases"—that's very simple to understand. But then we look at the production-related waste, and I wonder what is this increase in production-related waste attributed to? Production-related waste, again, includes releases, transfers offsite, onsite treatment, and energy recovery and recycling. Hopefully the majority of production-related waste is in recycling—that's what we're hoping for. Still, when you look at the fact that production-related waste is increasing, you wonder whether TRI is achieving the ultimate corporate behavior that you want it to achieve. It's nice that they're reducing their releases, but you want them also to start going towards source reduction. Then, you say, let's focus on PPA, because PPA is where we're starting to look at source reduction. Maybe it's partly something EPA could do more—we focused a lot on releases in the past years, in our public data releases and our public data release reports, etc. Maybe we should start putting a little bit more "context" to the data—that's been a big buzzword for us—and highlighting production-related waste and corporate behavior, if you will, and the trends that we see. Part of the difficulty of that, though, is trying to make that relevant to the public—showing what that means for a community. They understand what a *release* means, and they can take that information and use it to determine risk within their community, and that's what we would hope they do. But, what does recycling, or energy recovery, or treatment mean for that community just because the facility increased those amounts? So, it's not really easy for us to answer how to put that all in context.

When I was thinking about Lori's paper, and as I told her before the presentation, that's another big area that we always ask about internally. We look at our data, and sometimes we see facilities popping in and out of reporting through the years, and we wonder what they're doing when they're not reporting. They're obviously *below* the reporting threshold, but are they still releasing the chemical? Your analysis is very interesting to see what that impact would be. The one thing I wonder, and maybe this is irrelevant and wouldn't make a difference, but have you considered looking at where we tried to minimize the truncation bias with the PBT [Persistent, Bioaccumulative, and Toxic] chemicals? We lowered the thresholds, so that theoretically minimizes that truncation bias, and you could start looking at facilities that, for the PBT chemicals, weren't *added* as PBTs—they were just *made* PBTs—meaning they were always on the TRI list—if you look at facilities that were reporting for those chemicals prior to them being a PBT—and then maybe they dropped out before they were made a PBT, and then all of a sudden we *made* them a PBT and they came back into the universe, what are they reporting as a release there? Because now you know it's less than 25- or 10-thousand pounds, but it's greater than 100 or 10 pounds for their use or manufacturing or processing. How do those releases compare to the higher thresholds when they were reporting? Or how about facilities that reported for the first time because of the PBT chemicals? How are those releases comparing to facilities that were reporting prior to the [re-classification of the] PBT chemicals and the lowering of thresholds? That might just be something to help with the data here and verifying what you're finding, and I'd be curious to see if it does relate.

Nothing against your conclusions, *but* I thought your measure on how effective our policies are was kind of interesting. Actually, I have to give it some more thought, but the idea about having the same number of chemicals and the same number of reports based upon a policy decision, but the releases go down or maybe even the production-related waste decreases. Trying to apply that as a measure of effectiveness to our policy I find very interesting, and I'll have to think about how we might use that.

The idea about adding a question on our form to collect information about why they have no longer reported or actually reducing or eliminating the reporting thresholds—well, to be honest, that's not going to happen.

As far as the questionnaire, Mike, that you're getting ready to develop, I'm excited to see the results.

The thing I find interesting about both of these reports that kind of relates to what we're doing within TRI—we're doing a lot of modernization. One interesting note for the researchers here is we're working *really, really* hard to get the data out sooner. We're hoping that by November of this year we're going to have the 2003 data out on a facility-specific basis, so you'll be getting the data a lot earlier.

I look at the reports and I look at what we're doing now—we have a burden-reduction effort underway, and part of the burden reduction effort, for example, is to increase thresholds as one option. Then I look at Lori's paper and I go, "Oh—okay!" The one thing I find interesting, too, is that on one's really mentioning the Form A, and I'm curious to know why. Is that just because it's a lack of information now or it's useless? What's the feedback there? One of our options is to *look* at the Form A and maybe *increase* its use by increasing thresholds. Another option is "no significant change"—a facility can report what they reported the previous year just by certifying no significant change. And what is the meaning of that? Well, we have to figure that part out—that's the challenge.

I intend to read these papers again. There are some people back in my office who are working on a burden-reduction effort. I want to share these papers with them so they can consider the information presented here as they go through the rulemaking, because, again, I thought this was very good work on both of these papers.

Session V Discussant Comments
Tom Bierle, Resources for the Future

Overview

These papers deal with two of the most important questions about information disclosure:

- What does disclosed data mean? and,
- How are information disclosure programs working?

Snyder provides a very interesting addition to the body of research on just what TRI numbers mean. She adds what is to my knowledge a new and important caveat to the many qualifications—acknowledged but often unheeded—to the facile assumption that TRI is a comprehensive and relatively accurate measure of environmental performance.

Kraft, Abel, and Stephan focus in on how disclosure programs work. In a new and welcome installment to their ongoing and ambitious work on TRI, they move their analysis down to the state level on the way to examining how individual communities and facilities translate information into action.

As I turn to the individual papers, I will begin with Snyder's question of what the data mean and then move to Kraft, Abel and Stephan's analysis of how disclosure works.

Snyder

Snyder focuses on how reporting thresholds may lead to a significant under-reporting of actual TRI emissions, possibly accounting for 40% of the observed decline in emissions in Massachusetts. The argument rests on facility managers practicing "threshold-regarding behavior"—looking for relatively easy opportunities to reduce the use of chemicals below reporting thresholds and thereby avoid reporting emissions.

The analysis proceeds through three key steps:

- First was determining whether the facilities that specified in a questionnaire that they had ceased reporting because they had fallen below a use threshold were representative of other firms that had ceased reporting but had not specified why.

- Second was estimating why these other firms ceased reporting based on a model of "threshold-regarding behavior." Snyder estimated that 72% of these firms ceased reporting because they fell below thresholds, a number similar to the 66% among firms that answered the questionnaire.

- Third, was providing three estimates—upper bound, lower bound, and extrapolated—of what releases would have been if use thresholds had not existed. The upper bound used 100% of the previous year's releases, the lower bound used 0% of the previous year's releases, and the extrapolated used 79% to 93% of the previous year's releases.

Reporting thresholds are there because of the assumption that releases of chemicals used at levels below thresholds don't add much to the aggregate—they are essentially a *de minimis* exemption. Synder's analysis suggests that this assumption may be very wrong, undermining the validity of TRI as a measure of environmental performance. Not only do reporting thresholds affect the magnitude of trends but the ability to confidently rate and compare facilities using a common metric, which many analysts see as the most important aspect of TRI.

Unfortunately for this discussant, the degree to which these findings are significant rests on questions of methodology. Rather than dissect that methodology here, I will merely raise two questions:

- Barring some sort of sensitivity analysis, I suspect that one of the key variables here is the prediction that 72% of non-reporting facilities stopped reporting because they fell below a threshold. How sensitive are the results to even small changes in this number? What value would different approaches to estimation produce? What do we make of the fact that the state program explicitly encouraged companies to show a decline in use? Was there "program-regarding behavior" that encouraged firms to choose a particular response in the questionnaire?

- When looking at trends under the different scenarios, should they really begin at the same point in year 1? Wouldn't a worst case scenario involve different assumptions about what was not being reported in that first year, rather than assuming that all non-reported chemicals actually accounted for zero emissions?

Finally, I might simply acknowledge that advocates of materials accounting reporting might take issue with the contention that reducing chemical use "does not represent a real improvement in environmental performance." Indeed, advocates argued that lowering use led to lower risks from transportation, accidents at facilities, etc. As Snyder acknowledges, a specific policy goal of the Massachusetts program was reducing chemical use. Facility managers who identified a decline in chemical use in their TURA reports were doing exactly what the state program had encouraged them to do, not admitting to a crafty way of avoiding TRI-type reporting.

Kraft, Abel, Stephan

Kraft, Abel, and Stephan have undertaken a large project to take TRI data, warts and all, and understand why it affects firms' behavior. There are two aspects of this overall project that I particularly like. One is the specific focus on the agency of communities and firms and the acknowledgement that actions may be very case-specific. Second is bringing the tools of political science to this area of policy analysis, acknowledging that these programs are not operating in a political vacuum.

In this particular paper, the authors examine a variety of indicators that may explain state-level differences in the performance of firms. They find that the key variables that matter are 1) the level of conservation group membership in the state and 2) less ideologically polarized politics in the state. Political scientists must be very satisfied when political variables rise to the top.

The question arises: how should we interpret these results? Ultimately, the authors are going to combine the results of analysis at various levels of generality to come up with what I expect will be a nuanced interpretation. In the context of this paper, however, a few questions arise:

- How to interpret the results about conservation group membership? Does this mean that a more conservation-minded ethos permeates the business community; that state legislators and regulators are more likely to pursue stricter regulation; that NGOs with large memberships are able to push firms or push their members to push firms, more easily; or some other explanation? If the NGO explanation, how do we fit in the fact that most NGOs are nationally-based and don't get involved in state level policy or local decisions about facility permits, etc.?

- How to interpret the results about the polarization of politics? Do less polarized states have a more unified view about the value of environmental protection? Are they less prone to gridlock that distracts legislators, regulators, and communities? I suppose one could make the case that more polarization would have firms doing better in order to hedge against a change in administration that might punish them more. Less polarization may create the expectation of continuity and less impetus for firms to go the extra mile.

Two other questions come to mind as well:

- To what extent do these kinds of variables affect TRI differently from other environmental programs? Are we simply seeing generic differences in environmental regulation and enforcement among states or is there something different about how these variables affect community empowerment or facility managers' incentives to go beyond regulatory requirements in response to TRI.

- Finally, given that the data come from the period 1991 to 1997—a good bit of which was the era of low hanging fruit—how much does the analysis tell us about today's dynamics and opportunities for improving the program?

It will be interesting to see how these authors' future work can tease out these sorts of dynamics. I must say I am intrigued by the idea that "political factors can influence the *direction* of change, while non-political factors may influence the *intensity* of change."

Synthesis/Themes

The most challenging task for a discussant is to try to identify common themes in the papers presented. Although these two papers deal with very different questions about TRI, I do think there are some common themes.

First is the value of getting beyond analysis of aggregated national trends. At the state level, the smoothly declining slopes in national releases get far more complex. Both papers do a very good job of acknowledging this complexity, Snyder by being very cautious about applying her findings beyond Massachusetts and Kraft, Abel, and Stephan by welcoming idiosyncrasies as possible sources of interesting findings. I do wonder if state-level analysis will ultimately prove to be the most revealing level of disaggregation or merely a convenient way to divide up the world. I can see why it would be relevant in Massachusetts, where a more comprehensive disclosure program is in place. But I wonder whether Kraft, Abel, and Stephan will find that disaggregating to sub-state regions or even communities is ultimately a more revealing.

The second way these papers relate to each other is in providing insights into the motivations of corporations. Snyder discusses a dynamic of "threshold regarding behavior" by which firm managers see opportunities to "reduce" reported emissions by simply using slightly less of a particular chemical and thereby falling below reporting thresholds. This focus inside the firm on the motivations of individual managers may well be the kind of thing that Kraft, Abel and Stephan find as they move into facility-level surveys. One would not be surprised to ultimately conclude the TRI "works" because of a complex assortment of political, policy, community, and organizational motivators, of which corporate managers' keen eye on reporting thresholds is one.

Finally, Snyder's and related work does provide a bit of a thorn in the side of analysts like Kraft, Abel, and Stephan, and other people who work on disclosure. To suggest that the measuring tape we are using doesn't have the feet and inches quite right is not necessarily a welcome insight. The performers may not be the performers we thought they were (or at least in the way we thought they were) and likewise the strugglers may simply be less crafty about gaming the system. I don't think this is an insurmountable problem. The key is always keeping in mind that TRI numbers are constructs influenced by human agency, not objective measures of environmental performance. If efforts to explain why TRI numbers go up or down keep in mind the many ways that reporting facilities can make those numbers go up or down—some through real changes in the workings of physical plants and some on paper—the kind of analysis done by Snyder and the kind of analysis done by Kraft, Abel, and Stephan can be complementary rather than antagonistic. I should note that Kraft, Abel, and Stephan are taking one of these issues head on—that TRI reports on total pounds rather than an indicator or risk—in their larger work.

Ultimately, the key question for those interested in policy and EPA in particular is going to be what these and other studies tell us about how disclosed information ought to be used and how disclosure policies ought to be changed. I think both of the lines of research discussed in this panel will ultimately have that kind of pragmatic value.

Summary of the Q&A Discussion Following Session VI

Ann Wolverton (U.S. EPA, National Center for Environmental Economics)
[Note: Dr. Wolverton brought two questions for each presenter. For better cohesion and flow in this summary, the chronological order will be interrupted, with the responses from Dr. Kraft coming before the questions posed to Dr. Snyder.]

Dr. Wolverton began by addressing Dr. Kraft's "future plans of defining an analysis at the community level" and his "confidence about drilling down to the community level" because of the potential consistency between that and the state-level analysis. Mentioning that there has been a lot of recent discussion in the literature "about how results change all the time depending on the way in which you define the community," She asked Dr. Kraft how he planned to define "community" in his future research.

The second question addressed to Dr. Kraft asked whether the trend of production-related waste increasing over time "holds true when you normalize by production."

Michael Kraft (University of Wisconsin at Green Bay)
Dr. Kraft said he probably couldn't answer the second question but would pass it along to someone who could. Although he didn't believe they had normalized for that, he asserted, "I think there's still a trend there—it may be altered with normalization."

On the other hand, he said, "The first question is something that we've certainly thought about. What the question is getting at is: We're looking at state-level comparisons here, and we've said that gives us confidence that there is some kind of political factor at the state level, whether it's ideology, conservation group memberships, . . . We're only interested in how that plays out around the facility, because the whole point of the information release is that *communities*—and that's the language that's used, *communities*—take *cognizance* of this information, and, of course, some action follows. Of course, *state* groups might also take an interest in what's going on in the community, and that may be true of environmental justice groups at the *state* level or environmental groups more broadly even."

Dr. Kraft continued by saying that the community identification issue is complicated by the fact that "we're looking at *facilities*, and then we're looking at communities in which they are located." He suggested that in different circumstances "community" could mean "the city," "the county," or "the immediate two miles around a facility." Dr. Kraft went on to say, "I think we're inclined to take a broader view of surrounding community. That may get a *little* messy in a larger urban area—exactly where the boundaries ought to be," but he indicated that the risk screening model might help in that regard. Citing the successful use of this model in working with Region 5 air emissions, he explained that "it actually models the plume that would follow a factory, and you can identify exactly which neighborhoods are affected by a given facility. So, it isn't just geographic—for example, "x" blocks or miles away—you can get very specific. That's something we would certainly like to look carefully at to know what groups, what people, what citizens, what community leaders we need to talk to, so that's a *big* part of the next stage of the project."

Ann Wolverton's comments addressed to Lori Snyder:
Dr. Wolverton commented, "I was just curious about whether the same firms that are reporting in the U.S. EPA's TRI are also in the Massachusetts TRI and whether there is a way to make use of that. It may be that there's not a lot of intersection—I was just curious to know."

The second comment that Dr. Wolverton addressed to Dr. Snyder was: "You're focusing on the pounds of emissions and sort of what's going on with the threshold and how much you're *missing* in terms of *pounds*. I was curious about how much you might be missing if you attempted to translate that into a more risk-based measure?"

Lori Snyder (Harvard University)
In response to the first comment, Dr. Snyder clarified that the TRI reports are actually sort of a subset of what is reported in the other reports. She added that, consequently, one of the things she *could* do "is just look at chemicals that are reportable to TRI," although this could get "a *little* tricky" due to the fact that "sometimes, compound chemicals that are in TRI are defined differently in the State and Federal reports. Another complication would be that she has the "*use* information based on *State* thresholds." Dr. Snyder closed by saying that she did have plans to revisit this and justify her claims.

Elizabeth (Betsy) David (Stratus Consulting, Inc.)
Citing results from some "mid-to-late-90's" interviews of 100 Wisconsin firms, Dr. David said she and her colleagues found "three important reasons why people reduced their pollution," with the primary reason being "to stay in compliance." However, she added that "the *second* reason was that the *firm* perceived that its ranking on the TRI reports was *very important* to them [i.e., communities], so even though at community levels I didn't see much in the way of communities taking action on this information, *firms perceived* that the communities would, and so they changed their behavior." Dr. David commented that since this data was compiled at the same time as Dr. Kraft's data, he should also have gotten indications that "this perception was really a very important determinant of people's actions." Dr. David closed by citing the story of "a firm called Fort Hubbard Steel [in Green Bay, Wisconsin] that came out ranked very high on the TRI list" and subsequently modified its process from etching with acid to grinding (to the dismay of the Green Bay Metropolitan Sewage agency, who had been using the waste acid in their process to precipitate out phosphorous).

Dinah Koehler (University of Pennsylvania)
Dr. Koehler commented on John Dombrowski's assertion that engineering estimates sometimes provide a closer approximation of stack pollution than actual sampling

measurements. Citing her research, Dr. Koehler said "there are *huge* differences between what the National Toxics Inventory (NTI) estimates were at the 4-digit SIC level and the TRI." She had held hopes of *potentially* using the NTI as a substitute for the TRI, "given that there's all this noise in the TRI," but the fact that the difference is sometimes *so* great prevents her from doing so. She wondered whether Mr. Dombrowski could comment on what might be going on there.

John Dombrowski (U.S. EPA, Office of Environmental Innovation)
In response, Mr. Dombrowski said that if one is looking at "releases for *just* stack emissions," in that case monitoring *might* be the better of the two options. However, he stated, "In the general sense, though, I would say that when you look at fugitive emissions, for example, engineering estimates for the mass balance you're doing might be better than just occasional monitoring of a fugitive emission, because you can account for wherever the releases may be occurring." He clarified further, "my statement was in the sense of *all* monitoring data," and depending on what type of release you're talking about, one or the other of the methods might be preferable.

Mr. Dombrowski went on to say that he "just felt that people sometimes make an unfair assessment of the TRI data and discredit it because of the estimation that sometimes occurs," whereas he feels that "you have to look at the data *specifically* as to what you're using and then make an evaluation of *that*, but not an overall generalization of the TRI data." He added that "NEI (National Emissions Inventory) sometimes actually supplements their data with TRI data, so we capture sources that they may not be capturing. Sometimes we have captured better air data—with mercury releases, for example, I think we were capturing much more of a complete data set than what the Air Data Set was capturing at that time. So, again, you have to be *very* specific as to what you're looking at for the data element."

Randy Becker (U.S. Bureau of the Census)
Dr. Becker claimed that "the best paper was actually saved for last—it sounds like required reading for anyone who wants to use the TRI." He added that the paper "sets an *excellent* example for all of us, because what's important is getting the questions right and the econometric specification right—you need to know where the data come from and what their limitations are." Commenting that "we're spending a lot of money here on studies that use data to answer questions," Dr. Becker noted, "just because others use data blindly doesn't mean all of us have to. Lori's paper reminded me that we should probably also spend money on studies that evaluate the quality of the data—and probably also spend money on *improving* the quality of the data, as John said."

Furthermore, Dr. Becker said that in looking at the TRI, "before we chalk everything up to community activism, there's also regulation running parallel to this. In fact, some of the pollutants in TRI are actually regulated because they're ozone precursors." Consequently, in efforts to comply with regulations for cleaning up these precursors or other pollutants, facilities "may be cleaning up TRI and it has nothing to do with community activism whatsoever." Dr. Becker added that "while there's no *direct* measure of how much regulation a plant is facing, you could control for whether it is in a county that is in non-attainment of the National Ambient Air Quality Standards. Also, in terms of the conforming community, perhaps more important than TRI is something like ozone action days, which, again . . . may be driving things rather than community activism or just the information disclosure."

Michael Kraft
Dr. Kraft responded that "we do make a comment in the paper to the effect that many facilities clearly do alter their actions based on regulatory pressures or anticipated regulation—community pressure is *not* always the explanation—it's a *multi-faceted* situation. He also clarified that "there's a good bit of literature that suggests regulation is, in fact, a driving force, and maybe a lot more so than community pressure." In closing, Dr. Kraft stated, "TRI is predicated on the notion that the public has the right to know, and we're looking at what's going on in the community in part *because* of that, but that doesn't mean we're going to come to the conclusion that that's *the* most important factor."

Eric Orts (University of Pennsylvania)
Dr. Orts asked the following "quick question that also pertains to the reliability of the TRI data: . . . Have there been enforcement actions taken with respect to companies on whether they reported these data accurately or not? In another life I'm a securities law corporate academic, and certainly in the securities field reliability of information, even if there is enforcement, is sometimes suspect. But, for the most part, it's thought to be pretty good, in part because there's enforcement." Dr. Orts asked whether there are actual examples of the EPA going after companies that have reported bad data, and (because he thinks it's potentially a criminal act) whether a case has ever been referred to the Department of Justice.

John Dombrowski
In response, Mr. Dombrowski admitted that he didn't know whether there have actually been any criminal actions, but "there has been, and there continues to be, enforcement related to TRI data. He expounded by saying, "Every year our Regions do data quality audits, and they look for facilities that are under-reporting. . . . We've had some Regions even take actions on *over*-reporting, because the purpose of TRI is the public's right to know, and we want to provide the most accurate information. You also want to consider a level playing field between the facilities that *are* doing a good job with their data versus those that are doing a not-so-good job and just getting by."

Mr. Dombrowski also added, "Speaking of enforcement, there is currently an enforcement initiative ongoing right now on TRI . . . and you'll see a flyer—an enforcement alert for late reporters. We've done a lot of analysis on facilities that have reported their data late to EPA . . . and we're not talking about a trivial amount of data when you add it all up together on the late reporters. And, there is a statutory deadline for them to report and for us to get the information out to the public, so enforcement *is* quite active in the TRI program in various aspects."

Eric Orts—a follow-up question
"Have there been any cases of a civil penalty that's been assessed against a company because of infractions in this area?"

John Dombrowski
"Yes, there have been. Jon [Silberman], you might know better than I, but I have *heard*—and I don't know exact numbers—but through EPA's audit policy, for example, one of the more frequently disclosed violations by companies is TRI reporting violations."

Matt Clark (U.S. EPA, Office of Research and Development)
Dr. Clark commented, "We had one paper that we really wanted to present today (the author wasn't able to show up) that I would recommend to you—it's by Michael Vasu. He looked at the extent to which communities actually *knew* about TRI, and it turned out to be in the *low teens*. Not only that, more people reported knowing about a *fictitious* database than knew about the TRI."

Dr. Clark also added, "We are trying to get out a solicitation this year on the benefits of environmental information disclosure. It's going to cover a lot of stuff directly related to this."

Sarah Stafford (College of William and Mary)—another question
In a comment "kind of related to this idea of regulatory pressure" Dr. Stafford suggested to Dr. Kraft that "some potential regulations may be correlated with those political variables that you have in there," and she said she is "most concerned about pollution prevention regulations, both mandatory and voluntary." She cited the fact that in 1995 "at least two states had *required* pollution prevention actions" which, though hazardous waste based, "clearly had a big impact on TRI. Dr. Stafford added that some of her work suggested that there "could be some correlations as to which states adopt *voluntary* pollution prevention programs and what types of programs they have related to, specifically, the membership in environmental organizations." In closing, she said, "It's something worth looking at, just in terms of correlation."

Michael Kraft
Dr. Kraft stated, "We're not going to presume *anything* in the way that we word the questionnaire. We're certainly not going to assume that the community *knows* about the TRI . . ., and we're aware, of course, that State regulations factor into the equation."

End of Session VI Q&A