Corporate Environmental Behavior and the Effectiveness of Government Interventions

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

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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.

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[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,

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[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 complement the effects of formal regulation, which

[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.

[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 <u>other</u> 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 <u>other</u> 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.

[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 noncompliance 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

[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 both 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 <u>both</u> 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

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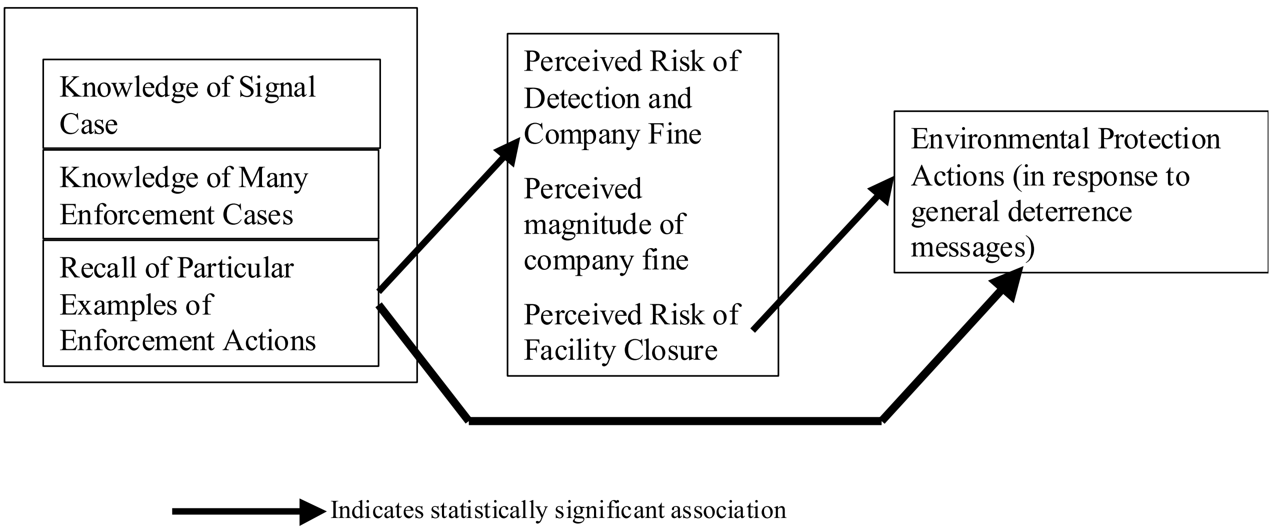
Facility Closure: df=190, F=10.168, p<.000, **Adj R^2=0.367**, Sig Vars: Asbes, Elec, Steel, Chem-KY (all +ve)
Detection: df=195, F=3.679, p<.000, **Adj R^2=.142**, Sig Vars: Chem-KY (+ve)
Company Fine: df=193, F=1.851, p=.043 **Adj R^2=.050**, Sig Vars: Particular Exs (+ve)
Individual Fine: df=185,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

For presentation at workshop on
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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

[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) $\text{Comply}^*_{ijt} = f(\text{REGS}_{ijt}, X_i, X_j, X_{ijt}{*}\text{REGS}_{ijt}, \text{OComply}_{ijt}, \text{YEAR}_t)$.

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

[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

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

$MC=MC(X_p,X_f)$

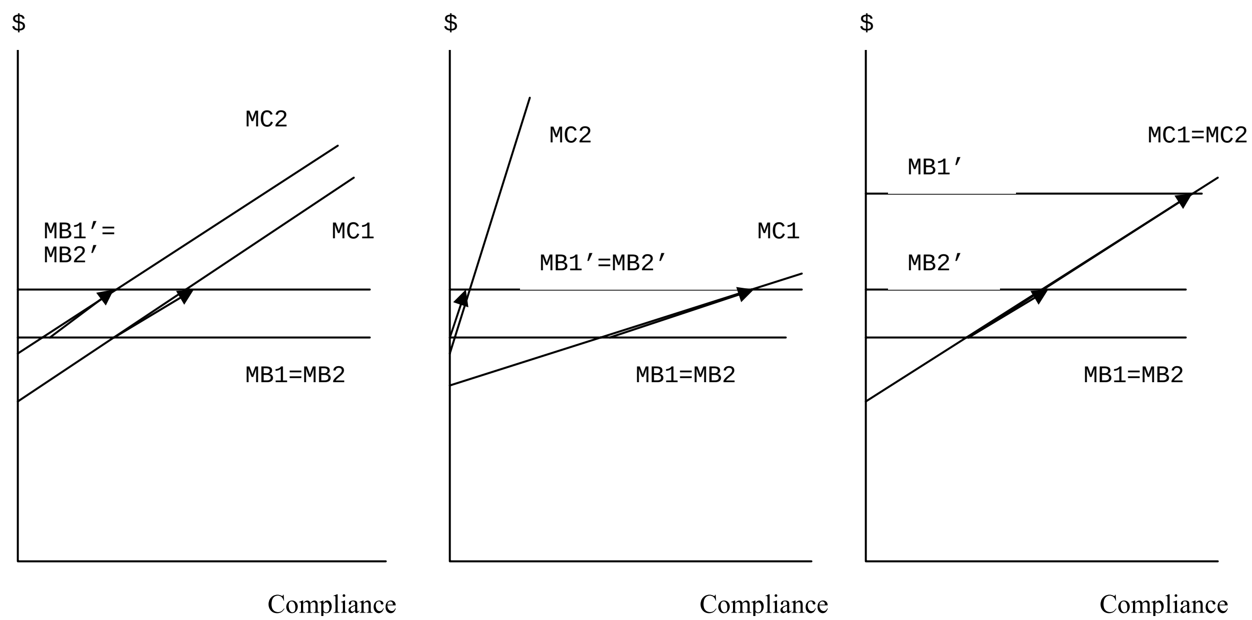

Figure 1a

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

Observations

- General Deterrence relies upon the "threat signal" being received and understood.
- 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).

Policy Implications

- 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

- Increasing Perceived Risk: given that many who responded to the survey overwhelmingly underestimated penalty size 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 number of penalties given out, and the broader applicability 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.

- Reminder Function: 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).
- Reassurance Function: 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

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* 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.