Labor Impacts of the Enforcement of the Clean Water Act

By

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Abstract

This dissertation is the collection of three papers that each examines a specific labor impact of the enforcement of the Clean Water Act. The chapters of the dissertation all use panel data from a unique survey of chemical manufacturing facilities operating between 1999 and 2001 to empirically examine how environmental enforcement policy affects the use of employees at regulated firms, specifically those employees whose job functions pertain to environmental management.

The first chapter explores the effects of enforcement on the amount of environmental labor employed by facilities regulated under the U.S. Clean Water Act. Specifically, the analysis examines the influence of monitoring inspections and enforcement actions, e.g., fines, on the number of employees allocated to environmental management. Empirical results show that environmental enforcement negatively affects the amount of environmental labor allocated by the sampled facilities. Specifically, federal inspections, informal enforcement actions, and monetary fines each negatively affect environmental employment.

The second chapter adds to the first by examining the influence of the overall environmental enforcement approach, contrasting a potentially innovative cooperative approach with the standard coercive approach, on the effects of government interventions on corporate environmental management, specifically environmental employment. The results show that the effectiveness of enforcement at inducing better environmental management depends on the overall regulatory enforcement approach. Controlling for various facility-level characteristics, I find that greater cooperation undermines enforcement effectiveness. As one example, monetary penalties positively affect the amount of environmental labor under a sufficiently coercive approach, yet negatively under a sufficiently cooperative approach. These results show that a cooperative enforcement approach is ineffective at best and counter-productive at worst, while a coercive approach is generally effective. Rather than cooperation representing an innovative policy, cooperation may simply reflect regulatory capture.

The third chapter examines the overall employment effects of environmental enforcement. To generate contributions, the study assesses various forms of enforcement, which include both government monitoring inspections and actual enforcement actions. The study first estimates effects of government interventions on total employment, consistent with previous empirical studies. Then the study jointly estimates a system of two equations – one for environmental labor and one for production labor – to identify the different effects of government interventions on environmental workers and production workers. Overall, the empirical results reveal that government interventions have a zero or negative effect on total employment. More important, the empirical results generally demonstrate that government interventions have a zero or positive effect on environmental employment, yet a zero or negative effect on production employment, consistent with the constructed theoretical framework. Thus, all previous labor studies, which examine only total employment, most likely generate results that support incomplete, if not misleading, conclusions.

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1 The Effects of Clean Water Act Enforcement on Environmental Employment

1.1 Introduction

This paper examines the effectiveness of government interventions at inducing compliance through the use of environmental labor. Within the economic literature, a number of studies empirically examine the effectiveness of interventions (e.g., inspections, warning letters, fines) at inducing compliance with environmental laws. These studies examine a wide range of environmental media (e.g., air, water, hazardous waste) and economic sectors (Gray and Deily, 1996; Laplante and Rilstone, 1996; Helland, 1998a; Helland, 1998b; Earnhart, 2004a; Earnhart, 2004b).

Labor is an important part of any facility's operations. Similarly, environmentally related labor is a key component of a facility's environmental management operations. As one dimension, most regulated facilities operate some sort of discharge treatment equipment demanding at least one environmental employee with proper training. As evidence, within the sample of facilities examined in this study, the presence of environmental labor is considerable: 4.6 % of the average facility's workforce specializes in environmental management.[1] Thus, facilities invest a significant amount of their person power into environmental management. Additionally, environmentally related labor is effective at lowering facility discharges (i.e., inducing compliance) in the chemical manufacturing sector (Earnhart and Glicksman, 2011).

[1] This value is higher than the value of 1 % provided by the Census Pollution Abatement Controls and Expenditures (PACE) survey for the chemical manufacturing sector. This contrast is expected since the sample includes only facilities regulated under the CWA, while the PACE survey covers all chemical manufacturing facilities.

Analysis on the impact of environmental enforcement on labor also carries political implications. In today's political environment, where environmental regulations and efforts to reduce pollution are considered detrimental to employment, the study's assessment of environmental employees is especially important. While enforcement might reduce employment in general operations, enforcement might actually spur greater environmental employment (Morgenstern et al., 2002).

The absence of analysis on environmental employees appears to stem directly from a lack of available data. As the nearest efforts, the Department of Commerce and the Bureau of Labor Statistics (BLS) have attempted to quantify this type of labor in the "Measuring the Green Economy Report" (Department of Commerce, 2010) and the "Employment in Green Goods and Services" report (Bureau of Labor Statistics, 2011), respectively. Both reports simply estimate the number of environmental jobs. The Department of Commerce uses an "output" approach, where environmental employment is calculated as a fraction of total employment based on how much output is considered "green." The BLS, on the other hand, uses a "process" approach, which calculates environmental employment based on the production process used, even if the output is not considered "green." Using this approach, the BLS estimates 24,733 environmental employees were working in the chemical manufacturing sector as of 2011. While these estimates are useful for aggregate analysis, this study claims that the data used here are superior to these estimates. This study's data were collected through a survey of chemical manufacturing facilities that captured the count of employees responsible for managing wastewater discharges, which were regulated by Clean Water Act permits. Thus, these data on environmental employees relate directly to regulatory compliance and, by extension, government inspections and enforcement actions designed to induce compliance (i.e., deter non-compliance).

My assessment of environmental labor allocation is the first study to examine this specific environmental management component. Instead, previous studies focus on other types of environmental management: implementation of an environmental management system [EMS] (Johnstone and Labonne, 2009), certification of an EMS (Christman and Taylor, 2001; Arimura et al., 2008; Dasgupta et al., 2000; Henriques and Sadorsky, 2007; and Delmas and Toffel, 2008), environmental self-audits (Earnhart and Leonard, 2013; Evans et al., 2011), and various other management forms (Garcia et al., 2009). Closer to this study, Greenstone (2002), Berman and Bui (2001), Gray et al. (2014), and Ferris et al. (2014) examine the impact of government regulations on employment, but do not specifically assess environmental employment. These studies examine the impacts of the imposition of various environmental regulations on *total* employment within an industry or at the facility level, while this study instead focuses on environmentally related employment.[2]

As its second contribution, this study focuses on the labor impacts of the *enforcement* of regulations. Previous studies focus on the *imposition* of regulations, while ignoring the enforcement element (Walker, 2011; Greenstone, 2002; Berman and Bui, 2001; Gray et al., 2014; Ferris et al., 2014).

This study proceeds as follows. Section 1.2 provides a literature review on environmental enforcement, environmental management, and the labor impacts of environmental regulation. Section 1.3 describes the relevant regulatory context. Section 1.4 discusses the econometric

[2] Using survey data, this study is able to assess this same effect on total employment, but the identified studies cannot assess the effect on environmental employment since the publicly available microdata do not distinguish between environmental and other employment.

framework. Section 1.5 provides a discussion of the data. Section 1.6 details the econometric analysis and interprets its results. Finally, Section 1.7 provides conclusions.

1.2 Literature Review

This section reviews the literature relating to environmental enforcement, management, and labor.

1.2.1 Public Enforcement of Environmental Laws

Becker (1968) offers the modern theoretical foundation for the public enforcement of environmental laws. Based on this foundation, the standard deterrence model posits that an enforcement agency monitors the compliance of regulated facilities and deters non-compliance by imposing sanctions in response to violations. Since this foundational work, a number of studies have expanded the standard model of deterrence; Polinsky and Shovell (2000) provide a thorough review of this literature.

Nearly all previous empirical studies explore this standard deterrence model by examining the effect of environmental enforcement on facility-level or firm-level environmental performance or management (e.g., Gray and Shadbegian, 2004; Shimshack and Ward, 2005; Gray and Deily, 1996; Laplante and Rhilstone, 1996; Earnhart, 2004a; Earnhart, 2004b; Earnhart and Leonard, 2013). Gray and Shimshack (2011) provide a comprehensive review of this empirical literature.

1.2.2 Environmental Management

This study analyzes the effect of enforcement, broadly interpreted to include all types of government interventions (including regulatory inspections), on the use of environmental labor by facilities regulated under the Clean Water Act. The use of environmental labor as the dependent variable sits within a larger literature exploring regulated facilities' environmental management, interpreted to include any method used by facilities to control pollution.

The first group of studies examines environmental management broadly by exploring facilities' decisions to establish and operate an environmental management system (EMS). In some cases, facilities decide to obtain certification of their EMSs based on commercial standards, such as ISO 14001 certification. Several empirical studies explore facilities' adoption of ISO 14001-certified EMSs (Christmann and Taylor, 2001; Arimura et al., 2008; Nakamura et al., 2001; Dasgupta et al., 2000; Henriques and Sadorsky, 2007; Delmas and Toffel, 2008; Mori and Welch, 2008).

The second group of studies analyzes specific types of environmental management, much like the present study. Some studies examine companies' decisions to undertake various environmental management and/or pollution prevention practices by summing across the practices (Khanna and Anton, 2002; Anton et al., 2004; Harrington et al., 2008). Other studies analyze companies' decisions to administer specific environmental management and pollution prevention practices (Khanna et al. (2007; Jones, 2010; Ervin et al., 2012; Garcia et al., 2009; Henriques and Sadorsky, 1996). Finally, some studies focus on one specific environmental management practice: environmental self-audits (Earnhart and Leonard, 2013; Evans et al., 2011; Earnhart and Harrington, 2014).

1.2.3 Labor Impacts of Environmental Regulation

Within the economic literature, there are a number of studies that examine the labor impacts of environmental regulation. First, Walker (2011) finds that firms respond to regulatory pressure by eliminating jobs, not necessarily changing their hiring practices. Second, Greenstone (2002) shows that the Clean Air Act's designation of counties as either in attainment or out of attainment has significant labor impacts in multiple manufacturing sectors; manufacturers operating in non-attainment counties lose significantly more employees in comparison to manufacturers operating in attainment counties. Third, Berman and Bui (2001) examine the stringency of air quality regulation in the Los Angeles area. The authors find that regulatory stringency has no significant employment effects. Fourth, Gray et al. (2014) study the impacts of the Cluster Rule on the number of jobs in the pulp and paper industry. The authors find minimal effects on the number of employees at facilities subject to the rule. Finally, Ferris et al. (2014) find that Phase I of the Title IV SO_2 trading program had negligible effects on employment at fossil fuel-fired plants.

1.2.4 Contributions of Present Study

This study contributes to these literatures in two ways. First, this study examines a previously ignored, yet highly important, form of environmental management: the amount of labor dedicated to environmental management. Second, this study is the first to examine the effects on employment from the *enforcement* of environmental regulations rather than the *imposition* of regulations.

1.3 Regulatory Context

This section describes the regulatory context relevant to the analysis.

1.3.1 National Pollutant Discharge Elimination System

This study examines environmental behavior relating to the U.S. Clean Water Act. One of the Act's main purposes is protecting water quality by controlling wastewater discharges from point sources. To this end, the EPA created the National Pollutant Discharge Elimination System (NPDES) to control these point source discharges. The system's main form of control is the issuance of facility-specific permits, which identify the pollutant-specific discharge limits imposed on regulated facilities.[3] Permits are issued and re-issued generally on a 5-year cycle by the EPA or authorized state agencies.[4]

When establishing discharge limits within individual facilities' permits, the issuing agency considers the relevant Effluent Limitation Guideline standard, which is designed to require a minimum level of wastewater treatment for a given industry, and the state water quality-based standard, which is designed to ensure that the water body receiving the discharges meets state-based ambient surface water quality standards. After a candidate discharge limit is determined under each standard, the more stringent limit is written into the permit.

Each permitted discharge limit represents a performance-based standard under which compliance is based solely on one's own discharges. Thus, a facility may use any available abatement method to comply with its permitted limits. A myriad of abatement methods are available to facilities: end-of-pipe treatment technologies (i.e., capital), deployment of labor, and other methods. Clearly the deployment of labor enhances the effectiveness of equipment and other methods. For example, wastewater engineers monitor the operation of treatment technologies.

In the NPDES system, permitted facilities are required to monitor and self-report their discharges on a regular basis. Thus, inspections are not needed to assess compliance with imposed discharge limits.

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[3] The EPA website provides an overview of the NPDES permitting system: http://water.epa.gov/polwaste/npdes/basics/upload/101pape.pdf.

[4] In order to obtain approval for NPDES authority, a state agency must demonstrate the regulatory capacity to administer the NPDES program. The EPA website lists the approved states: http://water.epa.gov/polwaste/npdes/basics/NPDES-State-Program-Status.cfm

To ensure compliance with issued permits, the EPA and authorized state agencies periodically inspect facilities and take enforcement actions as needed. Agencies possess great discretion over monitoring and enforcement decisions. While the EPA retains authority to monitor and impose sanctions on facilities, authorized state agencies are primarily responsible for monitoring and enforcement. Inspections represent the back bone of environmental agencies' efforts to monitor compliance and collect evidence for enforcement (Wasserman, 1984); inspections also maintain a regulatory presence (EPA, 1990). For enforcement, agencies use a mixture of informal enforcement actions (e.g., warning letters) and formal enforcement actions, which include penalties (i.e., fines).

Figure 1.1 displays the structure of environmental agencies and other entities involved in environmental enforcement. Lower-level personnel at the EPA and state agencies possess broad discretion over inspection decisions: who to inspect and when. Similarly, lower-level agency personnel possess broad discretion over decisions to take informal enforcement actions such as issuing "Notices of Violation" and warning letters: against which facilities to take enforcement actions and when. Both inspections and informal enforcement actions represent day-to-day activities conducted without much upper-level guidance.

Lawyers at environmental agencies are responsible for prosecuting enforcement cases before administrative judges or forwarding cases to the Department of Justice (DOJ) with a request for prosecution before civil judges. For example, lawyers at EPA regional offices may initiate an administrative proceeding in order to impose an administrative sanction, or may request that the DOJ initiate a civil court proceeding in order to impose a civil sanction on facilities that are seriously non-compliant. These lawyers operate with much discretion and without guidance from upper-level administrators. Importantly, in the EPA and presumably all state agencies, a firewall separates top administrators from enforcement cases in order to avoid even the impression of political influence.

Once agency or DOJ lawyers initiate enforcement proceedings, administrative or civil judges decide on the imposition of the formal sanctions.

The federal and state agencies hope that monitoring inspections and enforcement actions generate both specific and general deterrence. Specific deterrence prompts the particular facility inspected or enforced against to improve its subsequent compliance, while general deterrence prompts other facilities to improve their subsequent compliance (Cohen, 2000); both forms of deterrence are explained further in Section 1.5.

1.3.2 Chemical Manufacturing Sector

The Clean Water Act principally constrains wastewater discharges from point sources, which divide into two categories: municipal sources (i.e., municipal wastewater treatment facilities) and industrial sources.[5] This study focuses on a single sector within the category of industrial sources: chemical manufacturing facilities. This study's focus on a single sector is consistent with other empirical studies of industrial pollution (e.g., Laplante and Rilstone, 1996; Barla, 2007; Earnhart, 2009; Earnhart and Harrington, 2014).

The chemical manufacturing sector proves an excellent choice for analyzing the effect of government interventions on environmental labor. First, the EPA has shown a strong interest in this sector as evidenced by its study, jointly authored with the Chemical Manufacturing Association (CMA), on the root causes of non-compliance in this sector (EPA, 1999) and its own

[5] The EPA website describes industrial sources: http://water.epa.gov/polwaste/npdes/Industrial-and-Commercial-Facilities.cfm.

study on the compliance history for chemical manufacturers (EPA, 1997). Consistent with this interest, two sub-sectors in the industry, industrial organics and chemical preparations, were regarded by the EPA as priority sectors during a portion of the study period. Further, the CMA (now known as the American Chemistry Council [ACC]) has demonstrated a strong interest in promoting pollution reduction and prevention with its Responsible Care initiative. The chemical manufacturing sector also generates a large amount of wastewater; as evidence, data on wastewater discharged in 2008 that are disaggregated by 4-digit Standard Industrial Classification (SIC) code reveal that four of the 10 most polluting sub-sectors operate in the chemical manufacturing sector (EPA, 2011). Finally, this sector has a significant amount of labor devoted to environmental management. The average facility in the sample employs 75 employee person-months devoted specifically to environmental management (or roughly 6.25 full-time equivalent (FTE) employees). As important, according to BLS estimates, the chemical manufacturing sector has a total of 24,733 environmental workers employed, roughly 5% of the total green employment in the manufacturing industry, making the chemical manufacturing sector the most "green" employer of all aggregated sectors (Bureau of Labor Statistics, 2011). All these points notwithstanding, this study acknowledges that the results from a study of the chemical manufacturing industry may not generalize to other industrial sectors.

1.4 Data

This section describes the data used for the empirical analysis and discusses variation in the dependent variable.

1.4.1 Sources

This study gathers information from three main data sources to perform the empirical analysis. First, the study uses an original survey of facilities regulated under the National

Pollutant Discharge Elimination System (NPDES) program and operating in the chemical manufacturing industry; see Earnhart and Glicksman (2011) for details. The survey consists of a number of confidential questions that gather data on environmental management practices undertaken by individual facilities. Most importantly, the survey gathers data on the count of individuals employed at the facility whose primary job-related activities relate to environmental management.[6] The survey contains data for the years 1999, 2000, and 2001. In addition to environmental management practices, the survey also gathered information on facility characteristics (e.g., facility age) and characteristics of the firms that owned the facilities (e.g., ownership structure).

To implement the survey, Earnhart and Glicksman (2011) and collaborators identified the proper population based on a full extract drawn from the EPA Permit Compliance System (PCS) database, which records information on facilities permitted within the NPDES system, as of September, 2001. This extract includes 2,596 chemical facilities. To remain in the survey population, facilities needed to meet the following criteria: (1) possessed an NPDES permit, (2) faced restrictions on their wastewater discharges, (3) discharged regulated pollutants into surface water bodies, and (4) were operating as of 2002. Application of these criteria identified 1,003 facilities to contact. Of those facilities contacted between April of 2002 and March of 2003, 268

[6] This count is measured in employee person-month equivalent form. Given this unit of measurement, some values represent fractions below one. When log-transformed, the resulting values are negative.

facilities completed at least 90 %[7] of the survey, implying a 27 % response rate. This rate is comparable to previous large-scale surveys of industrial sectors (e.g., Arimura et al., 2008) and lies above the average response rate of 21 % as identified by a review of 183 published studies based on business surveys (Paxson, 1992).

To complement these survey data, this study also collected data from the EPA PCS database on each facility's (1) location, (2) NPDES major or minor classification, and (3) four-digit standard industrial classification (SIC) code. The PCS database also provides data on inspections conducted by federal and state regulators. Both the PCS database and the EPA Docket database provide data on federal formal enforcement actions, while only the PCS database provides data on informal enforcement actions. This study integrates these two databases.

1.4.2 Statistical Summary of the Dependent Variable

Table 1.1 shows the sample summary statistics of the dependent variable, primary regressors, and control factors. Most important, the average facility has roughly 75 individual-level person-months devoted specifically to environmental management issues.[8] The distribution of the environmental employee count is not normally distributed. After log-transformation, the distribution of the environmental employee appears normally distributed, as shown in Figure 1.2.

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[7] The survey includes responses from 268 facilities reflecting three years of environmental management, resulting in 804 possible observations. Since some survey questions were not answered by all respondents; the regression sample contains 709 observations, as shown in Table 1.2. I conduct a sample means test on all non-survey regressors between the regression sample and the observations excluded from the regression sample. The test statistics reveal no significant differences between these two sub-samples.

[8] To transform this value to the number of FTE employees, simply divide person-months by 12. Therefore, this value represents 6.25 FTE employees devoted to environmental management.

To assess the temporal variation in the count of environmental employees, this study explores the intra-facility variation in the dependent variable for the three years of data used in the analysis. For this assessment, the study calculates the standard deviation of each facility's count of environmental employees over the sample period and then generates summary statistics for this distribution. Based on the set of facility-specific values, the average facility-specific standard deviation is 5.25 and the standard deviation for the distribution of facility-specific values is 20.82. These two values reveal a coefficient of variation of 3.97. These statistics demonstrate considerable variation in the number of environmental employees within individual facilities over the sample period.

Table 1.1 also summarizes the primary regressors and control factors, which the next section describes.

1.5 Econometric Framework

This section builds an econometric framework for estimating the effects of government interventions on environmental employment.

1.5.1 Dependent Variable and Primary Regressors

In each year t, facility i chooses its level of environmental management, denoted as Y_{it}, which represents the number of facility-level person-months for employees dedicated to environmental management. The primary regressors of the analysis are government interventions: federal and state inspections, informal enforcement actions, and monetary penalties.[9]

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[9] Government interventions may be endogenous. Sub-section 1.6.l discusses this potential concern.

These primary regressors, which the study uses as measures of environmental enforcement, are expected to impact environmental labor in one of two ways. First, previous studies show that environmental management increases compliance with NPDES discharge limits (e.g., Earnhart and Harrington, 2014). Since facilities at least partially implement environmental management practices to comply with their NPDES limits, government interventions, which are designed to induce compliance, should increase the use of environmental management. This analysis examines one form of environmental management - environmental labor. Therefore, one should expect that government interventions used to induce compliance would increase the employment of environmental labor, which effectively improves compliance (Earnhart and Glicksman, 2011). However, environmental management in the form of environmental labor, at its heart, represents an employment outcome. The economic literature, as outlined in Section 1.2.3, shows that the majority of environmental regulations have either a negative impact on employment outcomes (Walker, 2011; Greenstone, 2002), or no impact on employment outcomes (Ferris, et al., 2014, Gray, et al., 2014). Therefore, since this study examines an employment outcome of environmental regulation, one can expect that the impact of enforcement may be negative or non-existent. Overall, the impact of environmental enforcement on environmental labor may be either positive, negative, or zero.

The primary regressors reflect measures of environmental enforcement in the form of government interventions, which include monitoring inspections and enforcement actions. Inspections in the NPDES program divide between federal inspections and state inspections. Enforcement actions divide between informal actions and monetary penalties. Similar to previous studies (Earnhart, 2009; Earnhart and Segerson, 2012), the analysis includes only federal enforcement actions, while excluding state actions, because they are generally small in magnitude. Moreover, the analysis splits government interventions into two categories: (1) government interventions against one's own facility, and (2) government interventions against all other similar facilities, which I consider as other facilities operating in the same sector and relevant geographical space. The former measure captures specific deterrence, while the latter measure captures general deterrence (Cohen, 2000). Specific deterrence is expected to weigh heavier on facilities as they experience the interventions firsthand.

This study creates the government intervention regressors as follows. First, inspections consist of those conducted by the EPA (federal) and those conducted by state agencies (state). Federal inspections are expected to weigh heavier on facilities than state inspections, as they are much rarer and are considered more severe.[10] For the measures of specific deterrence, the analysis uses the number of federal or state inspections conducted in the 24 months preceding the current year at the individual facility, denoted as I_{it-1}^{EPAs} and I_{it-1}^{STs}, respectively.[11] For general deterrence, the analysis separately uses the number of federal or state inspections conducted in the 12 months preceding the current year at other facilities of similar size (based on the distinction between NPDES major and minor facilities) operating in the same EPA region, in the case of federal inspections, and in the same state, in the case of state inspections, divided by the number of similarly sized facilities operating in the same EPA region or state (Earnhart and Leonard, 2013). The analysis denotes these general deterrence measures as I_{it-1}^{EPAg} and I_{it-1}^{STg}, respectively.

[10] Section 1.6 discusses this point further.

[11] For federal and state inspections separately, the analysis tests whether inspections conducted in the 12 months preceding the current year and inspections conducted in the 13 to 24 months preceding the current year generate identical coefficient magnitudes. F-test statistics fail to reject the null hypothesis of equal coefficients.

The analysis constructs specific and general deterrence measures for informal enforcement actions identically to those for federal inspections. The resulting specific deterrence measure is denoted as $A_{it-1}{}^{s}$, while the general deterrence measure is denoted as $A_{it-1}{}^{g}$. For the monetary penalty measures, the analysis uses the total amount of penalties levied against the individual facility or other facilities. The specific and general deterrence measures are denoted, respectively, as $P_{it-1}{}^{s}$ and $P_{it-1}{}^{g}$.[12] For enforcement actions, one expects monetary penalties to generate a larger impact on environmental management than informal actions, such as warning letters, because monetary penalties are a very rare, extreme form of punishment. (Since the analysis only measures informal enforcement as a count yet penalties in monetary terms, this study cannot directly test whether the penalty coefficient exceeds the informal enforcement coefficient; instead, by comparing the two coefficient magnitudes, the study can identify the amount of money extracted through a penalty needed to generate an effect equal to a single informal enforcement action.)

Table 1.1 summarizes the primary regressors, which reflect federal and state inspections, informal enforcement actions, and monetary penalties. Summary statistics show that state inspections are conducted more frequently than federal inspections. The average facility is subjected to 1.5 state inspections over a 24-month period, yet only 0.07 federal inspections.[13] As for enforcement actions, informal actions are the most common type. The average facility is

[12] The analysis tests whether enforcement actions taken in the 12 months preceding the current year and enforcement actions taken in the 13 to 24 months preceding the current year generate identical coefficient magnitudes. As with inspections, F-test statistics fail to reject the null hypothesis of equal coefficients.

[13] Although federal inspections are conducted much less frequently than state inspections in the sample, the analysis is still able to generate statistically significant results for federal inspections.

subjected to 0.20 informal enforcement actions over a 24- month period, while only $127 worth of monetary fines. (The latter figure reflects a distribution of fines that includes a few large penalties and many 24-month periods without a single fine.)[14]

1.5.2 Control Factors

The empirical analysis controls for variation in other explanatory variables. Environmental management, especially the use of environmental employees, may depend on a number of facility-level and firm-level characteristics. First, environmental management may depend on the size of the regulated facility. The analysis measures facility size using two proxies: the number of facility employees and the NPDES facility classification. The analysis includes a “major facility” indicator, with “minor facility” as the omitted category.[15] Both of these control factors should positively affect environmental management since larger facilities surely expend more resources to control their waste streams to the same extent as smaller facilities.

Second, the industrial sub-sector in which a facility operates may impact a facility’s chosen extent of environmental management. Industrial sub-sector indicators control for variation in facilities’ abilities to control their operations based on the type of product being manufactured. The analysis includes two sub-sectoral indicators: organic chemical indicator and inorganic chemical indicator, with “other chemicals” as the omitted category.

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[14] Although monetary penalties seldom occur in the sample, I am able to show statistically significant effects of penalties on environmental labor.

[15] For the classification of each regulated facility, the EPA calculates a major rating with points assigned on the basis of toxic pollution potential, flow type, conventional pollutant load, public health impact, and water quality impact; the EPA classifies any discharger with a point total of 80 or more as a “major facility”.

Third, the analysis includes a control factor for firm ownership structure, as represented by the distinction between publicly held firms and other forms of ownership. This control factor captures many dimensions. Facilities owned by publicly held firms may possess greater access to external financing for environmentally related investment. And facilities owned by publicly held firms are held accountable to stock holders. Thus, publicly held firms may implement more environmental management (e.g., hire more environmental workers) at facilities in order to meet the demands of the stockholders. The analysis includes a publicly held firm indicator, with other firms as the omitted category.

Environmental management in the form of environmental labor may also depend on local community pressure, which is influenced by a facility's economic impact on the surrounding community. On one hand, as the size and visibility of a facility rises, the local community may apply more pressure on the facility to improve its environmental management. On the other hand, as the facility's economic impact grows, the local community may tread more lightly, fearing that the facility may shift part of its production to other sites or leave town altogether. Drawn from survey data, an indicator measures a "significant" or "great" economic impact, with a "small" or "very little" economic impact as the omitted category.

The analysis also includes control factors for attitudes of the workers associated with the regulated facility. Facilities with employees who express greater overall concern for the environment, as drawn from survey data, should expend greater environmental management effort, and thus, hire more environmental employees. The analysis includes controls for attitudes held by facility employees and by facility management. First, the analysis includes a facility's self-reported measure of concern about the environment as reflected in environmental workers' views. The measure ranges between 1 and 10, with 10 signifying the greatest possible concern.

As a complement, the analysis includes a measure of the environmental concern held by facility employees in general (i.e., beyond environmental employees).

Attitudes of facility management relate to the effectiveness of government interventions for inducing compliance with NPDES discharge limits. One attitudinal measure captures management's subjective perception of inspections' effectiveness. The second attitudinal measure captures management's subjective perception of monetary fines' effectiveness. Both measures are binary, revealing an "effective" perception, with a "not effective" perception as the omitted category. If a manager feels that inspections or fines are effective at inducing compliance, he/she may be more inclined to practice better environmental management in order to stay in compliance. If, however, the manager feels that inspections or fines are ineffective, he/she may conclude that hiring employees devoted to environmental management is a waste of valuable resources.

These facility-level and firm-level measures are collectively denoted as F_{it} in the empirical model specification.

Finally, the analysis controls for variation in regulatory pressure not already reflected in government intervention measures by including year and regional indicators, denoted as D_t and L_i, respectively, as regressors.

Table 1.1 includes summary statistics for the control factors. Most interestingly, the average facility employs roughly 260 workers overall. The majority of facilities in the sample are designated within the NPDES program as "minor" facilities, are owned by publicly held firms, and are located in the eastern half of the United States. Finally, Table 1.1 displays the coefficients of variation for the regressors; these statistics reveal meaningful variation in the regressors.

1.5.3 Primary Regression Equation

The analysis estimates a semi-log specification by logging the count of environmental employees for the dependent variable. Given this functional form, the coefficients of the various government intervention factors reflect semi-elasticities: percent changes in the count of environmental employees prompted by one unit increases in government interventions. The following equation captures the functional relationship between the number of environmental employees and the identified explanatory variables:

$$f(Y_{it}) = \alpha + \beta_1 I_{it-1}^{EPAs} + \beta_2 I_{it-1}^{STs} + \beta_3 I_{it-1}^{EPAg} + \beta_4 I_{it-1}^{STg} + \beta_5 A_{it-1}^{s} + \beta_6 A_{it-1}^{g} + \beta_7 P_{it-1}^{s} + \beta_8 P_{it-1}^{g}$$
$$+ \eta F_{it} + \mu D_t + \theta L_i + \varepsilon_{it}, \qquad (1.1)$$

where β_1 through β_8 are the coefficients of interest, α represents the intercept term, and ε_{it} represents an exogenous error term. The empirical analysis estimates this regression equation to obtain coefficient estimates and standard errors for the regressors of interest.

1.6 Econometric Analysis

This section details the econometric analysis of government interventions and environmental labor, by first discussing the potential endogeneity of the primary regressors, then discussing estimation techniques, and finally interpreting the estimation results, including an assessment of economic impacts implied by the coefficient estimates.

1.6.1 Potential Endogeneity of the Primary Regressors

First, the government intervention measures used in the analysis may be endogenous. However, this study claims that the constructed measures are indeed exogenously determined with respect to environmental labor decisions. The general deterrence measures are clearly exogenous, as they reflect government interventions prompted by the behavior and performance of other facilities. The specific deterrence measures are exogenous as well given the separation in time between lagged government interventions and current environmental management decisions, consistent with nearly all previous studies using lagged intervention measures (Earnhart, 2009; Helland, 1998a; Helland, 1998b; Earnhart and Leonard, 2013; Earnhart and Harrington, 2014). A review of the literature, provided by Gray and Shimshack (2011), confirms this point. As one of the very few studies to assess the endogeneity of lagged intervention measures, Earnhart and Friesen (2014) demonstrate that specific deterrence measures appear exogenous.

By treating the primary regressors as exogenous, the empirical analysis proceeds by employing the standard estimation procedures.

1.6.2 Estimation Techniques

The empirical analysis utilizes a fixed effects estimator, which includes facility-specific indicators as regressors, to address and exploit the panel structure of the sampled data. Thus, identification stems exclusively from intra-facility variation. Further, the analysis clusters standard errors at the facility level.[16] The analysis does not use a random effects estimator, which also addresses panel data, because the Hausman Test of Random Effects statistic rejects the null hypothesis of consistent estimates. The use of a fixed effects estimator is consistent with nearly all previous studies of environmental enforcement and environmental management.

The empirical analysis includes four models (i.e., regressor sets) to assess the robustness of the results. Model 1 is the parsimonious model, which includes only the primary regressors. Model 2 adds the regional and year indicators. Model 3 represents the full model, which

[16] As an alternative specification, standard errors are clustered at the state level. The resulting empirical results differ only slightly from those presented, while maintaining identical statistical significance.

incorporates all facility-level and firm-level controls, in addition to the primary regressors and region and year indicators. Table 1.2 reports the fixed effects estimates for Models 1, 2, and 3.

Model 4 further assesses the robustness of the results. Much of the sampled data is collected using a one-time survey, so many of the control factors are time-invariant over the sample period. By construction, the fixed effects estimator subsumes the time-invariant factors into the facility-specific fixed effects. To retain the effects of these time-invariant factors, the analysis interacts each time-invariant factor with a trio of year indicators (1999, 2000, 2001). Each year-specific interaction term reflects the year-specific effect of a given time-invariant factor. Since this model generates estimation results highly similar to those results generated by Models 1, 2, and 3, the study neither tabulates nor interprets the Model 4 results.

1.6.3 Results

This sub-section interprets the fixed effects estimates shown in Table 1.2. The empirical results reveal that, of the eight primary regressors, consisting of four types of government interventions (federal inspections, state inspections, informal enforcement actions, and monetary penalties) in two forms of deterrence (general and specific), three regressors significantly affect the amount of environmental labor employed by NPDES-regulated facilities.

First, federal inspections in the form of general deterrence negatively impact environmental labor at NPDES-regulated facilities.[17] Yet state inspection-related general deterrence does not influence environmental labor. This pair of results is robust across all three

[17] Some states during the sample period had yet to receive authority to implement the NPDES program. For these states, federal inspections were the only type of inspection conducted during the sample period. Dropping these states from the analysis does not meaningfully change the estimated effects of federal inspections.

models. As mentioned above, federal and state inspections differ meaningfully in their purpose and severity. State inspections are generally seen as less severe than federal inspections. State agencies conduct inspections more frequently, and often inspect to provide compliance assistance rather than to gather evidence for enforcement cases (Earnhart, 2004b). Interestingly, neither state nor federal inspections in specific deterrence form significantly affect environmental labor.

Second, specific deterrence stemming from both types of enforcement actions - informal actions and monetary penalties - negatively impacts environmental labor. These relationships are robust to the choice of model since the coefficient magnitudes and significance levels vary only slightly across the models.

This sub-section next discusses the empirical results in further detail. As noted above, environmental enforcement measures are expected to influence environmental management, specifically environmental labor, in one of two ways. First, facilities utilize environmental management to comply with their NPDES permitted discharge limits. If facility managers see environmental labor as an important part of their environmental management systems, then government interventions should increase the number of individuals employed in this specialized form of labor. However, if environmental employees are seen simply as another form of expendable labor, rather than as an important part of an EMS, then government interventions may in fact cause facility managers to fire environmental employees in order to cut costs. The empirical results show that certain types of government interventions result in the loss of environmental employees. Specific deterrence stemming from both types of enforcement actions, as well general deterrence from federal inspections, negatively impact environmental employment. State inspections (in both forms of deterrence), specific deterrence from federal inspections, and general deterrence from both types of enforcement actions generate no significant impact on environmental labor. Therefore, the empirical results show that environmental regulation has either a negative or zero effect on employment labor, much like previous studies of the overall labor impacts from the imposition of environmental regulation (e.g., Walker, 2011; Greenstone, 2002; Ferris, et al., 2014).

These empirical results highlight a number of interesting points in regard to environmental regulation and enforcement and their effects on environmental management including the use of environmental labor. This study shows that the enforcement of environmental regulation has the same impact on environmental labor as the imposition of environmental regulation has on overall labor: both negatively impact labor.

A number of reasons explain these similar impacts. First, facility managers may view environmentally related employment as simply another form of employment at the facility. Rather than view environmental labor as instrumental in the facility's environmental management efforts to comply with regulatory permits, facility managers may view environmental labor as no different from all employees that are subject to termination in order to save costs. As shown previously in the literature, this study reveals that environmental regulation does indeed negatively impact employment, even environmentally related employment.

Second, factors other than costs imposed via government interventions may push facility managers toward compliance with their NPDES limits. For example, "intrinsic motivations," such as meeting societal or professional norms, may prompt managers to comply. Meeting these norms generates "warm glow" for the managers. If the regulator takes overly severe actions to keep facilities in compliance (e.g., federal inspections, monetary fines), these actions may crowd out intrinsic motivation to comply. At worst, this crowding effect leads to counter-productive government interventions in that facility managers expend less effort on environmental management in response to these interventions. A facility manager may also seek to comply with permits, by hiring more environmental labor, to be seen as altruistic, thus, signaling his/her environmental “goodness” (Benabou and Tirole, 2006). However, if the regulator takes overly severe forms of enforcement, these interventions may “jam” the facility manager’s signal. The facility manager becomes reluctant to continue his/her prosocial behavior because society (e.g., customers, investors) is less able to discern voluntary compliance from “coerced” compliance.

Third, facility managers may feel a sense of relief when other facilities experience government interventions. Enforcement agencies generally face fixed budgets. Perhaps a specific facility manager feels that the likelihood of a government intervention drops when other facilities experience more government interventions. For example, this study shows that general deterrence from federal inspections negatively affects environmental employment. A specific facility manager may witness federal inspections conducted at other facilities and then conclude that his/her facility will *not* be inspected because the EPA regional office has no discretionary funds left. This conclusion causes the specific facility manager to allocate fewer resources to environmental management.

Fourth, government interventions may negatively affect environmental labor due to a re-allocation of environmental management effort. If a facility employs a substantial amount of environmental labor, yet still comes under scrutiny from the regulator (in the form of government interventions), the facility manager may conclude that the environmental workers are not effectively keeping the facility in compliance, prompting the manager to fire workers in order to allocate more resources on other environmental management efforts. The most likely recipient of the reallocation of environmental management funds is pollution abatement technology. Although most abatement technology must be operated by environmental employees with specific training, managers may feel that the combination of more technology and a smaller (yet positive) amount of workers provides the best path towards compliance.

1.6.4 Robustness Checks

This sub-section assesses the robustness of the conclusions supported by the study's empirical results. As noted above, estimates from the four models support identical conclusions. The analysis further assesses the robustness of the empirical results by re-estimating the regression for sub-samples based on facility size and location.

As mentioned in Section 1.3, enforcement of the NPDES program is administered by EPA regional offices and individual state agencies. Thus, facilities' responses to government interventions may vary across regions and states. To assess robustness based on facilities' locations, the analysis uses Model 3 to re-estimate the regression equation using two sub-samples: facilities operating in the eastern U.S. and facilities operating in the western U.S., where east and west are based on U.S. Census designated regions. Table A.1 of the appendix displays the resulting estimates. As shown, conclusions are robust to the location of the facility, with the single exception of general deterrence from federal inspections; the entire sample is needed to generate a significantly negative result.

Enforcement of the NPDES program also depends largely on the NPDES designation of "major" facilities versus "minor" facilities. Table A.2 of the appendix displays the results from a re-estimation of Model 3 with major and minor facilities separated into two sub-samples. As shown, most of the conclusions are robust to the separation between major and minor facilities. In particular, the negative effect of specific deterrence from monetary penalties is robust to the size of the facility. Interestingly, minor facilities in the survey sample never faced informal enforcement actions over the sample period. Thus, the significant result for this type of intervention and form of deterrence comes exclusively from major facilities. Finally, similar to geographic location, the significant result for general deterrence from federal inspections requires use of the entire sample.

1.6.5 Economic Impacts

This last sub-section assesses the economic importance of the results drawing on the statistically significant estimates from Model 3 using the full sample.

The average facility employs 75 employee person-months devoted to environmental management. As the empirical results show, all statistically significant government interventions negatively affect environmental labor. First, by conducting one more inspection at every facility of similar size in a given EPA region (i.e., general deterrence), the federal regulator decreases the number of environmental employee person-months at an individual facility by 67 % or roughly 50 person-months based on the average facility (equivalent to 4.2 FTE employees). While this impact is highly substantial, note that one extra federal inspection equals three standard deviations in the sample. For enforcement, both informal actions and monetary penalties generate a significant impact on environmental employment based on specific deterrence. Issuing one more informal enforcement action decreases environmental employment by almost 2 % or 1.5 person-months based on the average facility (equivalent to only 0.125 FTE employees). Similarly, levying a $ 10,000 fine against a facility, rather than no fine, decreases the number of environmental employee person-months by 3 %, which represents over two person-months (equivalent to 0.188 FTE employees) for the average facility. This small impact seems even less substantial by noting that a $ 10,000 increase nearly equals three standard deviations in our sample.

1.7 Conclusions

This study seeks to determine the effect of government interventions on the use of environmental management, specifically environmentally related labor. The analysis examines chemical manufacturing facilities permitted under the NPDES program over the years 1999 to 2001. The analysis finds that all environmental enforcement measures have a zero or negative impact on the amount of environmentally related labor employed at facilities in the sample. Specifically, empirical results show that general deterrence from federal inspections, specific deterrence from informal enforcement actions, and specific deterrence from monetary penalties all lower the amount of environmental labor employed by NPDES-regulated facilities. These results raise a number of interesting questions about the use of environmental labor as a form of environmental management. Further, the empirical results identify the types of government interventions that do not appear to decrease environmental employment.

This study contributes much to the debate over environmental enforcement policy and its impact on environmental labor. The need for future research on this important question remains. As one especially interesting idea, future research should examine the allocation of labor versus that of wastewater treatment capital at regulated facilities, along with facilities' adjustments to this allocation in response to government interventions. In addition, future studies should explore more sectors, more types of environmental media (e.g., air, hazardous waste), and other aspects of environmental management. Finally, future studies should go beyond environmental management efforts by examining the extent of compliance, as determined by the ratio of actual discharges to permitted limits.

Table 1.1: Sample Summary Statistics

Variables	Mean	Std. Dev.	Coef. of Variation
Dependent Variable			
Environmental employees (person-month count)	74.94	179.1	2.390
Primary Regressors			
# of federal inspections / # of other facilities by EPA region (1-yr lag)	0.029	0.050	1.754
# of state inspections / # of other facilities by state (1-yr lag)	0.676	0.967	1.430
# of federal inspections during preceding 24-month period	0.068	0.330	4.825
# of state inspections during preceding 24-month period	1.497	2.475	1.653
# of informal enforcement actions / # of other facilities by EPA region (1-yr lag)	0.077	0.190	2.477
Monetary penalty amount / # of other facilities by EPA region (1-yr lag)	73.95	366.6	4.957
# of informal enforcement actions during preceding 24-month period	0.200	1.169	5.845
Monetary penalty amount during preceding 24-month period	127.9	3,577	27.97
Facility / Firm Characteristics			
Major facility classification (vs minor facility)	0.386	0.487	1.262
Organic chemical manufacturing (vs other chemicals)	0.437	0.496	1.135
Inorganic chemical manufacturing (vs other chemicals)	0.310	0.463	1.494
Facility owned by publicly-held firm (vs privately-held firm)	0.635	0.482	0.760
Facility employees (count)	260.9	481.6	1.850
Economic impact of facility: significant/great (vs small/very little)	0.710	0.454	0.639
Facility’s attitudes toward inspection effectiveness: effective (vs not effective)	0.529	0.500	0.945
Facility's attitudes toward monetary fine effectiveness: effective (vs not effective)	0.395	0.489	1.238
Facility's environmental concern - all employees: 1=lowest, 10=highest	7.377	1.705	0.231
Facility's environmental concern - environmental employees: 1=lowest, 10=highest	8.894	1.332	0.150
Year/Region Controls			
EPA Region 1 (0,1) [regions 8, 9, 10 omitted]	0.034	0.180	5.357
EPA Region 2 (0,1) [regions 8, 9, 10 omitted]	0.090	0.286	3.192
EPA Region 3 (0,1) [regions 8, 9, 10 omitted]	0.131	0.337	2.573
EPA Region 4 (0,1) [regions 8, 9, 10 omitted]	0.246	0.431	1.752
EPA Region 5 (0,1) [regions 8, 9, 10 omitted]	0.164	0.371	2.262

Table 1.1 (continued)

EPA Region 6 (0,1) [regions 8, 9, 10 omitted]	0.220	0.415	1.886
EPA Region 7 (0,1) [regions 8, 9, 10 omitted]	0.067	0.250	3.720
Year 2000 (0,1) [Year 1999 omitted]	0.333	0.472	1.417
Year 2001 (0,1) [Year 1999 omitted]	0.333	0.472	1.417

Table 1.2: Results from Panel Estimation of Log-Environmental Employee Person-Month Count

Primary Regressor	Model 1	Model 2	Model 3
Inspections			
# of federal inspections / # of other facilities by region (1-yr lag)	**-0.503**	**-0.656**	**-0.669**
	(0.043)	**(0.023)**	**(0.018)**
# of state inspections / # of other facilities by state (1-yr lag)	-0.009	-0.008	-0.019
	(0.586)	(0.642)	(0.251)
# of federal inspections during preceding 24-month period	-0.027	-0.028	-0.029
	(0.475)	(0.470)	(0.384)
# of state inspections during preceding 24-month period	0.008	0.007	0.007
	(0.284)	(0.372)	(0.388)
Enforcement			
# of informal enforcement actions / # of other facilities by region (1-yr lag)	0.016	0.021	0.030
	(0.843)	(0.808)	(0.731)
Penalty amount / # of other facilities by region (1-yr lag)	-0.00003	-0.00005	-0.00005
	(0.248)	(0.101)	(0.131)
# of informal enforcement actions during preceding 24-month period	**-0.019**	**-0.019**	**-0.019**
	(0.035)	**(0.037)**	**(0.037)**
Penalty amount during preceding 24-month period	**-0.000003**	**-0.000003**	**-0.000003**
	(0.008)	**(0.008)**	**(0.002)**
Constant	**3.014**	**2.999**	**2.693**
	(0.000)	**(0.000)**	**(0.000)**
Number of Observations	743	743	709
Facility indicators included	Yes	Yes	Yes
Regional indicators included			
Year indicators included	No	Yes	Yes
Facility/firm characteristics included	No	No	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at the 10 % level or better ($p \leq 0.10$).
Standard errors are clustered at the facility level.

Figure 1.1: National Pollutant Discharge Elimination System Monitoring and Enforcement

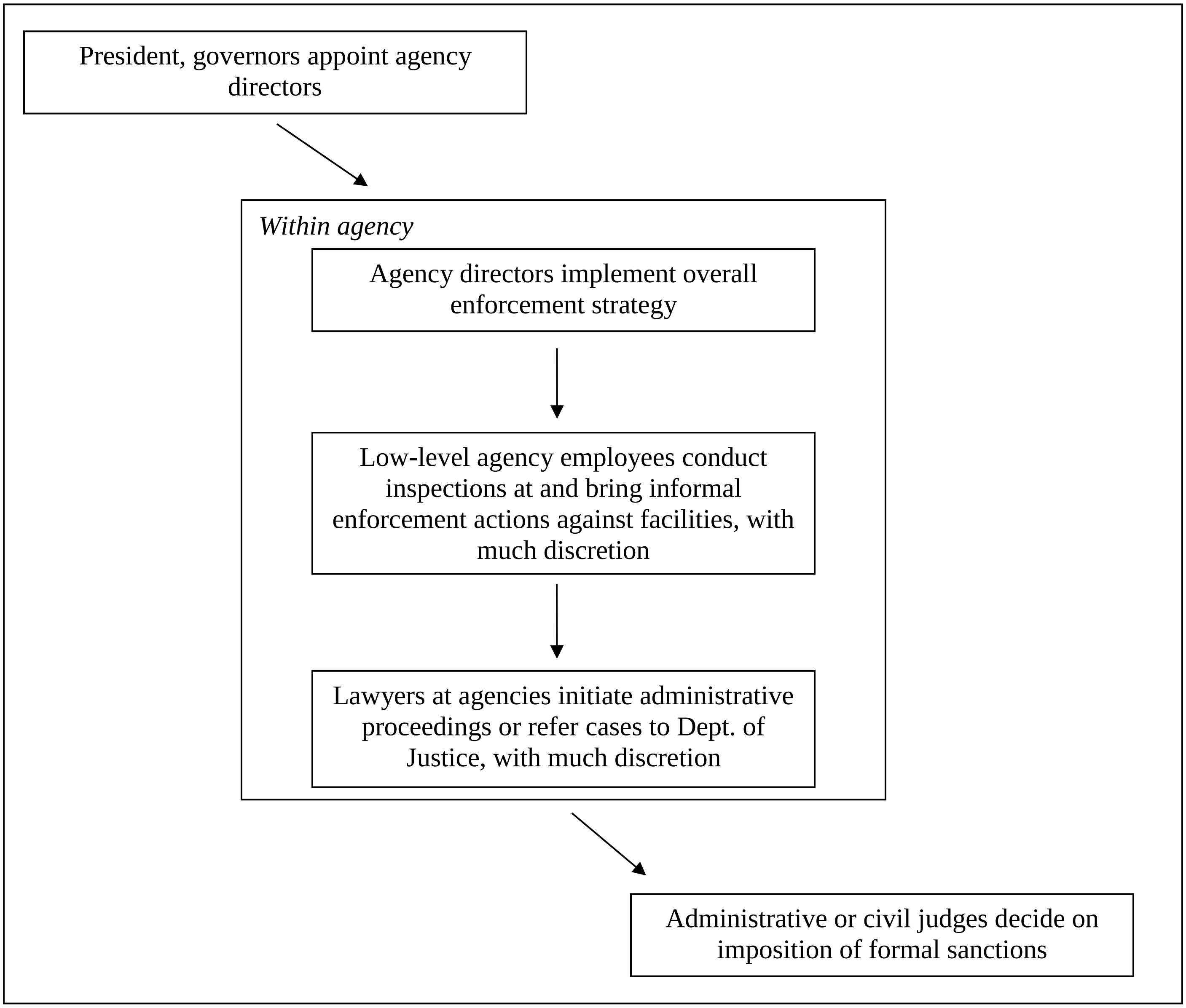
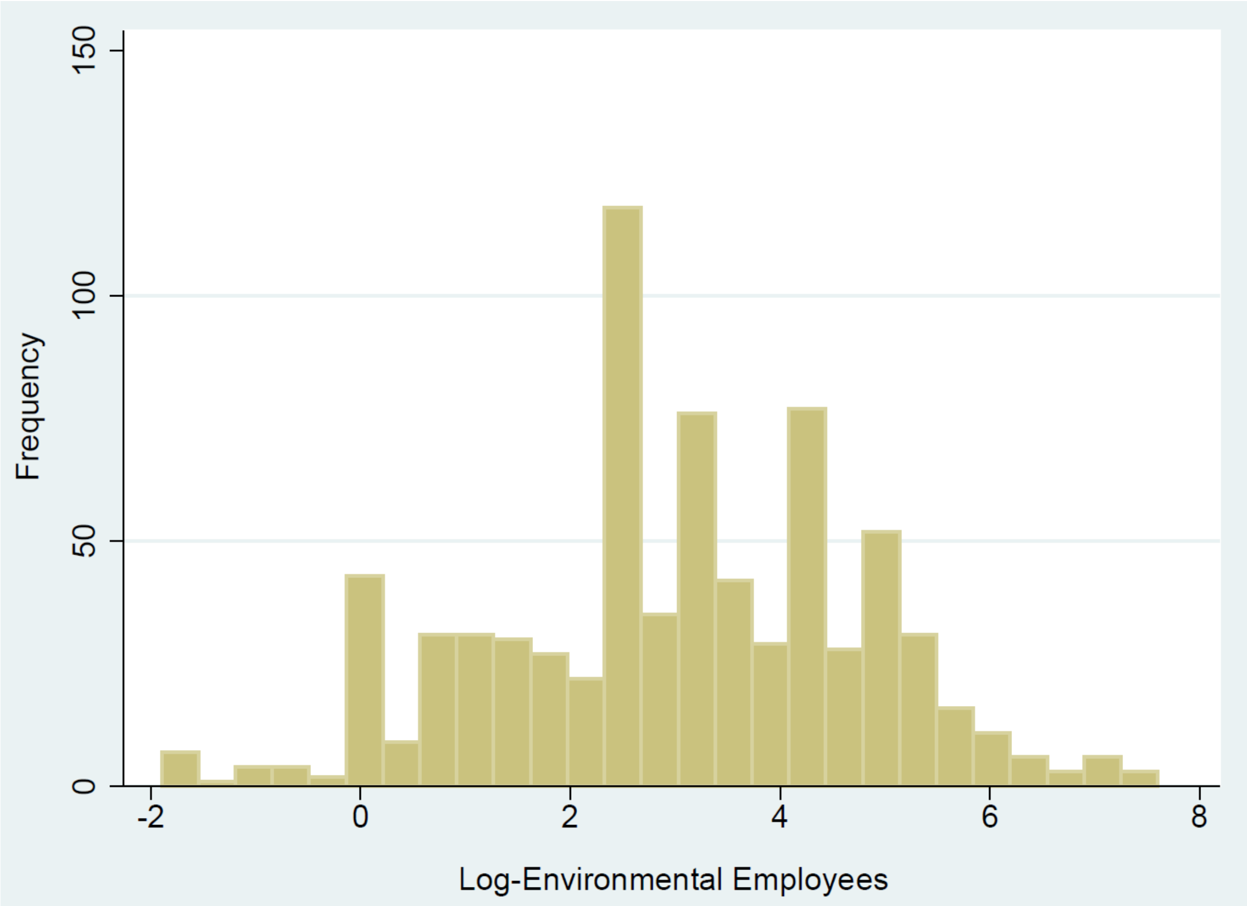


Figure 1.2: Histogram of Log-Environmental Employee Person-Month Count



2 Effect of Cooperative Enforcement Strategies on Wastewater Management: Innovation or Regulatory Capture?

2.1 Introduction

Government interventions of polluting facilities, such as monitoring inspections, warnings, and fines, have been the norm for inducing compliance with environmental laws since the early 1970s. The economic literature is rife with empirical analysis that examines the efficacy of such interventions across a wide range of environmental media and economic sectors (Gray and Deily, 1996; Laplante and Rilstone, 1996; Helland, 1998a; Helland, 1998b; Earnhart, 2004a; Earnhart, 2004b).

These government interventions represent components of a broader environmental enforcement policy. Within the environmental policy realm, there exists a fierce debate about the better way to induce environmental compliance through enforcement. The debate focuses on the comparative merits of two enforcement approaches - the coercive (or deterrence-based) approach and the cooperative (or flexibility-based) approach. Under a coercive approach, the environmental regulator, such as the Environmental Protection Agency (EPA), deters facilities from non-compliance with environmental laws by imposing enforcement sanctions for violations. Consistent with the basic deterrence model (Becker, 1968), the coercive approach operates on the premise that regulated facilities do not wish to comply with environmental requirements. Thus, the imposed sanctions are designed to make non-compliance more expensive than compliance. In contrast, under a cooperative approach, the environmental regulator provides flexibility to regulated facilities as a means of facilitating compliance. Contrary to the coercive approach, the cooperative approach operates on the premise that regulated entities react to a variety of motives, such as societal and professional norms, that supply adequate incentives to comply with regulatory obligations. This debate has recently gained attention from a feature piece in the New York Times that discusses North Dakota's cooperative approach to the regulation of oil wells in the Bakken shale (Sontag and Gebeloff, 2014).

Since the initial implementation of federal environmental protection laws in the United States, enforcement has shifted away from exclusive reliance on coercive enforcement and towards a more partnership-based, less adversarial, cooperative approach (Stoughton et al., 2001). Further, many states have replaced traditional coercive enforcement with a form of cooperation (Andreen, 2007). This shift has stemmed partially from the perspective that a cooperative approach is more “innovative” than traditional, coercive enforcement. Despite the debate prompted by this progression, very little empirical research directly compares the two approaches regarding the ability of each approach to induce environmental compliance.

One can interpret the contrast between coercion and cooperation using the lens of regulatory capture. Captured regulators do not advance the interests of those they serve (e.g., society at large) but rather the special interests of the regulated community (Stigler, 1971; Laffont and Tirole, 1991).[18] From this perspective, what appears as cooperation may be nothing more than regulatory capture. In fact, on the spectrum of coercion to cooperation, regulatory capture lies at the upper end of extreme cooperation (Zinn, 2002). Most relevant to the current study, the risks of regulatory capture are most acute in the realm of enforcement (Zinn, 2002), where agency discretion is substantial. Despite this strong potential for regulatory capture, no

[18] The recent case of North Dakota's regulation of the oil and gas industry, as featured in a New York Times feature article, presents an excellent example of apparent regulatory capture.

previous study of regulatory capture uses a measure of cooperative enforcement to reflect potential regulatory capture.

This study contributes to the literatures on government intervention effectiveness and regulatory capture, as well as the debate over enforcement strategy, by exploring the extent of cooperation extended by regulators to regulated facilities versus the extent of coercion exerted against facilities as part of the regulator's overall enforcement strategy. In particular, this study explores the influence of the overall enforcement strategy on the effects of government interventions on the extent of environmental management expended by regulated facilities.[19] As an additional contribution to the regulatory capture literature, this study explores environmental regulation, which few previous studies consider (e.g., Earnhart, 1997; Deily and Gray, 1991).

As a second contribution to the literature on government intervention effectiveness, this study examines a previously ignored, yet highly important, form of environmental management: the amount of labor dedicated to environmental management (i.e., number of employees devoted specifically to environmental management at a given facility). Clearly, labor is an important part of a facility's operations. Similarly, environmentally related labor represents a critical input into any facility's efforts to manage its waste stream. Most regulated facilities operate some sort of discharge treatment equipment demanding at least one environmental employee with proper training. Most important, environmental labor effectively improves compliance with pollution control laws (Earnhart and Glicksman, 2011). The presence of environmental employees is substantial. Within the sampled facilities, the average ratio of environmental employees to

[19] Environmental management is defined as any method used by facilities to control pollution, e.g., self-audits, internal monitoring protocols, end-of-pipe treatment technologies.

overall employees at an individual facility equals 0.046; meaning 4.6 % of the average facility's workforce specializes in environmental management.[20] Thus, facilities invest a significant amount of time and resources into ensuring the necessary human expertise is present in their operations. Finally, in today's political environment, where environmental regulations and efforts to reduce pollution are considered detrimental to employment, the study's assessment of environmental employees is important. The study's empirical results can help to reveal how best to conduct government interventions and craft an overall enforcement strategy in ways that boost environmental-related employment.

Despite this importance, no previous economic study of environmental management explores the allocation of environmental labor. Instead, previous studies examine other types of environmental management: implementation of an environmental management system [EMS] (Johnstone and Labonne, 2009), certification of an EMS (Christman and Taylor, 2001; Arimura et al., 2008; Dasgupta et al., 2000; Henriques and Sadorsky, 2007; and Delmas and Toffel, 2008), audits (Earnhart and Leonard, 2013; Evans et al., 2011), and various other management forms (Garcia et al., 2009). As the closest studies, Greenstone (2002), Berman and Bui (2001), Gray et al. (2014), and Ferris et al. (2014) examine the impact of government regulation on total employment at a facility or within an industry, but do not specifically assess environmental employment. In the present study, I focus on the impacts of monitoring and enforcement on environmentally related employment. Previous studies, however, examine the effect of

[20] This value is higher than the value of 1 % provided by the Census Pollution Abatement Controls and Expenditures (PACE) survey for the chemical manufacturing sector. The substantially larger percentage for the present sample is expected; the sample includes only facilities regulated under the CWA, while the PACE survey covers all chemical manufacturing facilities.

regulation on *total* employment. (Using the survey data, I am able to assess this same effect on total employment, but the identified studies cannot assess the effect on environmental employment since the publicly available microdata do not distinguish between environmental and other employment.)

The absence of analysis on environmental employees follows from the lack of available data. As the nearest efforts, the Department of Commerce and the Bureau of Labor Statistics (BLS) have attempted to quantify this type of labor in the "Measuring the Green Economy Report" (Department of Commerce, 2010) and the “Employment in Green Goods and Services” report (Bureau of Labor Statistics, 2011), respectively. Both reports estimate the number of environmental jobs. The BLS estimates 24,733 environmental employees were working in the chemical manufacturing sector as of 2011. While these estimates are useful for aggregate analysis, I claim that my data are superior since these data were collected through a survey of chemical manufacturing facilities that captured the count of employees responsible for managing wastewater discharges, which were regulated by Clean Water Act permits. Thus, my data on environmental employees relate directly to regulatory compliance and, by extension, government inspections and enforcement actions designed to induce compliance, i.e., deter non-compliance.

As its final contribution, this study focuses on the labor impacts of the enforcement of regulations. All previous studies of labor impacts ignore the enforcement aspect of regulation, instead focusing on the imposition of regulations (Greenstone, 2002; Berman and Bui, 2001; Gray et al., 2014; Ferris et al., 2014).

In order to generate these contributions, this study constructs an index that ranges from a completely coercive approach to a completely cooperative approach. Then the analysis interacts this index with various measures of government interventions: federal inspections, state inspections, informal enforcement actions (e.g., notices of violation), and monetary penalties. By interpreting the coefficients associated with these interaction terms, the analysis is able to determine whether greater cooperation (i.e., less coercion) improves or undermines the effectiveness of the various government interactions for prompting greater environmental protection effort from regulated facilities in the form of environmental labor. If a cooperative enforcement approach improves the effectiveness of government interventions, then cooperation could be regarded as an innovative, proactive environmental enforcement policy. If a cooperative enforcement approach instead undermines the effectiveness of government interventions, then cooperation could be interpreted as regulatory capture under a different name. This interpretation is even more appropriate if greater cooperation leads to counter-productive effects, i.e., government interventions negatively impact environmental labor under a cooperative enforcement approach. For this empirical analysis, the present study gathers data on environmental labor using a phone survey administered to U.S. chemical manufacturing facilities regulated under the Clean Water Act.

The rest of the paper proceeds as follows. Section 2.2 reviews the literature on environmental enforcement, environmental management, regulatory capture, and the labor impacts of environmental regulations. Section 2.3 describes the relevant regulatory context. Section 2.4 constructs a conceptual framework, which produces testable hypotheses. Section 2.5 describes the econometric framework. Section 2.6 discusses the studied data. Section 2.7 details the econometric analysis and its results. Finally, Section 2.8 concludes, while discussing the policy implications of the empirical results.

2.2 Literature Review

This section reviews the literature relating to environmental enforcement, management, labor, and regulatory capture.

2.2.1 Public Enforcement of Environmental Laws

Both theoretical and empirical analysis explores the public enforcement of environmental laws. Most of the theoretical analysis focuses on the coercive approach to enforcement. The theoretical foundation for the coercive approach is found in the model of Becker (1968). Since then, a number of studies have expanded this model; Polinsky and Shovell (2000) provide a thorough review of this literature. In this model, the enforcement agency monitors the compliance of regulated facilities and deters non-compliance by imposing sanctions in response to violations.

The theoretical literature lacks a conceptual framework capturing the form of cooperation explored in the present study. The related studies focus on specific aspects of cooperation, rather than an overarching relationship between the regulator and the regulated facility. As one primary example, Harrington (1988) shows that regulators and regulated entities can cooperate with one another. Other studies examine different, specific aspects of cooperation. For example, regulators cooperate by enforcing some laws more stringently in an attempt to induce better compliance with others (Heyes and Rickman, 1999; Arguedas, 2005; Amacher and Malik, 1998; Heyes, 2005). As the most relevant theoretical framework, Scholz (1991) shows that a cooperative strategy of enforcement can improve the effectiveness of enforcement.

Nearly all of the previous empirical studies explore the coercive model by examining the effect of environmental enforcement on facility- or firm-level environmental performance or management (Gray and Shadbegian, 2004; Shimshack and Ward, 2005; Gray and Deily, 1996;

Laplante and Rhilstone, 1996; and Earnhart, 2004a; Earnhart, 2004b; Earnhart and Leonard, 2013). Gray and Shimshack (2011) provide a thorough review of this literature.

Empirical studies of the cooperative approach are few. One such study examines state programs to reduce erosion and sediment in urban areas in North Carolina (Burby and Paterson, 1993). Burby (1995) examines this same sector; he finds that the better programs tend to the highly coercive ones. Harrison (1995) examines pulp and paper mills operating in Canada, where regulators employ a more cooperative approach, and in the US, where regulators employ a more coercive approach. She tests whether compliance rates are higher in Canada or the US and finds that Canadian compliance rates are much lower than U.S. rates. Lastly, Andreen (2007) finds that compliance rates for major dischargers regulated under the Clean Water Act did not significantly change during a period when many states were moving from a coercive approach to a more cooperative one.

2.2.2 Regulatory Capture

The literature on the theory of regulatory capture is large and influential in economics. Stigler’s seminal paper (1971) provides a theoretical basis for regulatory capture, and also empirically tests the theory using data on the railroad industry. Peltzman (1976), Tirole (1986), and Laffont and Tirole (1991) expand the theory. Other theoretical studies of regulatory capture model the main reasons why capture is possible: asymmetric information between firms and the regulator (Lohmann, 1993; Snyder, 1991) and positive incentives for the regulator, such as a revolving door of employment between regulators and industry (Che, 1995; Salant, 1995). More closely related to the current study, Maloney and McCormick (1982) examine regulatory capture in the realm of environmental regulation. The authors first theoretically model regulation of an industry that produces negative externalities (e.g., environmental regulation), while demonstrating that regulation creates incentive for capture. Zinn (2002) argues that regulatory capture lies at the upper end of the spectrum from coercion to cooperation between the regulator and a regulated entity.

While many studies theoretically explore regulatory capture, far fewer studies empirically examine different forms of regulatory capture.[21] These empirical studies cover a wide range of regulatory realms: telecommunications (Besley and Coate, 2003; Dnes, 1995; De Figueiredo and Edwards, 2007), trade (Hansen and Park, 1995; Eicher and Osang, 2002), and energy (Dal Bo and Rossi, 2007). Dal Bo (2006) provides a thorough review of both the theoretical and empirical literatures.

2.2.3 Environmental Management

This study's assessment of the effect of enforcement on environmental labor sits within a larger literature exploring regulated facilities' environmental management decisions. A number of studies examine a facility's decision to establish and operate an environmental management system (EMS). In some cases, facilities decide to obtain certification of their EMSs based on commercial standards, such as ISO 14001 certification. Christmann and Taylor (2001), Arimura et al. (2008), Nakamura et al. (2001), Dasgupta et al. (2000), Henriques and Sadorsky (2007), Delmas and Toffel (2008), and Mori and Welch (2008) examine facilities' adoption of ISO 14001-certified EMSs. More relevant to the present study, several previous studies analyze specific types of environmental management. Khanna and Anton (2002), Anton et al. (2004), and Harrington et al. (2008) examine companies' decisions to undertake various environmental

[21] A number of case studies examine regulatory capture in single instances (e.g., Portman, 2014; Grant 2011).

management and/or pollution prevention practices by summing across the practices, i.e., dependent variable is a count of practices. Khanna et al. (2007), Jones (2010), Ervin et al. (2012), Garcia et al. (2009), and Henriques and Sadorsky (1996) separately analyze companies' decisions to administer specific environmental management and pollution prevention practices. Some studies focus on one specific environmental management practice: environmental self-audits (Earnhart and Leonard, 2013; Evans et al., 2011; Earnhart and Harrington, 2014).

2.2.4 Labor Impacts of Environmental Regulation

Within the economic literature, many studies examine the labor impacts of various environmental regulations. As examples, Greenstone (2002) finds that the Clean Air Act’s designation of attainment vs. non-attainment counties has significant labor impacts in multiple manufacturing sectors. Berman and Bui (2001) examine the stringency of air quality regulation in the Los Angeles area. Gray et al. (2014) study the impacts of the Cluster Rule on the number of jobs in the pulp and paper industry, and find minimal effects. Finally, Ferris et al. (2014) find that Phase I of the Title IV SO_2 trading program had negligible effects on employment at fossil fuel-fired plants.

2.2.5 Contributions of Present Study

This study contributes to these literatures in three ways. First, this study explores the extent of cooperation extended by regulators to regulated facilities versus the extent of coercion exerted against facilities as part of the regulator’s overall enforcement strategy. In particular, this study assesses the influence of the overall enforcement strategy on the effects of government interventions on the extent of environmental management expended by regulated facilities. In the process, the study assesses whether a cooperative enforcement strategy improves the effectiveness of government interventions, and thus appears “innovative”, or undermines the effectiveness of government interventions, and thus simply reflects regulatory capture. In the worst case, cooperation may actually lead to counter-productive effects of government interventions on environmental management. Second, this study examines a previously ignored, yet highly important, form of environmental management: the amount of labor dedicated to environmental management. Finally, this study is the first to examine the effects of employment from the enforcement of environmental regulations rather than the imposition of regulations.

2.3 Regulatory Context

This section describes the regulatory context relevant to the analysis.

2.3.1 National Pollutant Discharge Elimination System

This study examines environmental behavior relating to the U.S. Clean Water Act (CWA). One of the CWA's main purposes is protecting water quality by controlling wastewater discharges from point sources. To this end, the EPA created a permitting program to control these point sources known as the National Pollutant Discharge Elimination System (NPDES). The system's main form of control is the issuance of facility-specific permits, which identify the pollutant-specific discharge limits imposed on regulated facilities.[22] Permits are issued and re-issued generally on a 5-year cycle by the EPA or authorized state agencies. When establishing discharge limits within individual facilities' permits, the issuing agency considers the relevant Effluent Limitation Guideline standard, which is designed to require a minimum level of wastewater treatment for a given industry, and the state water quality-based standard, which is designed to ensure that the water body receiving the discharges meets state-based ambient

[22] The EPA website provides an overview of the NPDES permitting system: http://water.epa.gov/polwaste/npdes/basics/upload/101pape.pdf

surface water quality standards. After a candidate discharge limit is determined under each standard, the more stringent limit is written into the permit. Each discharge limit represents a performance-based standard under which compliance is based solely on one's own discharges. Thus, a facility may use any available abatement method to comply with its permitted limits. A myriad of abatement methods are available to facilities: end-of-pipe treatment technologies (i.e., capital), deployment of labor, and other methods. Clearly the deployment of labor enhances the effectiveness of equipment and other methods. For example, wastewater engineers monitor the operation of treatment technologies.

In the NPDES system, permitted facilities are required to monitor and self-report their discharges on a regular basis. To ensure compliance with issued permits, the EPA and state agencies periodically inspect facilities and take enforcement actions as needed. Agencies possess great discretion over monitoring and enforcement decisions. The use of inspections and enforcement actions occur both in cooperative and coercive regimes. In this sense, enforcement is neither “traditional” nor “innovative”; it is both. While the EPA retains authority to monitor and impose sanctions on facilities, the state regulators are primarily responsible for monitoring and enforcement. Inspections represent the base of environmental agencies’ efforts to monitor compliance and collect evidence for enforcement (Wasserman, 1984); inspections also maintain a regulatory presence (EPA, 1990). As for enforcement, agencies use a mixture of informal enforcement actions (e.g., warning letters) and formal enforcement actions, which include penalties (i.e., fines). The EPA expects monitoring inspections and enforcement actions to generate both specific and general deterrence. Specific deterrence prompts the specific facility inspected or enforced against to improve its subsequent compliance, while general deterrence prompts other facilities to improve their subsequent compliance (Cohen, 2000); both forms of deterrence are explained further in Section 2.5.

2.3.2 Regulatory Structure

This sub-section describes the structure of environmental agencies and other entities involved in environmental enforcement. Figure 2.1 displays this structure. Both the EPA and nearly all state agencies possess the authority to inspect NPDES facilities and take enforcement actions against facilities in non-compliance.[23] Agencies enforce the Clean Water Act by issuing warning letters or initiating and prosecuting cases before judges who are able to impose fines. Lower-level personnel at the EPA and state agencies possess broad discretion over inspection decisions: who to inspect and when. Similarly, lower-level agency personnel possess broad discretion over decisions to take informal enforcement actions such as issuing "Notices of Violation" and warning letters: against which facilities to take enforcement actions and when. Both inspections and informal enforcement actions represent day-to-day activities conducted without much upper-level guidance.

As important, lawyers at environmental agencies are responsible for prosecuting enforcement cases before administrative judges or forwarding cases to the Department of Justice (DOJ) with a request for prosecution before civil judges. For example, lawyers at EPA regional offices may initiate an administrative proceeding in order to impose an administrative sanction, or may request that the DOJ initiate a civil court proceeding in order to impose a civil sanction on facilities that are seriously non-compliant. These lawyers operate with much discretion and

[23] In order to obtain approval for NPDES authority, a state agency must demonstrate the regulatory capacity to administer the NPDES program. The EPA website lists the approved states: http://water.epa.gov/polwaste/npdes/basics/NPDES-State-Program-Status.cfm

without guidance from upper-level administrators. Critically, a firewall separates top administrators from enforcement cases at the EPA and presumably all state agencies in order to avoid even the impression of political influence.

Once agency or DOJ lawyers initiate enforcement proceedings, administrative or civil judges decide on the imposition of the formal sanctions.

In strong contrast to these inspection and enforcement case decisions, the choice of overall enforcement strategy lies at the top levels of environmental agencies. This strategic choice represents a high-level decision made by top agency administrators, who are appointed by the U.S. President, in the case of EPA headquarters and regional offices, and by governors, in the case of state agencies. Therefore, the enforcement strategy is chosen by a distinctively different set of agency officials and separately from how inspections and enforcement actions are decided on a regular basis.[24]

2.3.3 Chemical Manufacturing Sector

The CWA primarily constrains wastewater discharges from point sources, which fall into one of two categories: municipal sources (i.e., municipal wastewater treatment facilities) and industrial sources.[25] This study focuses on a single sector within the category of industrial sources: chemical manufacturing facilities. This focus on a single sector is consistent with other empirical studies of industrial pollution (e.g., Laplante and Rilstone, 1996; Barla, 2007; Earnhart, 2009; Earnhart and Harrington, 2014).

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[24] The EPA website depicts the basic elements of the enforcement process: http://www2.epa.gov/enforcement/enforcement-basic-information.

[25] The EPA website describes industrial sources: http://water.epa.gov/polwaste/npdes/Industrial-and-Commercial-Facilities.cfm.

The chemical manufacturing sector proves an excellent choice for analyzing the influence of enforcement approach on the effect of government interventions on environmental labor. First, the EPA has shown a strong interest in this sector. The EPA jointly authored a study with the Chemical Manufacturing Association (CMA) on the root causes of non-compliance in this sector (EPA, 1999). The EPA also published its own study on the compliance history for chemical manufacturers (EPA, 1997). Two sub-sectors in the industry, industrial organics and chemical preparations, were regarded by the EPA as priority sectors during a portion of the study period. Further, the CMA has demonstrated a strong interest in promoting pollution reduction and prevention with its Responsible Care initiative. The chemical manufacturing sector also generates a large amount of wastewater. Data on wastewater discharged in 2008 that are disaggregated by 4-digit Standard Industrial Classification (SIC) code reveal that four of the 10 most polluting sub-sectors operate in the chemical manufacturing sector (EPA, 2011). Finally, the chemical manufacturing sector employs a substantial number of environmental workers. As mentioned, the average facility in the sample has a ratio of environmental employment to total employment of 0.046. According to BLS estimates, the chemical manufacturing sector employs 24,733 environmental workers, roughly 5 % of the total green employment in the manufacturing industry, making the chemical manufacturing sector the most "green" employer of all aggregated sectors (Bureau of Labor Statistics, 2011). Although the preceding reasons explain why this sector is appropriate for analysis, I acknowledge that the results from a study of the chemical manufacturing industry may not generalize to other industrial sectors.

2.4 Conceptual Framework

2.4.1 Effects of Government Interventions on Environmental Management

This section constructs a theoretical framework from which testable hypotheses are derived. This framework draws upon Becker (1968), Earnhart and Segerson (2012), Earnhart (2013), and Earnhart and Friesen (2014). Each individual firm faces environmental regulations, imposed within its NPDES permit, with which it must comply. (The theoretical analysis assumes that each firm owns a single facility so no difference exists between the firm and facility.) In each year, the manager chooses the firm's level of environmental management, as measured by the count of person-months for which employees spend dedicated to environmental tasks. The firm manager has a utility function $U(\Pi, Z)$, where Π reflects the firm's net profits and Z reflects non-monetary factors that influence decisions, which are discussed further in sub-section 2.4.2. Utility is increasing in both components. The firm generates gross profits per period of π and faces environmental compliance costs of c, such as wastewater engineer salaries, in each period. The probability of detection, if the firm violates the law, is p. Once detected, a violation leads to a fine of F.

2.4.1.1 Standard deterrence model

This section first constructs the standard deterrence model (Becker, 1968). In this sub-section, non-monetary factors, Z, are suppressed in the utility function by assuming they are irrelevant; these factors are re-introduced in the next sub-section. The firm receives a certain net profit of π - c if it complies; yielding the following level of managerial expected utility:

$$EU(comply) = U(\pi\text{-}c)\,. \tag{2.1}$$

However, if the firm violates the law, the expected utility is as follows:

$$EU(violate) = p \times U(\pi\text{-}F) + (1\text{-}p) \times U(\pi)\,. \tag{2.2}$$

In this situation, the manager chooses to comply when (2.1) > (2.2), and violates otherwise. An increase in either the probability of detection, p, or the size of the fine once detected to be in non-compliance, F, reduces (2.2), thereby making it more likely that any given firm complies. The enforcement agency increases the probability of detection by conducting inspections more frequently and increases the size of the fine by imposing a bigger fine.

2.4.1.2 Intrinsic Compliance Motivations

This sub-section extends the deterrence model by allowing the manager's utility function to depend on non-monetary factors, Z, so that these factors influence the manager's compliance decision. (The survey of chemical manufacturing facilities captures some of these non-monetary factors as explained further in Section 2.5.) The theoretical analysis focuses on intrinsic compliance motivations, such as the internalization of norms regarding environmental compliance existing in local communities (social norms) and professional organizations (professional norms). Suppose that $Z = Z_c > 0$ when the firm complies, while $Z = Z_v = 0$ when the firm violates. The act of compliance increases Z due to the "warm glow" feelings of meeting social or professional norms. More generally, the magnitude of Z_c depends on social and professional norms regarding environmental compliance, along with other intrinsic motivations. A manager facing a larger Z_c is therefore more likely to comply, ceteris paribus.

Clearly, alternative formulations of Z_v and Z_c are possible. For example, violations may generate a "cold prickle" effect so that $Z_v < 0$. Since the manager's utility is rising in Z, the positive relationship between Z and compliance likelihood continues to hold as long as $Z_c > Z_v$. This critical difference reflects the manager's desire to comply due to intrinsic motivations. This addition of non-monetary factors extends the standard model to yield the following expected utilities:

$$EU(comply) = U(\pi\text{-}c, Z), \text{ and} \tag{2.3}$$

$$EU(violate) = p \times U(\pi\text{-}F, Z) + (1\text{-}p) \times U(\pi, Z)\,. \tag{2.4}$$

In this extended model, compliance is increasing in both enforcement and intrinsic motivations. However, the manager's intrinsic motivation to comply is not connected to enforcement decisions, so enforcement generates no trade-off. The analysis captures this trade-off by incorporating additional elements. First, the analysis removes the implicit assumption that the firm manager possesses full information about the enforcement parameters faced by the firm. In reality, firm managers possess only imperfect knowledge about these factors (Polinsky and Shavell, 2000). For example, enforcement agencies rarely announce the probability of detection. In this context, firm behavior is driven by perceptions of the enforcement parameters rather than objective values. Consistent with this reality, the analysis assumes that the firm manager possesses imperfect knowledge about the enforcement parameters. In particular, let $p°$ denote the manager's perception of the likelihood of being caught and $F°$ be the assessment of the fine severity. The expected utility from violation then becomes the following:

$$EU(violate) = p° \times U(\pi\text{-}F°, Z) + (1\text{-}p°) \times U(\pi, Z)\,. \tag{2.5}$$

Based on the extended model of Section 2.4.2, increases in $p°$ and/or $F°$ lead to improved compliance.

2.4.2 Coercion versus Cooperation

Finally, the analysis incorporates the factor of coercive intensity, denoted as I. Coercive intensity improves the deterrence effects stemming from enforcement by inflating enforcement perceptions: $p°$ and $F°$. One can interpret coercive intensity and cooperation in the light of regulatory capture. Cooperation may in fact be a form of regulatory capture (Zinn, 2002). As regulatory capture rises, coercive intensity wanes. Put differently, as trust and compromise rises, rather than oversight and principle, the blade of enforcement's knife dulls and the legitimacy of enforcement withers.

On the opposite side of the ledger, coercive intensity undermines the non-monetary benefits of compliance, Z_c. A firm manager enjoys a weaker "warm glow" when he/she is deterred from non-compliance rather than choosing to comply for his/her own intrinsic reasons. Put differently, the monetary rewards to comply "crowd out" the intrinsic motivation to comply (Fehr and Falk, 2002; Frey and Jegen, 2001). Given these relationships involving coercive intensity, increases in coercive intensity lead to greater deterrence from non-compliance but less intrinsic desire to comply.

With this trade-off in place, the theoretical framework informally generates three pairs of hypotheses based on the aforementioned coercive and cooperative models. The first pair of hypotheses, jointly labeled as H1, relates to the main effect of the overall enforcement approach.

H1: <u>*Coercive model*</u> *- If non-monetary factors are absent, i.e., firm managers possess no intrinsic motivation to comply, then an increase in coercive intensity, I, leads to more compliance.*

<u>*Cooperative model*</u> *- If enforcement perceptions do not differ from objective measures of enforcement likelihood and severity due to variation in coercive intensity, then an increase in coercive intensity, I, leads to less compliance.*

The coercive hypothesis holds even if non-monetary factors are present, as long as the connection between coercive intensity and intrinsic motivation is sufficiently weak so the deterrence effect generated by greater coercive intensity dominates. Similarly, the cooperative hypothesis still holds even if coercive intensity positively influences enforcement perceptions, as long as this positive relationship is sufficiently weak so the crowding out effect generated by greater coercive intensity dominates.

The second pair of hypotheses, jointly labeled as H2, relates to the effect of inspections on compliance. As shown in sub-section 2.4.1.1, increased inspection frequency prompts greater compliance. However, in the presence of intrinsic motivations, the level of coercive intensity influences the effect of inspections on compliance. Moreover, this influence differs between federal and state inspections. Regulated firms may perceive federal inspections as more coercive in nature since they are frequently conducted to gather evidence to support enforcement cases, while regulated firms may perceive state inspections as more cooperative since they generally provide compliance assistance (Earnhart, 2004b). Thus, federal inspections undermine intrinsic motivations more than state inspections.

***H2**: <u>Coercive model</u> - An increase in coercive intensity improves the effectiveness of federal inspections at inducing greater compliance, yet degrades the effectiveness of state inspections.*

<u>Cooperative model</u> - *An increase in coercive intensity improves the effectiveness of state inspections at inducing greater compliance yet degrades the effectiveness of federal inspections.*

The third pair of hypotheses relate to enforcement. As shown in sub-section 2.4.1.1, larger fines prompt greater compliance. However, in the presence of intrinsic motivations, the level of coercive intensity influences the effect of enforcement on compliance. Moreover, this influence differs across the forms of enforcement: informal enforcement actions and penalties (as described in Section 3). Regulated firms may perceive informal enforcement actions as the least coercive in nature and penalties as the most coercive. Thus, informal enforcement actions undermine intrinsic motivations less and penalties undermine intrinsic motivations more. Given this distinction, the final set of hypotheses follows, jointly labeled as H3.

H3: *Coercive model - An increase in coercive intensity improves the effectiveness of enforcement at inducing greater compliance with the improvement smaller for informal enforcement actions and larger for penalties.*

Cooperative model - An increase in coercive intensity degrades the effectiveness of enforcement with the degradation smaller for informal enforcement actions and larger for penalties.

These hypotheses are derived from a deterministic model. In reality, compliance depends on both the firm's efforts and random factors. The firm cannot guarantee compliance, and as such, always faces a probability of a fine. The theoretical results still hold as long as this probability of being fined when the firm employs more environmental labor in order to comply is sufficiently smaller than the probability of being fined when the firm employs less labor in order to comply. While a firm cannot guarantee its compliance status, they are able to increase the likelihood of compliance by employing more environmental labor. Thus, any theoretical examination of a firm's efforts to comply parallels the theoretical analysis of compliance status.

2.5 Econometric Framework

This section draws upon the theoretical framework to build an econometric framework for estimating the influence of enforcement strategy on the effects of government interventions on environmental employment.

2.5.1 Dependent Variable and Primary Regressors

In each year t, facility i chooses its level of environmental management, denoted as Y_{it}, which represents the count of person-months devoted to environmental management by facility employees. The primary regressors are the overall enforcement strategy and government interventions.[26] The analysis constructs a multi-dimensional measure of enforcement strategy, which is described fully in Section 2.6 and depicted in Table 2.1.

Other primary regressors capture government interventions. First, government interventions divide between inspections and enforcement actions; moreover, inspections divide between federal inspections and state inspections, and enforcement actions divide between informal actions and monetary penalties. Similar to some previous studies (Earnhart, 2009; Earnhart and Segerson, 2012), the analysis includes only federal enforcement actions, while excluding state actions, because the latter are small in magnitude and data are challenging to secure. Second, the analysis splits government interventions into two categories: (1) government interventions against one's own facility, and (2) government interventions against other facilities that are similar to one's own. The former generate specific deterrence, while the latter generate general deterrence (Cohen, 2000); which is the threat of receiving an intervention.

The analysis constructs the government intervention regressors as follows. Consider first federal and state inspections. For the measures of specific deterrence, the analysis uses the number of federal or state inspections conducted in the 24 months preceding the current year at the individual facility, denoted as I_{it-1}^{EPAs} and I_{it-1}^{STs}, respectively.[27] For the measures of general deterrence, the analysis uses the number of federal or state inspections conducted in the 12 months preceding the current year at other facilities of similar size (based on the distinction

[26] These primary regressors may be endogenous. Section 2.6 discusses this potential concern.

[27] For federal and state inspections separately, the analysis tests whether inspections conducted in the 12 months preceding the current year and inspections conducted in the 13 to 24 months preceding the current year generate identical coefficient magnitudes. F-test statistics fail to reject the null hypothesis of equal coefficients.

between NPDES major and minor facilities) operating in the same EPA region, in the case of federal inspections, and in the same state, in the case of state inspections, divided by the number of similarly sized facilities operating in the same EPA region or state (Earnhart and Leonard, 2013), denoted as I_{it-1}^{EPAg} and I_{it-1}^{STg}, respectively.

The analysis constructs specific and general deterrence measures for informal enforcement actions in a manner similar to inspections. The resulting specific deterrence measure is denoted as A_{it-1}^{s}, while the general deterrence measure is denoted as A_{it-1}^{g}. For the penalty measures, the analysis uses the total amount of penalties levied against the individual facility or other facilities rather than the count of penalties. The specific and general deterrence measures are denoted, respectively, as P_{it-1}^{s} and P_{it-1}^{g}.[28]

In order to determine the influence of overall enforcement strategy on the effects of these four types of government interventions, measured in two deterrence forms, the analysis interacts the enforcement strategy index, R_i, with each government intervention measure. This framing implies eight factors of regulatory deterrence, plus their interactions with the enforcement strategy index. While sizable, this number of primary regressors is consistent with enforcement of the NPDES program, as described in Section 2.3.

2.5.2 Control Factors

The empirical analysis controls for variation in other explanatory variables. Environmental management may depend on facility and firm characteristics. First, industrial sub-

[28] Similar to inspections, regarding the specific deterrence measures, the analysis tests whether enforcement actions taken in the 12 months preceding the current year and enforcement actions taken in the 13 to 24 months preceding the current year generate identical coefficient magnitudes. As with inspections, F-test statistics fail to reject the null hypothesis of equal coefficients.

sector indicators control for variation in facilities' abilities to control their operations based on the type of product being manufactured. The analysis includes two sub-sectoral indicators: organic chemical indicator and inorganic chemical indicator, with "other chemicals" as the omitted category.

Second, environmental management, especially labor, may depend on the size of the regulated facility. The analysis measures facility size using two proxies: the number of facility employees and the NPDES facility classification. The analysis includes a "major facility" indicator, with "minor facility" as the omitted category.

Third, firm ownership structure, as represented by the distinction between publicly held and privately held ownership, captures a host of dimensions; for example, facilities owned by publicly held firms may possess greater access to external financing for environmentally related investment. The analysis includes a publicly held firm indicator, with privately held firm as the omitted category.

The analysis also includes a control factor to capture a facility's economic impact on the surrounding community. On one hand, as the impact of a facility rises, the local community may apply more pressure on the facility to improve its environmental management. On the other hand, as the facility's size and influence grow, the local community may tread lightly, fearing that the facility may shift part of its production to other sites or leave town altogether. The included measure reflects a "significant" or "great" economic impact, with a "small" or "very little" impact as the omitted category.

Environmental management may also depend on attitudes of the people associated with the regulated facility. The first pair of attitudes is held by facility employees, and the second by facility management. Inclusion of these attitudinal measures helps to control for intrinsic motivations to comply with NPDES permits. First, the analysis includes a facility's self-reported measure of concern about the environment as reflected in environmental workers' views. The measure ranges between 1 and 10, with 10 signifying the greatest possible concern. As a complement, the analysis includes a measure of the environmental concern held by facility employees in general (i.e., beyond environmental employees). Facilities employing workers with a higher level of environmental concern are expected to be more conscientious about environmental management, and thus, employ more environmental employees. These measures reflect the non-monetary factors (Z) of the conceptual framework, as described in Section 2.4.2; the conceptual element Z rises as these measures grow closer to 10.

Attitudes of facility management relate to the effectiveness of government interventions for inducing compliance with NPDES discharge limits. One attitudinal measure captures management's subjective perception of inspections' effectiveness. The second attitudinal measure captures management's subjective perception of monetary fines' effectiveness. Both measures are binary, revealing an "effective" perception, with a "not effective" perception as the omitted category. If a manager feels that inspections or fines are effective at inducing compliance, he/she may be more inclined to practice better environmental management in order to stay in compliance. If, however, the manager feels that inspections or fines are ineffective, he/she may conclude that hiring employees devoted to environmental management is a waste of valuable resources.

Collectively, these facility-level and firm-level measures are denoted as F_{it}.

Finally, the analysis controls for variation in regulatory pressure not already reflected in government intervention measures by including EPA regional indicators, denoted as L_i, and year indicators, denoted as D_t, as regressors. The use of regional indicators controls for "unmeasured" spatial variation in monitoring and enforcement.[29] The use of year indicators controls for "unmeasured" temporal variation.

2.5.3 Primary Regression Equation

The following equation captures the functional relationship between the number of environmental employees and the identified explanatory variables:

$$Y_{it} = \alpha + \delta R_i + \beta_1 I_{it-1}^{EPAs} + \beta_2 I_{it-1}^{STs} + \beta_3 I_{it-1}^{EPAg} + \beta_4 I_{it-1}^{STg} + \beta_5 A_{it-1}^{s} + \beta_6 A_{it-1}^{g} + \beta_7 P_{it-1}^{s} + \beta_8 P_{it-1}^{g} + \beta_9 (R_i \times I_{it-1}^{EPAs}) + \beta_{10} (R_i \times I_{it-1}^{STs}) + \beta_{11} (R_i \times I_{it-1}^{EPAg}) + \beta_{12} (R_i \times I_{it-1}^{STg}) + \beta_{13} (R_i \times A_{it-1}^{s}) + \beta_{14} (R_i \times A_{it-1}^{g}) + \beta_{15} (R_i \times P_{it-1}^{s}) + \beta_{16} (R_i \times P_{it-1}^{g}) + \eta F_{it} + \theta L_i + \mu D_t + \varepsilon_{it}, \quad (2.6)$$

where β_1 through β_{16} are the coefficients of interest, α represents the intercept term, and ε_{it} represents an exogenous error term.[30] The empirical analysis estimates this regression equation to obtain coefficient estimates and standard errors of the regressors of interest.

2.6 Data

2.6.1 Sources

To perform the empirical analysis, this study gathers information from a number of data sources. Most important, the study draws upon an original survey of regulated facilities in the chemical manufacturing industry; see Earnhart and Glicksman (2011) for details. This survey includes a series of questions that require the respondents to characterize the nature of their

[29] The empirical analysis alternatively estimates a specification using state dummy indicators in lieu of regional indicators. The alternative results support the same conclusions reported below.

[30] I identify the count of environmental employee person-months as the dependent variable. Thus, the analysis estimates a linear specification. I expect government interventions and the overall enforcement approach to affect the magnitude of environmental labor in an absolute sense, especially since I control for the total number of facility employees.

relationship and interactions with Clean Water Act regulators.[31] The survey also gathers data on environmental management undertaken by individual facilities, most importantly, the number of person-months employees devote to environmental management.[32] To implement the survey, Earnhart and Glicksman (2011) and collaborators identified the proper population based on a full extract drawn from the EPA Permit Compliance System (PCS) database, which records information on facilities permitted within the National Pollutant Discharge Elimination System (NPDES), as of September, 2001. This extract includes 2,596 chemical facilities. To remain in the survey population, facilities needed to meet the following criteria: (1) possessed an NPDES permit, (2) faced restrictions on their wastewater discharges, (3) discharged regulated pollutants into surface water bodies, and (4) were operating as of 2002. Application of these criteria identified 1,003 facilities to contact. Of those facilities contacted between April of 2002 and March of 2003, 268 facilities completed at least 90 %[33] of the survey, implying a 27 % response rate. This rate is comparable to previous large-scale surveys of industrial sectors (e.g., Arimura et al., 2008) and lies above the average response rate of 21 % as identified by a review of 183 published studies based on business surveys (Paxson, 1992).

From this survey, multiple dimensions represent the relationship between the regulator and regulated entity, capturing the overall enforcement approach. The dimensions are as follows.

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[31] The respondents were told their responses would be kept confidential from the regulators.

[32] To transform the person-month measurement to a count of full-time equivalent (FTE) employees, simply divide the person-months by 12.

[33] The survey includes responses from 268 facilities reflecting three years of environmental management, resulting in 804 possible observations. As shown in Table 5, the regression sample contains 688 observations, as some survey questions were not answered by all respondents. I conduct a difference of means test on all non-survey regressors for the initial sample and the regression sample. The test statistics reveal no significant differences between the initial and regression samples.

The first dimension captures the general relationship between the regulator and the regulated facility: (1) generally cooperative or (2) generally coercive. The second dimension captures the prevalence of fair treatment of the facility by the regulator: (1) always fair, (2) sometimes fair, or (3) always unfair. Environmental regulation is commonly perceived by regulated entities as "unfair"; by extension, inflexible enforcement of this regulation might also be perceived as "unfair" (Zinn, 2002). More directly, an excessively stringent deterrence-based approach may be counterproductive by engendering perceptions that enforcement is "unreasonable" (Faure, 2012; Hawkins, 1984). In contrast, a cooperative enforcement approach, which is flexibly implemented, should mitigate the perceived unfairness and unreasonableness of regulation and enforcement directly. With these perspectives in mind, "always fair" treatment reflects a more cooperative approach, while less than "always fair" treatment reflects a more coercive approach. The third dimension captures the stability of the relationship as reflected in the assignment of regulatory agency officials: the facility typically works (1) with the same individual water regulatory official or (2) with multiple regulatory officials that vary with circumstances. Typically working with the same individual regulatory official is more likely to facilitate a cooperative relationship, while working with multiple regulatory officials is less likely to facilitate a cooperative relationship, i.e., more likely to lead to a coercive relationship.[34] The fourth dimension captures the quality of the working relationship as reflected in a facility's decision to seek assistance from the regulator's supervisor to help with a difference of opinion between the facility and the regulator. The absence of a request for assistance reveals a more

[34] The presence of multiple regulators does not reflect additional regulatory attention due to poor management or weak compliance; instead, this presence reflects the specialization of regulatory oversight in certain cases, e.g., certain regulatory personnel understand particular treatment technologies better.

cooperative relationship, while the presence of a request reveals a more coercive relationship. The fifth dimension also captures the quality of the working relationship but in this case the facility may seek assistance from an elected official. Again, the absence of a request reveals a more cooperative relationship, while the presence of a request reveals a more coercive relationship. The last dimension captures the level of trust supported by the relationship as reflected in a facility's willingness to allow regulators access to plant operations if the regulators arrive unannounced. Greater trust reflects a more cooperative relationship, while less trust reflects a more coercive relationship.[35]

From these multiple dimensions, the analysis constructs an index by summing the indicators of cooperation presence for each of the enforcement strategy dimensions.[36] This index, ranging between 0 and 6, distinguishes enforcement strategies along a spectrum of coercion-cooperation. The lowest point on this index, 0, reflects a fully coercive strategy, while the highest point, 6, reflects a fully cooperative strategy.[37] This index, denoted as R_i in the empirical specification, represents the empirical counterpart to the conceptual factor of coercive intensity, I, even though the index is inversely proportional to this factor. (As shown in the next sub-

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[35] The analysis directly evaluates neither the effects of compliance incentive policies, which encourage regulated entities voluntarily to discover, disclose, and correct violations (e.g., Short and Toffel, 2008), nor compliance assistance policies, which include outreach, on-site assistance, and responses to assistance requests. Instead, the analysis allows these details to be incorporated into the measured dimensions of the enforcement approach.

[36] Principal component analysis reveals that a simple index is sufficient in this case.

[37] My use of this index is econometrically equivalent to including all of the individual dimensions as regressors, while constraining the coefficient magnitudes to equal one another. Moreover, the empirical analysis treats the index as a cardinal measure even though it represents a sum of indicators. The empirical analysis assesses this treatment by generating and incorporating a separate indicator for each level of the index excepting the lowest level. Under the null hypothesis of cardinality, the set of level indicator coefficients are equal. F-test statistics fail to reject this null hypothesis.

section, the dimensions underlying the enforcement approach index do not vary over the sample period).[38]

To complement these survey data, the study also collected data from the EPA PCS database – information on each facility's (1) location, (2) NPDES major or minor classification, and (3) four-digit standard industrial classification (SIC) code. The PCS also provides data on inspections conducted by federal and state regulators. Both the PCS database and the EPA Docket database provide data on federal formal enforcement actions, while only the PCS database provides data on informal enforcement actions. The study integrates these two databases.

2.6.2 Statistical Summary

This sub-section summarizes the data. First, it assesses the enforcement strategy index. As shown in Table 2.2, the index is skewed strongly to the right, as a facility's relationship with its regulator appears more cooperative than coercive for almost all of the facilities. Nearly 39 % of facilities experience a fully cooperative relationship with their regulators, while no facility experiences a fully coercive relationship. As a matter of fact, only 2 % of the facilities experience a relationship that is more coercive than cooperative (index < 3), with an additional 7 % of facilities facing a relationship that is a reasonably balanced mix of cooperation and coercion (index = 3). Thus, the strongest variation in the index lies at the upper reaches of cooperation (index = 4 through 6). Table 2.3 offers a state-specific distribution of the index. The distribution shows that the sample contains very limited intra-state variation of the index; 79 %

[38] Some of the dimensions underlying the index reflect decisions made by regulated facilities. Therefore, some may be endogenously determined. Section 2.7 addresses this issue.

of states possess a coefficient of variation at or below 0.20. Therefore, the index reflects agency choices that are not specific to any individual facility but instead common to a given state. Thus, the analysis more strongly relies on variation in the index across states.

Table 2.4 shows the sample summary statistics of both the primary regressors and control factors. Most importantly, the average facility has roughly 75 employee person-months devoted to work specifically on environmental management issues. The average cooperation index value is 5.01, representing almost full cooperation.

To explore the intra-facility variation in the dependent variable, the analysis calculates the standard deviation of each facility's person-month count of environmental employees over the sample period and then generates summary statistics for this distribution. Based on the set of facility-specific values, the average facility-specific standard deviation is 5.25 and the standard deviation for the distribution of facility-specific values is 20.82. These two values reveal a coefficient of variation of 3.97. These statistics demonstrate considerable variation in the number of environmental employee person-months within individual facilities over the sample period.

Table 2.4 also highlights inspections and enforcement actions. Clearly, state inspections are more frequently conducted than federal inspections. The average facility is subjected to 1.5 state inspections over a 24-month period, yet only 0.07 federal inspections.[39] Informal actions are the most common type of enforcement action. The average facility is subjected to 0.20 informal enforcement actions over a 24- month period, while only $ 127 worth of monetary fines. (The latter figure reflects a highly skewed distribution of fines involving a few large penalties and

[39] Although federal inspections are conducted much less frequently than state inspections in the sample, I am able to generate statistically significant results for federal inspections.

many 24-month periods without a single fine.)[40] Finally, Table 2.4 displays the coefficients of variation for the regressors; these statistics reveal significant variation in both the primary and control regressors.

2.7 Econometric Analysis

This section details the econometric analysis used to test the hypotheses presented in Section 2.4, by first describing the identification strategy, then discussing estimation techniques, and finally interpreting the estimation results, including marginal effects and economic impacts.

2.7.1 Identification

This sub-section assesses the potential endogeneity of the key explanatory variables. First, some of the elements underlying the enforcement strategy index are potentially endogenous since they represent regulated facilities' decisions, e.g., seek assistance from an elected official.[41] To test for endogeneity, the analysis employs an instrumental variables (IV) approach, while identifying first one instrument and then a pair of instruments; the latter is needed to statistically test instrument validity. (As noted in sub-section 2.7.2, I address the panel data structure using random effects and fixed effects estimators; the test statistics shown here stem from the random effects estimator; the fixed effects estimator generates test statistics that support identical conclusions.) As the primary instrument, the analysis uses maturity of a state's NPDES program, which reflects the number of days since the state obtained primacy over the NPDES program. This instrument should be relevant (i.e., helps to determine the level of

[40] Even though monetary fines occur infrequently in the sample, I am able to generate statistically significant results for fines.

[41] However, the lack of intra-state variation of the index shows that the enforcement strategy reflects agency choices that are not specific to any individual facility but instead common to a given state. Regardless, I test for endogeneity of the index.

cooperation-coercion on the overall enforcement strategy index) since states with a long tenure of experience regulating facilities have more time to craft more cooperative relationships. The first stage estimates of the IV estimation procedure, shown in Table B.1 of the appendix, help to assess the impact of state permitting primacy on the potentially endogenous regressor, conditional on the covariates identified above. These first stage estimates reveal that the primary instrument appears relevant, given an F-test statistic of 55.05, which clearly rejects the null hypothesis of a zero effect (p=0.000).

The analysis needs two instruments to test for validity, i.e., the instruments are orthogonal to the error process (Baum et al., 2003). For this testing, the analysis decomposes the state-level primacy measure into two components: an indicator of state primacy and the length of time possessing primacy conditional upon obtaining primacy.[42] This pair of instruments also appear relevant, given a partial F-test statistic of 28.11, which rejects the null hypothesis of zero effect (p=0.000). Conditional upon the second stage including the effects of regulatory approach, monitoring inspections, and enforcement actions, I argue that primacy has no direct effect on the extent of environmental employment provided by CWA-regulated facilities. In other words, all of the impacts of primacy relevant to environmental employees are channeled through the regulatory approach, inspections, and enforcement. As statistical evidence, I employ the Sargan-Hansen Test of Overidentifying Restrictions; the test statistic fails to reject the null hypothesis that the two instruments are valid (p=0.550).

Since two instruments appear both relevant and not invalid, the analysis conducts a Hausman test of exogeneity to assess whether the enforcement strategy index appears

[42] Although these two instruments are related, I argue that both are necessary to test for validity.

endogenous. The Hausman Test statistic of 0.381 fails to reject the null hypothesis of exogeneity (p=0.537). Thus, use of IV estimation does not appear warranted based on the use of the enforcement strategy index as the key primary regressor.

Government interventions may also be endogenous. However, this study claims that the constructed measures are indeed exogenously determined with respect to environmental labor decisions. The general deterrence measures are clearly exogenous, as they are prompted by the behavior and performance of other facilities. The specific deterrence measures should be exogenous as well given the separation in time between lagged government interventions and current environmental management decisions, consistent with nearly all previous studies using lagged intervention measures (Earnhart, 2009; Helland, 1998a; Helland, 1998b; Earnhart and Leonard, 2013; Earnhart and Harrington, 2014). As one of the very few studies to assess the endogeneity of lagged intervention measures, Earnhart and Friesen (2014) demonstrate that specific deterrence measures appear exogenous. By the principle of transitivity, interactions between the enforcement strategy index and government intervention measures should be exogenous as well. Finally, government intervention measures are potentially endogenous in the first stage estimation where the enforcement strategy index represents the dependent variable. However, the study claims these measures are exogenous given the separation across decision makers – inspectors, agency attorneys, and judges – described in Section 2.3 and depicted in Figure 2.1, and the separation over time as government monitoring moves to enforcement proceedings to judicial decisions.

Since all of the regressors appear exogenous, the empirical analysis proceeds by employing the standard estimation procedures.

2.7.2 Estimation Techniques

To address the panel structure of the sampled data, the empirical analysis employs the standard panel data estimation techniques of random effects and fixed effects estimation. To test whether or not the random effects estimates are consistent, the study conducts a Hausman Test of Random Effects. The test statistic fails to reject the null hypothesis that random effects estimates are consistent (p=0.621). The conclusions supported by the estimation results are robust to the choice of estimator. To demonstrate this point, Table 2.5 displays both the random effects estimates and fixed effects (i.e., facility indicators included) estimates based on the broadest set of regressors.

To assess further the robustness of the results, the analysis includes three models (i.e., regressor sets). The first is the parsimonious model (Model 1), which excludes all control factors. The second model adds the year and regional indicators (Model 2). The full model includes all of the control factors (Model 3). The next sub-section primarily uses the full model estimates to interpret the empirical results. The analysis clusters standard errors at the facility level.[43]

2.7.3 Results

This sub-section interprets the results generated from both random effects and fixed effects estimation, which are found in Table 2.5. Due to the inclusion of interactions, I only briefly discuss the main coefficients and interaction coefficients, while reserving substantial discussion for the marginal effects of the primary regressors.

[43] As an alternative specification, standard errors are clustered at the state level. The resulting empirical results differ only slightly from those presented, while maintaining identical statistical significance.

The main coefficients for the government intervention measures identify the marginal effects when the overall enforcement approach index equals 0, i.e., a fully coercive strategy. This level of the index does not occur in the sample of data. Therefore, the following effects are interpreted as projections for a completely coercive regulatory regime, which is feasible given the substantial discretion granted to environmental protection agencies. The estimation results show that four types of government interventions significantly affect a facility's count of environmental employees under these conditions. The effects of federal inspections – both in general and specific deterrence form – are significantly positive. The effect of monetary penalties based on specific deterrence is also significantly positive. These interventions therefore induce better environmental management under a fully coercive strategy. As described in Section 2.5, these particular interventions are considered more severe than others. As expected, the less severe measures, namely state inspections and informal actions, do not generate a positive effect. While the effects of state inspections on environmental management do not prove statistically significant under coercion, the general deterrence effects of informal actions prove statistically negative.

This sub-section next assesses how the effectiveness of interventions changes as the enforcement strategy moves away from coercion and towards cooperation by examining the interaction coefficients. These coefficients reveal the effect of increasing the enforcement strategy index by one step on the slope coefficient associated with each intervention type. The interactions involving federal inspections – in terms of both specific and general deterrence – are significantly negative.[44] Thus, federal inspections become more effective as the enforcement strategy becomes more coercive, which supports Hypothesis H2. Next, the interaction between informal enforcement actions and the enforcement strategy is significantly positive for general deterrence. Thus, less severe enforcement actions become more effective at inducing stronger environmental management as the strategy moves toward cooperation, which supports Hypothesis H3. Finally, the interaction between monetary penalties and the enforcement strategy is significantly negative for specific deterrence. Similar to federal inspections, monetary penalties, which represent more severe enforcement actions, become less effective as the enforcement strategy becomes more cooperative. Put differently, penalties become more effective as the enforcement strategy becomes more coercive; this result supports Hypothesis H3. Not surprisingly, the measures with insignificant main coefficients also generate insignificant interaction coefficients.

Before assessing marginal effects under less than fully coercive conditions, this sub-section discusses the coefficient estimates involving control factors. This discussion focuses on effects statistically different from zero.

Consider facility characteristics. First, facility size, as proxied by the number of total workers employed at a facility, positively affects the amount of environmental employees working at a facility. Intuitively, larger facilities need better environmental management in order to remain compliant. Second, facilities owned by publicly held firms employ a higher number of

[44] Some states during the sample period had yet to be granted authority to implement the NPDES program ("primacy"). For these states, federal inspections were the only type of inspection available during the sample period. Dropping these states from the analysis does not meaningfully change the estimated effects of federal inspections.

workers devoted to environmental management. As noted in Section 2.5, publicly held firms are more visible in the eyes of various stakeholder communities, e.g., customers, investors (Arora and Cason, 1995), so these firms might tend to hire more environmental employees at their facilities. Third, the economic impact of a facility has a significantly positive effect on the amount of environmental labor employed. This result reveals that local communities place more pressure, not less, on more visible facilities. Interestingly, none of the attitudinal measures prove statistically significant.

In order to check the robustness of these conclusions, the analysis assesses the results from the three models and two panel data estimators. Estimates from the three models support identical conclusions with a single exception in the case of monetary penalties in specific deterrence form. The significantly positive effect relies upon the full set of controls. As noted above, the random effects and fixed effects estimates are highly similar; in particular, they support identical conclusions relating to the primary regressors and nearly identical conclusions relating to the control factors.

2.7.4 Marginal Effects

To determine the effects of government interventions on the count of facility-level environmental employee person-months under varying conditions of coercion/cooperation, this sub-section explores the marginal effects generated by the regression estimates. Tables 2.6 and 2.7 display the marginal effects for specific deterrence and general deterrence measures, respectively, while Figures 2.2 through 2.5 display the 90% confidence intervals for the set of government interventions. This exploration of marginal effects represents a test of the hypotheses derived in Section 2.4.[45]

Hypothesis H2 focuses on the contrast between federal and state inspections based on the notion that federal inspections are more severe than state inspections. The generated marginal effects appear to support this hypothesis. Under a completely coercive model (index = 0), federal EPA inspections have a positive impact on environmental management, while state inspections have no significant impact. Moreover, as shown in Figure 2.2, the federal impact of specific deterrence remains significantly positive until the enforcement approach index rises to four (out of six), being statistically zero thereafter, while the federal impact of general deterrence remains significantly positive until the enforcement approach index rises to two, after which the impact is statistically zero. Further, as shown in Figure 2.3, both the specific and general forms of state inspections remain statistically insignificant as the enforcement approach index rises above 0, indicating greater and greater cooperation. When moving from a coercive relationship to a cooperative one (moving down the rows in Tables 2.6 and 2.7), the differential between the marginal effects of federal and state inspections falls, consistent with a "dulling" of the intrinsic motivation to comply, as reflected in Hypothesis H2.

Next, the marginal effects of enforcement follow a pattern similar to that of inspections, but with two major differences. Contrary to state inspections, the less severe form of enforcement – informal actions – generates significantly negative marginal effects when the strategy is fully coercive. As shown in Figure 2.4, this effect is significant until the index rises to

[45] I note again that marginal effects based on an index value of 0 (fully coercive approach) represent projections for a fully coercive strategy, which does not occur in the sample but is feasible given the great discretion granted to regulatory agencies.

2, after which the effect is statistically zero. In contrast, the marginal effect of the more severe enforcement measure – monetary penalties – is significantly positive under a fully coercive strategy and remains so until the index rises to 4, which is slightly cooperative. However, as shown in Figure 2.5, the marginal effect of penalties becomes significantly negative once the enforcement strategy is sufficiently high – index values of 5 and 6, which represent almost fully and fully cooperative relationships, respectively. Whereas for inspections the loss in intrinsic motivation lowers the positive impact of deterrence, for penalties, the loss in intrinsic motivation overwhelms the impact of deterrence under sufficiently strong cooperation. Therefore, both informal actions and penalties, which differ considerably in severity, prompt a loss in intrinsic motivation that overwhelms the positive effect of deterrence dependent upon which side of the cooperation spectrum regulators act.

Based on the assessed marginal effects, this sub-section reassesses the hypotheses derived in Section 2.4. Hypothesis H1 demonstrates that the effectiveness of government interventions depends on the level of cooperation vs. coercion. As shown in Tables 2.6 and 2.7, the generated marginal effects for certain interventions support this hypothesis. The effects of federal inspections (both specific and general deterrence), informal actions (only general deterrence), and monetary penalties (only specific deterrence) depend significantly on the level of cooperation. Thus, the extent of cooperation/coercion influences most types of intervention. Under sufficiently coercive conditions, the more severe interventions positively impact environmental management. However, under sufficiently cooperative conditions, inspections lose their effectiveness, while fines appear to generate so much ill will that they become counter-productive. Conversely, for less severe intervention types, namely state inspections and informal actions, the opposite is true. Under full cooperation, these interventions have no effect on environmental management. However, the mismatch of using an informal enforcement action under full coercion proves counter-productive by actually decreasing environmental labor. Collectively, these results demonstrate that effective monitoring and enforcement relies upon interventions with "teeth" conducted under coercive conditions. Matching the severity of the government intervention with the enforcement strategy is especially important for enforcement actions, as a mismatch actually causes facilities to decrease the amount of environmental workers employed.

The second set of hypotheses, H2, deals with the effectiveness of federal versus state inspections. Consistent with H2, federal inspections, the more severe inspection type, positively affect environmental management only under sufficiently coercive conditions. However, the reverse relationship does not hold for the less severe state inspections: state inspections are not more effective under more cooperative conditions. Tables 2.6 and 2.7 show these results in the third through sixth columns.

The third set of hypotheses, H3, focuses on the comparison across the types of enforcement. Matching enforcement type and regulatory approach helps to improve the effectiveness of enforcement. The more severe action of penalty imposition produces a positive environmental management effect under a sufficiently coercive approach and a negative effect under a sufficiently cooperative one, consistent with H3. Partially consistent with H3, the less severe enforcement type, informal action, proves ineffective under both coercive and cooperative conditions. Whereas monetary penalties prove effective under full coercion and counter-productive under full cooperation, the opposite does not hold true for informal enforcement actions. Informal enforcement actions prove effective at reducing environmental labor under a fully coercive strategy and prove simply ineffective under a fully cooperative strategy. Tables 2.6 and 2.7 display the results for these hypotheses in the final four columns.

In sum, the empirical results support the coercive model: greater coercion improves the effectiveness of government interventions but only for the more severe types of interventions.

2.7.5 Economic Impacts

This last sub-section assesses the economic significance of the reported estimates while focusing exclusively on the statistically significant effects. In the current economic climate, where environmental regulation is oftentimes on the chopping block of federal and state budgets, this analysis shows that enforcement policy can be implemented in ways to promote the use of labor.[46]

The average facility employs 75 employee person-months devoted to environmental management. When matching an extra federal inspection to a fully coercive enforcement strategy, based on specific deterrence, a regulator can increase the number of environmental employee person-months by 28 (equivalent to 2.33 FTE employees), which represents a 37 % increase in the count of person-months for environmental workers at the average facility. (One extra federal inspection represents three sample standard deviations.) Based on general deterrence, using this same match, a regulator can increase the number of environmental employee person-months by 88 (equivalent to 7.33 FTE employees), which represents a 117 % increase for the average facility. For enforcement actions, both types generate a significant impact on environmental employment. Based on general deterrence, mismatching an extra

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[46] This analysis cannot demonstrate whether or not increases in environmental labor displace other forms of labor employed by regulated facilities. However, this analysis shows that, in the very least, greater monitoring and enforcement can increase labor in one regard.

informal enforcement action with a fully coercive strategy decreases the amount of environmental employment by 40 person-months (equivalent to 3.33 FTE workers), which represents a 53 % drop in the use of environmental labor. On the other hand, matching an increase in the monetary penalty level with a fully coercive strategy leads to more environmental workers based on specific deterrence. Specifically, an increase of $ 1000 raises the number of environmental employee person-months by 43 (equivalent to 3.58 FTE employees), which represents a 57 % increase for the average facility. (A $ 1000 increase represents roughly 28 % of one sample standard deviation). However, under a fully cooperative strategy, a $ 1000 increase in the monetary fine level generates the opposite effect: a decrease of 9 employee person-months devoted to environmental management (equivalent to 0.75 FTE workers), which represents a 12 % decrease for the average facility.

2.8 Conclusions

The purpose of this paper was to determine the effect of regulator approach on government interventions on the use of environmental management. The analysis examined chemical manufacturing facilities permitted under the NPDES program, for the years 1999-2001. The analysis finds that under a sufficiently coercive approach, the more severe government interventions – federal inspections and monetary penalties – positively affect environmental management; yet less severe government interventions – informal enforcement actions – negatively affect environmental management, specifically, environmental labor. However, once the approach moves sufficiently toward cooperation, these effects become statistically zero for federal inspections and informal enforcement actions and significantly negative for monetary fines. Conversely, the less severe type of inspections – state inspections – do not affect environmental employment, no matter the overall enforcement approach.

These results highlight three main points: (1) the coercive or cooperative nature of the regulator's enforcement approach matters when analyzing the efficacy of government interventions at inducing better environmental management, (2) to improve (and not decrease) environmentally related employment, the regulator must match government intervention severity with the overall enforcement approach, and (3) the imposition, as well as the enforcement, of environmental regulations affect employment at permitted facilities.

As important, based on these results, I conclude that cooperation does not appear "innovative". In general, greater cooperation *undermines* the effectiveness of government interventions once the analysis includes control factors, especially for the more substantive types of intervention, namely federal inspections and monetary fines. Moreover, under strategies that are more cooperative than coercive, all types of government interventions prove ineffective at best. In the worst case, greater cooperation leads to counter-productive effects for monetary fines. Thus, I conclude that, in the chemical manufacturing sector during the sample period, the cooperation extended by regulators is not innovative but perhaps regulatory capture.

In closing, this study adds much to the debate over the optimal environmental regulatory policy, both in terms of regulator approach and type of intervention to pursue. Of course, the need for future research on this important question remains. This study explores only one sector; in order to understand better the effect of regulator approach, future research should explore more sectors. Further, this study examines only one element of the compliance landscape: environmental management in the form of environmental workers. Although this element is extremely important, future research should examine actual levels of compliance, as determined by actual discharges relative to permitted allowances.[47]

[47] This study could have explored the level of compliance of facilities, but this exploration would have reduced the sample size substantially; only major facilities in the NPDES system are required to report discharges. By exploring environmental labor as the dependent variable, this study exploits data on both types of facilities in the sample: majors and minors.

Table 2.1: Coercive v. Cooperative Relationship Elements Used to Construct the Regulatory Approach Index

Survey Element	Dimension	Coercive Response (0)	Cooperative Response (1)
How likely is the facility to allow unannounced visits from the regulator?	Trust	“Somewhat likely” or “likely” (9.52 %)	“Always likely” (90.48 %)
What is the assignment of regulatory officials?	Stability	Multiple individuals (43.20 %)	Same individual (56.80 %)
How fair is the treatment from the regulator?	Fairness	“Sometimes fair” or “unfair” (18.65 %)	“Always fair” (81.35 %)
What is the general relationship between the regulator and regulated entity?	General relationship	Coercive (2.39 %)	Cooperative (97.61 %)
Did the facility request assistance from the regulator’s supervisor?	Quality of working relationship	Request (19.28 %)	No request (80.72 %)
Did the facility request assistance from elected officials?	Quality of working relationship	Request (4.78 %)	No request (95.22 %)

Table 2.2: Regulatory Approach Index

Approach Index	Frequency	Percent	Cumulative Percent
0	0	0.00	0.00
1	3	0.40	0.40
2	12	1.61	2.01
3	51	6.83	8.84
4	135	18.07	26.91
5	255	34.14	61.04
6	291	38.96	100.00

Table 2.3: State-Specific Distribution of Regulatory Approach Index

State	Mean	Std. Dev.	Coef. of Variation
Alaska	5.00	0	0
Connecticut	6.00	0	0
Kansas	6.00	0	0
Maine	5.00	0	0
Montana	6.00	0	0
Oklahoma	4.00	0	0
Oregon	6.00	0	0
Utah	4.00	0	0
Wisconsin	6.00	0	0
Minnesota	5.50	0.55	0.01
North Carolina	5.50	0.55	0.01
Virginia	5.50	0.55	0.01
West Virginia	5.20	0.41	0.08
Delaware	5.67	0.50	0.09
Nebraska	5.67	0.50	0.09
Washington	5.67	0.50	0.09
Maryland	5.60	0.51	0.09
South Carolina	5.40	0.51	0.09
South Dakota	4.50	0.55	0.12
Tennessee	5.40	0.68	0.13
Arkansas	5.14	0.66	0.13
Texas	4.59	0.69	0.15
Mississippi	4.80	0.78	0.16
Iowa	4.87	0.80	0.16
California	5.50	0.91	0.17
New York	5.50	0.91	0.17
Pennsylvania	5.35	0.91	0.17
Alabama	5.45	0.98	0.18
New Jersey	4.79	0.96	0.20
Louisiana	4.60	0.92	0.20
Rhode Island	5.00	1.01	0.20
Illinois	5.00	1.13	0.23
Georgia	5.40	1.24	0.23
Ohio	5.13	1.22	0.24
Kentucky	4.29	1.06	0.25
Massachusetts	5.25	1.34	0.26
Missouri	4.20	1.21	0.29
Indiana	5.00	1.60	0.32
Florida	3.75	1.42	0.38

Table 2.4: Sample Summary Statistics

Variables	Mean	Std. Dev.	Coef. of Variation
Dependent Variable			
Environmental employees (person-month count)	74.74	178.9	2.394
Primary Regressors			
Regulatory enforcement approach index: fully coercive (= 0) to fully cooperative (= 6)	5.008	1.026	0.205
No. federal inspections / No. other facilities per region (1-yr lag)	0.029	0.050	1.754
No. state inspections / No. other facilities per region (1-yr lag)	0.674	0.966	1.433
No. federal inspections during preceding 24-month period	0.068	0.330	4.825
No. state inspections during preceding 24-month period	1.491	2.472	1.658
No. informal enforcement actions / No. other facilities per region (1-yr lag)	0.077	0.190	2.477
Penalty amount / No. other facilities per region (1-yr lag)	73.68	366.0	4.967
No. informal enforcement actions during preceding 24-month period	0.200	1.168	5.840
Penalty amount during preceding 24-month period	127.5	3,571	28.01
Interactions between Regulatory Enforcement Approach and Government Interventions			
Enforcement approach index × federal inspections (general)	0.147	0.265	1.803
Enforcement approach index × state inspections (general)	3.492	5.234	1.499
Enforcement approach index × federal inspections (specific)	0.348	1.677	4.819
Enforcement approach index ×state inspections (specific)	8.008	14.07	1.757
Enforcement approach index × informal actions (general)	0.383	0.945	2.467
Enforcement approach index ×penalty amount (general)	357.99	1,770.56	4.946
Enforcement approach index × informal actions (specific)	0.855	4.976	5.820
Enforcement approach index × penalty amount (specific)	687.75	18,524.4	26.93
Facility Characteristics			
Major facility classification (vs minor facility)	0.384	0.487	1.268
Organic chemical manufacturing (vs other chemicals)	0.437	0.496	1.135
Inorganic chemical manufacturing (vs other chemicals)	0.310	0.463	1.494
Facility owned by publicly-held firm (vs privately-held firm)	0.634	0.482	0.760
Facility employees (count)	259.9	480.9	1.850
Economic impact of facility: significant/great (vs small/very little)	0.710	0.454	0.639
Facility’s attitudes toward inspection effectiveness: effective (vs not effective)	0.529	0.500	0.945
Facility's attitudes toward monetary fine effectiveness: effective (vs not effective)	0.393	0.489	1.244

Table 2.4 (continued)

Facility's environmental concern - all employees: 1=lowest, 10=highest	7.378	1.704	0.231
Facility's environmental concern - environmental employees: 1=lowest, 10=highest	8.896	1.331	0.150
Year/Region Controls			
EPA Region 1 (0,1) [regions 8, 9, 10 omitted]	0.034	0.180	5.357
EPA Region 2 (0,1) [regions 8, 9, 10 omitted]	0.090	0.286	3.192
EPA Region 3 (0,1) [regions 8, 9, 10 omitted]	0.131	0.337	2.573
EPA Region 4 (0,1) [regions 8, 9, 10 omitted]	0.246	0.431	1.752
EPA Region 5 (0,1) [regions 8, 9, 10 omitted]	0.164	0.371	2.262
EPA Region 6 (0,1) [regions 8, 9, 10 omitted]	0.220	0.415	1.886
EPA Region 7 (0,1) [regions 8, 9, 10 omitted]	0.067	0.250	3.720
Year 2000 (0,1) [Year 1999 omitted]	0.333	0.472	1.417
Year 2001 (0,1) [Year 1999 omitted]	0.333	0.472	1.417

Table 2.5: Results from Panel Estimation of Environmental Employee Person-Month Count

Independent Variable	Model 1 Random Effects	Model 2 Random Effects	Model 3 Random Effects	Model 3 Fixed Effects
Primary Regressors				
Regulatory enforcement approach index: coercive (0) to cooperative (6)	-2.891	2.046	3.251	
	(0.791)	(0.830)	(0.707)	
No. federal inspections / No. other facilities per region (1-yr lag)	80.28	**88.96**	**88.66**	**94.66**
	(0.122)	**(0.074)**	**(0.073)**	**(0.057)**
No. state inspections / No. other facilities per region (1-yr lag)	-0.383	-1.416	-0.413	0.455
	(0.948)	(0.796)	(0.941)	(0.935)
No. federal inspections during preceding 24-month period	**32.24**	**30.99**	**28.56**	**29.45**
	(0.074)	**(0.081)**	**(0.072)**	**(0.063)**
No. state inspections during preceding 24-month period	-0.0120	0.0594	0.507	0.905
	(0.995)	(0.974)	(0.776)	(0.895)
No. informal enforcement actions / No. other facilities per region (1-yr lag)	**-43.20**	**-41.28**	**-40.62**	**-39.98**
	(0.039)	**(0.045)**	**(0.047)**	**(0.057)**
Penalty amount / No. other facilities per region (1-yr lag)	-0.0031	-0.0030	-0.0008	-0.0004
	(0.604)	(0.620)	(0.908)	(0.947)
No. informal enforcement actions during preceding 24-month period	-2.557	-2.569	-1.797	-1.065
	(0.413)	(0.416)	(0.581)	(0.748)
Penalty amount during preceding 24-month period	**-0.0048**	-0.0057	**0.0431**	**0.0315**
	(0.021)	(0.418)	**(0.034)**	**(0.044)**
Interactions between Regulatory Enforcement Approach and Government Interventions				
Enforcement approach index × federal inspections (general)	-20.75	**-21.40**	**-20.78**	**-21.80**
	(0.112)	**(0.085)**	**(0.094)**	**(0.078)**
Enforcement approach index × state inspections (general)	-0.173	0.0143	-0.199	-0.370
	(0.896)	(0.991)	(0.876)	(0.771)
Enforcement approach index × federal inspections (specific)	**-7.340**	**-7.110**	**-6.437**	**-6.698**
	(0.085)	**(0.090)**	**(0.085)**	**(0.072)**
Enforcement approach index × state inspections (specific)	0.135	0.128	0.0255	-0.0437
	(0.708)	(0.719)	(0.940)	(0.895)
Enforcement approach index × informal actions (general)	**9.251**	**9.309**	**8.658**	**8.863**
	(0.036)	**(0.035)**	**(0.048)**	**(0.048)**
Enforcement approach index × penalty amount (general)	0.0001	0.00009	-0.0003	-0.0003
	(0.944)	(0.953)	(0.849)	(0.828)
Enforcement approach index × informal actions (specific)	0.278	0.229	0.0281	-0.130
	(0.739)	(0.786)	(0.974)	(0.883)
Enforcement approach index × penalty amount (specific)	**0.0008**	0.0011	**-0.0087**	**-0.0064**
	(0.031)	(0.447)	**(0.033)**	**(0.041)**

Table 2.5 (continued)

Facility Controls				
Organic chemical manufacturing (vs other chemicals)			-0.941	
			(0.973)	
Inorganic chemical manufacturing (vs other chemicals)			-19.68	
			(0.339)	
Facility employees (count)			**0.0435**	
			(0.014)	
Facility owned by publicly-held firm (vs privately-held firm)			**21.91**	
			(0.046)	
Economic impact of facility: significant/great (vs small/very little)			**37.07**	
			(0.055)	
Facility's attitudes toward inspection effectiveness: effective (vs not effective)			-22.48	
			(0.323)	
Facility's attitudes toward monetary fine effectiveness: effective (vs not effective)			-2.158	
			(0.891)	
Facility's environmental concern - environmental employees			9.820	
			(0.425)	
Facility's environmental concern - all employees			-7.356	
			(0.515)	
Constant	89.65	17.72	-25.37	**57.52**
	(0.141)	(0.738)	(0.644)	**(0.000)**
Number of Observations	703	703	688	688
Year indicators included	No	Yes	Yes	Yes
Regional indicators included	No	Yes	Yes	No
Facility indicators included	No	No	No	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at the 90 % level or better ($p \leq 0.10$).
Standard errors are clustered at the facility level.

Table 2.6: Marginal Effects of Government Interventions on Environmental Labor: Specific Deterrence

Regulatory Index	% of Sample	Fed Inspections		State Inspections		Informal Actions		Penalty Amount	
		Magnitude	p-value	Magnitude	p-value	Magnitude	p-value	Magnitude	p-value
0	0.0	**28.56**	**0.072**	0.507	0.776	-1.80	0.581	**0.043**	**0.034**
1	0.4	**22.12**	**0.069**	0.532	0.714	-1.77	0.470	**0.034**	**0.035**
2	1.6	**15.68**	**0.063**	0.558	0.622	-1.74	0.304	**0.026**	**0.035**
3	6.8	**9.25**	**0.054**	0.583	0.477	-1.71	0.125	**0.017**	**0.037**
4	18.1	**2.81**	**0.088**	0.609	0.263	-1.68	0.109	**0.008**	**0.041**
5	34.1	-3.63	0.262	0.634	0.101	-1.66	0.291	**-0.0003**	**0.001**
6	39.0	-10.07	0.139	0.660	0.171	-1.63	0.480	**-0.009**	**0.026**

Table 2.7: Marginal Effects of Government Interventions on Environmental Labor: General Deterrence

Regulatory Index	% of Sample	Fed Inspections		State Inspections		Informal Actions		Penalty Amount	
		Magnitude	p-value	Magnitude	p-value	Magnitude	p-value	Magnitude	p-value
0	0.0	**88.66**	**0.073**	-0.413	0.941	**-40.62**	**0.047**	-0.0008	0.908
1	0.4	**67.88**	**0.071**	-0.612	0.888	**-31.96**	**0.051**	-0.0011	0.836
2	1.6	**47.10**	**0.073**	-0.811	0.795	**-23.30**	**0.062**	-0.0014	0.720
3	6.8	26.32	0.115	-1.01	0.611	-14.65	0.105	-0.0017	0.540
4	18.1	5.53	0.676	-1.21	0.312	-5.99	0.377	-0.0020	0.385
5	34.1	-15.25	0.433	-1.41	0.337	2.67	0.701	-0.0023	0.418
6	39.0	-36.03	0.227	-1.61	0.516	11.33	0.231	-0.0026	0.515

Note: Bold text identifies coefficients that are significant at the 90 % level or better ($p \leq 0.10$).

Figure 2.1: National Pollutant Discharge Elimination System Monitoring and Enforcement

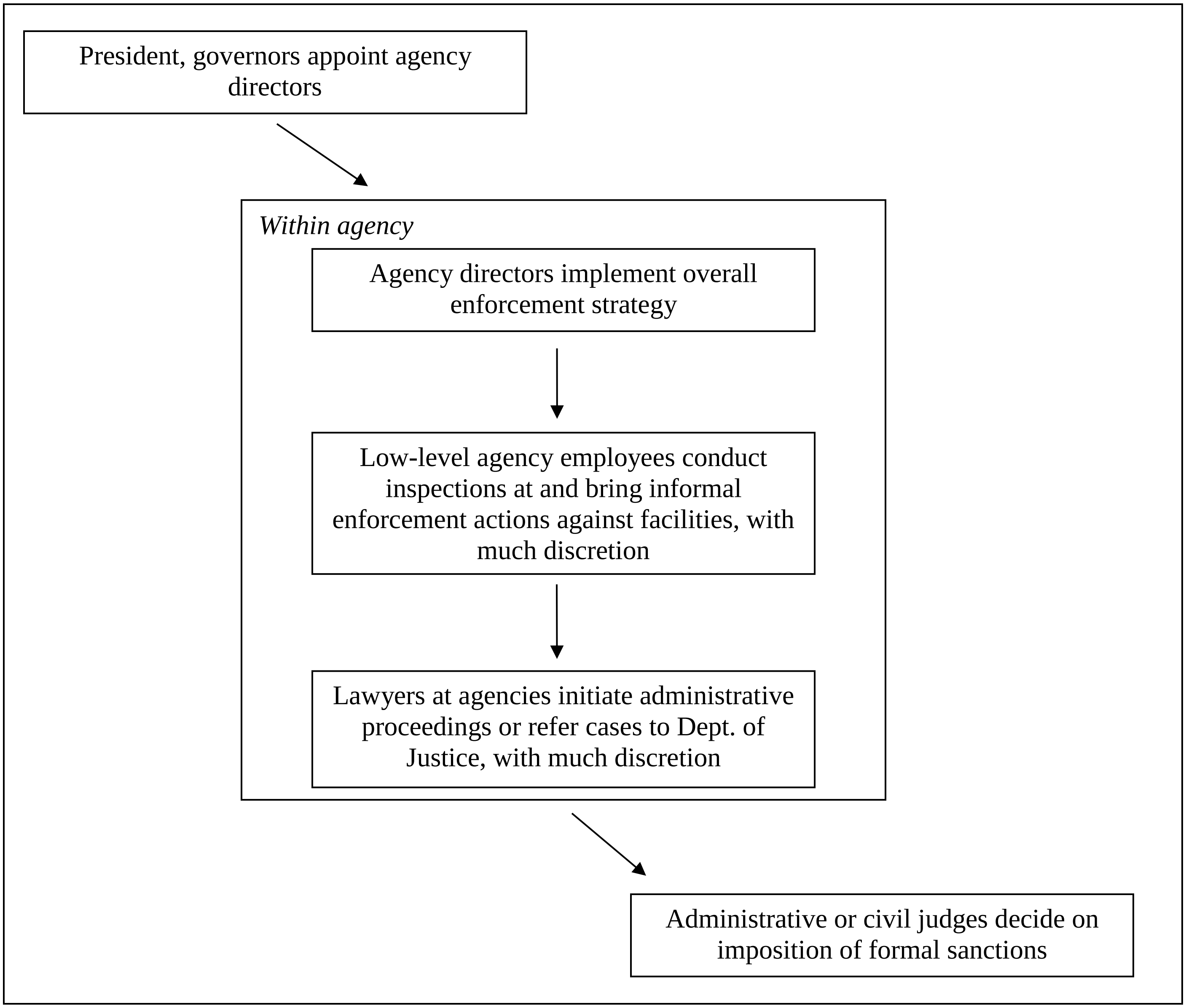


Figure 2.2: Marginal Effects – Federal Inspections

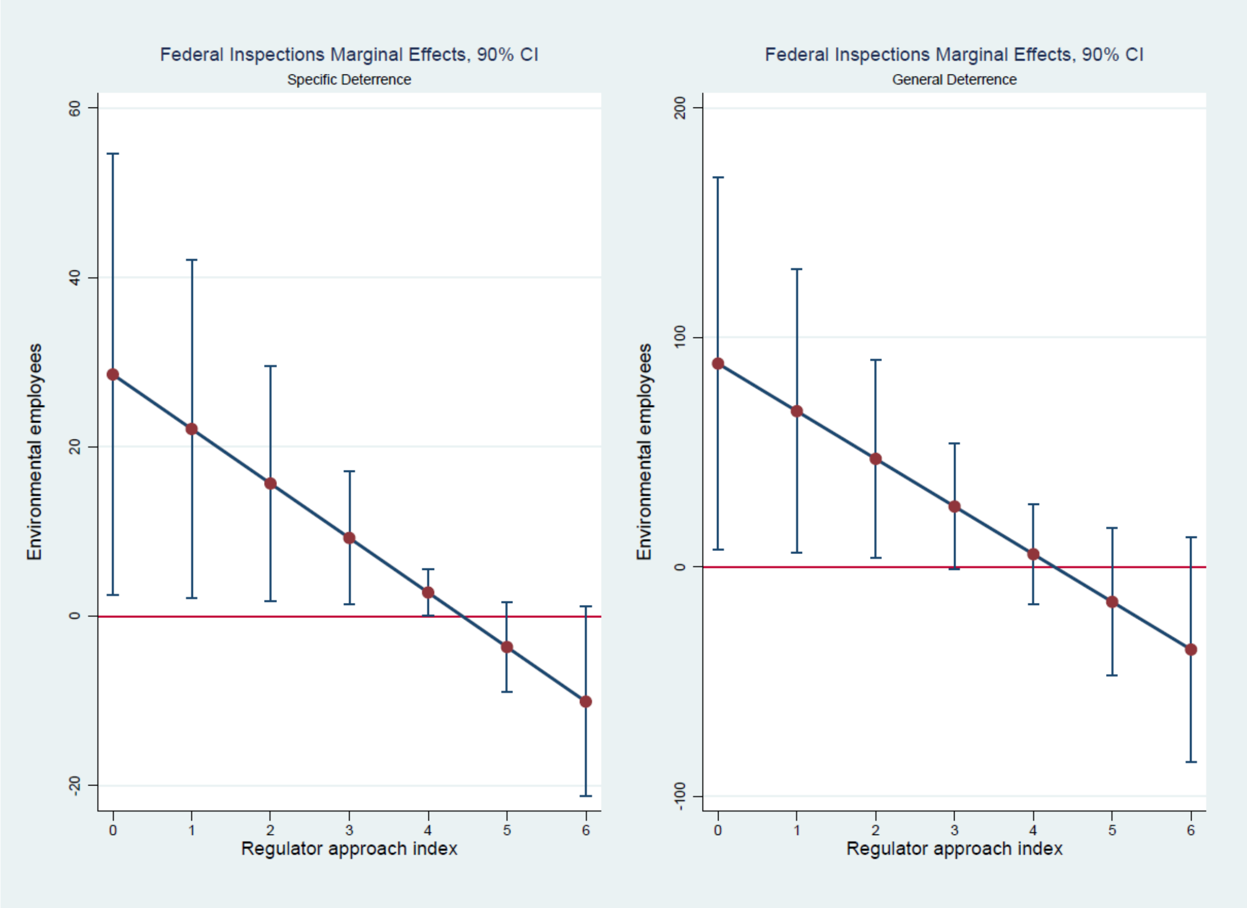


Figure 2.3: Marginal Effects – State Inspections

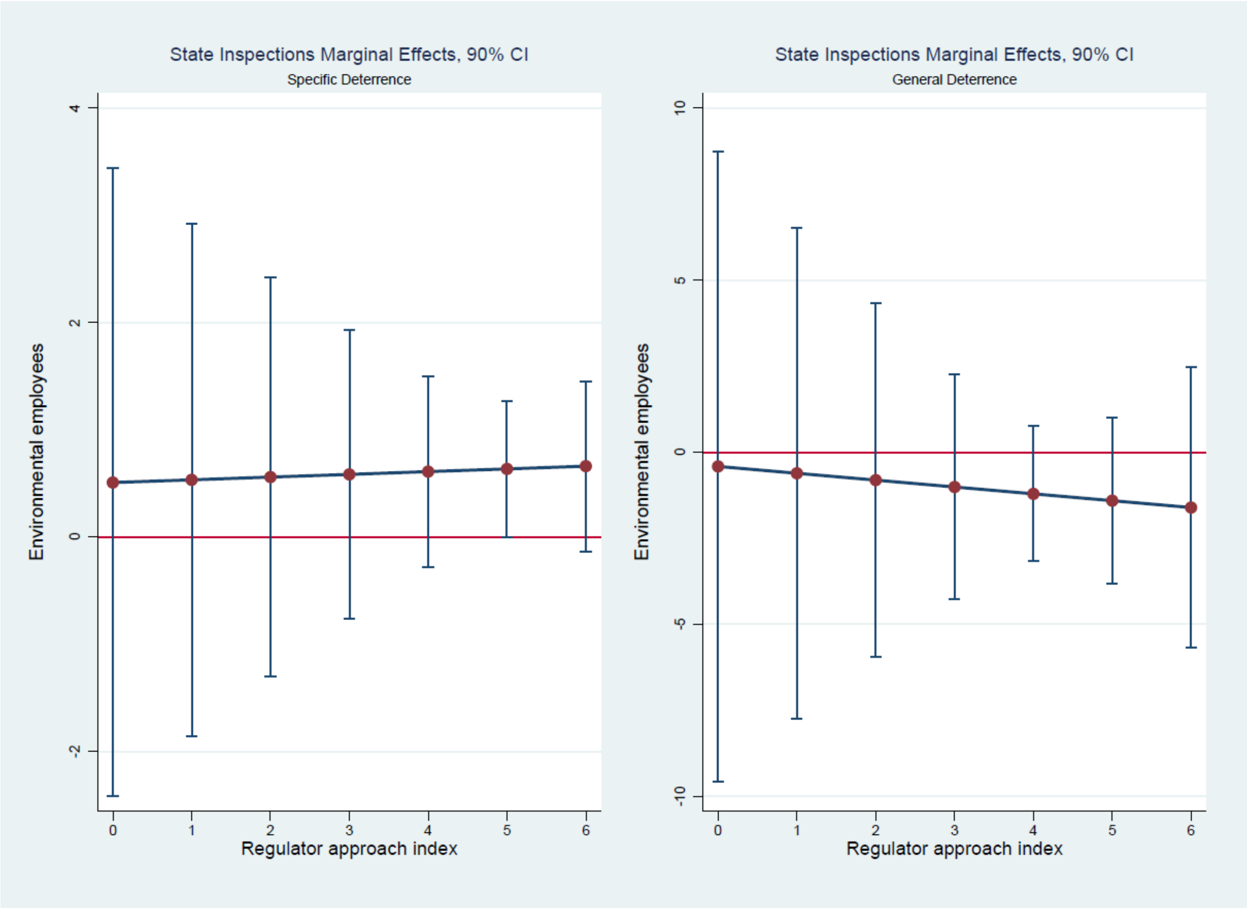


Figure 2.4: Marginal Effects – Informal Enforcement Actions

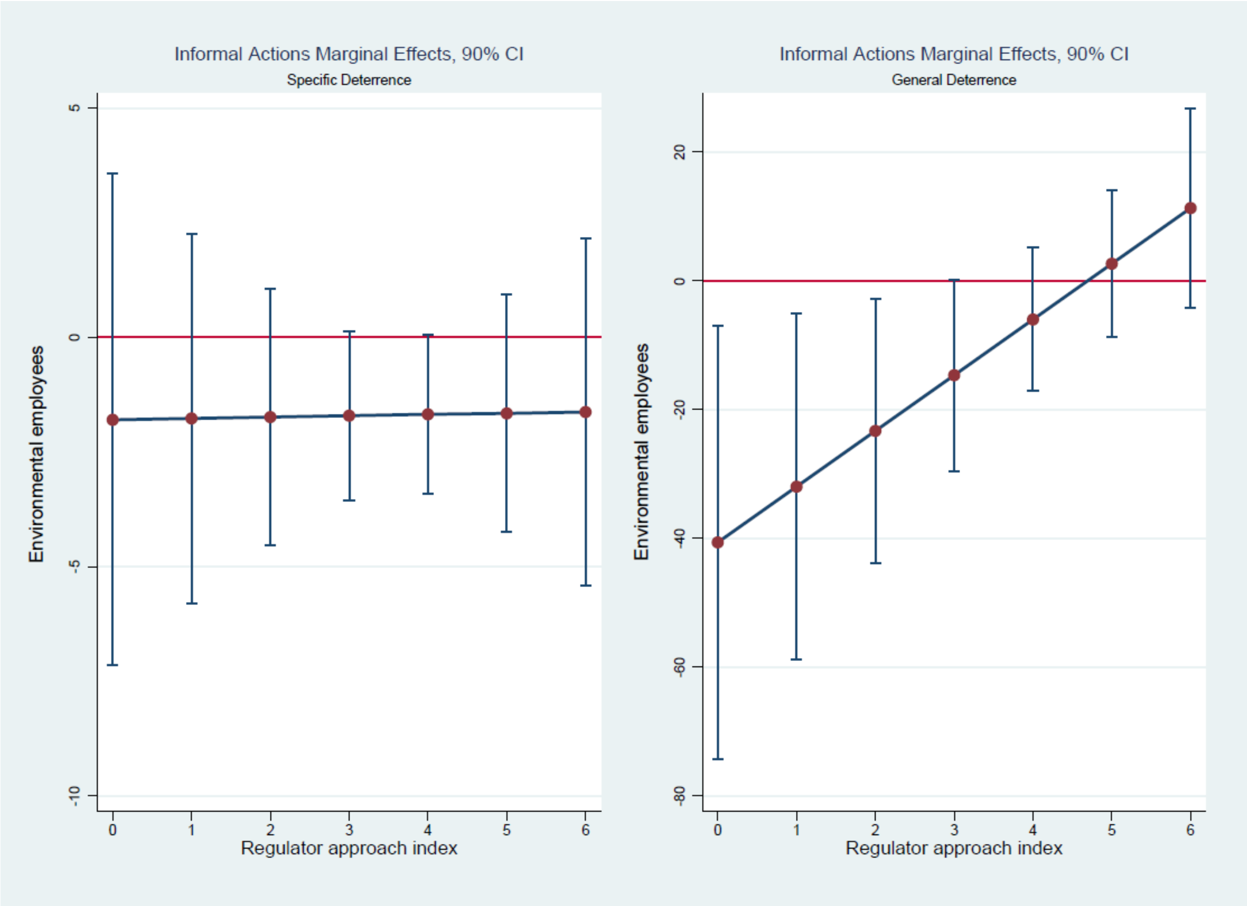
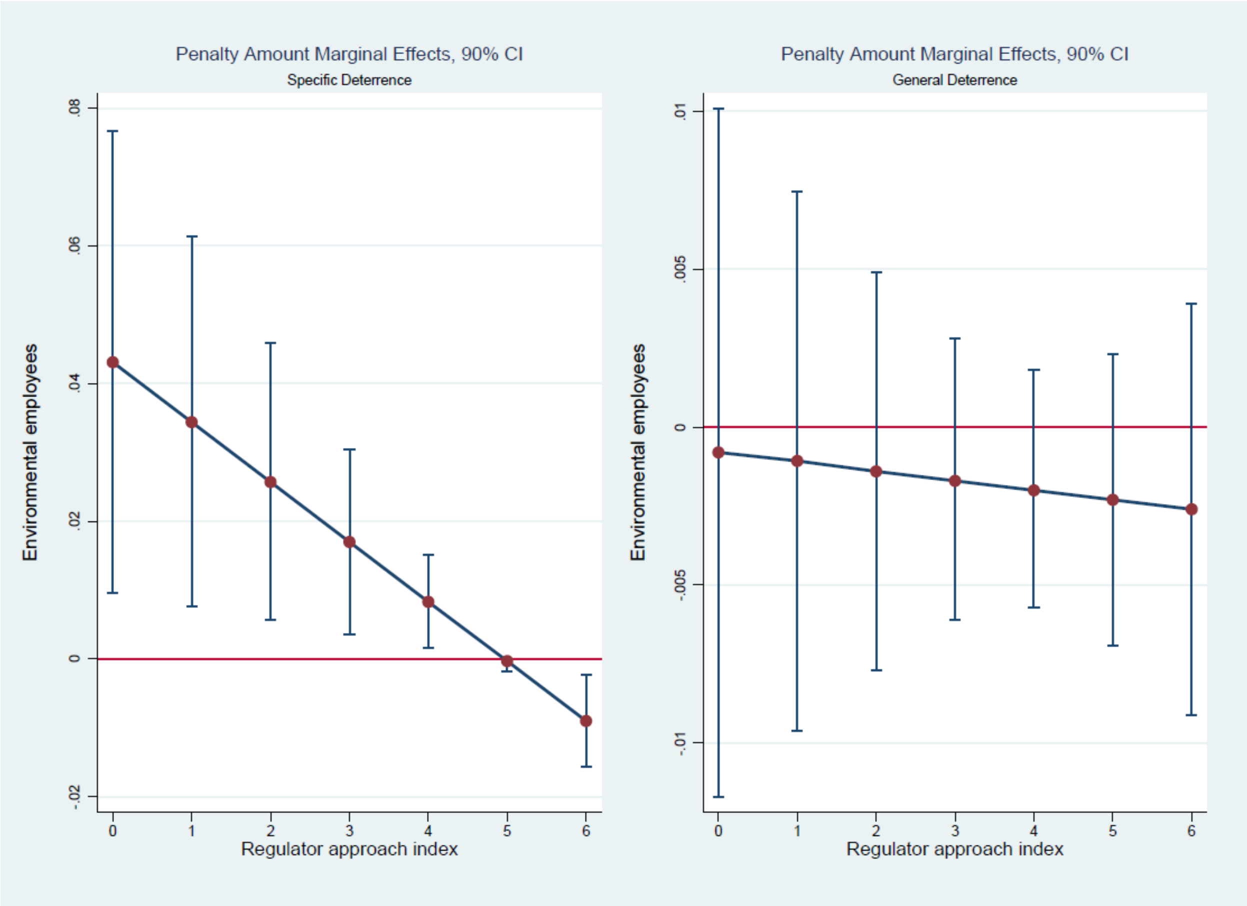


Figure 2.5: Marginal Effects – Monetary Penalty Amount



3 The Effect of Regulatory Enforcement on Facility-Level Employment: Environmental Workers vs. Production Workers

3.1 Introduction

Economists and policy-makers debate whether or not jobs and environmental protection are mutually exclusive. Environmental regulation imposes additional costs on regulated facilities, which may pass these costs onto workers by cutting jobs or lowering wages (or both). This pass-through represents backward cost-shifting onto labor. The debate over the impact of environmental regulation on employment has proven especially fierce in today's political environment where environmental protection budgets are under attack. The debate remains because the empirical literature on the labor effects of environmental regulation provides ambiguous conclusions. Almost all empirical studies find a statistically negligible effect (Morgenstern et al., 2002; Ferris, et al., 2014) or negative effect (Greenstone, 2002; Walker, 2011) on the number of employees in an industry or at an individual facility. To contribute to this policy debate, this study examines the effects of environmental regulation, specifically its enforcement, on three labor outcomes: total employment, production employment, and employment dedicated to environmental management (hereafter "environmental employment").

Previous empirical studies of labor explore the imposition of environmental regulation. However, imposition is only the first step in protection of the environment through regulation. After an environmental regulation is imposed, continued effort in the form of enforcement is necessary to ensure facilities' compliance with any regulation (Helland, 1998a; Helland, 1998b; Earnhart, 2004a; Earnhart, 2004b; Gray and Shimshack, 2011). Environmental enforcement takes place in the form of various government interventions: monitoring inspections, informal enforcement (e.g., warnings), and formal enforcement (e.g., monetary penalties). Absent compliance, environmental regulation imposes no costs on regulated facilities. By ensuring compliance, enforcement imposes real costs on facilities. As compliance rises, compliance costs also grow. Moreover, enforcement directly imposes costs through the use of monetary fines or indirectly imposes costs by distracting regulated facilities through inspections or enforcement proceedings. Thus, greater enforcement leads to higher non-compliance costs and eventually higher compliance costs. However, no previous study examines the employment effect of environmental enforcement. This study fills this void by examining the effect of Clean Water Act enforcement on employment at regulated facilities within the U.S. chemical manufacturing sector.

Within the economic literature on the employment effect of environmental regulation, most studies note that pollution abatement activities require some amount of labor input (Morgenstern et al., 2002; Ferris, et al., 2014). In fact, Morgenstern et al. (2002) claim that environmental regulation may actually increase labor. However, these studies are unable to quantify this type of labor, as data on environmental employment only exist in aggregate form (Department of Commerce, 2010; Bureau of Labor Statistics, 2011).[48] This study is able to examine two types of labor – environmental and production – using data from a unique survey that specifically instructs respondents to quantify separately these two labor types. Simply put, environmental employees engage in environmental management, which includes any method used by facilities to control pollution, e.g., environmental self-audits, internal monitoring protocols, end-of-pipe treatment technologies. In the studied sample, the presence of environmental employees is substantial, representing nearly 5 % of the average facility's

[48] These aggregate data reflect estimates rather than actual measures of labor.

workforce. In contrast to environmental workers, production workers engage in production activities.

By combining the two types of laborers, this study estimates an overall employment impact of environmental enforcement at regulated facilities. More importantly, this study distinguishes by labor type, estimating a separate effect of enforcement on environmental employees and production employees. Both results represent contributions to the empirical literature on the link from environmental regulation to employment.

To produce these contributions, the study first estimates the effects of various types of government interventions on the overall number of workers employed at a regulated facility. This first contribution provides insight on the overall impact of enforcing the Clean Water Act. Depending on the type of government intervention, the empirical results show that environmental enforcement has a negative or zero effect on the total number of workers employed at regulated facilities.

Of course, each overall impact reflects the net result from two countervailing forces. Theoretically, greater enforcement should spur more employment of environmental workers, as noted above, yet possibly prompt regulated facilities to shed production workers. To discern these two effects, the empirical analysis jointly estimates a system of equations with the two types of labor as separate dependent variables. The empirical results reveal that government interventions generally increase the employment of environmental workers or have no meaningful effect, while government interventions decrease the employment of production workers or have no meaningful effect.

The rest of the paper proceeds as follows. Section 3.2 reviews the pertinent literatures. Section 3.3 describes Clean Water Act regulation of the chemical manufacturing sector. Section

3.4 constructs a theoretical framework, which generates empirically testable hypotheses. Section 3.5 describes the econometric framework. Section 3.6 discusses the data and provides summary statistics. Section 3.7 details the econometric analysis and reports the empirical results, while interpreting them in light of the theoretically derived hypotheses. Section 3.8 concludes and assesses briefly future research.

3.2 Literature Review

This study contributes to three distinct economic literatures. First and most important, this study contributes to the growing literature on the labor impact of environmental regulation. Second, the study contributes to the literature on the public enforcement of environmental laws, which examines the effects of various government interventions on decisions made at environmentally regulated facilities. Finally, this study contributes to the literature on environmental management, of which environmental labor is one important form.

3.2.1 Labor Impacts of Environmental Regulation

The economic literature examining the labor impacts of environmental regulation is important, yet surprisingly thin. All previous studies examine the labor impacts of the imposition of regulations at either the level of an individual facility or individual industry. First, Morgenstern et al. (2002) examine the employment effects of greater environmental spending at the industry level of four key industries: pulp and paper mills, plastic manufacturers, petroleum refineries, and iron and steel mills. The authors find that increased environmental spending does not cause a significant change in employment. Walker (2011) examines the changes in employment as a result of the Clean Air Act Amendments of 1990. He finds that firms respond to the imposition of this environmental regulation by eliminating jobs. Greenstone (2002) finds that the Clean Air Act's designation of attainment vs. non-attainment counties has significant labor impacts in multiple manufacturing sectors. Berman and Bui (2001) examine the stringency of air quality regulation in the Los Angeles area. They find that regulatory stringency has no significant employment effects. Gray et al. (2014) study the impact of the Cluster Rule on employment in the pulp and paper industry. They find minimal effects on the number of employees at facilities subject to the rule. Sheriff, et al. (2015) examine the employment effects of the Clean Air Act's Ozone National Ambient Air Quality Standards on the U.S. electric power sector. Finally, Ferris et al. (2014) find negligible employment effects when examining the effect of Phase I of the Title IV SO_2 trading program on fossil fuel-fired plants' employment.

3.2.2 Public Enforcement of Environmental Laws

A related literature explores the enforcement of environmental laws. As the seminal study, Becker (1968) provides the theoretical foundation for the public enforcement of laws including environmental laws. In this foundational study, the enforcement agency monitors the compliance of regulated facilities and deters non-compliance by threatening to impose sanctions in response to violations. Since this seminal work, a number of theoretical studies have expanded Becker's basic model; Polinsky and Shovell (2000) thoroughly review this theoretical literature.

As important, numerous empirical studies explore the enforcement of public laws, which include environmental laws. This review focuses on the environmental studies. The majority of empirical environmental studies analyze the effect of environmental enforcement on facility- or firm-level environmental performance, e.g., compliance, or management, e.g., self-audits (Gray and Shadbegian, 2004; Shimshack and Ward, 2005; Gray and Deily, 1996; Laplante and Rhilstone, 1996; Earnhart, 2004a; Earnhart, 2004b; Earnhart and Segerson, 2012). Gray and Shimshack (2011) provide a comprehensive review of this empirical literature on environmental enforcement.

3.2.3 Environmental Management

A third large literature examines the environmental management decisions of regulated facilities. Given the empirical thrust of the present study, this review focuses on previous empirical studies. Many studies examine a facility's decision to establish and possibly certify an environmental management system (EMS). While several certification avenues are available, many facilities obtain certification based on commercial standards, such as the ISO 14001 standard. Arimura et al. (2008), Nakamura et al. (2001), Dasgupta et al. (2000), Henriques and Sadorsky (2007), Delmas and Toffel (2008), and Mori and Welch (2008) examine facilities' adoption of ISO 14001-certified EMSs. Whether or not they are part of an EMS, numerous environmental management tools are available to facilities. Several studies analyze specific types of environmental management. Khanna and Anton (2002), Anton et al. (2004), and Harrington et al. (2008) examine companies' decisions to implement various environmental management practices including pollution prevention practices, measured as a count. Khanna et al. (2007), Jones (2010), Ervin et al. (2012), Garcia et al. (2009), and Henriques and Sadorsky (1996) analyze companies' decisions to implement specific environmental management practices, each measured separately. Other studies focus on one particularly policy-relevant environmental management practice: environmental self-audits (Earnhart and Leonard, 2013; Evans et al., 2011; Earnhart and Harrington, 2014).

3.2.4 Contributions of Present Study

This study contributes to these literatures in two ways. First, this study examines separately the effects of environmental regulation on two distinctively different forms of labor: production labor and environmental labor. Previous labor studies identify the need for labor when conducting pollution abatement activities (e.g., Morgenstern et al., 2002). However, the publicly available microdata do not allow empirical studies to examine separately the employment effects by labor activity. Second, this study examines the effect on employment from the *enforcement* of environmental regulation rather than the *imposition* of regulation. No previous published study explores this link.

3.3 Clean Water Act Regulation of Wastewater from the Chemical Manufacturing Sector

3.3.1 National Pollutant Discharge Elimination System

This study examines facility behavior prompted by environmental regulation, specifically the Clean Water Act (CWA). The CWA's main purpose is to protect water quality. To this end, the CWA controls wastewater discharges from point sources.[49] The EPA created the National Pollutant Discharge Elimination System (NPDES) to control these point source discharges. The system's main form of control is the issuance of facility-specific permits, which identify the pollutant-specific discharge limits imposed on regulated facilities.[50]

To establish discharge limits within individual facilities' permits, the issuing agency considers any relevant Effluent Limitation Guideline standard and water quality-based standard. The former is designed to require a minimum level of wastewater treatment for a given industry and the latter is designed to ensure that the water body receiving the discharges meets ambient surface water quality standards. After a potential discharge limit is calculated under each standard, the permitting agency writes the stricter of the two into the permit.

[49] Point sources directly discharge into a waterbody, usually from a pipe or outfall, or indirectly discharge into a municipal wastewater collection system. In contrast, non-point sources generate discharges diffusely through run-off from agricultural fields, urban settings, or construction sites into a waterbody. This study focuses on point sources.

[50] The EPA website provides an overview of the NPDES permitting system: http://water.epa.gov/polwaste/npdes/basics/upload/101pape.pdf.

The permitted discharge limit represents a performance-based standard. Compliance with this standard is based on a facility's own discharges. Thus, each facility is able to use any available abatement method to comply with its permitted limit. A number of abatement methods are available to facilities: end-of-pipe treatment technologies (i.e., capital), deployment of labor, and other methods.

NPDES-permitted facilities are required to monitor and self-report their discharges on a regular basis. Therefore, inspections are not needed to assess compliance with imposed discharge limits. More important, inspections cannot measure this type of compliance because limits constrain discharges measured over a period of time, e.g., entire month. Inspections can only measure the concentration of pollution in a discharge stream at a moment in time.

To ensure compliance with permits, the EPA and authorized state agencies periodically inspect facilities and take enforcement actions when the facility is not in compliance. Agencies possess great discretion over monitoring and enforcement decisions. Thus, environmental enforcement activity can vary considerably over time and across administrations. In the NPDES program, authorized state agencies are the primary party responsible for monitoring and enforcement, even though the EPA retains authority to inspect and impose sanctions on facilities as well. Inspections represent the main monitoring activity. Regulatory agencies use inspections as a vehicle for gathering evidence for future enforcement actions (Wasserman, 1984). In addition, agencies oftentimes use inspections to offer compliance assistance. As needed, agencies use a mixture of informal enforcement actions, such as warning letters, and formal enforcement actions, including monetary penalties (i.e., fines), to deter non-compliance.

Conceptually, monitoring inspections and enforcement actions create both specific and general deterrence. Specific deterrence is the pressure to comply generated when a specific facility itself is subjected to a government intervention. Specific deterrence prompts the particular facility to improve its subsequent compliance. General deterrence, on the other hand, is the pressure to comply based on government interventions taken against other facilities. Thus, general deterrence prompts other facilities to improve their subsequent compliance (Cohen, 2000). Collectively, when an agency conducts an inspection at or takes an enforcement action against a particular facility, this facility faces greater specific deterrence and other facilities face greater general deterrence. These two forms of deterrence imply that each facility bases it perceptions of enforcement likelihood and severity on its own experiences (specific deterrence) and other facilities' experiences (general deterrence). [General deterrence stems only from other facilities who are seen by the particular facility as sufficiently similar to serve as peers for the purpose of updating the facility's perceived likelihood of a future government intervention and perceived magnitude of any future government intervention, e.g., fine size.]

3.3.2 Chemical Manufacturing Sector

Point sources of wastewater fall into one of two main categories: municipal sources (i.e., municipal wastewater treatment facilities) and industrial sources.[51] This study focuses on a single sector, chemical manufacturing, which falls into the industrial sources category. The focus on a single industrial sector is consistent with other empirical studies of industrial pollution (e.g., Laplante and Rilstone, 1996; Barla, 2007; Earnhart, 2009; Earnhart and Harrington, 2014).

For a number of reasons, the chemical manufacturing sector serves as a good choice for analyzing the employment effects of government interventions. First, the EPA has shown a

[51] The EPA website describes industrial sources: http://water.epa.gov/polwaste/npdes/Industrial-and-Commercial-Facilities.cfm.

strong interest in this sector. The EPA and the Chemical Manufacturing Association (CMA) jointly authored a study on the causes of non-compliance in the chemical manufacturing sector (EPA, 1999). Further, the EPA solely studied the compliance history of facilities operating in this sector (EPA, 1997). Second, the EPA considered two sub-sectors in the industry (industrial organics and chemical preparations) as priority sectors during a portion of the study period. Third, the CMA (now known as the American Chemistry Council [ACC]) has demonstrated a strong interest in promoting pollution reduction and prevention with its Responsible Care initiative. Fourth, wastewater data disaggregated by 4-digit Standard Industrial Classification (SIC) code reveal that four of the 10 highest polluting sub-sectors operated in the chemical manufacturing sector as of 2008 (EPA, 2011); this evidence demonstrates that the chemical manufacturing sector is very important in terms of total wastewater. Finally, the chemical manufacturing sector employs many environmental workers and even more production workers. The average facility in the sample allocates roughly 5 % of its workers to perform tasks specifically related to environmental management. Further, according to the BLS, the chemical manufacturing sector had almost 25,000 environmental workers employed across the industry as of 2011. This figure represents roughly 5 % of the total environmental employment in the manufacturing industry, which makes the chemical manufacturing sector the most "green" employer of all aggregated sectors (Bureau of Labor Statistics, 2011).

3.4 Conceptual Framework

This section constructs a simple theoretical model from which the study derives empirically testable hypotheses relating to the effects of enforcement on the two specific types of labor – environmental and production – and labor in general.

3.4.1 The Effects of Government Interventions on Overall Labor

Hypothesis H1a: The effect of government interventions on overall facility-level labor is positive.

The environmental enforcement literature states that government interventions, in the form of inspections or enforcement actions, are used by the regulating agency to achieve compliance with issued discharge permits (Earnhart, 2004a; Earnhart, 2004b; Shimshack and Ward, 2011). Further, the environmental management literature states that in order to achieve or increase compliance, regulated facilities partake in numerous environmental management techniques (e.g., ISO 14001 certification performing environmental self-audits), especially after experiencing inspections and enforcement actions (Delmas and Toffel, 2008; Earnhart and Leonard, 2013; Earnhart and Harrington, 2014). In addition to these standard EMS practices, facilities hire environmental workers to ensure compliance with their permitted allowable discharges, and these employees have proven successful at generating compliance (Earnhart and Glicksman, 2011). Therefore, Hypothesis H1a proposes that when a regulating agency conducts inspections and imposes enforcement actions at a facility, the recipient of the interventions will hire environmentally related workers in order to achieve compliance with their permits. For H1a to hold, this increase in the amount of environmental workers must be paired with the managerial decision to keep the number of production workers unchanged, or only slightly decreased.[52]

Hypothesis H1b: The effect of government interventions on overall facility-level labor is zero or negative.

[52] A discussion of the effects on different types of workers is provided in the following section.

Alternatively, managers may respond to government interventions in a negative way. All previous studies of the effects of environmental regulation on overall labor find a negative effect (Walker, 2011; Greenstone, 2002) or a statistically negligible effect (Ferris, et al., 2014; Gray et al., 2014) on employment outcomes. H1b is based on the idea that environmental regulation (its imposition as well as its enforcement), especially fines, impose additional costs on facilities. In order to meet these costs, managers must cut costs in other areas of operation, including wages. Therefore, in order to cut labor costs, managers must lay-off workers to remain profitable. Under H1b, managers are still expected to increase the number of environmental workers, as this is necessary to achieve compliance once the facility is subjected to government interventions. However, H1b differs from H1a in that this increase in environmentally related employment is offset by the decrease in production labor. Under H1b, after experiencing government interventions, the overall facility-level employment numbers experience a net decrease or no change. Therefore, H1b does not hypothesize the sign of the change in labor types, rather that the magnitudes of the labor type changes are different enough to cause a decrease in overall facility-level employment.

3.4.2 The Effects of Government Interventions on Different Types of Labor

Hypothesis H2: *The marginal effect of an increase in the number of firm environmental workers is a decrease in the number of production workers.* [53]

[53] Conversely, the marginal effect of a decrease in the number of firm environmental workers is an increase in the number of production workers. However, this is not expected to be the case, as government interventions are expected to increase environmental management, and thus, the number of environmental workers employed at a facility.

Consider a price-taking, competitive firm[54] that employs two types of substitutable labor: environmental workers, L_e, and production workers (i.e., non-environmental workers), L.[55] The firm must pay each worker a wage, w, depending on the type of work performed by that employee. In each time period, each individual firm faces environmental regulations, imposed within its NPDES permit, with which it must comply. For the theoretical model, I denote this standard level of allowable discharges as $\bar{E}$. Therefore, the firm produces two products: (1) the final product to be sold at market, Q, and (2) the environmental product, i.e. the act of complying with the standard set by the regulating agency, denoted E.[56] Because the two types of employees are substitutes, each final product is produced by its respective employee type (e.g., environmental employees produce the environmental product). To represent the two products produced by the firm in each time period, consider the following two downward-concave production functions:

$$Q = ln\,(L) \tag{3.1}$$

$$E = L_e^b \text{, where } 0 < b < 1. \tag{3.2}$$

For each firm, I assume that only Q can produce profits, with a final product price of p. Because of this assumption, the environmental product only enters the firm's profit equation as a cost, as the firm must employ environmental labor exclusively to avoid violation (i.e., avoid exceeding its permitted level of discharges, $\bar{E}$), not to increase its profits. Thus, each firm attempts to maximize its profit function, Π:

[54] I assume that each firm owns a single facility. Therefore, no difference exists between the firm and the facility.

[55] Because the two types of labor are substitutes, the amount of total employees at each firm, L_T, is equal to the sum of environmental and production workers: $L_T = L_e + L$.

[56] An increase in each type of labor is associated with an increase in production of the respective product. Therefore, the hiring of more production workers, L, results in a higher quantity of Q, and the hiring of more environmental workers, L_e, results in a higher quantity of E.

$$\Pi = p * ln(L) - wL - wL_e . \tag{3.3}$$

In this firm, production and environmental workers perform explicitly different tasks, and thus, supply and demand for each labor type result in wages that depend on the worker. Therefore, I will allow the wage, *w*, to depend on the type of labor by substituting $w = L + L_e$ into the profit function. Finally, I substitute $L_e = E^{1/b}$ into the profit function. This allows each firm to solve its profit maximization problem:

$$max\ \Pi = p * ln(L) - (L + E^{1/b})*L - (L + E^{1/b})* E^{1/b} . \tag{3.4}$$

Once the firm solves its maximization problem in Equation (3.4), it is evident that the marginal effect of an increase in environmental labor is a decrease in production labor.[57]

As mentioned in Hypothesis H1a, the purpose of government interventions is to induce compliance, which is the environmental good *E* in this model. Thus, when firms experience government interventions (such as monetary fines), they are expected to increase production of the environmental good, and in order to do so, hire more environmental workers, L_e. Therefore, this theoretical result shows that if firms are subjected to a government intervention, they will hire more environmental workers, which in turn will cause the firm to decrease the number of substitutable production workers.

3.5 Econometric Framework

This study examines the effects of Clean Water Act enforcement on facility-level employment. The study first estimates the effects of government interventions on the total number of full-time equivalent (FTE) workers at each facility, regardless of the specific job-

[57] The complete derivation can be found in Appendix C.

related function in which these workers participate. The study then jointly estimates the effects of environmental enforcement on two types of employees: environmental employees and production employees. This section proceeds by first discussing the dependent variables, then the primary and control regressors, and then by constructing the regression equations.

3.5.1 Dependent Variables

In each year *t*, facility *i* chooses its level of environmental workers, denoted Y_{1it}, and its level of production workers, denoted Y_{2it}, which sum to the overall level of workers: $Y_{it} = Y_{1it} + Y_{2it}$. In order to determine the effects of government interventions on facility-level employment, the analysis estimates the relationship between each of these three dependent variables and a set of primary regressors and control factors, as described below.

3.5.2 Primary Regressors

The primary regressors are measures of environmental enforcement, i.e., government interventions, namely inspections and enforcement actions. The regressors separately measure federal inspections and state inspections and separately measure informal actions and monetary penalties. Similar to some previous studies (Earnhart, 2009; Earnhart and Segerson, 2012), the study includes only federal enforcement actions, while excluding state enforcement actions, since no database provides complete information for state enforcement actions. Second, the study splits government interventions into two categories: government interventions against one's own facility (specific deterrence) and government interventions against other facilities that are similar to one's own (general deterrence).

The study constructs the government intervention regressors in the following way. First, the study constructs the inspection measures. For specific deterrence, the analysis uses the number of federal or state inspections conducted in the 24 months preceding the current year at the individual facility, denoted as $I_{it\text{-}1}^{EPAs}$ and $I_{it\text{-}1}^{STs}$, respectively.[58] For general deterrence, the analysis uses the number of federal or state inspections conducted in the 12 months preceding the current year at other facilities of similar NPDES facility status operating in the same EPA region, in the case of federal inspections, and in the same state, in the case of state inspections, divided by the number of similar status facilities operating in the same EPA region or state (Earnhart and Leonard, 2013), denoted as $I_{it\text{-}1}^{EPAg}$ and $I_{it\text{-}1}^{STg}$, respectively. The NPDES program distinguishes between major facilities and minor facilities; this distinction reflects the NPDES facility status.

Next, the analysis constructs the enforcement measures in a way similar to that of inspections. The resulting specific deterrence measure for informal actions is denoted as $A_{it\text{-}1}^{s}$, while the general deterrence measure is denoted as $A_{it\text{-}1}^{g}$. For the penalty measures, the analysis uses the total amount of penalties levied against the individual facility or other facilities. The specific and general deterrence measures are denoted, respectively, as $P_{it\text{-}1}^{s}$ and $P_{it\text{-}1}^{g}$.[59]

3.5.3 Control Factors

The analysis creates and includes as controls factors derived from facility- and firm-level characteristics, as well as local community characteristics, that may influence employment.

First, the industrial sub-sector in which a facility operates may impact labor decisions. Facilities' abilities to control their operations – both environmental and production – may depend

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[58] For the inspection-related specific deterrence measures, the study tests whether inspections conducted in the 12 months preceding the current year and those conducted in the 13 to 24 months preceding the current year generate identical coefficient magnitudes. F-test statistics fail to reject the null hypothesis of equal coefficients.

[59] For the enforcement-related specific deterrence measures, the study tests whether enforcement actions taken in the 12 months preceding the current year and enforcement actions taken in the 13 to 24 months preceding the current year generate statistically identical coefficient estimates. F-test statistics fail to reject the null hypothesis of equal coefficients.

on the type of product being manufactured. The analysis includes two indicators to control for variation in this ability: one indicator for organic chemicals and another indicator for inorganic chemicals, with “other chemicals” as the omitted category.

Second, the age of a particular facility may impact the optimal number of workers employed, either in an environmental or production capacity. The analysis includes facility age as a control factor. One can expect that the older a facility is the more helpful are environmental employees for keeping the facility compliant with its NPDES permits. Similarly, as facility age rises, production employees become more helpful at maintaining the older equipment.

Third, firm ownership structure, as represented by the distinction between publicly held and non-publicly held ownership, captures a number of firm-related influences. For example, publicly held firms may possess greater access to external financing for environmentally related investment. Therefore, the analysis includes a publicly held firm indicator.

The analysis also includes control factors to capture a facility's relationship with the surrounding community. The first measure captures the economic impact of the facility on the surrounding community. On one hand, as the impact of a facility rises, the local community may apply more pressure on the facility to improve its environmental management. On the other hand, as the facility’s size and influence grow, the local community may tread lightly, fearing that the facility may shift part of its production to other sites or leave town altogether. The included measure reflects a "significant" or "great" economic impact, with a "small" or "very little" impact as the omitted category. Second, the analysis includes a control factor that measures the direct relationship of the facility with community leaders. The analysis includes an indicator that represents whether or not facility management has met with community leaders to discuss the environmental impact of the facility on the local community. This measure controls for attitudes that community leaders may hold in regard to whether or not they believe the facility is making a conscious effort to be environmentally aware, or if the facility management are environmentally aware. If facility leadership decides to make a concerted effort to meet with community leaders, the community may be less inclined to pressure the regulator to bring interventions upon the facility, which may result in the use of less environmental employees at the facility. On the other hand, a facility that is proactive enough to meet with community leaders may be more inclined to practice better environmental management, as they are clearly concerned with their environmental impact on the community.

The number of overall employees and the allocation of workers between environmental management and production may also depend on the attitudes of the people associated with the regulated facility. One control factor captures a facility's environmental workers' self-reported measure of concern about the environment. The measure ranges between 1 and 10, with 1 signifying the least concern and 10 signifying the greatest concern. This attitudinal measure should help to control for variation in workers' intrinsic motivation to comply with NPDES permits.

Two other control factors reflect facility managers' attitudes towards the effectiveness of government interventions for inducing compliance with discharge limits. One measure captures management's subjective perception of inspections' effectiveness, while the second measure captures management's subjective perception of monetary fines' effectiveness. Both measures are binary, representing an "effective" perception, with a "not effective" perception as the omitted category. If a manager feels that inspections or fines are effective at inducing compliance, he/she may be more inclined to hire more environmental workers. If, however, the manager feels that inspections or fines are ineffective, he/she may conclude that hiring employees devoted to environmental management wastes resources.

Collectively, these facility- and firm-level measures are denoted as F_{it}.

The use of environmental employees as a means of achieving compliance at a given facility may also depend on local community characteristics (Earnhart, 2004b). Community characteristics are only expected to influence environmental employees as these characteristics proxy for the extent of pressure exerted by local communities on facilities to exhibit better pollution control, i.e., deliver better local environmental quality. In contrast, I expect no link from local community characteristics to production employees.

The analysis exploits county-level measures of local community characteristics. All monetary measures are inflation-adjusted into 2002 dollars. The first community characteristic is per capita personal income. Higher income communities are more likely to apply pressure on local facilities to practice better environmental management (e.g., by hiring more environmental workers) since environmental quality is a normal good (Earnhart, 2004c). Second, the analysis controls for local labor market conditions using two proxies: (1) the unemployment rate, and (2) the number of wage and salary jobs in the community. A local community is more likely to pressure facilities to provide better environmental quality when the unemployment rate is low or the number of individuals earning a salary or wages is high. Conversely, communities facing economically difficult times are more likely to focus on economic growth than environmental quality. Finally, population density is correlated with the local community pressure placed on a facility to improve local environmental quality by conducting better environmental management, e.g., employ more environmental workers. In a community where individuals are more densely populated around a polluting facility, the local community is more likely to urge the facility to generate less pollution; hiring more environmental employees reduces pollution (Earnhart and Glicksman, 2011).

These community-level characteristics are collectively denoted as C_{it}.

Finally, the analysis controls for variation in regulatory pressure not already reflected in government intervention measures by including time dummies, denoted D_t, and EPA regional indicators, denoted as L_i. The use of regional indicators controls for "unmeasured" spatial variation in monitoring and enforcement.

3.5.4 Functional Relationships

The analysis first estimates the functional relationship between overall workers and the set of primary and control factors. The analysis estimates a semi-log specification by log-transforming the dependent variable, as is standard with studies of employment. This specification facilitates easy interpretation of the coefficients: a one unit increase in each regressor is associated with a percentage change in total employment. The following empirical specification captures the functional relationship to estimate:

$$f(Y_{it}) = \gamma + \delta_1 I_{it-1}^{EPAs} + \delta_2 I_{it-1}^{STs} + \delta_3 I_{it-1}^{EPAg} + \delta_4 I_{it-1}^{STg} + \delta_5 A_{it-1}^{s} + \delta_6 A_{it-1}^{g} + \delta_7 P_{it-1}^{s} + \delta_8 P_{it-1}^{g} + \eta F_{it} + \tau C_{it} + \mu L_i + \theta D_t + \varepsilon_{it}, \tag{3.5}$$

where δ_1 through δ_8 are the coefficients of interest, γ represents the intercept term, and ε_{it} represents an exogenous error term.

Next, the analysis jointly estimates the relationships between each labor type and the set of primary and control regressors. Again, the analysis estimates a semi-log specification by log-transforming each dependent variable. The following system of equations represents the joint-estimation specification:

$$f(Y_{1it}) = \alpha_0 + \alpha_1 I_{it-1}^{EPAs} + \alpha_2 I_{it-1}^{STs} + \alpha_3 I_{it-1}^{EPAg} + \alpha_4 I_{it-1}^{STg} + \alpha_5 A_{it-1}^{s} + \alpha_6 A_{it-1}^{g} + \alpha_7 P_{it-1}^{s} + \alpha_8 P_{it-1}^{g} + \alpha_9 F_{it} + \alpha_{10} C_{it} + \alpha_{11} L_i + \alpha_{12} D_t + \varepsilon_{1it} \tag{3.6}$$

$$f(Y_{2it}) = \beta_0 + \beta_1 I_{it-1}^{EPAs} + \beta_2 I_{it-1}^{STs} + \beta_3 I_{it-1}^{EPAg} + \beta_4 I_{it-1}^{STg} + \beta_5 A_{it-1}^{s} + \beta_6 A_{it-1}^{g} + \beta_7 P_{it-1}^{s} + \beta_8 P_{it-1}^{g} + \beta_9 F_{it} + \beta_{10} L_i + \beta_{11} D_t + \varepsilon_{2it}, \tag{3.7}$$

where α_1 through α_8 and β_1 through β_8 are the coefficients of interest, α_0 and β_0 represent the intercept terms, and ε_{1it} and ε_{2it} represent the correlated error terms.

The analysis jointly estimates this system of equations using seemingly unrelated regression (SUR) (Zellner, 1962), which is helpful for two reasons. First, SUR allows for correlation between the two error terms. Therefore, SUR facilitates proper cross equation restriction testing (Wooldridge, 2002, pg. 185-191). The analysis explores cross equation restrictions in order to test hypotheses comparing coefficients between the two equations, as described below. Second, SUR generates efficiency gains for the coefficient estimates over estimating the equations separately using OLS. If the two equations contain exactly the same set of regressors, then joint estimation generates coefficient magnitudes and standard errors no different from those generated by estimating each equation separately using OLS. However, if the regressor set differs between the equations, then the SUR estimates are more efficient than the OLS estimates (Davidson and MacKinnon, 1993, pg. 294-295). As mentioned in sub-section 3.5.3, local communities pressure facilities only to generate better environmental quality by conducting more environmental management; local community characteristics proxy for this environmental pressure. In contrast, local communities are not expected to exert pressure on facilities for more production workers. Accordingly, the analysis includes the set of local community characteristics as regressors only in the estimation of overall and environmental employees – Equations (3.5) and (3.6), excluding these characteristics from the estimation of production employees – Equation (3.7). Consequently, joint estimation generates efficiency gains.

3.6 Data

3.6.1 Sources

The study draws upon three main data sources to gather the information necessary to conduct the empirical analysis. First, the study draws upon a survey of regulated facilities in the chemical manufacturing industry.[60] The survey chiefly gathers data on environmental management undertaken by individual facilities. Most importantly, the survey separately gathers information on the number of environmental and production employees at each facility. The survey also gathers information about each facility's attitudes toward government intervention effectiveness.

Between April 2002 and March 2003, the survey was administered by phone to all chemical manufacturing facilities permitted within the NPDES program as of September, 2001 (2,596 facilities) that met the following criteria: (1) faced restrictions on their wastewater discharges, (2) discharged regulated pollutants into surface water bodies, and (3) were operating as of 2002. [The EPA Permit Compliance System (PCS) database identified all NPDES-permitted facilities operating in the chemical manufacturing sector.] Of the 2,596 permitted facilities, 1003 met the identified criteria. Of the 1003 facilities contacted for the survey, 268 completed the survey, implying a 27 % response rate. This rate is comparable to other large-scale surveys of industrial sectors (e.g., Arimura et al., 2008). Also, this response rate is higher than the average response rate for similar surveys of 21 % (Paxson, 1992).

[60] See Earnhart and Glicksman (2011) for specific details regarding the survey.

In addition to these survey data, the study uses data from the EPA PCS database. Specifically, the study uses information on each facility's location and four-digit standard industrial classification (SIC) code. The study also uses data on inspections conducted by both federal and state regulators. The PCS database and also the EPA Docket database provide data on federal formal enforcement actions, while only the PCS database provides data on informal enforcement actions; the study integrates data from the two sources.

3.6.2 Statistical Summary

Table 3.1 provides summary statistics for the dependent variables, the primary regressors, and the control factors. As shown, the average facility employs roughly 259 workers in total. Further, the average facility employs six individuals to work specifically on environmental management issues and 256 individuals to work on production.

Table 3.1 also identifies key summary statistics for the primary regressors. As shown, state agencies conduct inspections much more frequently than EPA regional offices conduct inspections. This is to be expected since state agencies are primarily responsible for monitoring. The average facility is subjected to 1.5 state inspections over a 24-month period, yet only 0.07 federal inspections.[61] For enforcement actions, the more common action is the less severe of the two types. The average facility is subjected to 0.20 informal enforcement actions over a 24-month period, yet is fined only $ 127. (The latter figure reflects a highly skewed distribution of fines involving a few large penalties and many 24-month periods without a single fine.)[62]

[61] Although federal inspections are conducted much less frequently than state inspections in the sample, the empirical analysis generates statistically significant results for federal inspections.

[62] Even though monetary fines occur infrequently in the sample, the empirical analysis generates statistically significant results for fines.

Finally, in order to display the meaningful variation of the primary regressors, Table 3.1 displays the coefficients of variation for the government intervention measures.

3.7 Econometric Analysis

3.7.1 Potential Endogeneity of Government Interventions

The decision by the regulating agency to inspect and levy enforcement actions on facilities may be endogenous. Regulating agencies may target facilities with poor records of compliance as the recipients of government interventions, in the hopes that the facility will improve compliance, which should result in hiring more environmental labor. However, this study claims that the constructed measures are exogenously determined with respect to overall, environmental, and production labor decisions.

First, the general deterrence measures are clearly exogenous. These measures reflect government interventions prompted by the behavior and performance of other facilities. Second, the specific deterrence measures are exogenous due to the separation in time between lagged government interventions and current employment and environmental management decisions, consistent with nearly all previous studies using lagged intervention measures (Earnhart, 2009; Helland, 1998a; Helland, 1998b; Earnhart and Leonard, 2013; Earnhart and Harrington, 2014). A comprehensive review of the environmental enforcement literature confirms that all previous empirical studies treat lagged interventions as exogenous (Gray and Shimshack, 2011). As such, the analysis proceeds treating all regressors as exogenous.

3.7.2 Regressor Sets

The analysis considers three models in order to assess the robustness of all estimated results with respect to the choice of regressor sets. Model 1 is the parsimonious model, which includes only the eight primary regressors. Model 2 adds regional indicators and facility and firm characteristics as control factors. Model 3 additionally includes the set of local community characteristics as control factors except in the case of the production employee equation. Inclusion of these last control factors generates efficiency gains when using SUR to estimate jointly the system of equations. Given this feature, the study treats Model 3 as the primary model using Models 1 and 2 for assessing the robustness of the results.

3.7.3 Estimation Techniques

This section discusses the estimation techniques utilized to find the effects of government interventions on labor. This study uses a number of estimation techniques but treats one type of technique – the between-group estimator – as the primary technique. Still the study assesses the robustness of the results with respect to the choice of estimation technique. In other words, by employing various estimators, the analysis is able to assess the robustness of the estimates.

To identify the effects of government interventions on overall employment levels at chemical manufacturing facilities, the analysis utilizes three estimation techniques. Each estimator either addresses or exploits the panel nature of the data, which offers annual data over the three-year period between 1999 and 2001. To exploit the panel data structure, the analysis employs two standard panel data estimators: fixed effects estimation and random effects estimation. A Hausman Test of Random Effects shows that the random effects estimates are consistent ($p=0.588$). Consequently, the analysis interprets both sets of estimates. The remaining estimators merely address the panel data structure. One technique estimates the pooled data using OLS, i.e., pooled OLS, while clustering at the facility level. A second technique uses OLS to estimate separately individual year-specific cross-sections of the panel data. The final technique implements a between-group estimator by averaging each dependent and independent variable by facility across the three panel years and using OLS to estimate the functional relationship based on the set of average values.

As explained below, the study focuses on the between-group estimator. Table 3.2 reports these estimates. Appendix Tables D.1 and D.2 report, respectively, the fixed effects and random effects estimates, and pooled OLS with clustering at the facility level estimates. Moreover, the analysis downplays the year-specific estimates because certain government intervention types occur quite infrequently. For example, the EPA imposed no monetary fines against the sampled facilities in the 24-month period preceding both 1999 and 2000; thus, some specific deterrence measures lack variation.

As with overall labor, the analysis employs various techniques to estimate environmental labor and production labor. The ideal estimator both exploits the panel data structure and jointly estimates the system of equations using SUR. Random effects SUR fits these two criteria. The Stata user-written XTSUR command implements random effects SUR, however, this command does not implement fixed effects SUR.[63] This command does not facilitate the Hausman Test of Random Effects, which assesses whether or not the random effects estimates are consistent. Based on random effects estimation of the two equations separately, the Hausman Test of Random Effects statistics indicates that the random effects estimates are consistent for one of the two equations. The associated test p-values are 0.883 and 0.012 for the environmental employee and production employee equations, respectively. Consequently, the random effects estimates for production labor are admittedly inconsistent.

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[63] Because of the large number of facility-level indicators necessary to run fixed effects regression using XTSUR, the command is unable to provide fixed effects estimates at all.

To assess the robustness of the results, the study implements additional estimators that meet one of the two criteria identified for the ideal estimator. One of the alternative estimators only exploits the panel data structure: fixed effects estimation of the two regression equations separately. Other alternative estimators only jointly estimate the two regression equations using SUR while addressing the panel data structure in various ways: pooled SUR estimation, year-specific cross-section SUR estimation, and between-group SUR estimation. Of these last three estimators, the between-group SUR estimator provides the most reasonable balance; this estimator uses the panel data by exploiting the three-year averages, unlike the year-specific cross-sections, while avoiding any concern about omitted variable bias, unlike pooled SUR. Similar to the estimation of overall employees, the analysis again downplays the estimates of the year-specific cross-sections of data, as some specific deterrence measures lack sufficient variation.

The study tests cross equation hypotheses stemming from pairwise comparisons of the government intervention coefficients between the two labor-specific equations. For example, the federal inspection specific deterrence coefficient from the environmental labor equation equals its counterpart from the production labor equation, i.e., $\alpha_1 = \beta_1$. Joint estimation of the two-equation system is critical for properly testing these hypotheses when the two equations' error terms are correlated. Error term correlation implies that joint estimation is needed to address the covariance between coefficients derived from the two individual regression equations. Breusch-Pagan Tests of Residual Independence assess whether or not the error terms are correlated. As the null hypothesis, the error terms are not correlated. As shown in Table 3.3, all of the Breusch-Pagan Test statistics derived from between-group SUR estimation strongly reject the null hypothesis of uncorrelated error terms (p=0.000). As shown in Appendix Table D.5, the

Breusch-Pagan Test statistic also rejects the null hypothesis of uncorrelated error terms for the alternative joint estimator. Thus, joint estimation is warranted for the cross equation hypothesis testing.

Collectively, this assessment leads me to focus on the between-group estimator because it generates at least consistent and unbiased estimates, exploits the panel data to some extent, and facilitates proper testing of cross equation hypotheses within a SUR framework when jointly estimating the system of equations reflecting environmental labor and production labor.

Table 3.3 reports the between-group SUR estimates. Appendix Tables D.3 through D.5 report the fixed effects estimates, random effects SUR estimates, and pooled SUR estimates respectively. The year-specific cross-section SUR estimates are available upon request.

3.7.4 Results

This sub-section interprets the primary results stemming from between-group estimation. The next sub-section interprets the alternative estimation results in order to assess the robustness of the results with respect to the choice of estimator.

3.7.4.1 Overall Labor

First, this sub-section interprets the between-group estimates for overall labor, which are shown in Table 3.2. The estimated effects of government interventions on overall labor support conclusions similar to those conclusions supported by the estimated effects of environmental regulation on employment from all previous empirical analyses. The results show that, of the four types of interventions, which are split into two deterrence forms, all are statistically zero or significantly negative. These results collectively support Hypothesis H1b: government interventions either negatively affect overall employment or not at all. This support shows that, although government interventions may increase the use of environmental workers, any decrease in production workers neutralizes or dominates this increase.

Of the government interventions examined, estimation results reveal that seven of the eight types have a statistically zero effect on the number of overall workers. Federal inspections, state inspections, informal enforcement actions (in both specific and general deterrence form) and monetary penalties (for general deterrence) do not cause a facility to change its overall level of labor. The noted specific deterrence measures do not necessarily carry direct monetary consequences. Instead, these specific deterrence measures merely reflect indirect costs and an increase in the likelihood or magnitude of a future monetary sanction. Based on the estimates, managers do not meaningfully alter their chosen levels of overall employment levels in response to consequences stemming from inspections or informal enforcement. General deterrence measures reflect only increases in the threat of receiving the associated type of intervention. Based on the estimates, these threats do not prompt managers to change their chosen levels of overall employment. In stark contrast, monetary fines reflected in the specific deterrence measure directly generate costs. Not surprising, the effect of this factor on overall employment is significantly negative. Thus, when facilities must pay a monetary fine for their poor environmental performance, facilities cut labor in general.

3.7.4.2 Environmental and Production Labor

The previous results, in the case of zero employment effects, fail to provide information on whether managers respond at all when the regulating agency decides to intervene. A statistically zero effect of interventions on overall labor, as is almost exclusively the case, only shows that the overall level of employment does not change at a facility as a result of interventions. However, both the environmental management and labor effects of regulation literatures provide evidence that environmental regulation may in fact increase labor in one regard. Therefore, it is important to examine what causes the statistically negligible effects seen in the literature and in the previous sub-section.

While consistent with the previous studies on the effect of environmental regulation on labor, the estimated effects of government interventions on overall labor masks the theoretically derived countervailing effects of government interventions on the two types of labor: environmental and production. To assess these countervailing effects, this sub-section interprets the between-group SUR estimates shown in Table 3.3.

The estimation results reveal that three of the eight deterrence measures significantly affect the number of environmental employees at regulated facilities, while only one of the eight measures significantly impact the number of production employees. As mentioned, the purpose of environmental enforcement is to induce facility compliance with NPDES discharge limits through better environmental management, including an increase in the number of environmental workers. Model 3 results, shown in Table 3.3, demonstrate this point for two of the three significant interventions: federal inspections and monetary penalties in general deterrence form.

Interestingly, informal enforcement actions in the form of general deterrence decrease environmental workers. This counter-intuitive result is found in the empirical literature. Some previous empirical studies of environmental enforcement generate counter-intuitive results for general deterrence (e.g., Stafford, 2003; Earnhart, 2004b).

If facilities perceive that regulatory agencies face a fixed budget, enforcement actions taken against other similar regulated facilities actually reduce the resources available to take enforcement actions against one’s own facility. Consequently, a facility manager feels “the storm has passed” with other facilities taking the hit; accordingly, the threat of a future intervention drops, prompting the facility manager to reduce the extent of environmental management, including the use of environmental workers.

Thus, the perception of a fixed regulatory budget helps to explain the negative effect of informal enforcement-based general deterrence on environmental labor. Symmetrically, this logic explains any positive effect of informal enforcement-based general deterrence on production labor. To capture this logic, the theoretical framework could be modified to examine the perceived fine imposed on non-compliant discharges. As the perceived fine falls, due to the "passing storm", the facility chooses to reduce environmental labor and raise production labor because the relative price of marketable production rises.

This sub-section next interprets the results from estimating the dependent variable of production employees. Although the great majority of government intervention effects are statistically zero, production employee numbers see only a decrease as a result of environmental enforcement. Monetary penalties in specific deterrence form negatively affect the number of production workers. The direct extraction of monetary resources prompts managers to scale back production labor.

The preceding results support Hypothesis H2 for some but not all of the government interventions examined. As described in Section 3.4, Hypothesis H2 states that the effects on the number of environmental workers and the number of production workers after government interventions have an inverse relationship. Specifically, when assuming that an intervention results in the increased use of environmental workers in order to achieve compliance, this causes a decrease in the number of production workers. Hypothesis H2 is supported by those interventions with zero effect on either type of worker, as the need for more environmental product (i.e., compliance) does not occur, and thus, there is no need to decrease production labor.

Hypothesis H2 is also supported by those interventions where the signs for environmental and production workers are opposites, although empirical results do not show this to occur in the sample.[64] For federal inspections and monetary penalties in general deterrence form, this inverse relationship does not necessarily hold. For these interventions, the positive relationship between the two inspection types and environmental employees is expected, but this is not matched by a decrease in production employees. For these interventions, it appears as though managers feel the need for additional compliance is necessary, but the lack of a monetary component to these interventions does not compel managers to cut back on production labor. Finally, the expected negative relationship between monetary fines in specific deterrence form and production workers is not accompanied by a positive increase in environmental employees. This is caused by the extreme need of managers to decrease input costs by all means. Therefore, the need to decrease the number of production workers to meet bottom line targets is not met with the motivation to increase compliance. Additionally, monetary fines are extremely rare and severe, and their imposition may invoke a loss of manager intrinsic motivation to comply with NPDES permits.

Next, this sub-section discusses collectively the effects of environmental enforcement on overall labor and the specific types of labor. First, few forms of government interventions influence overall labor. However, empirical results show that the overall negative or zero effect on labor is quite misleading. By estimating the effects of environmental enforcement on different types of employment, the analysis finds several significant effects. First, state inspections in specific and general deterrence form, federal inspections in specific deterrence form, and

[64] Although this result is not seen for statistically significant interventions, the signs of the coefficient estimates almost exclusively represent this theoretical finding.

informal enforcement action-related specific deterrence do not affect either labor type, or overall labor. Thus, these interventions do not affect labor at all. Next, federal inspection and monetary penalty-related general deterrence positively affects environmental workers. However, these interventions have no effect on production workers or overall labor. Informal enforcement actions in general deterrence form negatively affect environmental employees, but do not affect production employees or overall employees. Finally, the negative effect of specific deterrence-related monetary fines results in a negative effect on overall facility-level employment. Together, these results show that although estimation of government interventions on overall employment shows minimal employment effects, labor effects do occur depending on the type of labor employed.

Finally, this sub-section assesses the robustness of the results presented in Tables 3.2 and 3.3 by examining the three model specifications presented. The coefficient estimates support conclusions that are robust to the choice of model specification for all government intervention measures, outside of the parsimonious model. Since the local community characteristics significantly affect the number of environmental workers, Model 3 dominates Models 1 and 2. Thus, my focus on Model 3 as the primary model seems warranted. Thus, the lack of complete robustness across the three models seems inconsequential.

3.7.5 Tests of Cross Equation Restrictions

The joint estimation of equations (3.6) and (3.7) offers the ability to test properly cross equation restrictions. This testing is important because any examination of overall labor implicitly imposes the restriction that each regressor equally affects environmental workers and production workers. This study converts these restrictions into hypotheses to test. Specifically, the analysis explores hypotheses comparing the effect of each particular government intervention on the two types of labor. With these hypotheses in mind, this sub-section tests whether or not a particular government intervention coefficient from one equation equals its counterpart from the other equation. By testing the null hypothesis that the two slope coefficients in each pair of related terms are equal, the analysis determines whether the effect of each government intervention differs between the two types of labor. For example, by testing the null hypothesis that $\alpha_3 = \beta_3$, the analysis assesses whether or not federal inspection-related general deterrence impacts environmental employees and production employees equally. Table 3.4 displays the test results. The results reveal that several pairs contain slope coefficients that statistically differ. Federal inspections, informal enforcement actions, and monetary fines in general deterrence form differently affect the two types of labor – environmental and production. These results show that managers do not take the same actions for each type of employee after receiving an intervention. For example, a federal inspection at a facility similar to one's own facility prompts a manager to increase the allocation of environmental labor, but does not cause the manager to change the allocation of production labor. These results again highlight the misleading nature of the overall labor effects of government interventions by masking the countervailing effects of government interventions on the two labor types.

Next, Table 3.5 shows the tests of cross equation restrictions of joint significance of the government interventions. Again using federal inspections in general deterrence form as an example, by testing the null hypothesis that $\alpha_3 = \beta_3 = 0$, the analysis is able to determine whether federal inspections significantly impact labor decisions at the facility in any way. Whereas a test of the coefficient in the overall labor estimation would show no significance for seven of the eight intervention measures, performing this test across the jointly estimated equations allows the analysis a deeper look at the labor decisions made by managers. Table 3.5 shows that federal inspections, informal enforcement actions, and monetary penalties in general deterrence forms reject the null hypothesis that jointly, the interventions are equal to zero. The results reveal that although the effects of government interventions on overall labor may remain unseen, there are indeed management decisions made to alter labor in various forms.

3.8 Conclusions

This study delves into the employment effects of environmental regulation, specifically its enforcement, on chemical manufacturing facilities regulated under the Clean Water Act over the years 1999 to 2001. An important and growing economic literature examines the employment effects stemming from the imposition of environmental regulation. However, this literature fails to account for the differences among employment types when examining these effects. To contribute to this literature, this study jointly estimates a system of equations to assess the effects of environmental regulation on environmental and production employees separately. Moreover, the existing literature examines only the employment effects of regulation imposition. This study further contributes by examining the enforcement of environmental regulation. The labor impacts of environmental enforcement are especially important since environmental agencies allocate considerable resources to ensure adherence with regulations after they have been imposed on facilities because regulation without adherence is useless.

Empirical results show that the overall facility-level employment effects of government interventions are almost all statistically zero. As the single exception, monetary penalties in specific deterrence form have a negative effect on overall employment. This set of findings is consistent with the literature, where all studies find a statistically negative or zero effect of regulation on employment. However, results from the joint estimation of environmental labor and production labor as separate outcomes within a system of equations show that a number of government interventions affect environmental and production labor differently.

These results offer policy implications. They support the claim that environmental regulation can indeed increase labor in one regard. Further, when regulatory agencies take enforcement action against regulated facilities, managers respond by changing the composition of the facility's workforce. The overall result is negative in one case.

While this study contributes much to the debate over environmental enforcement policy and its effects on labor, the need for future research remains. Future research should examine the allocation of labor versus that of other inputs, specifically environmental treatment capital. In addition, future studies should explore more sectors and more types of environmental media (e.g., air, hazardous waste).

Table 3.1: Sample Summary Statistics

Variables	Mean	Std. Dev.	Coef. of Variation
Dependent Variables			
Facility employees (FTE count)	259.9	480.9	1.850
Environmental employees (FTE count)	6.23	14.91	2.373
Production Employees (FTE count)	256.82	486.92	1.900
Primary Regressors			
No. federal inspections / No. other facilities per region (1-yr lag)	0.029	0.050	1.754
No. state inspections / No. other facilities per region (1-yr lag)	0.674	0.966	1.433
No. federal inspections during preceding 24-month period	0.068	0.330	4.825
No. state inspections during preceding 24-month period	1.491	2.472	1.658
No. informal enforcement actions / No. other facilities per region (1-yr lag)	0.077	0.190	2.477
Penalty amount / No. other facilities per region (1-yr lag)	73.68	366.0	4.967
No. informal enforcement actions during preceding 24-month period	0.200	1.168	5.840
Penalty amount during preceding 24-month period	127.5	3,571	28.01
Facility Characteristics			
Organic chemical manufacturing (vs. other chemicals)	0.437	0.496	1.135
Inorganic chemical manufacturing (vs. other chemicals)	0.310	0.463	1.494
Facility owned by publicly-held firm (vs. privately-held firm)	0.634	0.482	0.760
Age of facility (years)			
Economic impact of facility: significant/great (vs. small/very little)	0.710	0.454	0.639
Meeting with community leaders (vs. no meeting)	0.640	0.480	0.750
Facility's environmental concern - environmental employees: 1=lowest, 10=highest	8.896	1.331	0.150
Facility’s attitudes toward inspection effectiveness: effective (vs not effective)	0.529	0.500	0.945
Facility's attitudes toward monetary fine effectiveness: effective (vs not effective)	0.393	0.489	1.244
County-level Community Characteristics			
Per capita personal income (2002 $)	28,833.4	7518.7	0.261
Unemployment rate	4.650	1.418	0.305
Wage and salary employment (# of jobs)	291,208	560,671	1.925
Population density	866.6	1548.0	1.786

Table 3.1 (continued)

Year/Region Controls			
EPA Region 1 (0,1) [regions 8, 9, 10 omitted]	0.034	0.180	5.357
EPA Region 2 (0,1) [regions 8, 9, 10 omitted]	0.090	0.286	3.192
EPA Region 3 (0,1) [regions 8, 9, 10 omitted]	0.131	0.337	2.573
EPA Region 4 (0,1) [regions 8, 9, 10 omitted]	0.246	0.431	1.752
EPA Region 5 (0,1) [regions 8, 9, 10 omitted]	0.164	0.371	2.262
EPA Region 6 (0,1) [regions 8, 9, 10 omitted]	0.220	0.415	1.886
EPA Region 7 (0,1) [regions 8, 9, 10 omitted]	0.067	0.250	3.720

Table 3.2: Results from Between-Group Estimation of Total Facility-Level Employees

Independent Variable	Model 1	Model 2	Model 3
Primary Regressors			
No. federal inspections / No. other facilities per region (1-yr lag)	7.31	-1.24	-1.83
	(0.140)	(0.781)	(0.687)
No. state inspections / No. other facilities per region (1-yr lag)	0.235	0.235	0.215
	(0.330)	(0.338)	(0.374)
No. federal inspections during preceding 24-month period	0.102	0.106	0.120
	(0.738)	(0.578)	(0.507)
No. state inspections during preceding 24-month period	0.053	-0.037	-0.030
	(0.444)	(0.587)	(0.655)
No. informal enforcement actions (count) / No. other facilities per region (1-yr lag)	-2.95	0.394	0.519
	(0.198)	(0.891)	(0.859)
No. informal enforcement actions (count) during preceding24-month period	**-0.096**	0.034	0.028
	(0.097)	(0.603)	(0.671)
Penalty amount ($) / No. other facilities per region (1-yr lag)	**0.002**	0.0008	0.0009
	(0.018)	(0.612)	(0.596)
Penalty amount ($) during preceding 24-mth period	-0.00002	**-0.00005**	**-0.00006**
	(0.377)	**(0.000)**	**(0.000)**
Facility Controls			
Organic chemical manufacturing (vs. other chemicals)		-0.124	-0.126
		(0.518)	(0.516)
Inorganic chemical manufacturing (vs. other chemicals)		**-0.560**	**-0.526**
		(0.002)	**(0.003)**
Facility owned by publicly-held firm (vs. privately-held firm)		**0.684**	**0.674**
		(0.000)	**(0.000)**
Age of the facility (years)		**0.007**	**0.007**
		(0.022)	**(0.022)**
Economic impact of facility: significant/great (vs. small/very little)		**1.00**	**0.967**
		(0.000)	**(0.000)**
Meeting with community leaders (vs. no meeting)		**0.570**	**0.593**
		(0.000)	**(0.000)**
Facility's environmental concern - environmental employees		0.033	0.036
		(0.537)	(0.498)
Facility's attitudes toward inspection effectiveness: effective (vs. not effective)		-0.115	-0.078
		(0.521)	(0.677)
Facility's attitudes toward monetary fine effectiveness: effective (vs. not effective)		0.110	0.066
		(0.562)	(0.734)

Table 3.2 (continued)

County-Level Community Characteristics			
Per capita personal income (2002 $)			0.00002
			(0.235)
Unemployment rate			**0.177**
			(0.042)
Wage and salary employment (# of jobs)			0.0000002
			(0.113)
Population density			-0.00009
			(0.133)
Constant	**4.31**	**2.84**	1.65
	(0.000)	**(0.000)**	(0.109)
Regional indicators included	No	Yes	Yes
Number of Observations	261	240	238

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at 90% level or better ($p \leq 0.10$).
Standard errors are clustered at the facility level.

Table 3.3: Results from Between-Group Joint Estimation of Environmental and Production Employees

Independent Variable	Model 1 Env. Employees	Model 1 Prod. Employees	Model 2 Env. Employees	Model 2 Prod. Employees	Model 3 Env. Employees	Model 3 Prod. Employees
Primary Regressors						
No. federal inspections / No. other facilities per region (1-yr lag)	**12.90** **(0.023)**	4.13 (0.366)	**14.06** **(0.023)**	-6.66 (0.161)	**14.02** **(0.024)**	-6.97 (0.148)
No. state inspections / No. other facilities per region (1-yr lag)	0.123 (0.518)	0.226 (0.142)	0.084 (0.639)	0.224 (0.103)	0.034 (0.848)	0.225 (0.102)
No. federal inspections during preceding 24-month period	0.357 (0.438)	0.196 (0.598)	0.394 (0.335)	0.193 (0.538)	0.430 (0.286)	0.195 (0.534)
No. state inspections during preceding 24-month period	**0.114** **(0.091)**	0.060 (0.271)	0.019 (0.759)	-0.032 (0.511)	0.036 (0.568)	-0.032 (0.509)
No. informal enforcement actions (count) / No. other facilities per region (1-yr lag)	**-5.23** **(0.062)**	-1.587 (0.484)	**-9.21** **(0.013)**	4.14 (0.145)	**-7.94** **(0.034)**	4.27 (0.137)
No. informal enforcement actions (count) during preceding 24-month period	-0.035 (0.761)	-0.087 (0.349)	0.082 (0.418)	0.042 (0.593)	0.080 (0.425)	0.041 (0.597)
Penalty amount ($) / No. other facilities per region (1-yr lag)	**0.004** **(0.024)**	**0.002** **(0.089)**	**0.004** **(0.019)**	-0.0009 (0.557)	**0.004** **(0.052)**	-0.0009 (0.544)
Penalty amount ($) during preceding 24-mth period	0.00005 (0.811)	-0.00003 (0.523)	0.00002 (0.609)	**-0.00007** **(0.053)**	0.00001 (0.841)	**-0.00007** **(0.053)**
Facility Controls						
Organic chemical manufacturing (vs. other chemicals)			-0.060 (0.813)	-0.129 (0.508)	-0.023 (0.929)	-0.116 (0.560)
Inorganic chemical manufacturing (vs. other chemicals)			-0.344 (0.200)	**-0.596** **(0.004)**	-0.303 (0.254)	**-0.591** **(0.004)**
Facility owned by publicly-held firm (vs. privately-held firm)			**0.777** **(0.000)**	**0.609** **(0.000)**	**0.786** **(0.000)**	**0.612** **(0.000)**
Age of the facility (years)			**0.007** **(0.096)**	**0.008** **(0.013)**	0.006 (0.132)	**0.008** **(0.013)**
Economic impact of facility: significant/great (vs. small/very little)			**0.605** **(0.006)**	**1.07** **(0.000)**	**0.613** **(0.006)**	**1.06** **(0.000)**
Meeting with community leaders (vs. no meeting)			**0.937** **(0.000)**	**0.533** **(0.001)**	**0.967** **(0.000)**	**0.539** **(0.001)**
Facility's environmental concern - environmental employees			**0.184** **(0.011)**	0.021 (0.701)	**0.171** **(0.017)**	0.020 (0.719)
Facility's attitudes toward inspection effectiveness: effective (vs. not effective)			0.088 (0.677)	-0.095 (0.560)	0.079 (0.709)	-0.094 (0.566)

Table 3.3 (continued)

Facility's attitudes toward monetary fine effectiveness: effective (vs. not effective)			-0.136 (0.534)	0.112 (0.476)	-0.128 (0.561)	0.126 (0.455)
County-Level Community Characteristics						
Per capita personal income (2002 $)					0.00003 (0.126)	
Unemployment rate					**0.156** **(0.090)**	
Wage and salary employment (# of jobs)					0.00000009 (0.657)	
Population density					0.00003 (0.725)	
Constant	-0.035 (0.811)	**4.28** **(0.000)**	**-4.17** **(0.000)**	**2.81** **(0.000)**	**-5.78** **(0.000)**	**2.87** **(0.000)**
Breusch-Pagan Test of Residual Independence	**45.67** **(0.000)**		**19.11** **(0.000)**		**15.92** **(0.000)**	
Number of Observations	252	252	234	234	232	232
Regional indicators included	No	No	Yes	Yes	Yes	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at 90% level or better ($p \leq 0.10$).

Table 3.4: Test of Cross Equation Restrictions: Test of Equal Slopes

Government Intervention	χ^2	p-value
Specific Deterrence		
Federal inspections	0.28	0.596
State inspections	0.98	0.323
Informal enforcement actions	0.12	0.723
Monetary fines ($)	2.39	0.122
General Deterrence		
Federal inspections	**9.56**	**0.002**
State inspections	0.96	0.326
Informal enforcement actions	**8.94**	**0.003**
Monetary fines ($)	**4.87**	**0.027**

Table 3.5: Test of Cross Equation Restrictions: Joint Significance Test

Government Intervention	χ^2	p-value
Specific Deterrence		
Federal inspections	1.26	0.531
State inspections	1.03	0.598
Informal enforcement actions	0.75	0.688
Monetary fines ($)	4.26	0.119
General Deterrence		
Federal inspections	**9.56**	**0.008**
State inspections	2.73	0.255
Informal enforcement actions	**8.95**	**0.011**
Monetary fines ($)	**5.09**	**0.079**

Notes:
Tests performed after between-group joint estimation of environmental employees and production employees - specification equations 3.6 and 3.7, results in Table 3.3.
Bold text identifies tests that significantly reject the null hypothesis at the 90% level or better ($p \leq 0.10$).

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Appendix A: Robustness Checks – Chapter 1

Table A.1: Results from Panel Estimation of Log-Environmental Employee Person-Month Count by Geographic Location

Independent Variable	Eastern facilities	Western facilities
No. federal inspections / No. other facilities by region (1-yr lag)	-0.490 (0.259)	-0.702 (0.116)
No. state inspections / No. other facilities by state (1-yr lag)	-0.0290 (0.329)	-0.0149 (0.294)
No. federal inspections during preceding 24-month period	-0.144 (0.104)	0.0043 (0.847)
No. state inspections during preceding 24-month period	0.0120 (0.510)	0.00116 (0.859)
No. informal enforcement actions / No. other facilities per region (1-yr lag)	0.215 (0.165)	-0.0693 (0.424)
Penalty amount / No. other facilities per region (1-yr lag)	-0.00054 (0.853)	-0.00005 (0.151)
No. informal enforcement actions during preceding 24-month period	**0.114** **(0.000)**	**-0.0191** **(0.044)**
Penalty amount during preceding 24-month period	**-0.000138** **(0.050)**	**-0.000003** **(0.000)**
Constant	**2.835** **(0.000)**	**2.528** **(0.000)**
Observations	359	350
Facility indicators included	Yes	Yes
Year indicators included	Yes	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at the 10 % level or better ($p \leq 0.10$).
Standard errors are clustered at the facility level.

Table A.2: Results from Panel Estimation of Log-Environmental Employee Person-Month Count by NPDES Facility Classification

Independent Variable	Minor facilities	Major facilities
No. federal inspections / No. other facilities by region (1-yr lag)	-0.721 (0.514)	-0.481 (0.146)
No. state inspections / No. other facilities by state (1-yr lag)	0.0206 (0.545)	-0.0302 (0.209)
No. federal inspections during preceding 24-month period	0.0678 (0.224)	-0.0359 (0.269)
No. state inspections during preceding 24-month period	0.0039 (0.790)	0.0123 (0.119)
No. informal enforcement actions / No. other facilities by region (1-yr lag)	0.443 (0.512)	0.0305 (0.801)
Penalty amount / No. other facilities by region (1-yr lag)	-0.00052 (0.958)	-0.00003 (0.460)
No. informal enforcement actions during preceding 24-month period		**-0.0198** **(0.036)**
Penalty amount during preceding 24-month period	**-0.000172** **(0.031)**	**-0.000002** **(0.007)**
Constant	**2.213** **(0.000)**	**3.481** **(0.000)**
Observations	428	281
Facility indicators included	Yes	Yes
Year indicators included	Yes	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at the 10 % level or better ($p \leq 0.10$).
Standard errors are clustered at the facility level.

Appendix B: First-Stage Estimation of Regulatory Approach Index – Chapter 2

Table B.1: First Stage Estimation of Regulatory Approach Index

Independent Variable	Coefficient
State primacy (time in days)	**0.006** **(0.000)**
State primacy (vs. none)	**-1.522** **(0.000)**
Major facility classification (vs. minor facility)	-0.252 (0.247)
Organic chemical manufacturing (vs. other chemicals)	0.196 (0.171)
Inorganic chemical manufacturing (vs. other chemicals)	-0.161 (0.378)
Facility employees (count)	**0.0002** **(0.009)**
Facility owned by publicly-held firm (vs. privately-held firm)	0.0899 (0.568)
Economic impact of facility: significant/great (vs. small/very little)	0.0557 (0.681)
Facility's attitudes toward inspection effectiveness: effective (vs. not effective)	0.183 (0.197)
Facility's attitudes toward monetary fine effectiveness: effective (vs. not effective)	-0.122 (0.463)
Facility's environmental concern - environmental employees	-0.027 (0.523)
Facility's environmental concern - all employees	**0.099** **(0.029)**
No. federal inspections / No. other facilities per region (1-yr lag)	**2.112** **(0.078)**
No. state inspections / No. other facilities per region (1-yr lag)	-0.041 (0.275)
No. federal inspections during preceding 24-month period	0.014 (0.926)
No. state inspections during preceding 24-month period	0.028 (0.179)
No. informal enforcement actions (count) / No. other facilities per region (1-yr lag)	0.124 (0.695)

Table B.1 (continued)

Penalty amount ($) / No. other facilities per region (1-yr lag)	-0.000004
	(0.920)
No. informal enforcement actions (count) during preceding 24-month period	0.018
	(0.462)
Penalty amount ($) during preceding 24-mth period	0.000003
	(0.557)
Constant	**4.673**
	(0.000)
Partial F-test of Relevant Instruments – primacy (0, 1)	**28.11**
	(0.000)
Year indicators included	Yes
Regional indicators included	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at 90% level or better ($p \leq 0.10$).
Standard errors are clustered at the state level.

Appendix C: Derivation of Results for Hypothesis H2 – Chapter 3

To solve the firm's maximization problem, I assume homogeneity of the environmental product created among firms. Thus, all firms choose to achieve compliance at the level of $\bar{E}$, and *b* in the maximization problem is set to one. Further, since *p* is the price of the good, this value must be > 0.

$$max\ \Pi = p * ln\ (L) - L^2 - 2LE - E^2$$

$$\frac{\partial \Pi}{\partial L} = \frac{p}{L} - 2L - 2E = 0$$

$$0 = 2L^2 + 2EL - p$$

$$L = \frac{-2E \pm \sqrt{4E^2 - 8\mathrm{p}}}{4}$$

Appendix D: Alternate Estimation Tables – Chapter 3

Table D.1: Results from Panel Estimation of Total Facility-Level Employees

Independent Variable	Model 1 Fixed Effects	Model 2 Random Effects
Primary Regressors		
No. federal inspections / No. other facilities per region (1-yr lag)	-0.246	-0.210
	(0.256)	(0.331)
No. state inspections / No. other facilities per region (1-yr lag)	-0.004	-0.002
	(0.655)	(0.790)
No. federal inspections during preceding 24-month period	-0.063	-0.051
	(0.271)	(0.370)
No. state inspections during preceding 24-month period	-0.003	-0.002
	(0.475)	(0.690)
No. informal enforcement actions (count) / No. other facilities per region (1-yr lag)	-0.014	-0.024
	(0.790)	(0.664)
No. informal enforcement actions (count) during preceding 24-month period	**-0.033**	-0.030
	(0.090)	(0.119)
Penalty amount ($) / No. other facilities per region (1-yr lag)	-0.00001	-0.00001
	(0.473)	(0.492)
Penalty amount ($) during preceding 24-mth period	**0.000003**	**0.000003**
	(0.018)	**(0.035)**
Constant	**6.04**	**2.07**
	(0.000)	**(0.000)**
Number of Observations	708	708
Facility controls included	Yes	Yes
Year indicators included	Yes	Yes
Regional indicators included	No	Yes
Facility indicators included	Yes	No

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at 90% level or better ($p \leq 0.10$).
Standard errors are clustered at the facility level.

Table D.2: Results from OLS Estimation of Total Facility-level Employees (Pooled Data)

Independent Variable	Coefficient
Primary Regressors	
No. federal inspections / No. other facilities per region (1-yr lag)	-0.574 (0.692)
No. state inspections / No. other facilities per region (1-yr lag)	0.121 (0.310)
No. federal inspections during preceding 24-month period	-0.028 (0.791)
No. state inspections during preceding 24-month period	-0.005 (0.889)
No. informal enforcement actions (count) / No. other facilities per region (1-yr lag)	**0.538** **(0.063)**
No. informal enforcement actions (count) during preceding24-month period	0.046 (0.364)
Penalty amount ($) / No. other facilities per region (1-yr lag)	**0.00008** **(0.095)**
Penalty amount ($) during preceding 24-mth period	**-0.00002** **(0.000)**
Constant	**2.76** **(0.000)**
Number of Observations	708
Facilities controls included	Yes
Regional indicators included	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at 90% level or better ($p \leq 0.10$).
Standard errors are clustered at the facility level.

Table D.3: Results from Separate Panel Estimations of Environmental and Production Employees

Independent Variable	Dependent Variable: Environmental Employees	Dependent Variable: Production Employees
Primary Regressors		
No. federal inspections / No. other facilities per region (1-yr lag)	**-0.652**	-0.253
	(0.025)	(0.279)
No. state inspections / No. other facilities per region (1-yr lag)	-0.022	-0.007
	(0.189)	(0.466)
No. federal inspections during preceding 24-month period	-0.043	-0.067
	(0.265)	(0.255)
No. state inspections during preceding 24-month period	0.007	-0.003
	(0.372)	(0.504)
No. informal enforcement actions (count) / No. other facilities per region (1-yr lag)	0.024	-0.006
	(0.792)	(0.919)
No. informal enforcement actions (count) during preceding 24-month period	**-0.022**	-0.032
	(0.022)	(0.105)
Penalty amount ($) / No. other facilities per region (1-yr lag)	**-0.00006**	-0.00001
	(0.084)	(0.554)
Penalty amount ($) during preceding 24-mth period	**-0.000002**	**0.000004**
	(0.024)	**(0.003)**
Constant	-0.558	**6.01**
	(0.408)	**(0.000)**
Number of Observations	679	679
Facility controls included	Yes	Yes
Year indicators included	Yes	Yes
Facility indicators included	Yes	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at 90% level or better ($p \leq 0.10$).
Standard errors are clustered at the facility level.

Table D.4: Results from Joint Random Effects Estimation of Environmental and Production Employees

Independent Variable	Dependent Variable Environmental Employees	 Production Employees
Primary Regressors		
No. federal inspections / No. other facilities per region (1-yr lag)	0.983 (0.334)	-0.625 (0.390)
No. state inspections / No. other facilities per region (1-yr lag)	0.031 (0.495)	-0.043 (0.193)
No. federal inspections during preceding 24-month period	0.139 (0.136)	0.025 (0.708)
No. state inspections during preceding 24-month period	0.021 (0.223)	**-0.050** **(0.000)**
No. informal enforcement actions (count) / No. other facilities per region (1-yr lag)	0.077 (0.784)	0.192 (0.339)
No. informal enforcement actions (count) during preceding 24-month period	**0.049** **(0.096)**	-0.005 (0.814)
Penalty amount ($) / No. other facilities per region (1-yr lag)	**0.0002** **(0.030)**	**0.0001** **(0.043)**
Penalty amount ($) during preceding 24-mth period	-0.000007 (0.326)	-0.000005 (0.375)
Number of Observations	673	682
Facility controls included	Yes	Yes
Community characteristic controls included	Yes	No
Regional indicators included	Yes	Yes
Year indicators included	Yes	Yes
Facility indicators included	No	No

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at 90% level or better ($p \leq 0.10$).
To perform the random effects regressions, the "xtsur" command was used in Stata.

Table D.5: Results from Joint Estimation of Environmental and Production Employees

(Pooled Data)

Independent Variable	Dependent Variable Environmental Employees	 Production Employees
Primary Regressors		
No. federal inspections / No. other facilities per region (1-yr lag)	2.50 (0.150)	-1.30 (0.329)
No. state inspections / No. other facilities per region (1-yr lag)	-0.037 (0.629)	**0.115** **(0.051)**
No. federal inspections during preceding 24-month period	**0.328** **(0.053)**	0.026 (0.842)
No. state inspections during preceding 24-month period	0.032 (0.275)	**-0.007** **(0.770)**
No. informal enforcement actions (count) / No. other facilities per region (1-yr lag)	-0.342 (0.511)	**0.851** **(0.041)**
No. informal enforcement actions (count) during preceding 24-month period	**0.094** **(0.047)**	0.040 (0.276)
Penalty amount ($) / No. other facilities per region (1-yr lag)	0.00002 (0.888)	0.0001 (0.410)
Penalty amount ($) during preceding 24-mth period	-0.00001 (0.483)	**-0.00002** **(0.098)**
Constant	**-5.33** **(0.000)**	**2.76** **(0.000)**
Breusch-Pagan Test of Residual Independence	**40.17** **(0.000)**	
Number of Observations	673	673
Facility controls included	Yes	Yes
Community characteristic controls included	Yes	No
Regional indicators included	Yes	Yes

Notes:
p-values are shown in parentheses.
Bold text identifies coefficients that are significant at 90% level or better ($p \leq 0.10$).