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ENFORCEMENT OF POLLUTION REGULATIONS IN A DECLINING INDUSTRY

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Abstract

A regulatory agency enforcing compliance in a declining industry might recognize that certain plants would close rather than comply, and that these closings would impose large costs on the local community. EPA enforcement activity in the U.S. steel industry is examined for evidence of this result. A three-equation system linking EPA enforcement decisions, company plant-closing decisions, and company compliance decisions is estimated. The results indicate that the EPA directed fewer enforcement actions toward plants with a high predicted probability of closing and plants that were major employers in their community; also, plants predicted to face relatively heavy enforcement were more likely to close.

I. Introduction

Critics of U.S. pollution-control policies frequently complain that the government pursues the benefits of reduced pollution without fully considering 'the costs. While much attention has focused on the inefficiency of the EPA's technology-based regulations, which ignore the potential cost savings of allowing firms to equalize marginal abatement costs,[1] a more politically explosive issue concerns the potential trade-offs between pollution control and jobs. A firm's decision to curtail or discontinue operations at a plant can impose substantial adjustment costs on the local community, including lost taxes and reduced income for local residents. A regulator might consider these costs as part of the total cost of pollution reduction, and allocate enforcement efforts so as to reduce these costs to local communities.[2]

In this paper, we examine EPA activity at U.S. steel plants during the years 1977-1986 for evidence that the EPA's enforcement activity was responsive to measures of the possible economic disruption from plant closings.[3] During this period, the EPA faced the problem of enforcing new, higher air-quality standards on an industry that was a major polluter, but was also undergoing severe contraction. We estimate a simultaneous system of EPA enforcement decisions and company plant-closing decisions to test the hypothesis that the EPA directed less enforcement activity toward plants that were likely to close, or that were located where a closing would generate higher-than-average adjustment costs.

We model the regulator as wishing to reduce steel industry pollution at minimum cost, including local adjustment costs. Expected local adjustment costs depend on the probability that the plant will close, and on the amount of local disruption that will occur if the plant does close.· Firms, in turn, must decide which plants to close during the contraction, and they include their prediction of future enforcement activity by the EPA in their assessments of future plant profits.

We round out the system with a third equation modeling company decisions about whether to comply with pollution regulations at a plant, because several researchers have found a relationship between enforcement and compliance.[4] We follow Bartel and Thomas (1985) by including an equation for this decision, though in our case a firm's decision to comply is likely to be subordinate to its decision about whether to close the plant.

We estimate our three-equation model using data on 49 plants, which together represented virtually all the capacity of the U.S. integrated steel industry in 1976.[5] The steel industry has several characteristics that increase the likelihood of observing EPA sensitivity to potential adjustment costs. First, the industry produces a great deal of pollution, forcing the EPA to take some action toward it.[6] Second, the industry contracted sharply during the test period: of the 49 plants in our sample, 21 closed by 1987. Third, steel plants employ large amounts of workers, increasing local adjustment costs.

In Section II we discuss the model of EPA activity and company plant-closing and compliance decisions. We explain the econometric specification used in Section III, and give a brief description of the data set in Section IV. The results are discussed in Section V, and Section VI is the conclusion.

II. Model

Assume that new anti-pollution legislation raising air-quality standards is enacted. Assume further that one of the major polluters is an industry that is contracting because of declining demand. We first discuss the EPA enforcement decision in this situation, and then company plant-closing and compliance decisions.

The Enforcement Decision

We assume the regulator maximizes net marginal social benefit, and thus that enforcement activity is a function of the benefits and costs of pollution control. The social benefit of regulating air pollution at steel plants comes from reducing the pollution they produce. Thus, other things being equal, regulators will create more social benefit by enforcing compliance at plants emitting higher levels of pollution.

This benefit will vary from place to place, however, depending on local conditions: other things being equal, the benefit from reducing pollution will be greater in a more heavily polluted area. Further, the benefits from enforcement at a plant will also vary according to whether the plant is already in compliance. The return on additional enforcement pressure will be lower at those plants already in compliance, or those more likely to be brought into compliance.

We model the total social cost of pollution enforcement in two parts. The first part consists of the cost to firms, in extra investment, increased operating costs, and reduced productivity, of complying with regulations.[7] As previous authors have noted, the net social benefit of pollution control is maximized if the EPA enforces regulations so as to equalize marginal abatement costs.

The second part of the total social cost is the adjustment cost experienced by the local community if a plant closes rather than comply with

EPA regulations. When plants close, society loses the labor hours of unemployed workers, their unemployment insurance payments, and the resources required by local communities to adjust (downward) the provision of such services as police and fire protection.[8] If regulatory enforcement behavior might lead to some plant closings, regulators might direct their enforcement toward plants for which the social cost of closing is lower.9

In summary, the regulatory agency enforces compliance across plants so as to maximize the difference between the benefits and costs of pollution reduction. The benefits of enforcing pollution regulations depend on the amount of pollution plants produce, on the probability that they will be brought into compliance, and on local pollution levels. The costs of enforcement depend on the adjustment costs of local communities associated with a plant closing, as well as on the increase in company production costs.

The Plant-Closing Decision

The challenge to firms in a declining industry is to minimize their losses by closing those plants with the lowest expected net revenues. Thus, plants with the lowest expected revenue and the highest expected production costs, as as well as the oldest capital stock, should be closed.[10]

However, a firm must also consider the cost of complying with pollution regulations when ranking plants by expected net revenues. The cost of bringing a plant into full compliance will depend on the type of machinery already in place at the plant. The higher this cost, the lower the expected net revenues that will be earned by the plant, making a firm more likely to close it.

The expected compliance cost also depends on the level of enforcement that a firm expects to encounter at each plant. Other things being equal, plants expected to face more enforcement pressure will need to spend more for pollution control. Plants facing higher expected enforcement activity will have higher expected compliance costs, and thus lower expected net revenues; such plants are more likely to close.

Similarly, firms will be less likely to close plants that are already in compliance or easy to bring into compliance, perhaps because of past investment decisions or because of differences in local county regulations. Therefore, ceteris paribus, the probability of a plant being in compliance should be inversely related to the probability of a plant being closed. Thus, firms minimize their losses by closing plants with the lowest expected net revenues, the oldest capital, the highest expected compliance costs, and the lowest probability of being in compliance. Firms are more likely to close plants where more enforcement is expected to occur, since enforcement is likely to raise compliance costs.

The Compliance Decision

In a declining industry, a firm's decision as to whether to bring a plant into full compliance may well be subsidiary to its decision about whether to close the plant. Nevertheless, we include a third equation in the model because, as stated above, enforcement decisions are likely to be influenced by whether a plant is in compliance or being brought into compliance in a timely manner. In turn, compliance may well be affected by expected enforcement, particularly among plants that will remain open. Other things being equal, a greater degree of compliance should be observed in plants expected to encounter more enforcement pressure.

A firm's decision about whether to bring a plant into compliance is closely tied to the firm's plant-closing decision: the cost of compliance, measured in dollars per ton of steel shipped, will be much higher for a plant that will soon close, giving a firm little incentive to bring it into compliance before shutting it down. Thus, we include the plant-closing decision as a determinant of the compliance decision, and expect that, other things being equal, we will observe less compliance at plants more likely to close.

Finally, holding expected enforcement constant, a firm's decision will also be affected by the expenditure required to bring a plant into full compliance. Compliance costs will vary across plants if each plant requires different control equipment, or if productivity losses differ. Ceteris paribus, a plant with higher compliance costs is less likely to be brought into compliance than one with lower costs.

Therefore, the firm's compliance decision depends on expected enforcement, on the probability of the plant closing, and on the amount of expenditure that would be necessary to bring the plant into full compliance.

III. Econometric Specification

We have developed a system with three endogenous variables:[8] EPA enforcement at a plant, the owning firm's decision whether to close the plant, and the firm's decision whether to bring the plant into compliance. These decisions are linked in our model for three reasons. First, enforcement at a plant depends on the probability that its owning firm will close the plant, and on the probability that it will bring the plant into compliance. Second, the probability of a plant being closed depends on the expected level of enforcement and on the ease with which the plant can be brought into compliance. Third, compliance depends on whether the plant is likely to be closed and on the expected enforcement faced by the plant.

We estimate the system using a two-stage, instrumental variables method, instead of a more efficient full-information, maximum-likelihood estimator, because the enforcement equation has a continuous dependent variable and is estimated with panel data, while the other two equations have dichotomous dependent variables and are estimated with cross-section data. We use the first-stage equations to generate predicted values for each decision, and then use the predicted values as instruments in the second-stage (structural) equations. In the first-stage estimations, the plant closing and compliance probabilities are estimated using logit models, while an ordinary regression model is used for the enforcement decision. All equations include a number of variables that are fixed for each plant: its location, product mix, size, the age of its capital in 1976, the amount of emissions it produces, and the cost of bringing the plant into full compliance. All equations also include the plant's employment relative to the size of its local labor market, which is measured in 1976 for the cross-sectional equations, and annually for the panel. The enforcement equation also includes year dummies and local unemployment rates.11

Two final adjustments are required to generate a full set of instruments for the second-stage equations. First, compliance data were unavailable for four plants. We estimate the first-stage compliance equation using the 45 plants for which we have compliance data, and use those coefficients to generate predicted compliance for all 49 plants.

Second, when a firm decides to close a plant, no more enforcement is directed toward that plant, potentially skewing the enforcement measure in the plant-closing and compliance equations. Also, the information about enforcement over time must be compressed into a single number for the cross-section estimations. We use the estimated enforcement equation to predict the log of enforcement in all years for every plant, including those that closed during the sample period, and use the sum of the predicted logs of enforcement.

The first-stage estimations, and the additional adjustments, yield the instruments: PCLOSE, the predicted probability of closing; PCOMPLY, the predicted probability of compliance; and PLENFSUM, the sum of the predicted logs of enforcement activity. We now discuss the structural equations in which these variables are used.

Enforcement

We use the following specification for the enforcement equation:

(1) $LENF_{i,t} = f(LEMIT_i, ATTAIN_i, PCOMPLY_i, PCLOSE_i, LRELEMP_{i,t}, CNTYU_{i,t}, COMPCAP_i, \text{YEAR dummies}, \text{STATE dummies}),$

where i indexes plants and t indexes time. The dependent variable, LENF, is the log of the number of enforcement actions directed toward the plant each year by agencies regulating air pollution.[12]

We have three measures of the benefits from enforcement. LEMIT is the log of the tons of pollutants emitted by a plant, reflecting the potential benefits from enforcement at the plant. ATTAIN is a dummy variable indicating that the plant is located in an area that has already met its air-quality standards; it controls for the lower marginal social benefit of reducing pollution in such areas. PCOMPLY, the predicted probability that the plant will be in compliance, indicates whether further enforcement is likely to induce additional compliance. We expect the coefficient on LEMIT to be positive, with the other two negative.

We use four variables to measure the cost of the compliance that enforcement is designed to produce. Three variables model the potential local adjustment costs that are the focus of this paper: PCLOSE is the predicted probability that the plant will close sometime during the sample period, indicating whether the plant is "near the borderline" of being closed; LRELEMP is the log of the ratio of employment at the plant to employment in the local labor market; and CNTYU, the local area unemployment rate, captures the difficulty that laid-off workers might have in finding their next job. We add a fourth variable, COMPCAP, the cost (per ton of capacity) of bringing the plant into full compliance, to control for the compliance costs paid directly by the firm. All four variables are expected to have negative coefficients.

Finally, the enforcement effort directed toward a particular plant depends on the total amount of enforcement being carried out (or at least being recorded) during each year in each state.[13] Equation (1) controls for variation in regulation over time and across states with YEAR and STATE dummies. But, with data on only 45 plants in 15 states, the state dummies could greatly reduce the explanatory power of the other plant-specific variables. As an alternative, we re-estimate equation (1), replacing the STATE dummies with a single variable, LSTATEAV, which measures the total enforcement done in a state during a year. This has the advantage of picking up changes in enforcement within each state over time as well as controlling for variation across states.

Plant Closing

To estimate the probability that a plant will close, we start with the model of steel company plant-closing decisions from Deily (1988), in which the expected net revenue of a steel plant depends solely on its individual characteristics.[14] We augment this model with a more detailed consideration of the regulatory environment, using the following specification:

$$(2)\quad CLOSE_i = f(COAST_i,\ SHAPES_i,\ LCAPNEW_i,\ LCAP_i,\ COMPCAP_i,\ PLENFSUM_i,\ PCOMPLY_i),$$

where i indexes plants. The dependent variable, CLOSE, is dichotomous, equalling one for those plants that closed by the end of 1987, and zero for those that remained open.

The first two variables are proxies for a plant's expected long-run revenues, based on the competition faced by the plant. COAST is a dummy variable indicating plants that are located on the coast, facing more import competition. SHAPES measures the percent of a plant's product mix comprised of products also made by minimills, another source of competition. The coefficients of both variables should be positive.

The variable LCAPNEW, the percentage of a plant's capacity that is new, controls for variation among plants in age of capital stock. LCAP, the annual steel producing capacity of the plant, controls for scale economies in steel production. The coefficients of both variables should be negative.

The final three variables are related to the costs the plant will face in complying with EPA regulations. COMPCAP, the cost of fully complying with pollution regulations, controls for variation in potential expenditures for pollution control. PLENFSUM, the sum of predicted logs of enforcement for the plant, measures the pressure to comply that the plant is expected to face. PCOMPLY is the predicted probability of the plant being in compliance. The coefficient on PCOMPLY should be negative, while COMPCAP and PLENFSUM should have positive coefficients.

Compliance

The third equation is the firm's decision about whether to bring a plant into compliance, and is specified as follows:

(3) $$COMPLY_i = f(PLENFSUM_i, PCLOSE_i, COMPCAP_i, LCAP_i).$$

The dependent variable, COMPLY, is a dummy measuring whether the plant has been brought into full compliance.

PLENFSUM, the sum of expected enforcement activity directed toward the plant during the sample period, indicates the pressures on the plant to comply. PCLOSE, the predicted probability that the plant will close, reflects the willingness of the firm to invest in compliance at the plant. COMPCAP is included to capture the cost of coming into compliance. Finally, LCAP, the capacity of a plant, is included to control for any scale economies in pollution control that may exist. The coefficients of PLENFSUM and LCAP are expected to be positive, while the others should be negative.

IV. Data

The basic cross-section sample consists of 49 steelmaking plants owned by the integrated producers listed by the Institute for Iron and Steel Studies (IISS, 1977), plus the Portsmouth, Ohio, plant of Cyclops.[15] In this section, we first describe the data used for the three endogenous variables, and then the data used for the ten exogenous variables.

Data on plant-level enforcement activity comes from the EPA's Compliance Data System (CDS).[16] The EPA uses the CDS to track enforcement actions and compliance status for major sources of pollution.[17] The CDS data include all enforcement actions directed toward the plant, and the number of actions directed toward the plant during a particular year is the principle measure of enforcement activity.18

We used two versions of the CDS as sources, one from early 1983 and the other from early 1987. The earlier data set is needed because plants are sometimes removed from the CDS after they close; several plants would have had to be dropped from the sample if only the later CDS data had been used. Of the 49 plants in the sample, only three are not found on either data set (two were closed in 1976, the other in 1978).

We also used the CDS data to develop the compliance measure, since each CDS contains a history of the compliance status of the plant over the previous eight quarters. Unfortunately for our purposes, we do not observe a well-defined, permanent decision to comply. Plants can come into compliance either by cutting emissions or by agreeing to a plan to cut emissions in the future. This leads to substantial movement in and out of compliance each quarter, as plants fail to meet previous compliance agreements and renegotiate new ones. We take the earliest year of compliance data available, 1981, and consider a plant to be out of compliance if it was out of compliance for two or more quarters of that year.[19] In all, 16 of 45 plants, representing 36 percent of the sample, were in compliance in 1981.

We defined a plant as "closed" when its steelmaking furnaces were shut down. In addition, three plants that experienced capacity reductions of over 65 percent were also included as closed plants. In all, 21 plants, representing 43 percent of the sample, closed during the period.

Necessary data for the exogenous variables include information about a plant's emissions, whether it is located in an attainment area, the cost of bringing it into compliance, the average level of enforcement in the state where the plant is located, plant employment relative to local employment, local unemployment, plant location, product mix, size, and the age of its capital stock. We discuss the data used in that order.

The National Emissions Data System (NEDS) is used by the EPA to track pollutant emissions by major stationary sources of air pollution. As with the CDS data, we use two versions of the NEDS, the end-of-year tapes from 1981 and 1985, so that information on those plants that were taken off the system before 1985 because of closing would be included. Again, all but three plants in the sample are on at least one of the NEDS data sets (the missing plants closed in 1976, 1978 and 1979).

The two NEDS data sets include the amount of a plant's emissions of five major pollutants, three of which were regularly present for steel plants (particulates, sulfur dioxide, and nitrogen oxides). The CDS data sets also contain emissions data on these pollutants, giving us up to four possible measures of plant-level emissions for each pollutant.

Three or four emission values for each pollutant were available for most plants. Since these values varied substantially across the four data sets, we selected the median of the available values for each pollutant, which gave us three measures of emissions at each plant. The three different pollutants had similar magnitudes. Consequently, for want of a better way of combining them, we summed up the three values to get a single measure of the pollution generated by the plant.[20]

The 1986 CDS indicates whether a plant is in an air quality control region that is attaining its standards for each of the major air pollutants. Because, according to the database, these standards are rarely achieved, we say that a plant is located in an "attainment" area if the area is attaining the standards for any of the three major pollutants. Even so, only seven plants were located in an attainment area.

The cost of full compliance is calculated for each plant using estimates in Temple, Barker and Sloane (1982) of the total cost to the industry of bringing each major piece of equipment into full compliance by 1984.[21] For each type of equipment, we took the total expected capital cost through 1985, and divided it by the gross capacity expected to exist in 1985 to get a cost-per-unit annual capacity.

Next, we collected data on the actual equipment in each plant, circa 1976, and its capacity (as near to 1976 as was possible to obtain). The cost of full compliance for a plant was then calculated as the cost per ton of capacity times annual capacity, summed over the different pieces of equipment in each plant, to get a figure of the required expenditure in millions of 1980 dollars. This last figure was then divided by plant capacity in 1976 to get compliance cost per ton of plant capacity.

Average state-level enforcement rates were calculated from the CDS data as the total number of enforcement actions in the state, minus the number of enforcement actions directed toward the particular plant, divided by the number of all other plants on the CDS for that state.

Information on the local labor market comes from the Bureau of Labor Statistics publication, Employment and Unemployment in States and Local Areas, in annual editions from 1976-1986. Labor market tightness is measured by the unemployment rate in the county where the plant is located.[22] The size of the local labor market is measured by the number of people employed in the county.

Employment at the plant is taken from the 1975-1976, 1979-1980 and 1981-1982 issues of Marketine Economics. Kev Plants. The numbers in an issue were assumed to refer to the first year of the issue (i.e., 1975, 1979 and 1981), and the remaining years of the sample were interpolated, with the 1981 value used for 1981-86.

Plants located on or near the East, West or Gulf coasts have a value of one for the dummy variable COAST; all others have a value of zero. The variable, SHAPES, is the percentage of hot-rolled capacity for producing plates, structural shapes and pilings, or hot-rolled bars and bar shapes. The hot-rolling capacity data is from the early 1960s, the last time that detailed product data were published. A plant's size is its annual raw-steel capacity in 1976 (IISS, 1977; IISS, 1979).

The percentage of new (post-1959) capacity in each of four major departments (coke-making, blast furnace, steel furnace, and primary rolling/continuous casting) was calculated, and the sum was divided by the number of these departments the plant operated. Thus, the figure is the percent of the plant that is "new," adjusted for the number of departments within the plant and for the amount of replacement within a department.

Table 1 presents the means and variances of the data used for each independent variable, for the three dependent variables of the first-stage estimations, and for the three instruments PCLOSE, PCOMPLY, and PLENFSUM.

V. Results

The results of the first-stage estimations are shown in Table 2. The enforcement equation does well, with several significant variables explaining over 45 percent of the variance in (the log of) enforcement actions. The plant-closing equation also does well, with several variables contributing to correctly predict 82 percent of the plant-closing decisions. The compliance equation is disappointing, however, with no significant coefficients and little explanatory power. This is probably because of the problems with consistently measuring compliance described earlier.

The second-stage equations are presented in tables 3 and 4. In general, the interactions between the decisions are as expected, although some of the exogenous variables offer significant surprises. We first discuss the enforcement equation estimations reported in table 3. The estimation in column 1 includes 14 state dummies to control for variation in state-level regulatory behavior, while the estimation in column 2 replaces the dummies with the variable LSTATEAV. The estimations are quite similar, but we prefer the more parsimonious model 2, and refer to its results in the following discussion.

Turning to the main thesis of the paper, we find evidence that enforcement behavior is indeed influenced by potential adjustment costs to local communities. The coefficient of PCLOSE is negative and significant; enforcement activity drops by 5 percent for each 10-percentage-point increase in the probability of closing. Further, the coefficient of the variable LRELEMP is also negative and significant, indicating that a 10 percent increase in employment size relative to the community work force decreases enforcement actions by 2.2 percent.

The sign of the third variable included to capture variation in potential adjustment costs, CNTYU, has an estimated coefficient that is positive and significant. This indicates that plants in countries with high unemployment receive more enforcement actions, rather than less as we expected. We investigate this result further by adding an interaction term, PCLOSE*CNTYU, to the enforcement equation, and re-estimating (column 3). The coefficient on the interacted term is negative and significant, while the coefficient of PCLOSE becomes positive and significant, indicating that the plant-closing effects on enforcement decisions are concentrated in counties with high unemployment.

Regulators seem to be "skewing" their enforcement more in these counties than in other areas, with greater enforcement on average, but much less for the plants that are in danger of closing. Specifically, increases in county unemployment'reduce enforcement activity when the probability of a plant's closing exceeds 89 percent. Stated differently, increases in the probability of closing reduce enforcement activity only when county unemployment exceeds 7.2 percent.

There are several possible explanations for this result. If areas with a high rate of unemployment are also high population areas, then the public-good nature of air pollution control may increase the benefits from reducing emissions in such areas relative to less populous locations. In addition, it is likely that more variation in pollution levels exists than we control for with the variable ATTAIN. If areas of high unemployment are also the most polluted areas (e.g., the "rust belt"), then again the benefits of pollution reduction would be greater relative to other areas.[23]

The other variables in the enforcement equation hold few surprises. Of the variables that proxy expected benefits of enforcement, the coefficient on LEMIT is positive and always significant, indicating that a plant producing 10 percent more emissions will receive 2.1 percent more enforcement activity. The coefficients of ATTAIN and PCOMPLY are negative as expected, but not significant. COMPCAP's negative coefficients, though insignificant, support the perception that regulators pay little attention to abatement costs. LSTATEAV's coefficient is significant and close to one, indicating it measures overall shifts in enforcement affecting all plants proportionally.

Estimation results for the plant-closing equation, presented in column 1 on table 4, reveal that firms are more likely to close plants that are expected to face more enforcement in the future: the estimated coefficient on PLENFSUM, which is positive and significant, indicates that a 10 percent increase in the enforcement index increases the probability of closing by 4.3 percentage points. Thus, regulatory activity does seem to affect which plants are closed.

The coefficient on the variable PCOMPLY is also negative, suggesting that plants that are more likely to be in compliance are also less likely to close, but it is not significant. The estimated coefficients on the exogenous variables indicate that small coastal plants with older capital are significantly more likely to close. The negative coefficient on compliance costs is surprising, but not significant.[24]

The second-stage compliance equation, like the first-stage one, explains very little about compliance. Virtually all of the signs are the opposite of what was expected, and none of the coefficients are significant.

VI. Conclusions and Future Work

The evidence presented here indicates that air-pollution regulators did allocate their enforcement activity as if they wanted to reduce local adjustment costs. Plants with a higher probability of closing experienced less enforcement pressure. This result was concentrated on plants located in counties with unemployment rates exceeding 7.2 percent. Further, plants that were major employers in their local labor market also encountered less enforcement activity.

Our results also show that company plant-closing decisions during this period of drastic industry decline were influenced by the enforcement activity of regulators. Plants predicted to face more enforcement were more likely to close. This suggests that regulatory enforcement did impose costs on the plants involved.

This pattern of enforcement, with stronger plants bearing more of the costs, reinforces previous work indicating that the regulatory burden has been heavier in faster-growing, high-employment regions. Thus, regulatory agencies appear to be sensitive to the "ability to pay" of those they regulate.

Our results throw little light on company compliance decisions, possibly because of the difficulties involved in measuring compliance. For this reason, our future research will include consideration of OSHA enforcement decisions, where there are better compliance measures and more clearly identified enforcement actions.

Future research will include examination of a firm's responses to regulatory activity on a company-wide basis, so that we may explore such questions as whether similar firms make similar compliance decisions, whether a single firm makes similar compliance decisions for all its plants and for different enforcement agencies, and whether compliance decisions are related to the economic health of the firm. Insight into these matters will ada to our understanding of the complex relationship between regulatory and firm decision-making processes.

Footnotes

1. Examination of the EPA's technology-based regulations, which require firms to install particular types of equipment, indicates that these regulations can be very inefficient (see Gollup and Roberts [1985], and the citations listed there). The EPA has responded with some limited attempts at more efficient control methodologies.

2. Legislators appear to respond to these potential costs in the way they frame regulations (for instance, Crandall, 1983).

3. We use EPA in this paper to refer to both the individual state pollution agencies and the federal agency. Much of the enforcement is actually done by the state agencies, under federal EPA supervision.

4. Bartel and Thomas (1985) model the interaction between OSHA regulatory activity and firm behavior with a three-quarter system of injury rates, inspections, and compliance; they find some evidence that these three decisions are inter-related. See also Gray and Jones (1988) for evidence that repeated OSHA inspections of the same plant find fewer violations on later inspections; Viscusi (1986) and Gray and Scholz (1989) for evidence that OSHA inspections lead to a reduction in injuries; and Gray (1986) for evidence that both OSHA and EPA enforcement actions were directed toward industries with more problems (higher injury rates or more emissions).

5. The steel industry can be roughly split into two categories: integrated firms and minimill firms. Unless otherwise stated, all references to the steel industry are references to the integrated firms.

6. "The iron and steel industry ... may be responsible for as much as 10 percent of all particulate air emissions..." Congressional Budget Office, 1987, p. 43.

7. See Crandall (1983), and Gollup and Roberts (1985), and references cited therein. See also Gray (1986, 1987) for evidence that industries facing a lot of enforcement actions tended to have lower productivity growth.

8. "When Bethlehem Steel decided to shut its Lackawanna, N.Y., plant, idling 7,300, Lackawanna authorities began planning layoffs of fire and police and other government workers: half the municipal budget came from Bethlehem's $6 million in taxes." David Nyhan, "Crisis in Steel and for a Way of Life," <u>Boston Globe,</u> page 1 and ff., 1/30/83.

9. In addition to considering local adjustment costs, regulators might avoid enforcement at a plant that was going to close (a) to avoid bad publicity if it appeared that the enforcement contributed to the plant closing, or (b) because they might decide that forcing a firm to spend millions on pollution control at a plant that will soon close is senseless (and perhaps impossible).

10. Other things being equal, a plant with an older capital stock is more likely to be closed than a plant with a newer capital stock simply because major reinvestment decisions should arise in the former first (Stigler, 1966). This effect will be exaggerated, of course, if newer capital is more efficient.

11. The area unemployment rate is not included in the other two equations because it varies substantially during the sample (so the 1976 value would not pick up cross-sectional differences) and may be affected if the plant is closed during the period (so the average unemployment during the sample might not be exogenous).

12. All variables with names beginning with L are measured in logs.

13. The amount of enforcement carried out varies from year to year, as enforcement budgets change, from state to state, due to differing state policies, and within states over time, as state policies evolve.

14. See Deily (1988) for a detailed description of the model, and for evidence that firm characteristics, such as size or extent of diversification, played little or no role in determining which plants closed in this industry.

15. Plants producing mainly specialty steels are excluded, as are small electric-arc-based plants.

16. All of the EPA data sets that we use have the plant as the unit of observation, and identify the name, street address, city, county, state, and industry of the plant. We used this information to find the records belonging to plants in our sample.

17. All plants in the sample would qualify for entry into CDS "Class A1" sources, emitting over 100 tons of pollutants per year.

18. For the estimations reported in this paper, we treated all reported enforcement actions equally. We did, however, attempt to identify "serious" enforcement actions, based on the brief description of the action provided in the CDS. These actions included inspections, notices of violation, emissions tests, penalties, and enforcement orders, and they made up 48.7 percent of the actions in the sample (4,539 of 9,316 actions). The results using only "serious" actions are similar to those using all actions.

19. The tapes also have data for the years 1982, 1985 and 1986, giving us a total of four possible years on which to base our measure of compliance. We chose to use the earlier 1981 data because by 1985-1986 several of the plants are "in compliance" solely by virtue of being completely shut down.

20. There were two plants for which no emissions data were available. They were given the predicted value from a regression of log(total emissions) on log(capacity), log(employment), log(new capital) and EARC (a dummy for electric-arc furnaces, which produce much less pollution). The R2 of this regression (for the other 47 plants) is .62.

21. This variable is created using the investment-per-ton capacity required to bring each particular plant into compliance; the costs of operating the equipment are not included. The two figures are highly correlated, however.

22. We use county rather that **SMSA** measures because, while all plants are in a county, not all are in an **SMSA**.

23. Perhaps the concentration of steel plants in a few high-unemployment states is part of the answer, but note that including state dummies or state unemployment rates does not affect the result.

24. Firms may be avoiding part of these costs by buying coke instead of producing it in their own coke ovens, which represent a major portion of pollution control expenditures. Imports of coke have increased during the 1980s.

Table 1
Means and Standard Deviations

VARIABLE	Enforcement (N=412)	Plant-Closing (N=49)	Compliance (N=45)
ATTAIN	0.17 (0.38)	--	--
CNTYU	8.92 (3.50)	--	--
COAST	0.11 (0.31)	0.14 (0.35)	0.13 (0.34)
COMPCAP	26.04 (8.55)	25.55 (9.01)	25.20 (8.61)
LCAP	1.05 (0.59)	0.93 (0.69)	0.96 (0.70)
LCAPNEW	3.49 (0.98)	3.25 (1.26)	3.40 (1.11)
LEMIT	9.00 (1.19)	8.89 (1.21)	8.91 (1.21)
LRELEMP	-3.55 (1.67)	-3.62 (1.74)	-3.67 (1.79)
LSTATEAV	.59 (0.31)	--	--
PCLOSE*CNTYU	2.87 (2.68)	--	--
SHAPES	0.32 (0.32)	0.36 (0.34)	0.37 (0.35)
CLOSE	--	0.43 (0.50)	0.38 (0.49)
COMPLY	--	--	0.36 (0.48)
LENF	2.05 (1.34)		--

Table 1 (Cont'd)
Means and Standard Deviations

PCLOSE	0.34 (0.29)	--	0.41 (0.33)
PCOMPLY	0.33 (0.18)	0.37 (0.20)	--
PLENFSUM	--	22.84 (5.92)	23.09 (6.05)

Source: Authors' calculations.

Table 2
First Stage Estimations[a]

DEPENDENT VARIABLE:	LENF[b]	CLOSE	COMPLY
INTERCEPT	-1.57*	-6.06	3.49
	(0.75)	(5.49)	(4.43)
COAST	-0.12	0.94	1.65
	(0.19)	(1.20)	(1.12)
SHAPES	0.27	2.68**	-0.12
	(0.18)	(1.37)	(1.05)
LCAP	0.53*	-2.54*	-0.31
	(0.12)	(1.12)	(0.78)
LCAPNEW	0.15*	-0.49	-0.20
	(0.06)	(0.32)	(0.31)
CNTYU	0.17*		--
	(0.02)		
ATTAIN	-0.14	--	--
	(0.15)		
LEMIT	0.13**	1.11**	-0.52
	(0.07)	(0.65)	(0.51)
LRELEMP	-0.14*	-0.27	-0.12
	(0.04)	(0.28)	(0.25)
COMPCAP	0.004	-0.09	0.03
	(0.007)	(0.05)	(0.05)
ADJUSTED R-SQUARED:	0.43		--
F-STATISTIC:	17.07	--	--
LL:	--	-21.70	-25.50
CORRECT PREDICTIONS:	--	82%	69%
N:	412	49	45

[a]Standard errors are in parentheses.
[b]Estimated equation included 10-year dummies.
*Significant at the 5 percent level.
**Significant at the 10 percent level.

Source: Authors' calculations.

Table 3

Second Stage Estimations[a]

DEPENDENT VARIABLE: LENF

	(1)[b]	(2)[c]	(3)[c]
INTERCEPT	-1.90**	-1.68*	-2.00*
	(1.00)	(0.74)	(0.73)
PCLOSE	-0.73*	-0.51*	2.02*
	(0.32)	(0.24)	(0.59)
LRELEMP	-0.14*	-0.22*	-0.20*
	(0.06)	(0.05)	(0.04)
CNTYU	0.13*	0.15*	0.25*
	(0.03)	(0.02)	(0.03)
PCLOSE*CNTYU	--	--	-0.28*
			(0.06)
LEMIT	0.33*	0.21*	0.17*
	(0.10)	(0.07)	(0.07)
ATTAIN	-0.004	-0.17	-0.19
	(0.18)	(0.15)	(0.15)
PCOMPLY	-0.07	-0.89	-1.18*
	(0.76)	(0.58)	(0.57)
COMPCAP	-0.01	-0.0002	0.01
	(0.01)	(0.01)	(0.01)
LSTATEAV	--	1.03*	0.78*
		(0.25)	(0.25)
ADJ R-SQ:	0.46	0.42	0.45
F-STAT:	12.14	17.63	18.77
N:	412	412	412

[a]Standard errors are in parentheses.
[b]Estimated equation included 10-year dummies and 14 state dummies.
[c]Estimated equation included 10-year dummies.
*Significant at the 5 percent level.
**Significant at the 10 percent level.

Source: Authors' calculations.

Table 4

Second Stage Estimations: plant-closing and compliance[a]

DEPENDENT VARIABLE:	CLOSE	COMPLY
INTERCEPT	0.89	-0.56
	(3.62)	(2.29)
PLENFSUM	0.43*	0.14
	(0.17)	(0.09)
PCOMPLY	-5.70	--
	(4.58)	
PCLOSE		0.43
		(1.35)
COAST	5.76*	--
	(2.45)	--
SHAPES	3.74*	--
	(1.62)	--
LCAP	-5.70*	-0.88
	(1.94)	(0.86)
LCAPNEW	-1.19*	--
	(0.45)	--
COMPCAP	-0.07	0.01
	(0.05)	(0.04)
LEMIT	--	--
LL:	-18.29	-27.51
CORRECT PREDICTION:	88%	67%
N:	49	45

[a]Standard errors are in parentheses.
*Significant at the 5 percent level.
**Significant at the 10 percent level.

Source: Authors' calculations.

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