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Abstract

This paper uses data from the U.S. electric power industry to explore the strategic responses of regulated firms to government enforcement. We focus on the enforcement of New Source Review, a provision of the Clean Air Act that imposes stringent emissions limitations on substantially modified older power plants. Starting in late 1999, the EPA sued the owners of 46 power plants for NSR violations. This paper explores how electric utilities responded to both the perceived *threat* of future action, and the action itself. We find that the threat of action did have a significant effect on emissions: plants that were likely to be named in the lawsuits (as determined by our discrete choice model of the lawsuit decision) reduced their emissions by about 17 percent on the eve of the lawsuits. After the lawsuits, we find no significant difference between those plants sued and other relatively dirty coal-fired power plants.

JEL Classification: L51, L94, Q58, and Q52

Keywords: pollution regulation, enforcement, New Source Review, electricity industry.

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1 Introduction

This paper uses data from the U.S. electric power industry to explore the strategic responses of regulated firms to government enforcement. We focus on the provisions of the Clean Air Act that impose stringent emissions limitations on new sources and extend these new-source limits to aging power plants that undergo substantial modification. In November 1999, the Environmental Protection Agency (EPA) announced a sweeping enforcement action against 24 electric power plants. The agency announced additional lawsuits in the following year, bringing the total to 46 plants owned by nine utilities. The lawsuits charged that the plants' parent utilities had failed to seek regulatory approval for major modifications that should have been reviewed by the agency to determine whether they triggered the more stringent emissions limits applicable to new sources.

These "New Source Review" (NSR) regulations offer a valuable test case for studying how the threat of enforcement affects the behavior of regulated firms, because we can identify precisely when that threat became salient. Although the law had been in place for decades, it was never vigorously enforced. In the sole prominent enforcement action brought by the EPA *prior* to the period we study, the court handed down a ruling that strongly favored the industry. Before 1998, therefore, there was little to make the industry concerned about the threat of a regulatory crackdown. In that year, however, the EPA announced a more aggressive stance. The industry did not know in advance *which* plants would be named in the suits; the ambiguity over how the law would be interpreted allowed the EPA considerable scope in deciding whom to target. But there was widespread expectation by the end of 1998 that the EPA was about to enforce the law more vigorously.

In this paper, we explore how electric utilities responded to the perceived threat of future action, as well as to the lawsuits themselves. Our measure of "response" focuses on plants' emissions rates, since those were not only a known trigger of regulatory action but also the source of concern that motivated the regulations in the first place. Of course, power plants were not equally vulnerable to the imminent enforcement. For example, power plants that had made major capital investments in previous years might have fallen under greater regulatory scrutiny.

To distinguish among power plants in the severity of the threat, therefore, we first investigate the determinants of the EPA's choice of which plants to name in the lawsuit. In line with the official agency stance, we find that the probability of enforcement action was higher at plants with large increases in emissions rates and large capital investments (excluding investments in pollution control equipment) over the previous fifteen years. However, the EPA was also more likely to target plants owned by large utilities. We also find that a plant's *current* emissions helped predict whether it was named in the EPA's lawsuits, controlling for the potential endogeneity of emissions and enforcement. This suggests that power plants had reasonable grounds to change their behavior during 1999 – that is, after the threat became known, but before the EPA announced its lawsuits.

In the second stage of our analysis, we use the estimated coefficients from our model of the agency's choice to construct a predicted enforcement probability for each plant. We regress plant-level annual emissions rates over the period 1996-1999 on this measure of the perceived threat. Here we focus exclusively on power plants that were required to participate in the first phase of the sulfur dioxide (SO_2) allowance market created by Title IV of the 1990 Clean Air Act Amendments. These were the oldest and dirtiest plants, and therefore among the most likely to be sued; moreover, they faced a constant regulatory regime over the period of interest, since Phase I lasted from 1995 through 1999. (In contrast, plants that entered the allowance market only in Phase II, starting in 2000, experienced a sharp change in air pollution regulation at just the same time as EPA was stepping up its enforcement.) We find strong evidence that firms sought to avert enforcement. Plants that were more likely to be sued show greater reductions in emissions, even controlling for fixed plant and year effects.

The story changes when we analyze the effects of the actual lawsuits. To do this, we regress emissions rates on an indicator variable that equals one for plants named in the lawsuits, and we extend our period of study to 2000 (the year after the first wave of lawsuits was announced). We account for the endogeneity between emissions and enforcement by using our predicted probability of enforcement as an instrument for the dummy variable indicating a lawsuit. While the plants named in the lawsuits reduced their emissions rates in the year 2000, all the other plants did as well. Thus there was no statistically significant effect of the lawsuits themselves on firm behavior.

Our paper relates to several existing strands of the economics literature. Our focus on the determinants of enforcement complements previous work on regulatory enforcement and its effects on compliance. In a study of the pulp and paper industry, Magat and Viscusi (1990) find that more strenuous enforcement (as measured by the frequency of inspections) increases subsequent compliance. Bartel and Thomas (1985) conclude that more frequent inspections increases compliance with workplace safety regulations, but find little evidence that compliance drives enforcement decisions.

More recent empirical analyses of enforcement have taken explicit account of the potential endogeneity between enforcement and the behavior of regulated firms (Gray and Deily 1996; Laplante and Rilstone 1996; Eckert 2004). For example, Gray and Deily use a simultaneous equations model to account for endogeneity; they find that enforcement of air pollution regulation induces compliance among regulated steel mills, while compliance averts enforcement. We address the same endogeneity issues here, using predicted enforcement probabilities as an instrument for actual enforcement decisions. A key difference, however, is our interest on how the *threat* of enforcement changes behavior *prior to* the enforcement decision itself. In other words, we also use the predicted probability of enforcement as the actual independent variable of interest in predicting behavior – a measure of the degree of threat, rather than a way of getting around endogeneity.[1]

In its topical focus, this paper is heir to a long line of literature on so-called "vintage-differentiated regulations" or VDRs, of which NSR is one of the most prominent examples.[2] Economists have long bemoaned the perverse investment incentives created by programs that differentially affect old and new sources of pollution. The underlying legislation that gave rise to NSR was the 1970 and 1977 Clean Air Act Amendments, which imposed stringent standards on new sources of emissions while exempting or "grandfathering" existing sources. These new-source standards led electric utilities to extend the operating lives of old power

[1] The studies that have taken explicit account of endogeneity have also framed their analysis in terms of the threat of enforcement; see for example Laplante and Rilstone (1996). But the use of an instrumental variables strategy simply ensures that the effect of enforcement is identified by the exogenous component of enforcement. Examining the effect of the threat of action *distinct from* the actual action requires analysing a window of time during which enforcement was imminent but had not yet taken place.

[2] See Stavins (2006) for an overview of the literature on VDRs.

plants, delaying the construction of new ones (Nelson 1984; Maloney and Brady 1988; Nelson *et al.* 1993).

In a recent paper, Bushnell and Wolfram (2006) [BW] identify a second perverse effect of VDRs: regulated firms are discouraged from undertaking investments that would improve the operating efficiency of existing units, in the fear that doing so will trigger enforcement. Consistent with this view, List *et al.* (2004) find that NSR slowed modification rates at industrial facilities in sectors other than electric power. To probe the extent of this distortion, BW examine NSR enforcement in the electric power industry, as we do, but ask a slightly different question: Did stepped-up enforcement by the EPA affect plant-level heat rates or expenditures on capital investment and operation & maintenance expenditure? They find some evidence of an effect on investment, but no evidence of an effect on O&M expenditure or heat rates.

Because BW and our paper use similar data to ask closely related questions, it is worth pointing out how the two studies diverge. First, BW are interested in vintage-differentiated regulation *per se*, and how enforcement of such regulations distorts investment decisions. In contrast, the motivation for our analysis is the strategic response of regulated firms to the threat of enforcement. As such, our analysis focuses only on those plants most likely to be sued: the Phase I plants. This eliminates differences in regulatory regimes over the time period studied.[3] Second, we delve into the EPA's decisions to target a certain set of plants in the lawsuits. BW focus on how the greater scrutiny affected plant operations and expenditures *ex post*. Third, our probability-of-lawsuit model identifies which plants were more likely to be sued, allowing us to see whether those plants responded more readily to the threat of enforcement. For their part, BW use the prevalence of scrubbers to capture relevant variation among power plants. Since a successful lawsuit by the EPA would require a plant to install scrubbers, plants that already *had* scrubbers were less likely to suffer large economic losses as a result of the lawsuits, and hence less likely to change their behavior.

The next section reviews the history of New Source Review regulation, setting the stage

[3]In contrast, BW consider a more diffuse sample of 329 plants subject to a variety of regulatory regimes. This provides them with a greater scope of exploring vintage differentiated regulations. However, Phase I and Phase II plants are likely to have very different responses circa 2000, the beginning of Phase II, and hence to the regulatory window.

for our subsequent analysis. Section 3 outlines our empirical strategy, and section 4 discusses the data. Section 5 presents our results, and the final section offers conclusions.

2 Regulatory background

Because this paper centers on the determinants of EPA's lawsuits, and the responses of the utility industry to the agency's actions, it is worth presenting the regulatory background in some detail. The roots of New Source Review lie in the 1970 Clean Air Act Amendments, when Congress first established federal authority over emissions from stationary sources such as coal-fired power plants. Reasoning that controlling pollution from new sources would be much less expensive than retrofitting older ones – and expecting that continued demand growth would lead utilities to replace older units as they aged – Congress established a nationwide uniform performance standard of 1.2 lbs of SO_2/mmBtus of coal, applicable on all new coal-fired generating units (among other categories of sources). In 1977, Congress amended the Clean Air Act further, augmenting the emissions-based standard with an additional requirement that individual sources reduce between 70 and 90 percent of the SO_2 in their flue gas. The only way to meet this percentage reduction requirement was to install a "flue-gas desulfurization" device, better known as a "scrubber." Hence the 1977 Amendments effectively represent a technology standard. At the same time, the 1977 legislation strengthened the national ambient air quality standards.

To implement these regulations, EPA required all potential new sources of emissions to apply for a so-called "Permit to Construct," which triggered an extensive review of the proposed facility. The requirements for being granted such a permit were more stringent in "nonattainment areas" that did not meet the ambient air quality standards. Nonetheless, costly pollution control requirements were still imposed on proposed sources in attainment areas, in order to prevent further deterioration of air quality. These stringent requirements on new sources created strong incentives for electric utilities to keep their older power plants in operation. Generating units built in the 1940s remained online years past their originally scheduled retirement dates, drawing the outrage of environmental advocacy groups and eventually attracting attention from regulators at EPA.

Of course, Congress had anticipated this problem in the original legislation. The statutory definition of "new source" explicitly included sources that subsequently underwent "modification," defined as "any physical change in, or change in the method of operation of, a stationary source which increases the amount of any air pollutant emitted by such source ...."[4] Taken literally, this provision would trigger New Source Review in response to virtually any maintenance operation at a power plant. Thus in implementing the Act, the EPA specified a more lenient characterization of "modification," which specifically required that the contemplated physical change result in a "significant net emissions increase" of pollution. In particular, EPA ruled out "routine maintenance, repair, and replacement" as a trigger for NSR.[5]

The scope of NSR was narrowed further in 1992, when EPA issued the so-called "WEPCo Rule" following a successful suit against the agency brought by the Wisconsin Electric Power Company. The ruling in that case by the U.S. Court of Appeals (7th Circuit) established that power plants could carry out "like-kind replacements" of boiler components without triggering New Source Review, and led the EPA to revise its methodology for estimating and evaluating the increased emissions that would result from changes to existing units in the electric power sector. In particular, the new rule excluded emissions increases due to growth in electricity demand. Even so, considerable ambiguity remained.

In July 1996, EPA announced a new effort to reform the NSR program, but couched it as "significantly reduc[ing] the number and types of activities at sources that would otherwise be subject to major NSR," "streamlin[ing] the overall NSR permitting process," and "relieving regulatory burden."[6] Among other proposals was a suggestion that the EPA might extend some of the WEPCo methodology to other industrial sectors. Two years later, the EPA followed up with a second notice, ostensibly to solicit more detailed comments on the WEPCo rule proposal. In the announcement, however EPA signaled a shift to a much more vigorous stance in its enforcement of NSR in the electric power sector. Specifically, the agency declared that "it appears that although there are a number of substantial changes to existing units, as well as an increase in the amount of electricity being generated ... changes to utility units

[4] 72 USC §7411(a).

[5] See, for example, CFR §51.166(b)(2).

[6] See the announcement of the proposed rule in the Federal Register, vol 61, No., 142 (July 23, 1996), p38251.

.... are not being reported to permitting agencies." The agency further warned that it had "reconsidered" the WEPCo rule's demand growth exclusion, and had "tentatively concluded that [it] should not be continued, ... especially in view of recent developments in the electric power sector."[7]

These changes did not go unnoticed by the industry. In August, the *Utility Environment Report* ran an article headlined "EPA Proposes 'WEPCo' Rule Changes; Would Required New Emissions Limits." In October, the industry's concerns increased, as word began to spread of imminent enforcement action against the electric utility industry. In an article entitled "EPA Seeking Naughty Coal-Fired Boiler Users," the *Electricity Daily* reported that agency had sent letters to several boiler manufacturers requesting information on "all coal-fired units over 25 MW constructed since 1930, subsequent recommended changes in operation, and any other known changes in operation since 1978." The article went on to report that:

> Agency officials believe an in-depth investigation will show that many utilities and other generators have not disclosed boiler modifications that would trigger new source review .... EPA reportedly plans to target 25 power plants initially for investigation and possible enforcement action. (*Electricity Daily*, vol. 11, No. 72, October 13, 1998)

A year later, on November 3, 1999, the EPA announced lawsuits against seven electric utilities (alleging violations at 24 power plants) as well as an administrative compliance order against the Tennessee Valley Authority (naming seven more plants). Subsequent lawsuits in March, April, and December of 2000 brought to 46 the total number of power plants targeted by the enforcement action. (Table 1 lists the holding companies, utilities, and power plants named in the lawsuits.)

3 Econometric Model

Our econometric analysis proceeds in two steps. First, we model the EPA's decision of which power plants to sue. Second, we look for evidence that the power plants that were eventually targeted – or those that were *likely* to be targeted – reduced their emissions in reaction to the threat of being sued.

[7]See the Federal Register, vol 63, No., 142 (July 24, 1998), p. 39860.

3.1 Likelihood of a lawsuit

We model the probability that a given plant was named in the EPA's lawsuits in 1999 and 2000 as a function of various plant characteristics. For this analysis, we construct a cross-sectional sample of 249 coal-fired power plants that had at least one generating unit built before the New Source Performance Standards (NSPS) took effect. Therefore, each plant in our sample was potentially subject to New Source Review. These include all of the coal-fired "Table A" plants – plants that housed at least one unit required to participate in Phase I of the Title IV allowance market, named after the table in the 1990 Clean Air Act that listed them.[8] The sample includes all 44 of the 46 plants named in the EPA lawsuits that were charged with evading new source review in the modification of existing emissions units.[9]

What factors should have contributed to the probability of a lawsuit? The lawsuits filed by the EPA cited specific violations of the law that dated as far back to 1979 and were concentrated in the late 1980s and early- to mid-1990s. We start by focusing on behavior over the same period. As discussed in the previous section, the EPA's definition of "major modification" sufficient to trigger New Source Review focused on changes that would increase a plant's emissions in expectation. The lawsuits should have been more likely at plants that had large increases in emissions (*maxchgemit*) or utilization (*maxchgutil*) in the years leading up to EPA's actions in 1999. The incentives to keep older plants operating were at the heart of the NSR controversy. Hence plants that reported large capital investments (*maxinvest*) or maintenance expenditures (*pctmaint*) in prior years, or came online earlier (*age*) may also have attracted more attention from the EPA. Because the agency's objective was ultimately to limit the damages from deteriorating air quality, it might have taken account of the attainment status of the county in which a plant was located (*attain*), the environmental damages that a particular plant caused per ton of pollution (*damages*), or

[8]Specifically, the analysis includes 105 of the 110 Table A plants. Five plants with Table A units are excluded: Breed (IN); Des Moines (IA), and North Oak Creek (WI), whose Table A units were retired by 1994; and Northport and Port Jefferson (NY), which did not burn coal. The remaining 144 plants in the data housed units on which construction began before 1971, hence were grandfathered out of the NSPS and subject to state regulation.

[9]The violations at the remaining two plants – the Miller and Scherer Plants operated by Georgia Power – concerned units that were built after the 1977 Amendments took effect but did not comply with the relevant NSPS. Hence their presence on the list of plants targeted by the EPA can easily be explained by their flagrant violation of the clear meaning of the legislation, rather than the nuances of how it was implemented by the agency.

the fraction of a plant's generating capacity at scrubbed units ($scrub\_shr$). Finally, to the extent that EPA chose high-profile cases to maximize the deterrent effect of its actions, it might have been more likely to identify violations at facilities owned by large parent utilities ($firmsize$). We take logarithms of age and firm size to account for the scaling of those variables.[10]

Under the assumption that idiosyncratic shocks (ε) were normally distributed, we estimate the probability of a lawsuit naming plant i using the following probit model:

$$\begin{aligned} \Pr(lawsuit_i) &= X_i'\beta + \varepsilon_i, \text{ where} \quad (1) \\ X_i'\beta &= \beta_0 + \beta_1 maxchgemit_i + \beta_2 maxchgutil_i + \beta_3 maxinvest_i + \beta_4 pctmaint_i \\ &\quad + \beta_5 \ln(age_i) + \beta_6 attain_i + \beta_7 damages_i + \beta_8 scrub\_shr_i + \beta_9 \ln(firmsize_i). \end{aligned}$$

We use the coefficient estimates from equation (1) to predict the likelihood that a given plant will be sued ($probsue$). This specification captures the effects of behavior through the early to mid 1990s, *before* the threat of enforcement action became acute. These predicted probabilities, which are based on exogenous factors, are used in the following subsection to examine whether firms changed their emissions as a result of the lawsuits.

Next, as a test of the endogeneity of the lawsuits, we examine whether the probability of a lawsuit was affected by a plant's total emissions in 1999 ($emit99$), immediately before the lawsuits were filed. This leads to an alternative specification:

$$\Pr(lawsuit_i) = \alpha \ln(emit99_i) + X_i'\beta + \varepsilon_i. \quad (2)$$

Because current emissions are potentially endogenous, we estimate equation (2) by probit with instrumental variables.[11] As instruments, we use the generating capacity of the plant ($size$); the allowable emissions rate imposed by state regulations ($so2reg$); the sulfur content of the lowest-cost fuel available to the plant ($so2lowc$); and the share of generating capacity at that plant accounted for by Table A units ($tblA\_shr$). Thus the first-stage regression is given by:

[10] We keep $maxchgemit$, $maxchgutil$, and $maxinvest$ in levels because these variables take on negative values, reflecting falling emissions or utilization, or capital depreciation (*i.e.*, negative net investment). Our results are essentially unchanged when we take logs of all these variables.

[11] We use the ivprobit function of Stata 9.

$$\begin{aligned} \ln(emit99_i) &= \gamma_1 \ln(size_i) + \gamma_2 \ln(so2reg_i) + \gamma_3 \ln(so2lowc_i) \\ &+\gamma_4 tblA\_shr_i + X_i'\beta + \eta_i. \end{aligned} \tag{3}$$

3.2 Emissions response to lawsuits

Next, we examine whether firms changed their emissions as a result of the lawsuits. For this analysis, we construct a panel data set that includes all coal-fired Table A plants from 1996 to 2000. These plants faced a constant regulatory regime throughout the period. We exclude from the sample other older plants which were not required to participate in Phase I of the allowance market.[12] Since those plants entered the allowance market in 2000, they confronted a new system of regulation precisely when the EPA began to crack down on NSR, which would complicate identification of the latter effect.

We first ask: Did the plants that were most likely to be sued reduce their emissions, relative to other plants? We focus on the emissions *rate*, rather than total emissions, in order to control for changes in demand and output substitution across plants. The dependent variable is the emissions rate at plant i in year t, measured in pounds of sulfur dioxide per million Btus of heat input ($emisrate_{it}$). The explanatory variable of interest is the probability of being sued. We use the predicted probability from the probit regression in equation (1) ($probsue$). Since the price of SO_2 allowances was a major determinant of emissions rates for Table A plants, we control for the average allowance price in each year ($price$). We also include plant-level fixed effects (δ_i). The resulting model is:

$$\ln(emisrate_{it}) = \mu_1 probsue_i \cdot year99_t + \mu_2 \ln(price_t) + \delta_i + \upsilon_{it}, \tag{4}$$

where $year99_t$ equals one in the year 1999 and zero otherwise.

We then examine the responses of plants that were actually sued, still focusing on Table A plants. We now include data for 2000, and separately estimate the responses in 1999 and

[12] Although some of these plants voluntarily participated in Phase I as "substitution units," the ones that chose to do so had already reduced their emissions for other reasons (Montero, 1998). Because of this adverse selection effect, we choose to focus on the plants that were required to participate in Phase I. Our results are unaffected by the inclusion of the non-Table A plants that participated in Phase I.

2000:

$$\ln(emisrate_{it}) = \mu_1 lawsuit_i \cdot year99_t + \mu_2 lawsuit_i \cdot year00_t + \mu_3 \ln(price_t) + \delta_i + \upsilon_{it}, \quad (5)$$

where $year00_t$ equals one in the year 2000 and zero otherwise. Given that lawsuit is potentially endogenous, we estimate this model using two stage least squares. We instrument for the two lawsuit-year variables using the predicted probability of a lawsuit (*probsue*) interacted with the two year indicator variables. We also estimate equations (4) and (5) with year fixed effects included, to control for contemporaneous factors that might have affected emissions rates.

4 Data

The data in this study are taken from a range of publicly available government sources. Table 2 provides summary statistics for all of the variables described below. We constructed the list of power plants sued by the EPA by combing through press releases and reports published by the Department of Justice and the EPA, and made available on their websites.

The historical data used to calculate maximum changes in emissions and utilization rates are from the Energy Information Administration (EIA) Form 767. For the years 1986 to 1998, we computed the maximum year-on-year change in emissions (*maxchgemit*, measured in thousands of tons of SO_2 and estimated on a mass-balance basis) and the utilization rate (*maxchgutil*, equal to generation as a percent of potential total generation). Data for the late 1990s (used in the panel data set) were taken from the eGRID database maintained by EPA. These data include Continuous Emissions Monitoring System (CEMS) data, as well as information on capacity and generation. We use these data to construct the measures of *size* (in gigawatts, GW or 1000 MW, of capacity) and *emit*99 (in tons of SO_2). The age of the power plants (in years as of 1999) and the sizes of their parent utilities (in GW of capacity) were also taken from eGRID.

Figures 1 and 2 illustrate the emissions data. Figure 1 plots annual emissions for all Table A plants combined over the period 1985 to 1999, based on the EIA data. Although emissions decline steadily through the early part of the period, they drop sharply in 1995, when the allowance market took effect. Figure 2 plots monthly emissions *rates* at the same set of plants (in pounds of SO_2 per million Btus of heat input, as recorded by CEMS), from 1996 through 2000. The lighter line traces the price path of SO_2 allowances ($price_t$), taken from Cantor Fitzgerald and Fieldston Publications. Over the five years depicted, the average emissions rate among Table A plants fell by approximately 15 percent. The decline appears to be especially pronounced in late 1999, immediately before and after the announcement of EPA's lawsuits (the vertical dashed line marks the announcement). This drop does not appear to be explained by allowance prices, which are *falling* at the same time.

The financial data are taken primarily from FERC Form 1 and span the period 1981 to 1998.[13] We construct our measure of capital investment as the year-on-year change in total expenditures on structures and improvements, equipment, and land, which are reported in cumulative form in the data. We then subtract out plant-level expenditures on abatement equipment (reported on EIA Form 767), in order to avoid counting large investments in scrubbers or the like as the kind of investment that might invite regulatory scrutiny. The *maxinvest* variable is the largest of these annual "net dirty" investments, expressed in millions of 2000 real dollars using the appropriate Handy-Whitman Electric Light and Power Construction cost index (taken from the *2003 Mergent Public Utility Manual*). The FERC data also include annual maintenance expenses, which we convert into real 2000 dollars using the producer price index for intermediate materials, goods, and components. The *pctmaint* variable equals the average maintenance expenses divided by the average capital expenses.

The indicator variable on SO_2 county attainment status (*attain*) is for the year 1990.[14] Environmental damages are based on a county-to-county source-receptor matrix for particulate matter (PM10), used by EPA to assess the benefits of clean air regulation (see Latimer (1996) and Abt (2000)). For each source, the variable *damages* is computed by multiplying the transfer coefficient representing the effect of a ton of SO_2 emissions from that source on ambient PM10 concentrations in each receptor county (in $\mu g/m^3$), times the 1990 population of the receptor county, and then summing over all 3080 receptor counties. Thus the variable represents a population-weighted measure of the effect of one ton of SO_2 emissions on ambient pollution concentrations.

[13]We thank Catherine Wolfram for providing these data.

[14]We thank Michael Greenstone and Ken Chay for providing these data.

State emissions regulations are reported on EIA Form 767. The variable $so2reg$ represents the highest allowable emissions rate among the units at the plant, expressed in pounds of sulfur dioxide per million Btus of heat input. (We use regulations for 1990, but they change very little over the time period.) The emissions rate of the lowest-cost fuel available ($so2lowc$), measured in lbs/mmBTU, is based on a set of plant-level coal-price regressions using a complete set of coal deliveries to power plants for the years 1972-1999, reported on FERC Form 423; see Keohane (2006) for details. The shares of plant capacity at scrubbed or Table A units, as of 1998, are also computed from EIA Form 767.

We estimate our probability-of-lawsuit model on 249 power plants, all housing units built before 1971 and therefore grandfathered out of the NSPS in the 1970 and 1977 Clean Air Acts.[15] Our response-to-enforcement model uses a panel of the 105 Table A plants. Table 2 presents summary statistics for all of the variables used in our analysis.

5 Results

5.1 Likelihood of a Lawsuit

Table 3 presents the results of estimating the likelihood of being sued. In Column 1, we look at the probability of a lawsuit as a function of historic behavior only, equation (1). Overall, the independent variables are reasonable predictors of the lawsuits ($pseudo$-$R^2 = 0.26$). The probability of a lawsuit increases with the maximum changes in historic emissions and investment. Statements by the EPA noted that plants with such characteristics would be targeted. The EPA also claimed to be looking for large changes in output, but we do not find supporting evidence of this. The coefficient on the emissions variable implies that a 1000-ton rise in a plant's maximum year-on-year emissions increase boosted the probability of a lawsuit by one percent. A similar increase in the likelihood of being sued resulted from a change of $23 million in the maximum investment in a single year.

The only political economy variable that is significant is firm size. Larger firms were more likely to be sued, with a 15 percent increase in size corresponding to a one percent increase in the probability of a lawsuit. This is consistent with the EPA choosing high-profile cases

[15] We lose ten observations in the IV probit model, due to missing data on state regulations and/or coal availability.

in order to maximize the deterrent effect. Measures of the environmental impacts of emissions (county attainment status and marginal damages) were not significant determinants of enforcement. Nor, surprisingly, was the share of plant capacity at scrubbed units significant.

Our motivating premise is that firms sought to avert being sued by reducing their emissions on the eve of enforcement. If so, we should find evidence that current emissions positively affected the probability of a lawsuit. To explore this possibility, we re-estimate the probability of a lawsuit using equation (2), this time including plant-level emissions in 1999; we use state regulations, low-sulfur coal availability, and the share of Table A units as instruments for emissions. Results for the first stage (equation (3)) are presented in column 2 of Table 3. The instruments are strong predictors. Plant size and the maximum allowable emissions rate under state regulation are both highly significant. In addition, emissions were greater for plants with larger historic changes in emissions, younger plants, and those with lower scrubbed capacity shares. Overall, we explain 66 percent of the variation in the first stage.

Column 3 presents estimates from the second stage of the instrumental-variables model (equation (2)). The results confirm the relevance of current emissions to the enforcement decision. All else equal, a plant whose 1999 emissions were seven percent higher was one percent more likely to be sued. With current emissions included in the analysis, historic emissions lose their explanatory power. However, maximum investment and firm size remain important predictors of the lawsuits. In this specification, older plants are also more likely to be sued.

We conclude that plants that had large increases either in emissions or capital expenditures, or that were owned by larger firms, were the primary targets of the EPA lawsuits. Furthermore, we find evidence that the lawsuits were responsive to the emissions decisions of the firms – making it plausible that firms would have responded strategically to the threat of enforcement.

5.2 Emissions Response to Lawsuits

Table 4 presents results from regressions of emissions rates on measures of enforcement, using plant fixed effects to sweep out plant characteristics. In columns 1 and 2, we ask whether firms reduced emissions rates at plants with greater probability of being sued (equation (4)). As this analysis focuses on firm behavior to the *threat* of being sued, we focus on the 1996 to 1999 period. In particular, our regressions estimate the effect of the predicted probability of enforcement on 1999 emissions rates, relative to emissions rates at the same plant in the three years prior, controlling for the price of SO_2 allowances and for all fixed characteristics of the plant.

In column 1, we find that plants with greater probability of being sued reduced their emissions rates. All firms had zero probability of being sued before 1999. The estimated coefficient on *probsue* implies that a plant which faced nearly certain enforcement (*i.e.*, *probsue* near 1) reduced emissions rates by approximately 15 percent.[16] Column 1 also includes our estimate of the elasticity of the emissions rate with respect to the price of SO_2 permits, which we estimate to be -0.07. The response is inelastic, but not unreasonably so: given the plant fixed effects, this is identified only by within-plant variation, and should be interpreted as a short run response to allowance price changes.

This estimated response to the threat of enforcement remains when we include year fixed effects, controlling for any other factors (common across plants) that changed in 1999. These results are presented in column 2 of the table. The coefficient on *probsue* is slightly larger; a plant that is highly likely to be sued reduced its emissions rate by approximately 17 percent in 1999. Of course, the incentive to avert enforcement was most relevant for plants on the margin. Looking across plants, a one standard deviation increase in the probability of being sued (about 0.25) results in a five percent reduction in the emissions rate. A final measure of the effect takes into account where a power plant stood relative to other facilities, since the EPA presumably targeted the plants who were the "worst offenders" – corresponding, in our framework, to those most likely to be sued. Moving from the 25th percentile of *probsue* to the 75th percentile (from a predicted probability of 0.04 to 0.38) implied a reduction in emissions rates of six percent. At the median plant, this corresponds to a drop in the emissions rate of 0.11 lbs SO_2/mmBtus relative to 1996-1998 levels, or (holding heat rates constant) a fall of 2200 tons in annual plant-level emissions.

These findings suggest that firms reduced emissions in 1999 in response to the threat of

[16] Percent change is approximately $e^{\mu_1} - 1$.

lawsuits, *regardless* of whether their plants were sued or not. In Columns 3 and 4 of Table 4, we examine whether the emissions rate at the plants that *were actually sued* fell after the lawsuits were filed. Here we expand the data set to include 2000, and separately test how firms responded in 1999 and 2000. Due to the potential endogeneity, we estimate this model using two stage least squares, using our predicted probabilities as instruments. In column 3, we find evidence that firms reduced emissions at the plants that were sued. In 2000, emissions rates fell 36 percent among this group of plants. However, this finding is not robust to the inclusion of year fixed effects (column 4). Emissions rates fell in the year 2000 across the board at Table A plants, by 16 percent on average. Taking that decline into account, the additional reduction at the targeted plants is not statistically significant. This may suggest that in 2000, all large polluters were concerned about the enforcement of NSR. Alternatively, other changes in the regulatory environment – most prominently, the advent of Phase II of the allowance market – may be responsible.

Furthermore, for 1999, we find the estimated response by the sued plants to be consistent with what we found for the threatened plants (*i.e.*, those likely to be sued). In particular, when we control for year fixed effects we find a similar response among plants that were eventually sued as we found earlier among those that were likely to be sued (compare columns 2 and 4). In contrast, after the lawsuits were announced, we find no difference between the firms that were actually sued and those who were not (yet) sued.

Overall, we find that firms reduced emissions rates at plants most likely to be targeted by the lawsuits. Moreover, we found earlier that plants with higher emissions in 1999 were more likely to be sued, all else equal (recall Table 3). Taken together, this evidence strongly suggests that firms were responding to the heightened threat of enforcement by reducing emissions, in the hope of averting further scrutiny by the EPA. In contrast, we find only weak evidence of a response once firms were actually sued.

6 Conclusions

In this paper, we have explored how electric utilities responded to greater regulatory scrutiny and an increased threat of enforcement. In line with the public stance taken by the EPA, we find that the probability of enforcement action was higher at plants with large, historic emissions increases or capital investments. However, the agency was also more likely to target plants owned by large utilities. When we include a plant's contemporaneous emissions in the lawsuit model, we find that it is a strong predictor of whether the plant was sued. We take this as evidence that firms had reasonable grounds to change their behavior in order to avert enforcement.

We then estimate the strategic responses of firms to the threat of enforcement, using our model of the lawsuit decision to construct predicted enforcement probabilities. This provides a measure of how vulnerable each plant was to the increased regulatory threat. We find that plants that were more likely to be sued in 1999 (based on decisions stretching back over the prior two decades) reduced their emissions rates by more, even controlling for fixed plant and year effects. The story changes when we analyze the effects of the actual lawsuits. While the plants named in the lawsuits reduced their emissions rates in the year 2000, all the other plants did as well. Thus there is no statistically significant effect of the lawsuits themselves on firm behavior.

Taken together, these results suggest a complementary pair of conclusions. Firms appear to respond strategically to a perceived threat of enforcement, changing their behavior to avert the scrutiny of regulators. But once firms are sued, this incentive evaporates. Judging from how firms responded, it seems that the EPA's "bark" is worse than its "bite."

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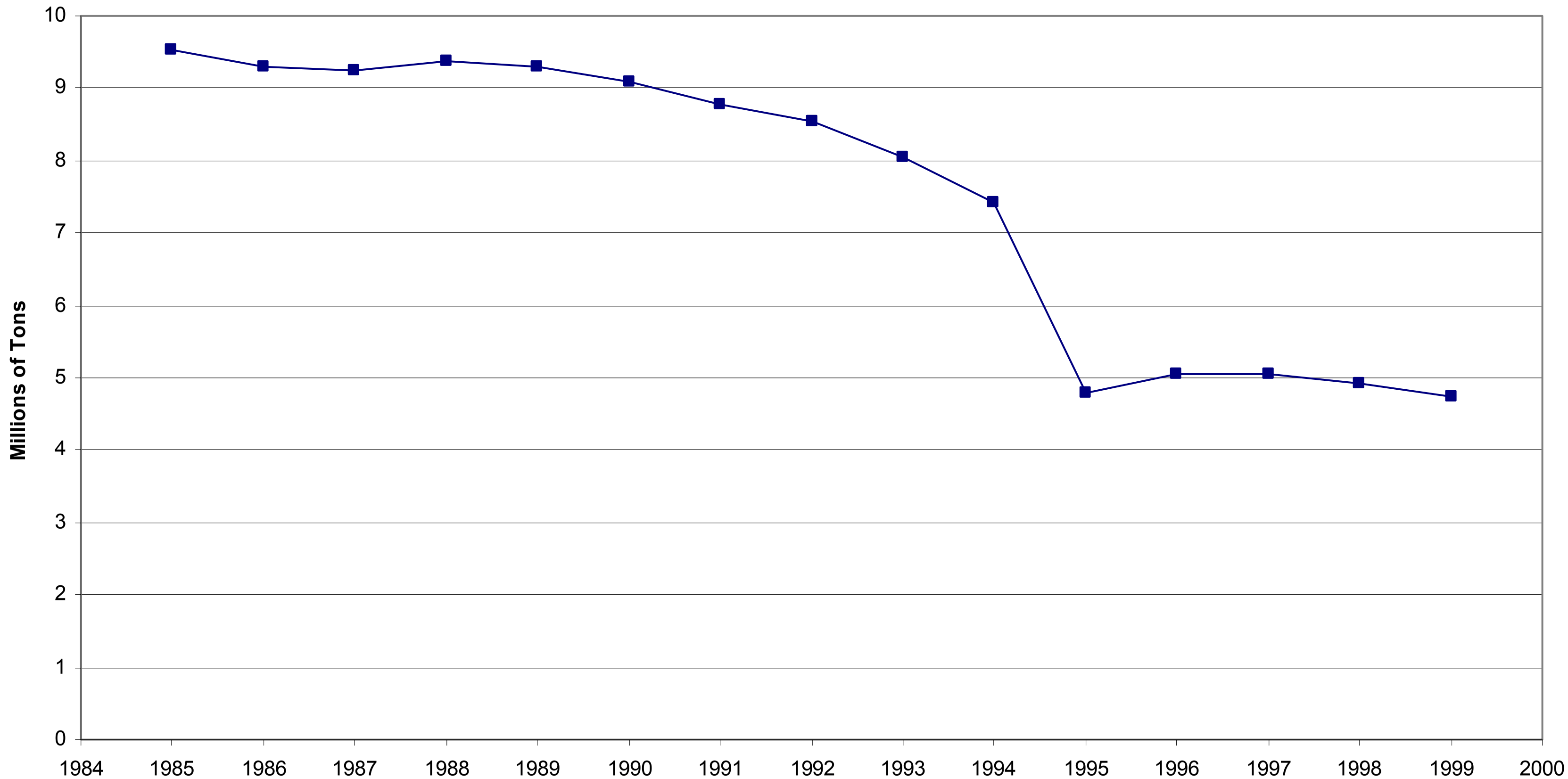

Figure 1: Historic SO_2 Emissions by Title A Plants. Source: EIA 767

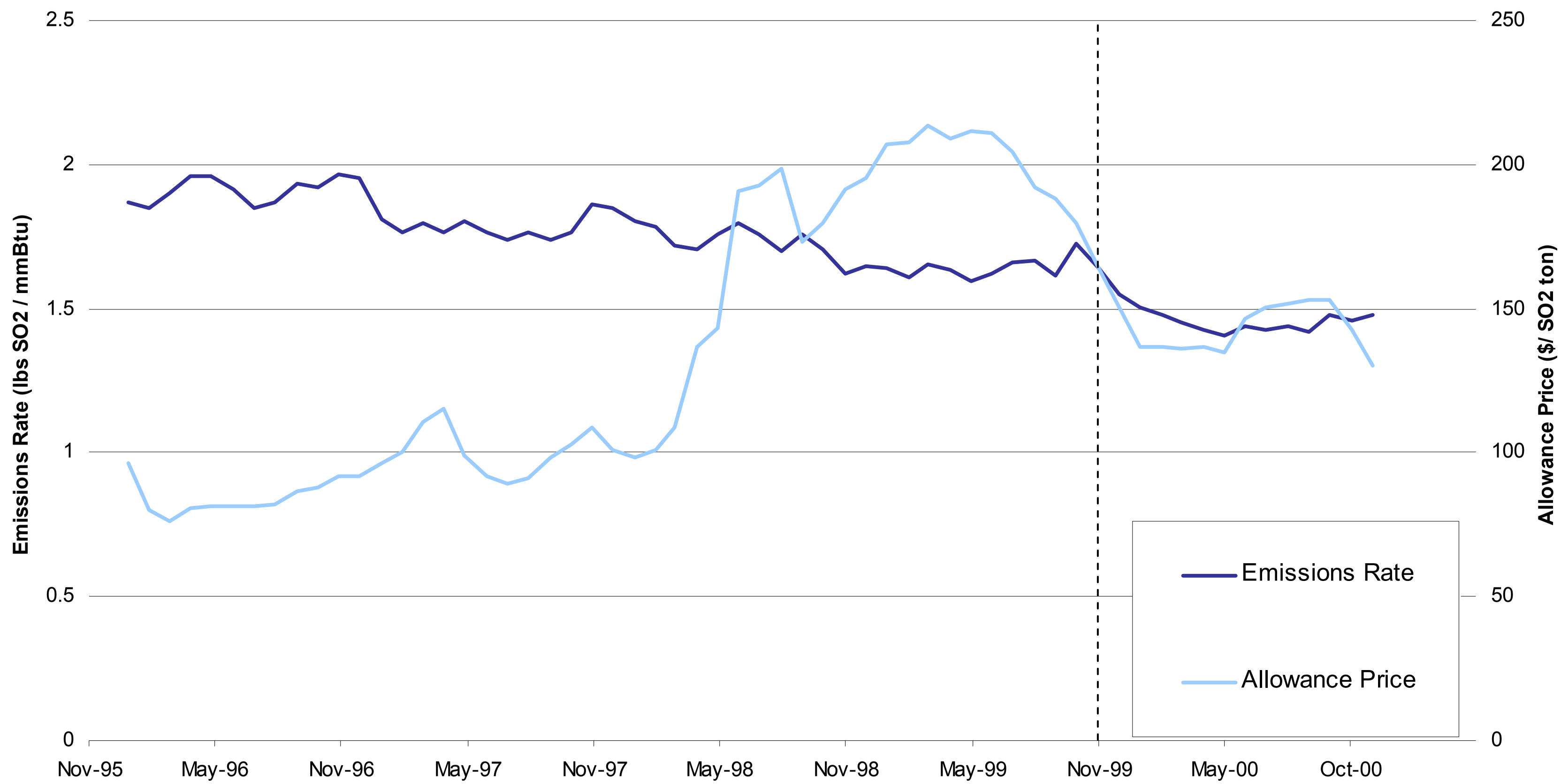

Figure 2: SO_2 Emissions Rate from Table A Plants (CEMS) and SO_2 Price.

Sources: Monthly emissions rates are from the EPA's Continuous Emissions Monitoring System (CEMS) and the prices are the average of the monthly price indices of Cantor Fitzgerald and Fieldston Publications as posted on the EPA web site.

Table 1

Companies and Power Plants Sued for Violating NSR

Holding Company (Utility)	Date of Lawsuit	Power Plants
American Electric Power (Cardinal)	November 1999	Cardinal
AEP (Central Operating)	November 1999	Philip Sporn
AEP (Indiana Michigan Power)	November 1999	Tanners Creek
AEP (Ohio Power)	November 1999	Mitchell; Muskingum River
Cinergy (Cincinnati Gas & Electric)	November 1999	Walter C Beckjord
Cinergy (Psi Energy)	November 1999	Cayuga
Dynegy (Illinois Power)	November 1999	Baldwin
FirstEnergy (Ohio Edison)	November 1999	W H Sammis
Southern (Alabama Power)	November 1999	Barry; Gorgas; James H Miller Jr
Southern (Georgia Power)	November 1999	Bowen; Scherer
TECO Energy (Tampa Electric)	November 1999	Big Bend; F J Gannon
Tennessee Valley Authority	November 1999	T H Allen; Bull Run; Colbert; Cumberland; John Sevier; Paradise; Widows Creek
Vectren (Southern Indiana Gas & Elec)	November 1999	F B Culley
AEP (American Electric Power)	March 2000	Clinch River; John E Amos; Kanawha River
AEP (Columbus Southern Power)	March 2000	Conesville
AEP (Ohio Power)	March 2000	Kammer
Cinergy (Psi Energy)	March 2000	R Gallagher; Wabash River
Southern (Alabama Power)	March 2000	E C Gaston; Greene County
Southern (Gulf Power)	March 2000	Crist
Southern (Mississippi Power)	March 2000	Jack Watson
Southern (Savannah Electric & Power)	March 2000	Kraft
Tennessee Valley Authority	April 2000	Kingston; Shawnee
Duke Energy Corporation	December 2000	Belews Creek; Buck; Cliffside; Dan River; G G Allen; Marshall; Riverbend; W S Lee

Table 2

Summary Statistics

Panel A: Cross-sectional data for Estimating Equation (1)

Variable	Units	Mean	Std. Dev.	Min	Max
lawsuit	0/1	0.18	0.38	0.00	1.00
maxchgemit	1000s tons	11.98	11.87	0.24	75.54
maxchgutil	Δ in ratio	0.16	0.08	0.03	0.64
maxinvest	million $2000	64.27	123.29	-0.09	976.33
pctmaint	ratio	0.05	0.04	0.00	0.68
age	years	45.66	15.18	20.00	99.00
attain	0/1	0.10	0.31	0.00	1.00
damages	see text	2.89	2.01	0.00	10.95
scrub_shr	ratio	0.09	0.26	0.00	1.00
firmsize	GW	21.26	19.00	0.32	66.56

Notes: 249 observations

Panel B: Additional Variables for Estimating Equations (2) and (3)

Variable	Units	Mean	Std. Dev.	Min	Max
emit99	1000s tons	34.81	38.95	0.07	245.24
size	GW	0.91	0.74	0.10	3.54
so2reg	lbs/mmBTU	3.47	1.97	0.10	12.00
so2lowc	lbs/mmBTU	3.24	1.46	0.67	5.69
tblA_shr	ratio	0.33	0.41	0.00	1.00

Notes: 239 observations

Panel C: Panel data for Estimating Equation (4)

Variable	Units	Mean	Std. Dev.	Min	Max
emisrate	lbs/mmBTU	1.95	1.30	0.01	6.70
lawsuit	0/1	0.22	0.42	0.00	1.00
prob	probability	0.24	0.25	0.00	0.99
price	$/ton	134.76	51.25	84.83	194.83

Notes: The number of observations is: 420 for emissions rate, 105 for lawsuit and *prob*, and 4 for price.

Table 3

Likelihood of Lawsuits

Variable	(1) Pr(*lawsuit*)	(2) ln(*emit99*)	(3) Pr(*lawsuit*)
ln(*emit99*)			0.860***
			(0.298)
maxchgemit	0.053***	0.018***	0.021
	(0.011)	(0.006)	(0.018)
maxchgutil	-0.010	-0.454	3.067*
	(1.527)	(0.646)	(1.803)
maxinvest	0.0022**	0.0001	0.0016*
	(0.0009)	(0.0004)	(0.0009)
pctmaint	-3.443	0.582	-1.167
	(7.167)	(1.070)	(7.948)
ln(*age*)	0.577	-0.394**	1.331**
	(0.407)	(0.181)	(0.520)
attain	-0.443	-0.217	-0.511
	(0.419)	(0.152)	(0.451)
damages	-0.010	0.032	-0.083
	(0.057)	(0.027)	(0.064)
scrub_shr	-0.648	-1.047***	0.225
	(0.524)	(0.202)	(0.670)
ln(*firmsize*)	0.330***	0.031	0.263*
	(0.120)	(0.045)	(0.137)
ln(*size*)		0.778***	
		(0.086)	
ln(*so2reg*)		0.311***	
		(0.099)	
ln(*so2lowc*)		0.102	
		(0.076)	
tblA_shr		-0.029	
		(0.147)	
constant	-4.679***	17.934***	-21.933***
	(1.605)	(0.680)	(6.186)
Obs	249	239	239

Notes: We note significance at the 1% (***), 5% (**), and 10% (*) levels.

Table 4

Emissions Response to Lawsuits

Variable	(1) ln(*emisrate*)	(2) ln(*emisrate*)	(3) ln(*emisrate*)	(4) ln(*emisrate*)
*prob*year99*	-0.163**	-0.185**		
	(0.069)	(0.083)		
*lawsuit*year99*			-0.153	-0.197*
			(0.100)	(0.115)
*lawsuit*year00*			-0.450***	-0.165
			(0.090)	(0.115)
ln(*price*)	-0.065**		-0.085**	
	(0.031)		(0.041)	
year97		-0.023		-0.023
		(0.025)		(0.033)
year98		-0.051**		-0.051
		(0.025)		(0.033)
year99		-0.050		-0.052
		(0.032)		(0.042)
year00		.		-0.178***
				(0.042)
Obs	420	420	525	525

Notes: We note significance at the 1% (***), 5% (**), and 10% (*) levels. All regressions include plant fixed effects. Columns 1 and 2 include data from 1996 to 1999. Columns 3 and 4 include data from 1996 to 2000.