Bush v. Gore and the Effect of New Source Review on Power Plant Emissions

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Abstract

New Source Review (NSR) requires that electric utilities meet emission standards when making modifications at existing power plants. The regulation makes it more costly for utilities to replace worn out parts, which can lead to greater retirements and lower utilization at older, coal-fired power plants. There has been considerable debate over what types of investments trigger NSR, but there is little empirical evidence of the effect of NSR policy on utilities' profits and emissions. Prior to the 2000 Presidential election, investors expected Bush to have a narrower NSR policy than Gore, which would allow utilities to replace old parts and delay retirement, making them more valuable. We use changes in stock prices and variation across utilities in generating assets to estimate the difference in the values of coal-fired boilers under the NSR policies of the two candidates. Investors expected the average boiler to be about $39 million more profitable under the Bush administration. We calculate that over the boilers' lifetimes, the additional utilization will have increased emissions by 13 million tons of sulfur dioxide, 2.8 million tons of nitrogen oxides and 680 million tons of carbon.

Keywords: Event Window, New Source Review, Coal Power Plants, Air Pollution

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I Introduction

The 1970 Clean Air Act regulates new pollution sources but not existing sources. The regulation of new sources increases the cost of building a new plant. The regulation makes old capital more valuable, creating an incentive for firms to delay capital retirements. Several authors have found that the Clean Air Act has caused electric utilities to delay shutting down older, "grandfathered", power plants.[1]

Because delayed retirements were causing emissions to decline more slowly than policy makers had expected, Congress created the New Source Review (NSR) program in 1977. The program requires that a firm making modifications to an existing source ensure that the modified source meet the same emission standards as a new source.[2] Since the firm must comply with a strict emission standard, NSR can increase the cost of extending the life of the plant. Congress expected NSR to increase the rate of capital turnover, and emissions would decline as new, cleaner plants replaced the old units.

Since its inception, the program has been extremely controversial in the utility sector. The debate has centered on what types of investment are included in the term "modification". The EPA generally favors a broad definition, including many types of investment. Utilities favor a narrow definition, potentially allowing them to continue making investments at older sources without being regulated. There has been considerable litigation over the definition of a modification, and the EPA has been unable to publish a comprehensive definition.

The policy debate has taken place in the absence of empirical evidence about the costs and benefits (i.e., lower emissions) of a broad NSR policy. Some have argued that a broad definition of NSR would be extremely costly to utilities, and that reducing pollution by market-based programs would be more efficient. It has been very difficult, however, to accurately measure the effect of NSR on utilities' profits and emissions.

This study uses variation in expected NSR policy of the two Presidential candidates in the 2000 election. We use changes in stock prices after the election and variation

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[1] See, e.g., Bushnell and Wolfram (2006). Theoretically, the Clean Air Act could cause emissions to increase in the short run if the delayed retirement effect is strong enough (Gruenspecht, 1982). This does not appear to have been the case with the Clean Air Act.

[2] The NSR program also affects the regulation of new sources. This aspect of the program has been far less controversial. We do not consider the effect of NSR on new sources in this paper.

across utilities in generating assets to estimate the effect of NSR policy on a utility's future profits and emissions.

Utilities expected the EPA to adopt a markedly different definition of NSR under Bush and Gore, which we refer to as a regime. Investors expected Gore to have a broad regime, in which many types of investment would trigger NSR. Bush was expected to favor a narrower regime, in which NSR would cover fewer types of investment. The NSR regime under Bush has been consistent with these expectations.

A comparison of utilities' stock prices before and after the election quantifies the effect of these two policies on profits and emissions. Similarly to Bushnell and Wolfram (2006), we define a non-controlled boiler as any coal-fired boiler that is not connected to a scrubber or affected by emission standards in the Clean Air Act. All other coal-fired boilers are labeled controlled.[3]

Because non-controlled boilers tend to be old, a utility must make large capital investments to keep them in operation, e.g., the utility must replace a turbine. Under a narrow definition of NSR (i.e., Bush), utilities could make these investments without triggering NSR. Under a broad definition this might not be possible, and the utility would have to retire the boiler or install a scrubber. The boilers would be more valuable under the Bush administration, and the stock price of a utility owning many non-controlled boilers would increase after the election, relative to other utilities.

Our baseline estimate is that the average non-controlled coal boiler is about $39 million more valuable under Bush. The estimate controls for other firm-level characteristics that might be confounding the results, and is fairly robust across specifications.[4]

We use the profit estimate to calculate the effect of NSR on emissions. We argue that the increase in value of a boiler is mainly due to greater utilization or later retirement under Bush. Assuming that these boilers would have been replaced by natural gas generators, we calculate the increase in emissions caused by the greater utilization of the

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[3] Our definition of a non-controlled boiler is slightly different from Bushnell and Wolfram, as discussed in Section IV.

[4] We have performed a similar investigation around the 2004 Presidential Election. There was considerable uncertainty over which candidate would win prior to Election Day. We do not observe a significant change in the stock prices of utilities with many non-controlled boilers in 2004, however. This is consistent with the fact that NSR was a much less important issue in 2004 than in 2000. By 2004 it seemed much less likely that Bush would be able to adopt a narrow regime in his second term.

non-controlled boilers. Between the year 2000 and the eventual retirement of these boilers, sulfur dioxide emissions will have increased by a total of 13 million tons, nitrogen oxides emissions by 2.8 million tons, and carbon dioxide emissions by 680 million tons. The results reflect the high emission rates of the non-controlled boilers, relative to the natural gas generators that would have replaced them.

II Previous Literature

This paper builds on a body of theoretical and empirical work on the regulation of new and existing pollution sources. Stavins (2005) discusses the effect of regulating new sources on capital retirement. We analyze a similar model, in which a firm generates revenue from a unit of capital and incurs operating costs that increase over time. The firm retires the capital when costs exceed revenue. The regulation of new pollution sources increases the cost of installing new capital, which reduces entry and raises the price of output. This increases the revenue earned by existing capital, causing firms to extend the life of their capital. We extend the model to show that NSR can raise the cost of delaying retirement.

There are two recent empirical studies of the effect of NSR on the electric utility industry. Bushnell and Wolfram find that the regulation of new sources causes firms to delay the retirement of existing units, consistent with the Stavins model. Furthermore, they argue that a broad NSR policy should cause firms to reduce capital expenditures at existing sources. The fuel efficiency of these boilers should decline, because the firm cannot perform cost-reducing maintenance or investment. They find, however, that NSR had at little effect on capital expenditures and fuel efficiency.

Keohane *et al*. (2006) investigate how utilities responded to the threat of NSR litigation in the late 1990s. They find that emissions decreased at plants that were more likely to be sued, which they argue was because utilities were trying to avoid litigation.

Our paper differs from these two studies in several ways. First, by analyzing changes in stock prices, we estimate the total effect of NSR policy on the profitability of a coal-fired boiler. In comparison, Bushnell and Wolfram examine two observable dimensions along which NSR could affect boilers, capital expenditure and fuel efficiency. The second difference is that our approach allows us to calculate the effect of NSR on emissions from these units.

There are several earlier empirical studies of NSR in the electricity sector. Maloney & Brady (1988) use a cross sectional analysis to show that NSR increases the age of capital and the level of emissions. They identify the effect of NSR using differences in environmental regulatory expenditures across states. Stanton (1993) shows that in the late 1980s, old (pre-1970) coal-fired boilers had higher utilization rates than new (post-1970) boilers.

A few studies examine the effect of NSR on other industries. List *et al*. (2004) use variation in non-attainment counties to estimate the impact of NSR on manufacturing plants in New York State. They find no effect on plant closures, but a reduction in the rate of plant modifications. Goldberg (1998) finds that corporate average fuel economy standards delayed the retirement of used cars that were not covered by the regulation.

Two recent papers use changes in stock prices around the 2000 Presidential Election to estimate the effect of the election on the values of other firms. Knight (2006) compares the stock prices of companies according to whether they were expected to be more profitable under Bush than Gore. He measures the probability that Bush would win the election using the Iowa Electronic Market from May to November of 2000. He finds that the stock prices of Bush-favored firms rose as the probability of a Bush victory increased.

Hughes (2006) finds that companies that were being sued by the EPA increased in value because of Bush's victory. Most of the companies in his analysis were being sued under the Superfund law, and not NSR. The Hughes paper raises the possibility that our results are biased because investors expected the candidates to have different litigation strategies for NSR. We provide empirical evidence that this is not a significant concern.

We focus on changes in stock prices after the election, rather than the May – November period studied by Knight and Hughes. We obtain qualitatively similar results if we employ their empirical strategy, using the Iowa data and stock prices during the earlier period, but we find evidence of unobserved profit shocks to utilities before the election, supporting the use of the later period.

III Background of NSR

A. Creation of NSR

The 1970 Clean Air Act imposed emission standards on stationary sources of pollution, known as New Source Performance Standards (NSPS). These standards did not apply to existing sources. Policymakers expected that firms would gradually replace their older, unregulated, capital with new equipment. Because new sources would be covered by the NSPS they would have lower emission rates, and pollution levels would fall in the long run.

By the late 1970s it seemed that the regulation of new, but not existing, sources was causing firms to delay the retirement of their existing capital. To address this issue, Congress created the NSR program in the 1977 Clean Air Act Amendments. The law states that a firm making a "modification" at an existing source must meet the same standards as new sources.

From the outset, there was considerable debate over the scope of NSR. After an initial court ruling (*Alabama Power v. Costle*), the EPA ruled that all investments except for "routine maintenance" would trigger NSR.[5] Debate over NSR has centered on what activity is covered by the routine maintenance exception. Utilities have favored a more narrow definition of routine maintenance, which would allow them to replace many types of equipment without triggering NSR. In contrast, the EPA has argued that certain "life-extending" investments should not be included in the routine maintenance exception. Because the EPA has not published a broad guideline for which investments constitute routine maintenance, the EPA evaluates potential NSR violations on a case-by-case basis.[6]

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[5] The EPA originally interpreted the word modification to mean any change in plant design that would increase emissions by 100 tons per year. In 1979, the U.S. Court of Appeals, in *Alabama Power v. Costle*, ruled that the emissions limit was not appropriate (NAPA, 2003). In response, the EPA revised the NSR rule in 1980, eliminating the emissions threshold and creating the routine maintenance exception.

[6] The court decision in *Wisconsin Electric Power Company v. Reilly* affirmed that the EPA could evaluate routine maintenance in this manner.

B. Effect of the Routine Maintenance Exception on New and Old Boilers

The next section presents a simple model characterizing the effect of NSR policy on the value of coal boilers; we outline the argument here. If a utility makes an investment that triggers NSR it will have to reduce emissions and likely install a scrubber. Most non-controlled boilers, which are not connected to scrubbers, are relatively old. A narrow NSR regime, in which most investments qualify as routine maintenance, would allow utilities to replace worn out parts at non-controlled boilers without installing a scrubber. Under a broad policy, however, the investment would trigger NSR, and the utility would have to install a scrubber. For an older boiler under a broad regime, the utility is not likely to make the investment because it would not be able to recover the cost of the scrubber. The utility will use the boiler less or retire it earlier, decreasing the boiler's value.

We refer to a boiler connected to a scrubber as controlled. The NSR regime does not affect the firm's investment decisions for a controlled boiler, because the boiler already has a scrubber. Consequently, NSR does not affect the value of a controlled boiler.

C. Expectations of NSR Policy Before the 2000 Presidential Election

In the year 2000, the EPA and electric utilities were devoting a lot of attention to NSR policy. On Nov 3, 1999, the EPA and the Department of Justice announced that they were taking legal action against the owners of 32 coal-fired power plants for making life-extending investments without the proper NSR permits (Department of Justice, 1999).[7] In response to the lawsuits, utilities lobbied Congress to limit the fines the EPA could impose. At the same time, the EPA was trying to publish a new rule that would clarify the routine maintenance exception, but had been unable to reach a final decision.

Investors expected the winner of the election to have a significant effect on the EPA's definition of NSR. Neither candidate announced a specific NSR platform, but there are several indications that the utilities expected the Bush administration to have a narrower, more favorable NSR policy. First, Bush would have considerable influence over the

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[7] The lawsuits were expanded in 2000 to include an additional 14 plants.

EPA's new NSR rule. State regulators and utilities planned a meeting to discuss NSR policy under a Republican administration for April of 2000. A number of environmental groups protested the fact that they were not invited to participate, and contemporary news reports suggest that the meeting would have included discussions about how to take advantage of the opportunities the Bush administration would present. In the end, the meeting was cancelled because of the bad publicity from the environmental groups.[8]

Second, Bush has promoted a narrow policy, which has not surprised industry groups. The White House was one of the main proponents of the EPA's Equipment Replacement Provision. The Provision would define a modification as any investment costing more than 20% of the boiler's replacement cost.[9] The regulation would essentially eliminate NSR for existing power plants.

Finally, evidence from campaign contributions of Political Action Committees (PAC) suggests that the utilities heavily favored Bush. In fact, all contributions from utility PACs made directly to a Presidential candidate went to Bush. Of course, it is possible that this pattern occurred because the utilities favored Bush for reasons besides NSR. The empirical strategy addresses this concern, since we control for other policies that may have affected utilities.

IV The Effect of NSR on Boiler Profits

Section IV.A describes a model of a firm's decision to retire a boiler or replace worn out parts. We show that utilities are more likely to retire boilers under a broad NSR regime, making the boilers less valuable. In section IV.B we show that because Gore was expected to have a broad NSR policy, a utility's stock price increased after the 2000 election in proportion to the number of non-controlled boilers it owned. Section IV.C discusses estimation of the effect of NSR on the value of non-controlled boilers.

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[8] Electric Utility Weekly, April 24, 2000.

[9] The Equipment Replacement Provision has been overturned by the D.C. Court of Appeals, but is being considered by the Supreme Court.

A. Effect of NSR on Boiler Retirements and Value

We consider an investor-owned utility that produces electricity and sells it to customers.[10] Utility i owns N_i^c coal-fired boilers and does not own any other types of power plants (e.g., natural gas). We use the term boiler to refer to all of the capital equipment used to produce electricity. The firm owns N_i^{co} boilers that are connected to scrubbers, which are labeled controlled. The utility owns N_i^{nc} non-controlled boilers, which are not connected to scrubbers. The firm is risk neutral, so the value of the firm's boilers equals the sum of expected discounted profits from the boilers.

The main decision for a utility is to determine when to retire its boilers. We assume that all of the utility's non-controlled boilers are identical at time t, i.e., they have the same age, size and utilization. We characterize the utility's retirement decision for these boilers first, and then consider controlled boilers.

We assume that the price of electricity is determined exogenously, and is constant over the boiler's life. The costs of the boiler include fuel costs, which are constant over time, maintenance costs, and investments to replace worn out parts. Similarly to Stavins, we assume that maintenance costs increase over time, so that average variable costs increase as the boiler ages. Furthermore, at time $t' > t$, the turbine will wear out. At that point, the utility can either replace the turbine, at cost T, or retire the boiler. We assume that the boiler stops working at time t' without a new turbine.[11]

Figure 1 plots the average revenue and average variable cost curves. The curves intersect at time t', which simplifies the discussion; the results would be similar as long as the intersection does not occur much later than time t'. The utility will retire the boiler at time t' because it will not be able to recover the cost of replacing the turbine.

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[10] This section focuses on the stock price of a vertically integrated utility. In the empirical work, we account for the fact that many utilities were forced to divest their generators in the late 1990s, particularly in the Northeast (U.S. Department of Energy, 2000).

[11] The assumption that the utility must retire the boiler if it does not replace the turbine is for simplicity. We could easily extend the model, and assume that if the utility does not replace the boiler, average variable costs would increase. The utility would use the boiler less often under a broad NSR regime, and the profits from the boiler would decrease, as in the model in the text. The empirical analysis allows for this possibility.

At time t, the EPA introduces two regulations, both of which affect the utility's retirement decision. First, the EPA requires that new boilers must meet stricter emission standards than existing boilers. As Stavins argues, the regulation increases the cost of installing a new boiler, which creates a barrier to entry and raises the price of electricity. In Figure 1, the average revenue curve for the existing boiler shifts up. If the cost of the turbine, *T*, is sufficiently small, the utility will replace the turbine and retire the boiler at a later date, time t''. The value of the boiler at time t is equal to π_t^c, the region between the cost and revenue curves in the diagram.

The EPA also imposes NSR at time t, announcing that certain investments or maintenance expenditures will require the utility to install a scrubber. The cost of replacing the scrubber is S. We refer to the regime r as the set of investments and maintenance that would trigger NSR. In particular, the EPA adopts the regime $\tilde{r}$, in which replacing a turbine would also require the utility to install a scrubber.

The utility's retirement decision and the effect of NSR on the value of the boiler depend on parameter values. The utility can either retire the boiler, or replace the turbine and install a scrubber. We define $\tilde{\pi}^c$ as the operating profits of the boiler after time t' (excluding the cost of the turbine) if it continues to operate, as shown in Figure 2. We characterize the retirement decision under the two regulations as follows:

Decision	Condition	Change in Profits Due to NSR
Retire	$\tilde{\pi}^c < T + S$	$-\tilde{\pi}^c$
Replace Turbine	$\tilde{\pi}^c \geq T + S$	$-S$

The utility replaces the turbine and installs a scrubber as long as $\tilde{\pi}^c$ exceeds the cost of the scrubber and new turbine; otherwise the utility retires the boiler at time t'. We define the variable $NSR(\tilde{r})$ as the absolute change in profits of a non-controlled boiler, due to regime $\tilde{r}$. Thus, $NSR(\tilde{r})$ equals S or $\tilde{\pi}^c$, depending on parameter values.[12] Note that the

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[12] The effect of NSR on profits is equal to S when the firm replaces the turbine, rather than T + S, because the effect is measured relative to the counterfactual policy where the EPA regulates new sources but does not adopt NSR.

NSR regime affects the value of the boiler when it is announced, at time t, rather than when the investment would take place, time t'.

For controlled boilers, the utility must also replace the turbine at time t'. A controlled boiler already has a scrubber, so the utility would not have to install a scrubber if it replaces the turbine. As a result, the utility will replace the turbine at t' and retire the boiler at t''. The NSR regime does not affect the value of the controlled boiler at time t.

When the EPA selects regime $\tilde{r}$ at time t, the sum of expected discounted profits, V_{it}, from the utility's coal boilers is:

$$V_{it} = -N_i^{nc} NSR(\tilde{r}) + N_i^c \pi_t^c , \qquad (1)$$

The first term shows that NSR reduces the value of a non-controlled boiler by $NSR(\tilde{r})$. Excluding the effect of NSR, the utility would earn π_t^c for both its controlled and non-controlled boilers. We refer to π_t^c as the non-NSR profits of coal boilers.[13]

B. The 2000 Presidential Election and the Utilities' Market Capitalizations

We use equation (1) to show how the 2000 Presidential Election affected a utility's market capitalization. To simplify the analysis, we assume that before the election $r = 0$ and that all boilers have the same age; we relax these assumptions in the empirical work. The firm expects the policies of the two candidates, Bush and Gore, to have different effects on the electricity sector. In other words, the election may affect the non-NSR profits of coal boilers. We define the variable $\pi_t^c(B)$ as the expected profits for a boiler, exclusive of NSR, if Bush were to become president. The variable $\pi_t^c(G)$ is the non-NSR expected profits of a boiler under Gore.

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[13] In this analysis, the firm makes its NSR decision at the boiler level. For each boiler it decides whether to install a scrubber or forego the investment. In practice, there may be economies or diseconomies across boilers located at the same plant. That is, the utility may be able to install one scrubber that will cover multiple boilers, or it may have to install more than one scrubber for a given boiler. We discuss this complication below.

The election occurs just after time t. After the election, the NSR regime changes from $r = 0$ to either $r = B$ or $r = G$. The effect of the regime on the profits of a non-controlled boiler is $NSR(B)$ or $NSR(G)$. The variable P_t is the expected probability that Bush will win at time t. The expected effect of NSR on profits at time t is:

$$P_t[-NSR(B)] + (1 - P_t)[-NSR(G)]. \qquad (2)$$

The expression is a weighted sum of the effect of the two regimes, where the weights are the probability each candidate will win.

We consider the change in the market value of the firm after the election. Time t corresponds to the day before the election, November 6, 2000. Because of the Florida recount process, the election was not decided until December 12, 2000, by the Supreme Court decision, *Bush v. Gore*. We define the variable ΔV_i as the percent change in market capitalization between November 6, 2000 and December 13, 2000. We assume that the conditional expected profits and NSR costs did not change during this time (e.g., $\pi_t^c(B)$), and drop the time subscripts.[14] We define the variable $\overline{N}_i^{nc} = N_i^{nc}/V_i$, where V_i is the market value of the firm on November 6, and similarly for the count of coal boilers. We use equation (1) and expression (2) to obtain the following equation:

$$\Delta V_i = (1 - P)\{\overline{N}_i^{nc}[NSR(G) - NSR(B)] + \overline{N}_i^{c}[\pi^c(B) - \pi^c(G)]\}. \qquad (3)$$

The percent increase in the market value of the firm is proportional to the expected probability Gore would win. The first term in brackets shows the effect of the different NSR regimes on market capitalization. If investors expected NSR to be more costly under Gore than Bush, the market capitalization of the firm would increase after the election of Bush. The second term shows that if investors expected coal boilers to be more profitable under Bush than Gore because of non-NSR policies, the market value of the firm would increase.

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[14] The assumption is supported by the fact that neither candidate unveiled major policy initiatives after the election occurred.

C. Estimating the Effect of the Candidates' NSR Policies on Profits

We derive the estimating equation from equation (3). We measure the percent change in market capitalization using stock prices of electric utilities. Utilities may own electricity generating assets other than coal boilers. We distinguish such assets by the type of energy used to produce electricity. The vector X_i includes the number of steam turbine natural gas generators, other natural gas generators, steam turbine oil generators, other oil generators, hydroelectric generators and nuclear generators. We separate steam from non-steam turbines because steam turbines are larger and have higher utilization rates. Note that X_i includes counts of generators, whereas N_i^c is a count of coal-fired boilers. We discuss the reason for this in the data section, but note that the generators are sources of profits for the utility. If investors expected nuclear generators to be more profitable under Bush, the stock price of a firm with many nuclear generators would increase.

We define the event window as November 6 – December 29, 2000. The end date is December 29 to allow investors time to respond to the election news. We could take a similar approach to Hughes (2006) and Knight (2006), using changes in stock prices and the expected probability of a Bush victory between May and November. We prefer to focus on the time period after the election. Using the empirical strategy of Hughes and Knight, we obtain qualitatively similar, though smaller, results, but they are quite sensitive to alternative specifications. Furthermore, there is some evidence that earnings announcements by electric utilities caused large changes in stock prices between September and early October. There is no evidence that similar events occurred during our event window, and our approach leads to more precise and robust results.

We define the parameter $\alpha_1 = (1-P)[NSR(G) - NSR(B)]$ and $\alpha_2 = (1-P)[\pi^c(B) - \pi^c(G)]$. After making these changes to equation (3) we obtain:

$$\Delta V_i = \alpha_1 \overline{N}_i^{nc} + \alpha_2 \overline{N}_i^c + \overline{X}_i \beta \qquad (4)$$

Equation (4) accounts for differences in the expected profits under the two candidates for each type of generator or boiler. We next account for the fact that aggregate shocks to the electricity sector could affect utilities by different amounts. For example, investors may have expected electricity demand to be different under Bush than under Gore because of different levels of economic activity. We adjust ΔV_i in equation (4) by the percent change in value predicted by a conventional market model. We estimate the expected return after the election using the equation:

$$R_{it} = \delta_{i1} MKT_t + \delta_{i2} SMB_t + \delta_{i3} HML_t + \delta_{i4} GAS_t + \varepsilon_{it} \tag{5}$$

where R_{it} is the return of firm i on date t, net of the risk-free interest rate; MKT_t, SMB_t and HML_t are the excess daily market return and the size and book-to-market factors in Fama and French (1993); and GAS_t is the daily return of a portfolio of natural gas utilities. We estimate separate parameters for each utility in equation (5) using daily stock returns from 1993 – 1995, a period of time in which there was relatively little debate over NSR. We refer to that period as the estimation window.

We use the estimated parameters from equation (5) and the realizations of the independent variables during the event window to calculate the percent change in market capitalization predicted by equation (5) for each firm. We subtract this value from the dependent variable in equation (4), to obtain $\Delta \hat{V}_i$. Estimating this equation controls for aggregate shocks to the electricity industry, unrelated to NSR (Linn, 2006). We add an error term to equation (4) because of the error in estimating the predicted return for each firm.

We make two final changes to equation (4). First, we replace the generator counts with generating capacity, and the count of coal boilers with the fuel use of these boilers. This relaxes the assumption that all generators and boilers of a given fuel type are identical. Instead, the estimating equation imposes the somewhat weaker assumption that there are constant returns to scale across generators and boilers within a category. Note that we continue to use counts of non-controlled boilers. This specification allows for a straightforward interpretation of α_1, as the change in value of the average non-controlled boiler. The results are similar in magnitude, though imprecise, if we use the fuel use of non-controlled boilers.

Second, we consider boilers covered by New Source Performance Standards (NSPS) to be controlled, even if they are not connected to a scrubber. These boilers have much lower sulfur dioxide emission rates than non-controlled boilers, and would likely find complying with NSR less costly. Because NSPS boilers began operating after 1971, the remaining non-controlled boilers are older and smaller.[15] We obtain the following equation:

$$\Delta\hat{V}_i = \alpha_1 \overline{N}_i^{nc} + \alpha_{2r} \overline{F}_i^{c} + \overline{G}_i \beta + \upsilon_i \qquad (6)$$

where $\overline{F}_i^{c}$ is the total fuel use of coal boilers divided by the market capitalization of the firm on November 6, 2000; and $\overline{G}_i$ is the vector of generating capacity of each fuel type, divided by market capitalization.

Equation (6) is the baseline estimating equation. The coefficient of interest is α_1, which measures the increase in value of the average non-controlled coal boiler. The estimate of α_2 is the change in value of all coal boilers due to non-NSR policies. The regression controls for profit shocks that affect all coal boilers or other generating assets, and for aggregate shocks. Under identifying assumptions discussed below, the coefficient α_1 is proportional to the difference in the effect of the NSR policies of the two candidates on profits. From the model in the previous subsection, $\alpha_1 = (1-P)[NSR(G) - NSR(B)]$; the coefficient measures the effect of NSR on profits, multiplied by the expected probability Gore would win the election.

We are interested in the effect of NSR policy on profits, $NSR(G) - NSR(B)$, so we need to determine P, the expected probability of a Bush victory on November 6. We use information from the Iowa Electronic Market to estimate this variable. Between May and November, market participants traded futures contracts for a Bush victory. The Republican contract paid $1, so the price of the contract can be interpreted as the

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[15] The results are similar if we exclude the NSPS boilers from the controlled category.

expected probability of a Bush victory (Knight, 2006 and Hughes, 2006).[16] On November 6, the probability was 0.7.

After estimating the effect of NSR policy on profits, we calculate the effect on emissions. Section VII describes the calculations.

We now discuss the interpretation and identification of α_1. The coefficient measures the change in value of a non-controlled boiler, relative to the average coal boiler. We interpret α_1 as the difference in the value of a non-controlled boiler under the two regimes, due to different utilization or retirement. In section IV.B we show that NSR could affect the value of a non-controlled boiler if the utility has to retire the boiler or install a scrubber. We provide empirical evidence that investors expected broad NSR to cause the installation of few scrubbers. A simple extension of our model would show, however, that NSR could also raise operating costs and reduce utilization. As a result, NSR primarily affects utilization and retirement.

A major empirical concern is that we may not properly control for non-NSR profit shocks to non-controlled coal boilers. The identification is valid if the change in non-NSR profits per unit of fuel use is the same for controlled and non-controlled boilers. As we show below, controlled and non-controlled boilers have similar fuel efficiencies, measured in megawatt hours of generation per BTU of fuel use. The similarity limits the types of unobserved shocks that could bias the results: any shock that affects electricity or fuel prices would affect the profits per unit of fuel use similarly for the two types of boilers.

It is possible that other policies affected controlled and non-controlled boilers differently. Two of the more prominent policies we consider are carbon dioxide and mercury policy. Climate change policy was one of the most important environmental issues in the 2000 Election. In campaign speeches and the televised debates, the two candidates favored dramatically different approaches.

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[16] More precisely, the contract would pay one dollar if Bush should win the popular vote. Following Hughes and Knight, we treat the contract as measuring the probability that Bush would win the election. Despite the fact that Bush actually won the election without winning the popular vote, we assume that market participants viewed this possibility as extremely unlikely, consistent with the history of U.S. Presidential Elections.

Although climate policy was an important issue in the election, climate policy would not differentially affect non-controlled boilers. The effect of a policy on the profits of a given boiler depends primarily on its carbon dioxide emission rate. As we show below, this rate is quite similar for controlled and non-controlled boilers, which reflects the fact that scrubbers do not remove carbon dioxide.

In 2000, the federal government was considering how to regulate mercury emissions from power plants.[17] Since a scrubber can reduce mercury emissions, it is possible that our results are confounded by expected mercury regulation. There are two reasons why we do not believe this is a major issue, however. First, although there were many unresolved issues, by the time of the election it seemed likely that there was going to be some regulation of mercury in the future. Consequently, stock prices should have responded to the effect of mercury regulation before the beginning of the event window.[18] Second, there were not likely to be major differences between the mercury policies of the two candidates. The Clinton/Gore administration was arguing for a similar policy to the policy the Bush EPA eventually favored (InsideEPA, 2000).

A third potentially confounding policy is the expected strategy of the two candidates for the NSR litigation discussed in Section III. Investors probably did not expect the candidates to have significantly different policies, however. The EPA Enforcement Division, which is distinct from the other branches of the EPA, initiated the litigation. Utilities probably expected that the Bush administration would have little effect on the enforcement division, which has largely been the case. Furthermore, when the EPA announced the equipment replacement provision, it said that the legal strategy for past violations of NSR would not change. This suggests that decisions about the litigation were made separately from decisions about the new NSR rule. In the empirical section, we provide evidence that our baseline estimates are not biased by differences in how the candidates were expected to pursue the litigation.

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[17] The 1990 Clean Air Act Amendments required the EPA to determine whether mercury and other toxic pollutants were a threat to public health and should be further regulated. On December 14, 2000, the EPA determined that mercury emissions from coal-fired power plants should be controlled. The Bush EPA opted for a flexible approach and in March 2005, the EPA finalized the Clean Air Mercury Rule, which created a national cap-and-trade system.

[18] The EPA published a mercury rule on December 15, 2000, but this was widely expected.

There are two possible reasons why our estimates of the effect of NSR on profits and emissions may be biased towards zero. First, investors may have expected Bush to reduce emissions by a tradable permit program, as he attempted to do in his first term. In 2002, the White House introduced the Clear Skies legislation. The law would have reduced emissions from power plants by a tradable permit program. It is likely that the program would have affected the profits of non-controlled boilers more, since they have higher emission rates. In that case the estimate of α_1 would reflect the increase in profits under Bush due to eliminating NSR, as well as the decrease in profits due to a tradable permit program. The estimate would understate the effect of NSR on profits and emissions.

The second source of downward bias is that we characterize non-controlled coal boilers as being potentially subject to NSR. This specification may not include a number of boilers that would also be affected by NSR, in which case we would underestimate the effect of NSR on emissions for the entire industry. We believe that we capture most of the effect, since controlled boilers have much lower emission rates than non-controlled boilers.

There are two final empirical issues. First, the model does not include general equilibrium effects of NSR, which could differentially affect the total profits of controlled boilers. For example, a broader NSR regime would cause utilities to retire older boilers, raising the price of electricity. However, unless the profits per unit of fuel use differ across the categories of boilers, this possibility would not bias the results.

Second, we have assumed that NSR affects boilers located in average cost regions similarly to other boilers. We view this as a reasonable assumption since utilities had already recovered the initial costs for most non-controlled boilers. Utilities would not likely be able to pass on the costs of NSR to consumers in average cost regions. In addition, we find no evidence that the change in value of boilers in the least regulated states was different from other boilers.

V Data Sources, Variable Construction and Summary Statistics

We use stock price data from the Center for Research in Security Prices (CRSP), boiler and generator data from DOE Form 767 and Form 860, and emissions data from the EPA. We construct a sample of 71 investor owned utilities whose stocks traded continuously from 1993 – 2000. We use this data to estimate equation (5) and compute the predicted percent change in market value for each firm. We subtract this from the actual percent change in market value between November 6, 2000 and December 29, 2000, to obtain the dependent variable in equation (6).

We use the DOE and EPA data to compute the independent variables. The 767 Form collects information on the design and operation of steam-driven electric plants with ratings of 10 megawatts or greater. We use data from 2001 instead of 2000 because the 2001 data has a larger sample of boilers. The data is at the boiler level and includes whether the boiler is connected to a scrubber, the boiler's location, primary fuel type, hours in service, the first year of operation, and the environmental regulations to which the boiler is subject.

We use the boiler's primary fuel type to distinguish coal-fired from oil- or gas-fired boilers. Each boiler is then labeled controlled if it is connected to a scrubber or covered by NSPS.[19] All other boilers are labeled non-controlled. There were two stages of NSPS: the first was part of the Clean Air Act of 1970 (known as NSPS-D), and the second was included in the Clean Air Act of 1977 (NSPS-Da). Boilers subject to NSPS-Da were essentially required to install a scrubber, and are classified as controlled. Boilers subject to NSPS-D, on the other hand, cannot emit more than 1.2 pounds of sulfur dioxide per million British Thermal Units (lb/mBTU) of heat input. Firms can achieve this emission rate either by installing a scrubber or in some cases, by using low-sulfur coal. We classify the NSPS-D boilers as controlled because they have much lower sulfur dioxide emission rates than other boilers not connected to scrubbers, 0.72 lb/mBTU as opposed to 1.66 lb/mBTU. In comparison, the average emission rate of boilers connected to scrubbers is 0.57 lb/mBTU.[20] The results are similar, though less precise, if we count NSPS boilers that do not have a scrubber as non-controlled. We prefer counting these boilers as controlled, to identify the coal boilers that would find a broad NSR regime the most costly.

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[19] Boilers can be serviced by more than one scrubber or share a scrubber with other boilers, depending on the configuration of the flue. We count a boiler as controlled if its flue is connected to at least one scrubber.

[20] Means are computed for the boilers in the final sample, as described in the text, and are weighted by fuel use.

For each utility in the data set, we construct a count of non-controlled and controlled boilers. We focus on coal boilers rather than the associated generators because it is more straightforward to determine whether a boiler is connected to a scrubber. The results are similar if we perform the analysis at the generator level.

For each utility, we use the DOE Form 860 to calculate generating capacity by generator type (natural gas, oil, hydroelectric and nuclear). We supplement these data with emissions and fuel input data for the year 2001 from the EPA's Clean Air Markets Acid Rain Program. The EPA data provides the annual mass of sulfur dioxide, nitrogen oxide, and carbon dioxide emissions from each boiler. We use the EPA's fuel data because it is measured in BTUs, rather than the DOE data, which is measured in physical units.

Table 1 provides summary statistics by utility and boiler. The first two columns of Panel A show the mean, standard deviation and median number of controlled and non-controlled boilers, per utility. The average utility has more than twice as many non-controlled boilers as controlled.

The first two columns of Panels B-D show boiler-level statistics for controlled and non-controlled boilers. Panel B reports fuel use, in trillion BTUs. Panel C reports utilization rate, defined as the fraction of hours the boiler was in operation. Panel D reports the number of years the boiler has been operating.

The two types of boilers are considerably different. Controlled boilers use about 2.5 times as much fuel, which is partly due to their higher utilization rate, and partly because they are larger. Controlled boilers are about 17 years younger on average.[21]

Table 2 shows additional statistics by boiler category. Panel A shows that controlled boilers have an average sulfur dioxide emission rate that is about one-third of the emission rate of non-controlled boilers.

The next two panels of Table 2 address two of the main issues related to the identification of the effect of NSR on boiler profits. Panel B supports the assumption that non-NSR policies affect controlled and non-controlled boilers similarly, per unit of fuel

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[21] Note that Stanton finds that pre-1970 boilers have higher utilization rates in the 1980s after controlling for covariates, though he uses a different sample.

use. We compute fuel efficiency by matching boilers to their associated generators.[22] We calculate the number of megawatt hours of electricity generation, per million BTU of fuel use for each generator. Panel B reports fuel efficiency for the generators in the indicated categories. The mean and median fuel efficiencies are nearly identical across categories, so that an unobserved shock to electricity prices or fuel costs would affect these boilers similarly, and would not bias our results.

Panel C suggests that carbon dioxide policies of the two candidates would have a similar effect on the profits of controlled and non-controlled boilers. The carbon dioxide emission rates are quite similar for the two types of boilers. Even if stock prices of electric utilities changed because of expected differences in carbon dioxide policy, this would not bias our results.[23]

Columns 3-5 of Tables 1 and 2 report the same summary statistics for different subsets of non-controlled boilers. Below we report separate results for three subsets of non-controlled boilers, to investigate whether the effect of NSR varied across categories. Column 3 includes boilers with utilization rates above the median utilization rate of non-controlled boilers. Column 4 includes boilers that began operating before 1971, and column 5 includes boilers with sulfur dioxide emission rates above the median for non-controlled boilers. Although highly utilized boilers are larger and slightly younger than the average non-controlled boiler, they are much older and produce less power than the average controlled boiler. High emission rate boilers have about the average age and utilization for non-controlled boilers.

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[22] We omit the small number of boilers connected to multiple generators. We exclude these boilers because we cannot determine how much electricity is produced per BTU of heat input.

[23] We investigate this issue further by separating coal boilers into two categories, based on their carbon dioxide emission rates, rather than whether they are connected to a scrubber. Using a specification similar to the baseline, it appears that high carbon emission boilers increased in value, suggesting that utilities expected a less costly carbon dioxide policy under Bush. This estimate is less precise than the estimate of α_1, however.

VI Effect of 2000 Presidential Election on Boiler Values

A. Main Results

Before reporting the regression estimates, we show the main result graphically. To construct Figure 3, we separate utilities into three categories: firms that do now own any non-controlled boilers, firms that own fewer than the median number of non-controlled, and firms that own more than the median.[24] For each day in the event window, we compute the average percent change in market capitalization from November 6 to that day, by category. [25] Figure 3 plots the difference between the percent change of utilities above and below the median number of non-controlled boilers, relative to utilities with zero non-controlled boilers. Figure 3 shows that stock prices responded to the election in December, as the uncertainty over the election was resolved. The stock prices of utilities with many non-controlled boilers increased only slightly more than other utilities in November. In early December, as it became more likely that Bush would prevail in the Florida recount, the stock prices of utilities with many non-controlled boilers increased much further. The relative values of these utilities increased somewhat in late December but remained stable for at least several months afterwards (not shown). In comparison, the values of utilities with few non-controlled boilers were similar to utilities with zero non-controlled, increasing slightly in late December[26].

Table 3 reports the estimates of equation (6). To construct the dependent variable we compute the percent change in market capitalization for each firm from November 6, 2000 to December 29, 2000. We subtract the predicted percent change in market capitalization from the actual change, where the predicted change is calculated using equation (5). The independent variables are a count of non-controlled coal boilers, fuel

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[24] The median is computed over utilities that own at least one non-controlled boiler.

[25] To construct the Figure we subtract the predicted percent change in market capitalization from the actual percent change, which is how we construct the dependent variable in the regressions.

[26] The relatively small change in stock prices for utilities below the median raises the possibility that the effect of NSR on the value of a boiler varies with the number of boilers owned by the utility. This implies that the OLS estimates of equation (6) could be driven by outliers. We obtain identical results to the OLS estimates, however, if we estimate equation (6) using a median regression. Results are available from the authors by request.

use of all coal boilers, and generating capacity by generator type. All independent variables are divided by the initial market capitalization of the utility, so that the parameter α_1 measures the change in value of the average non-controlled boiler. The estimate is proportional to the difference in expected profits under the two candidates.

The baseline specification is reported in column 1. The estimate of α_1 is 11.67 with standard error 5.70, which is significant at the 5 percent level. Assuming that the expected probability of a Bush victory was 0.7 before the election, the estimate implies that Bush's NSR policy was expected to increase the value of a non-controlled coal boiler by about $39 million (in 2000 dollars). The estimate corresponds to about a 2.5 year increase in use, assuming 2001 production levels. This figure is substantially less than the cost of installing a scrubber (about $120-$150 million)[27]. The estimate suggests that a broad NSR policy would have resulted in the installation of few additional scrubbers, but would have decreased the utilization or caused earlier retirements of non-controlled coal boilers. We return to the interpretation of the estimate in Section VII, where we calculate the effects of the candidates' NSR policies on emissions.

We briefly discuss the other estimated coefficients from equation (6) (not reported). Controlled coal boilers declined in value by less than $1 million, though the estimate is not statistically significant. This suggests that the non-NSR policies of the two candidates were expected to affect coal boilers similarly. Most natural gas and oil generators became more valuable (by about $10 million), which seems reasonable, given that many observers expected Bush to favor the oil and gas industries (Knight, 2006). Hydroelectric generators declined in value by about $2 million and nuclear generators increased in value by about $27 million, though neither estimate is precise.

The baseline estimate measures the change in value of the average non-controlled boiler. The specification uses a count of boilers, and we now consider whether there is heterogeneity among different types of non-controlled boilers. Columns 2 and 3 show the

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[27] This amount is the average capital cost plus 15 times the average annual operating costs. It is equivalent to using a 5% discount rate and a 28 year life. See Bellas (1998) for more details. An alternative interpretation of the estimate could be that as a result of Gore's NSR policy, investors expected utilities to install a scrubber in the future. In that case the estimate would reflect the discounted decrease in profits due to installing the scrubber. We do not favor this interpretation, however, because the estimate implies that investors expected the utilities to install scrubbers 23 years in the future. Given that most non-controlled boilers were at least 30 years old at the time, it seems unlikely that they would continue to operate for that much longer.

change in value for boilers with greater than the median utilization rate and boilers that began operating before 1971. The summary statistics for these boilers are in columns 3 and 4 in the first two Tables. One might expect NSR to have a greater effect on heavily used boilers. The estimate of α_1 is larger than the baseline, and is roughly in proportion to the fuel use of the boiler. For the older boilers, the estimate of α_1 is close to the baseline in column 3, suggesting that the value of an old boiler changed by a similar amount to the average boiler. Given the results in columns 1 and 2, there may be two offsetting effects for old boilers: they have lower fuel use, which makes NSR less costly per boiler, but they are older, and a broad NSR regime would restrict utilities' investments more.

The results of the next two specifications support the conclusion that the estimate of α_1 reflects a decrease in utilization or earlier retirement, rather than the cost of installing as scrubber. In column 4 we focus on boilers with high sulfur dioxide emission rates, as defined in Table 2. The costs of NSR might be higher for these boilers if utilities were to install abatement equipment. On the other hand, if the main effect of NSR is to reduce utilization, NSR would affect these boilers similarly to other non-controlled boilers. The estimate in column 4 is close to the baseline.

If a broad NSR policy were expected to cause scrubber installations, the cost of NSR would likely be greater for boilers located in counties that are in non-attainment for sulfur dioxide. The emission standards for these boilers could be considerably more stringent than for other boilers. However, this would only affect the boiler value if the utility were expected to install control equipment, rather than use the boiler less. Column 5 separates non-controlled boilers by attainment status, and reports the coefficient on non-attainment boilers. The standard errors are large, but there is no evidence that NSR under Gore would have been more costly for boilers in non-attainment areas.

The last two specifications in Table 3 address the assumption that non-NSR policies affected controlled and non-controlled boilers similarly, per unit of fuel use. The baseline specification includes fuel use of all coal boilers, which imposes the assumption of constant returns to scale for these boilers. We relax this assumption in column 6, separating the fuel use of coal boilers according to size. We define small boilers as having less than twice the median level of fuel use. Small boilers may be a more appropriate control group for the non-controlled boilers because they have similar average fuel use.[28] The estimate of α_1 is precise and close to the baseline, suggesting that the constant returns to scale assumption is reasonable.

Finally, as Table 1 shows, non-controlled boilers are considerably older than controlled boilers. If investors expected non-NSR policies of Bush to favor older boilers, our results might be biased. In column 7 we separate fuel use of coal boilers into two variables: fuel use of boilers that began operating before 1971, and fuel use of newer boilers. If this concern were important, we would obtain a positive estimate of the coefficient on fuel use of old boilers, and a smaller estimate of α_1. As column 7 shows, however, the estimate of α_1 is slightly larger than the baseline, and the coefficient on fuel use of old boilers is small and negative (not reported).

B. Alternative Specifications

Table 4 reports a number of alternative specifications. The results are fairly robust, though the precision varies somewhat across estimation models.

In the main specification, the estimation window used to construct the dependent variable spans 1993 – 1995, when NSR was a relatively minor issue. The relationship between the utilities' stock prices and the factors in equation (5) may vary over time, however. The results would be biased due to the large interval between the end of the estimation period and the event window in 2000. In column 1 we use an alternative estimation period, 1995 – 2000. The result is similar to the baseline estimate.

In the baseline specification, the event window ends on December 29, 2000 to insure that investors have fully responded to the election. This specification introduces potential bias if there were an unobserved shock to non-controlled boilers during the event period. We can partially address this concern by shortening the event window to December 13, 2000, the day after the Florida recount ended. In column 2 the estimate is smaller, 8.53, and significant at the 10 percent level. The baseline estimate is about 30 percent larger.[29]

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[28] The average fuel use of large coal boilers is 41.1 trillion BTUs and the average fuel use for small boilers is 9.1 trillion BTUs, which are comparable to columns 1 and 2 in Panel B of Table 1.

[29] As noted above, the EPA published a mercury rule on December 15, 2000. If this rule were unexpected and affected non-controlled coal boilers differently, the baseline estimate could be biased. The estimate in column 3 is smaller than the baseline, suggesting that this may be the case, though the estimates are not

We further investigate the stability of our estimate by extending the event window two months, to February 28, 2001. The estimate of α_1 in column 3 is about 45 percent larger than the baseline. The increase in magnitude raises the concern that the estimate of α_1 reflects an unobserved, non-NSR, profit shock that increased the returns of utilities owning many non-controlled boilers. We have investigated this concern further, re-estimating equation (6), and allowing the event window to end on each date from December, 29, 2000 to the end of April, 2001. The estimate of α_1 varies somewhat during this period, though not significantly, and the point estimate is between $10-20 million for the entire time period.

Hughes and Knight analyze daily changes in the probability of a Bush victory between May and November. We have performed a similar analysis, and find that the stock prices of utilities with many non-controlled boilers increase when the Bush probability increases. However, this result is not robust and there is some evidence that earnings announcements and forecasts in September and October affected the stock prices of utilities during this period. In contrast, there do not appear to have been such events in November or December, which is why we prefer to use changes in stock prices after the election. As column 4 reports, we obtain a much smaller, and statistically insignificant, result using the longer event window, May 1 – December 29.

We now consider whether the baseline estimate is biased by the EPA's litigation against the utilities. There are two main potential sources of bias. First, the litigation proceedings may have affected stock prices in November and December. In particular, the EPA reached a settlement agreement with Cinergy and sued Duke during the event window. Second, utilities may have expected the election to affect the EPA's strategy in the lawsuits. We argue in Section III that this is not likely, and we address the issue empirically in column 5. We omit the firms in the sample involved with NSR litigation, including Cinergy and Duke. The estimate is quite close to the baseline.[30]

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significantly different. As discussed earlier, however, the mercury rule was most likely anticipated and it probably does not bias the results.

[30] We have investigated the effect of litigation on stock prices further. We find some evidence that a utility's stock price falls around the time that the EPA announces the litigation, but the results are often imprecise.

Northeastern states began restructuring the electricity sector earlier than most other regions of the country. By the end of 2000, utilities had divested most of their generating assets. We include utilities located in the Northeast because our model predicts that since the utilities own few non-controlled coal boilers, the change in their stock prices should be smaller than for utilities in other regions; including the Northeastern utilities should improve the efficiency of the estimates. However, if investors expected the two candidates to have different policies for deregulating the industry, the baseline specification could be biased. In column 6 we omit the 29 utilities in our sample with boilers or generators in the Northeast. The estimate of α_1 is similar to the baseline estimate. We also separate states according to the level of regulation of electric utilities. We find that the value of non-controlled boilers located in the least regulated states changed similarly to other boilers (not reported), suggesting that deregulation is not biasing the results.

We further address the possibility of unobserved regional profit shocks in column 7. We control for coal fuel use and generating capacity by region, and the estimate of α_1 is similar to the baseline. The coefficient on Northeastern generating capacity is positive and significant, while the estimates for the other regions are insignificant. It is difficult to interpret that result, however, because Northeastern utilities have relatively large numbers of oil and gas generators. The estimate may be driven by a shock to these generators.

The baseline specification includes a count of non-controlled boilers and the fuel use of all coal boilers. The estimate of α_1 could be spurious if the relationship between profits and fuel use is nonlinear. We address this possibility in column 8 by including a count of all coal boilers in place of fuel use. The estimate of α_1 is similar to the baseline, though it is imprecise. The coefficient on coal boilers (not reported) implies that the average controlled boiler increased in value by about $2 million, which is much smaller than the increase in value of the average non-controlled boiler.[31]

The coal independent variables are measured at the boiler level. If there are economies to scale across boilers connected to the same flue or generator, the baseline

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[31] Alternatively, we could estimate a specification with fuel use of non-controlled boilers and fuel use of all coal boilers. The coefficient on non-controlled boilers is again insignificant, though the magnitude implies a similar change in value as the baseline specification.

estimate of the cost of NSR may be biased. For example, a utility may be able to install one scrubber on a flue that is connected to multiple boilers. In column 9 we construct an alternative measure of non-controlled and controlled units, using counts of flues in place of boilers. We consider a flue to be controlled if all boilers connected to a given flue are also connected to a scrubber. We control for fuel use of all coal units in this specification, and the result is quite similar to the baseline.

Finally, we address the fact that we construct the coal variables at the boiler level, and other variables at the generator level. The results are not affected if we use counts of non-controlled generators and the generating capacity of all coal generators in place of boilers (not reported).

VII Effect of NSR on Coal Boiler Emissions

We use the baseline estimate, in column 1 of Table 3, to calculate the effect of NSR on emissions. We consider emissions of sulfur dioxide, nitrogen oxides and carbon dioxide. This section describes the calculations and discusses the interpretation of the results.

The baseline estimate implies that investors expected the value of a non-controlled coal boiler to be $39 million higher because of Bush’s NSR policy. We first convert the estimated change in profits to the change in fuel use. We make two assumptions to perform this calculation. First, the increase in value corresponds to greater electricity generation, in kilowatt hours (kWh). The results in the previous section support this assumption, because it does not appear that utilities would have installed scrubbers under a broad NSR regime.[32]

The second assumption is that the average profit of non-controlled boilers is constant, and slightly larger than that of other coal boilers. The average profit of a coal boiler is $0.018 per kWh (EIA, 2004). According to the EPA's Integrated Planning Model assumptions (2004), the non-fuel variable costs of a scrubbed boiler are about $0.002

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[32] It is also possible that the increase in value is due to a decrease in costs under a narrower NSR regime. However, the results of Bushnell and Wolfram suggest that NSR probably has a small effect on costs.

higher than a non-scrubbed boiler, so we use $0.02 per kWh as the average profit of a non-controlled boiler.

This calculation yields the increase in electricity generation, in kWh, for the average non-controlled coal boiler under Bush. We convert that figure to fuel use, in million BTUs, using the average fuel efficiency of non-controlled coal boilers (see Table 2).

We use average emission rates of the non-controlled boilers to calculate the increase in emissions. The emission rates, in pounds per million BTUs (lb/mBTU), are 1.72 for sulfur dioxide, 0.38 for nitrogen oxides and 205 for carbon dioxide.

We extrapolate the increase in emissions of non-controlled coal boilers to the entire electricity sector. Our sample does not include some investor owned utilities (because of the need for a balanced panel from 1993 – 2000), other utilities and non-utilities. We inflate the total emissions from the 461 non-controlled boilers in the sample to the 765 total non-controlled boilers in the U.S. [33]

To calculate the effect of NSR on emissions, we account for the fact that if the non-controlled coal boilers would have generated less electricity under a Gore administration, that electricity would have been produced from other sources. We consider two possibilities: the electricity would have been replaced by combined cycle natural gas generation, or it would have been replaced by generation from new coal boilers that meet new source emission standards. In both cases we assume that the new units generate the same amount of electricity as the non-controlled boilers. We use the emission rate of scrubber-controlled boilers in our sample to approximate the emission rate of a new coal boiler, 0.59 lbs/mBTU.[34] The emissions rates for the other pollutants for coal and gas-fired generation are taken from the EPA's Integrated Planning Model assumptions (2004). New coal plants emit nitrogen oxides at a rate of 0.06 lbs/mBTU and carbon dioxide at 205 lbs/mBTU. Natural gas plants are assumed to emit zero sulfur dioxide, 0.02 lbs/mBTU of nitrogen oxides, and 117 lbs/mBTU of carbon dioxide.

Table 5 reports the effect of NSR on emissions under the two scenarios. The first column shows the results for natural gas and the second column shows the results for coal. Note that since there are currently no carbon dioxide emission standards, there

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[33] We would inflate our results by a similar amount if we use fuel consumption instead of boiler counts.

[34] We use this emission rate because new boilers do not have an emissions standard with respect to sulfur dioxide; they must remove 95% of their baseline emissions.

would be no effect on carbon dioxide emissions in the coal scenario. Between the year 2000 and the eventual retirement of the non-controlled boilers, the difference in NSR policies will have caused a substantial increase in emissions. Assuming new natural gas units would have replaced the non-controlled coal boilers, sulfur dioxide emissions will have increased by 13 million tons, nitrogen dioxide emissions by 2.8 million tons and carbon dioxide emissions by 680 million tons. For comparison, emissions from electric power plants in 2000 were 11 million, 5 million, and 2.4 billion tons (EIA, 2004). The increase in emissions is somewhat smaller under the coal scenario, in column 2. The large increases in emissions can be explained by the fact that the non-controlled boilers have much higher emission rates than newer plants.[35]

VIII Concluding Remarks

This study uses changes in stock prices after the 2000 Presidential Election to estimate the effect of NSR policy on the profits and emissions of coal boilers. Investors expected these boilers to be $39 million more valuable under a narrow policy of the Bush administration, relative to a broad policy under Gore. We argue that the difference in value is due to greater utilization, and calculate that before being retired, non-controlled coal boilers will have emitted an additional 13 million tons of sulfur dioxide, 2.8 million tons of nitrogen oxides and 680 million tons of carbon dioxide. These amounts are substantial, reflecting the fact that older, non-controlled boilers have much higher emission rates than the generators that would have replaced them.

In the debate over NSR, many utilities have claimed that enforcing a broad NSR regime would raise the cost of supplying electricity and harm reliability. They argue that market based incentives would be a much more efficient means of reducing emissions. As noted above, it is difficult to use our results to make an accurate comparison of the cost of reducing emissions using NSR, relative to market incentives. The relative costs of market programs and NSR remains an open question for future research.

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[35] An important policy question is whether reducing emissions via market incentives would be more efficient than using NSR. By making a number of additional assumptions, we can make a rough comparison. These assumptions are relatively strong, and we treat the results cautiously. Our results imply that the cost to utilities may be two to three times greater using NSR.

IX References

Bellas, Allen (1998). “Empirical Evidence of Advances in Scrubber Technology” *Resource & Energy Economics*, 20 (4), p. 327-343

Bushnell, James and Catherine Wolfram (2006). “The Economic Effects of Vintage-Differentiated Regulations: The Case of New Source Review.” Mimeo.

Electric Utility Week (April 24, 2000). “States Meet to Eye Reform for Air Program; Political Edge Criticized.”

Energy Information Administration (2004). Electric Power Annual. Washington DC

Goldberg, Pinelopi (1998). “The effects of the corporate average fuel efficiency standards in the US.” *Journal of Industrial Economics,* 46, p 1–33.

Gruenspecht, Howard (1982). "Differentiated Regulation: The Case of Auto Emission Standards." The American Economic Review, Papers and Proceedings
of the Ninety-Fourth Annual Meeting of the American Economic Association
72 (2), p. 328-331.

Hughes, Paul (2006). “Do EPA Defendenants Prefer Republicans? Evidence from the 2000 Election” *Economic Inquiry*, 44 (3), p 579-585.

InsideEPA, EPA (December 7, 2000). “OMB Clash over Mercury Controls on Power Plants.” 11(25)

Keohane, Nathaniel O., Erin T. Mansur and Andrey Voynov (2006). “Averting Enforcement: Strategic Response to the Threat of Environmental Regulation.”

Knight, Brian (2006). “ Are Policy platforms capitalized into equity prices? Evidence from the Bush/Gore 2000 election.” *Journal of Public Economics*, 90, p 751-773

Linn, Joshua (2006). “Stock Prices and the Cost of Environmental Regulation”, AEI-Brookings Related Publication 06-16

List, John, Daniel Millimet, & Warren McHone (2004). “The Unintended Disincentive in the Clean Air Act.” *Advances in Economic Analysis & Policy*, 4(2), Article 2.

Maloney, Michael and Gordon Brady (1988). “Capital Turnover and Marketable Pollution Rights.” *Journal of Law and Economics*. 31(1), p 203-226.

National Academy of Public Administration (2003). “A Breath of Fresh Air: Reviving the New Source Review Program.”

Stanton, Timothy (1993). “Capacity Utilization and New Source Bias: Evidence from the US Electric Power Industry.” *Energy Economics*. 15(1) , p -57-60.

Stavins, Robert (2005). “The Effects of Vintage-Differentiated Environmental Regulation.” RFF Discussion Paper 05-12.

United States Court of Appeals, 7th Circuit (1990). *Wisconsin Electric Power v. Reilly*, 893 F.2d 901, 905

United States Court of Appeals, D. C. Circuit (1979). Alabama *Power Co v. Costle*, 636 F.2d 323, 346-49.

United States Department of Energy (2000). “The Changing Structure of the Electric Power Industry 2000: An Update.”

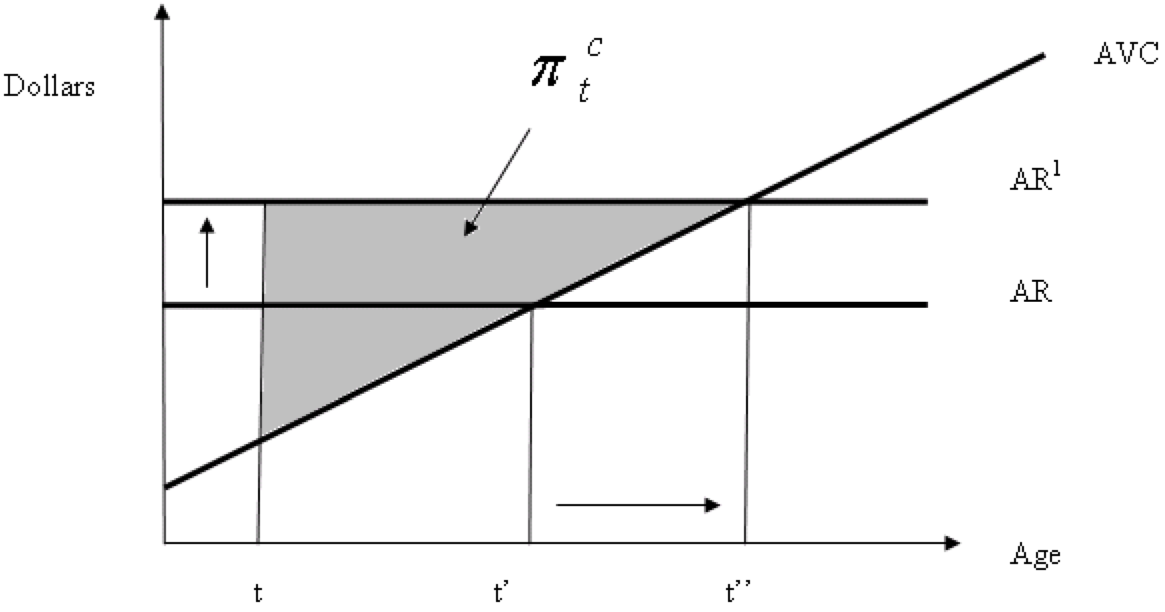
United States Department of Justice (November 3, 1999). “U.S. Sues Electric Utilities in Unprecedented Action To Enforce the Clean Air Act,” Press Release No. 524.

United States Environmental Protection Agency (2004). IPM Documentation Report. Available at: http://www.epa.gov/airmarkets/epa-ipm/

United States Environmental Protection Agency (2005). Clean Air Interstate Rule Regulatory Impact Analysis.

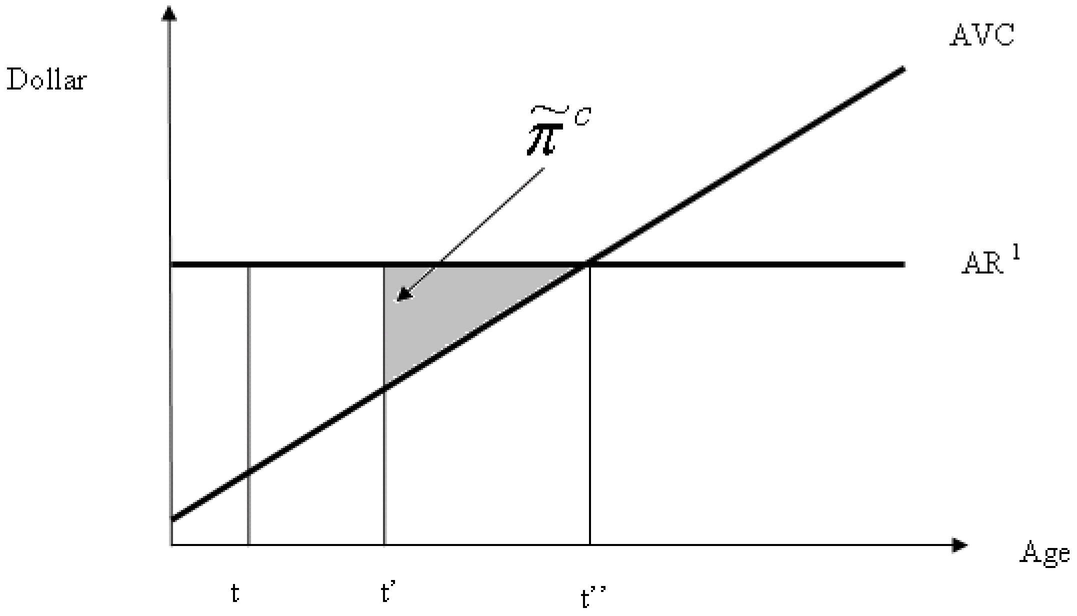
United States Supreme Court (2000). *Bush v. Gore*, 121 S. Ct. 525.

Figure 1: Effect of New Source Regulation on Boiler Retirement



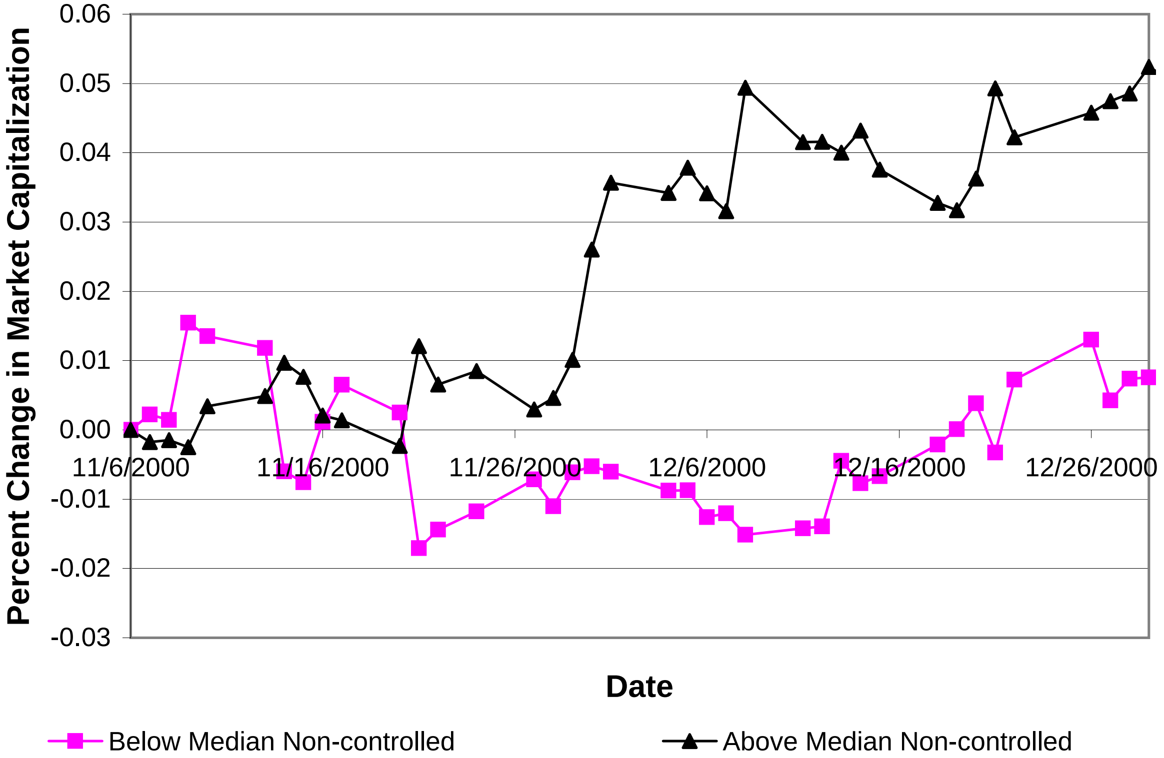
AR ^{1} is the average revenue of the boiler over its lifetime in the absence of regulation of new sources. AR is the average revenue of the boiler over its lifetime with the regulation of new sources. AVC is the average variable cost of the boiler over its lifetime. The current age of the boiler is t. A turbine must be replaced at time t'. The retirement age with and without regulation of new sources are t' and t'', respectively. The profit earned from the boiler with regulation of new sources is π_t^c .

Figure 2: Benefits of Replacing a Turbine



All curves and times are labeled as in Figure 1. The profit earned from the replacement of a turbine is $\widetilde{\pi}^{c}$.

Figure 3: Percent Change in Market Capitalization by Boiler Category, Relative to Control Group, 11/6/00 - 12/29/00



Notes: Controlled coal boilers are connected to a scrubber or covered by New Source Performance Standards. All other coal boilers are non-controlled. Utilities are separated into three categories: utilities that own zero non-controlled boilers, utilities that own fewere than the median number of non-controlled, and utilities that own more than the median number of non-controlled. For each category, the mean percent change in market capitalization is calculated, adjusted by the market model, from November 6 to December 29, 2000. The Figure plots the difference between the percent change of the market capitalization for utilities that own non-controlled boilers, and the percent change of utilities with zero non-controlled boilers.

Table 1

Utility and Boiler Summary Statistics

	Controlled boilers	Non-controlled boilers	High utilization non-controlled boilers	Pre-1971 non-controlled boilers	High emission rate non-controlled boilers
	(1)	(2)	(3)	(4)	(5)
			Panel A: Counts of Boilers By Utility		
Mean	2.42	6.46	3.13	5.55	3.85
Std Dev	3.57	10.28	4.87	8.56	7.13
Median	4	9	5	8	6.5
			Panel B: Fuel Use Per Boiler (trillion BTUs/Year)		
Mean	34.87	13.55	17.03	9.73	13.10
Std Dev	19.12	13.30	14.56	8.75	12.99
Median	35.49	8.49	11.34	7.16	7.90
			Panel C: Boiler Utilization Rate		
Mean	0.86	0.75	0.89	0.74	0.73
Std Dev	0.10	0.20	0.05	0.21	0.21
Median	0.87	0.81	0.90	0.79	0.78
			Panel D: Boiler Age (Years)		
Mean	24.68	41.51	39.31	43.78	41.66
Std Dev	10.48	8.66	8.00	7.10	8.39
Median	22	42	41	43.5	43

Notes: Variables are constructed from the Department of Energy Form 767, the CRSP database and the EPA Clean Air Markets Acid Rain Program database (see text). Cells report the mean, standard deviation and median of the indicated variables and categories of boilers. Controlled boilers include coal boilers that are connected to a scrubber and boilers that are covered by New Source Performance Standards. Non-controlled boilers include all other coal boilers. Column 3 includes non-controlled boilers that have above the median utilization rate of non-controlled boilers. Column 4 includes non-controlled coal boilers that began operation before 1971. Column 5 includes non-controlled boilers that have more than the median emission rate of sulfur dioxide. Panel A reports counts of boilers for utilities in the estimation sample (see text). Panels B-D report boiler statistics for boilers belonging to the utilities in Panel A. Panel B reports fuel use per boiler (in billion BTUs per year). Panel C reports the fraction of hours the boiler is in use. Panel D reports the number of years since the boiler began operating.

Table 2

Boiler Emission Rates and Fuel Efficiency

	Controlled boilers (1)	Non-controlled boilers (2)	High utilization non-controlled boilers (3)	Pre-1971 non-controlled boilers (4)	High emission rate non-controlled boilers (5)
			Panel A: Sulfur Dioxide Emission Rate (Pounds SO_2/mBTU)		
Mean	0.59	1.72	1.54	1.77	2.43
Std Dev	0.46	1.03	0.85	1.08	1.00
Median	0.54	1.45	1.34	1.46	2.18
			Panel B: Fuel Efficiency (MWh/mBTU)		
Mean	0.090	0.091	0.093	0.090	0.094
Std Dev	0.009	0.015	0.011	0.015	0.017
Median	0.090	0.092	0.093	0.090	0.095
			Panel C: Carbon Dioxide Emission Rate (Pounds CO_2/mBTU)		
Mean	205.38	205.17	205.19	205.13	205.09
Std Dev	2.15	1.54	1.38	1.53	0.78
Median	205.20	205.20	205.20	205.20	205.20

Notes: The data sources and categories of boilers are the same as in Table 1. Cells report the mean, standard deviation and median of the indicated variables and categories of boilers. Panel A reports emission rates of sulfur dioxide (SO_2), in pounds of SO_2 per million British Thermal Units (mBTU). Panel B reports fuel efficiency, in megawatt hours (MWh) of electricity generation per mBTU of fuel use. Fuel efficiency is calculated at the generator level using total fuel use of boilers associated with the generator. The calculations omit boilers connected to multiple generators. Panel C reports emission rates of carbon dioxide (CO_2), in pounds of CO_2 per mBTU.

Table 3

Effect of 2000 Election on the Value of Non-controlled Boilers

	(1) Non-controlled boilers	(2) High utilization non-controlled boilers	(3) Pre-1971 non-controlled boilers	(4) High emission rate non-controlled boilers	(5) Include non-attainment boilers	(6) Separate fuel use of large and small boilers	(7) Separate fuel use of old and new boilers
	Dependent variable: percent change in market capitalization						
Count of Non-Controlled Boilers	11.67 (5.70)	15.31 (10.75)	11.75 (5.95)	9.30 (6.48)	10.83 (7.90)	13.18 (5.41)	12.86 (5.24)
R^2	0.36	0.35	0.36	0.35	0.35	0.35	0.36
Number of Observations	71	71	71	71	71	71	71

Notes: Table 3 reports the estimate of α_1 in equation (6), estimated by Ordinary Least Squares (OLS). Huber-White standard errors are in parentheses. The reported coefficients are in millions of dollars. The sample includes 71 publicly traded utilities, whose stock prices traded continuously from 1993-2000. The dependent variable is the percent change in market capilization between November 6, 2000 and December 29, 2000, adjusting for aggregate shocks using equation (5) (see text). All regressions include controls for oil, natural gas, hydroelectric and nuclear generating capacity, where oil and gas generators are separated according to whether they include a steam turbine. Regressions include counts of non-controlled boilers and fuel use of all coal boilers. The non-controlled boilers in columns 1-4 include the boilers indicated by the column heading, as in Table 1. Column 5 includes a count of non-controlled coal boilers in non-attainment counties for sulfur dioxide, in place of the count of all non-controlled boilers. Column 6 uses the same category of non-controlled boilers as in column 1, but includes fuel use of small and large coal boilers separately. Column 7 includes fuel use of pre-1971 and post-1971 coal boilers separately.

Table 4

Alternative Specifications

	Estimation window is 1995-2000	Event window ends 12/13/01	Event window ends 2/28/01	Event window begins 5/1/00	Omit firms in NSR litigation	Omit Northeastern utilities	Control for generating capacity by region	Control for count of all coal	Counts of flues
				Dependent variable: Percent change in market capitalization					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Count of Non-Controlled Boilers	12.08	8.15	18.56	2.46	11.64	13.10	7.51	8.51	13.94
	(6.62)	(4.99)	(6.90)	(12.07)	(5.69)	(6.08)	(4.19)	(11.24)	(7.14)
R^2	0.40	0.39	0.50	0.19	0.36	0.29	0.32	0.36	0.36
Number of Observations	71	71	71	71	66	42	71	71	71

Notes: Table 4 reports OLS estimates of equation (6), with Huber-White standard errors in parentheses. The coefficients report the change in value of a non-controlled boiler, in millions of dollars, except for column 9, which reports the change in value of the average non-controlled flue. The sample is the same as in Table 3, except for columns 5 and 6. Column 5 omits American Electric Power, Cinergy, Duke, Firstenergy and Southern. Column 6 omits utilities with generators or boilers in the Northeast. The dependent variable is constructed similarly to Table 3. In column 1 the dependent variable is computed using an estimation window from 1995 - 2000. In column 2 the percent change in market capitalization is computed from 11/6/00 - 12/13/00. In column 3 the percent change is computed from 11/6/00 - 2/28/01. In column 4 the percent change in market capitalization is computed from 5/1/00 - 12/29/00. The dependent variable in columns 5-10 is the same as in Table 3. Colunms 1-6 and 9 include the same unreported independent variables as in column 1 of Table 3. Column 7 includes total fuel use of coal boilers by region, as well as generating capacity by region for non-coal generators. Column 8 includes a count of coal boilers in place of fuel use.

Table 5

Effect of 2000 Presidential Election on Emissions

	(1)	(2)
	Coal boilers replaced by:	
	Natural Gas (million tons)	Coal (million tons)
Sulfur Dioxide	13.33	8.74
Nitrogen Oxides	2.78	2.48
Carbon Dioxide	681.99	0.00

Notes: Table 5 reports the total change in emissions of the three pollutants, in millions of tons. The calculations use the estimate of the change in profits for a non-controlled boiler in column 1 of Table 3. Column 1 assumes that non-controlled coal boilers would have been replaced by new combined cycle natural gas generators. Column 2 assumes that non-controlled boilers would have been replaced by new coal boilers that meet Federal and local regulations. See text for details.