Corporate Environmental Policy and Product Market Competition*

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Abstract

Does product market competition affect corporate environmental policy? It is commonly believed that firms in competitive environments have stronger incentives to cut costs, which could lead them to neglect negative externalities. However, we find that cost cutting incentives could in fact be environmentally friendly. To arrive at this conclusion, we use a quasi-natural experiment of the restructuring of the utility industry in the US, which has opened the market to competition. We find that the restructuring has incentivized utilities to move to cheaper, but also less polluting, fossil fuels. Moreover, competition forces have smoothed out inefficient peak-capacity operation across competing plants, also contributing to reduction in pollution.

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Introduction

In the last several decades corporations have been increasingly pressured to reduce their impact on the environment. Policy makers, environmental groups, consumers, investors, employees, among others, demand that firms take actions such as altering production lines and investing in more environmentally friendly production processes to meet environmental norms. Not all firms respond equally to these calls. Some firms make massive investments to reduce their environmental impact while others resist the pressure and do not alter their operations. What determines firms' environmental policy and how to correctly assess the effect of firm policy on the environment are largely open questions.

In this study we examine the role of product market competition in corporate environmental policy. The effect of product market competition on environmental decisions of corporations is of particular relevance since competition often implies cost cutting incentives and an increased focus on profitability, which, in turn, comes at the expense of environmental protection (Friedman, 1970). However, cost cutting incentives might also have positive effects on the environment. For example, Alchian (1950) and Stigler (1958) argue that product market competition can lead to more efficient production within the organization. If efficient production is also less polluting, then product market competition could be environmentally friendly.

To examine the role of product market competition on corporate environmental policy we employ a quasi-natural experiment. Our setup is the restructuring of the utility industry in the US in the 1990's, which has opened the electricity market to competition. Focusing on this particular industry offers several important advantages. First, the utility industry is one of the most polluting industries in the world.[1] Second, data regarding corporate decisions in this industry is rich and detailed. In particular, the coverage in this industry includes all electric utility plants in the US, both privately and publicly held. We are able to obtain uniquely detailed plant-level data of fossil-fueled plants, including the amount of electricity produced, total heat emitted from burning fuel, the quantity and the environmental grade of each fossil fuel used, pollution abatement expenses, investments and existing equipment at the plant level, electricity prices, and production capacity. These data help pinpoint the precise channels by which competition affects corporate environmental policy. Third, the process of electricity generation is homogenous across fossil-

[1] For example, the Environmental Protection Agency (EPA) reports that in 2014, sulfur dioxide emission from US electric utilities accounted for 72% of its nationwide emission. Sulfur dioxide is a major hazardous chemical associated with the burning of fossil fuel.

fueled plants. As a result, the space of all possible production and investment decisions that, in turn, affect the environment is well-understood and quantifiable. Finally, the staggered passage of restructuring across US states during the 1990's mitigates endogeneity concerns and allows us identify the relation between competition and pollution in a causal way.

Our main finding is that the restructuring was followed by a plant-level decline in pollution compared with plants in non-restructured states. Using a difference-in-differences approach, we find that following the restructuring, the average plant in a restructured state has decreased its pollution levels by 18% compared to a plant in a state that was not restructured. The decrease was concentrated in larger plants, which reduced their average emission even more.

We then examine potential sources of the reduction in pollution. The technology of electricity generation dictates three types of actions that plant managers can undertake to alter the levels of emission: (1) enhanced pollution abatement, (2) change in fuel mix towards less polluting fuel, and (3) increased production efficiency (i.e., higher electricity generation for a given energy input).

Our first finding is that there is no supporting evidence of enhanced pollution abatement in restructured states compared with non-restructured states. In fact, plants in restructured states have actually reduced their abatement activity compared with plants in non-restructured states. For the average plant in the restructured state, investment in pollution-reducing equipment has decreased by 55% after the restructuring, compared with plants in non-restructured states. In addition, plants in restructured states have decreased their overall abatement expenses by 35% compared with plants in non-restructured states.

In contrast, we find strong evidence that plants in restructured states have reduced their environmental impact by changing their mix of fuel. Specifically, the affected plants moved away from petroleum (more polluting fuel) towards natural gas (least polluting fuel). For example, the percentage of units within affected plants that rely on gas has increased on average by 9% and the percentage of units within affected plants that rely on petroleum has decreased on average by 8% after the restructuring, compared with plants in non-restructured states. Coal use remained relatively stable, but, interestingly, plants increased their reliance on more polluting types of coal. Finally, we find that plant efficiency in restructured states has increased. The ratio between electricity output and heat input in restructured plants has increased compared to non-restructured plants.

After establishing the main findings, we explore the economic drivers of the change in emission. Our findings support two economic channels. First, we show that following the restructuring, cost-minimization incentives of plants in restructured states have increased. We demonstrate that the decision to increase the use of natural gas and the decision to decrease the quality of coal are both cost-efficient. Since price of natural gas at the time was lower than the price of petroleum, it was efficient for plants to move away from petroleum and rely more heavily on natural gas. The tendency of plants in restructured states to move towards cost-efficient fuels was larger among affected plants with particularly high cost structure before the restructuring. We note that the move towards cost-efficient fuels also resulted in reducing coal quality.

Second, we find a more efficient allocation of production across plants in restructured states, compared with non-restructured states. After the restructuring, utilities had to compete in the wholesale market and utilities with lower costs had an advantage over utilities with higher costs. Since variable production costs per unit of output increase with production level beyond a certain point, utilities naturally moved towards lower, more efficient production schedule in order to better compete over prices. Consistent with this argument we find that plants reduced capacity after the restructuring and the capacity decrease after the restructuring explains the efficiency gap between restructured plants and regulated ones.

We also ensure that our results are not driven by omitted variables that are correlated with both the restructuring and the drop in pollution. To that end, we examine parallel trends around the restructuring year and show that the reduction in pollution was statistically significant only after the restructuring. We also explore differences between Independently Owned Utilities (IOUs) and Municipal utilities (Munis) within states. The latter were largely exempted from restructuring. We find that Munis did not change the production or emission behavior following the restructuring. Third, we perform additional cross-sectional tests that further alleviate concerns of alternative causes for the change in pollution in utilities in restructured states.

We also discuss the extent to which firms' environmental strategy following the restructuring could be explained by alternative channels, identified in past studies. One argument is that consumers favor environmentally friendly producers and are willing to put a premium on their products. It is possible that with enhanced competition post-restructuring, utilities started to differentiate themselves by going green. To evaluate this argument, we take advantage of the fact that restructuring involved two separate stages – wholesale restructuring and retail access restructuring. While all restructured states have allowed electricity generators to compete in the wholesale market, only some have opened the markets to retail sales access, which would ultimately grant end-users the freedom to choose their electricity providers. If consumer channel is at play, then the impact of the reform on emission production should be particularly effective in states that have implemented retail competition. We find that this is not the case.

Another economic channel that could be at play is the legal channel. Since restructuring legislation involves major changes in rulings, its passage could potentially open the industry to lawsuits and litigations, some of which could be established on the grounds of environmental concerns. To the extent that restructuring exposes utilities to new legal threats, we might expect affected utilities to mitigate the legal risks by becoming more environmentally friendly.[2] However, in an additional set of tests we find that pollution has declined the most among cleaner plants that rely on gas as primary fuels, whereas plants that mostly rely on coal and therefore should be more susceptible to litigation risk, have increased emission levels.

Finally, we consider the role of the investor channel. If restructuring has attracted more environmentally friendly investor clientele, then that clientele could have demanded pollution reduction. We note that this channel, while consistent with our trend in emission as a whole, cannot explain the cross-sectional variations found in our study. For example, we find that coal-based plants have actually increased their emission levels, while gas-based plants have decreased emission. Moreover, long-term investors, who are known to value environmentally friendly policies the most (Starks, Venkat, and Zhu, 2017), are actually attracted to regulated utilities (e.g., Brochet, Loumioti, and Serafeim, 2012).

Our study makes several contributions to the literature. First, our findings that efficiency consideration led to more environmentally friendly policies in utilities is in line with arguments that profit maximization incentives could lead to environmentally friendly outcomes. We highlight the fact that higher efficiency can imply lower negative externalities. In our setting, regulated utilities had fewer incentives to adopt new, more efficient, production and higher pollution was the byproduct of this inefficiency. We also show a potentially important side effect of competition that is largely overlooked in the literature: Product market competition can lead to more efficient

[2] In addition, regulators might act favorably towards firms if they observe that they are environmentally friendly. For example, Hong, Kubik, Liskovich and Scheinkman (2019) find that regulators favor socially responsible firms, viewing them as more reputable.

allocation of resources across production units which, in turn, further reduces the negative impact of corporate production activity on the environment.

Our work also belongs to a growing finance literature that places one industry at the core of its empirical design to provide more precise inferences regarding the forces that shape corporate policies (e.g., Benmelech 2009, Benmelech and Bergman 2011, Gilje, Loutskina, and Murphy 2020, Decaire, Gilje, and Taillard 2020). This empirical setting is particularly important in a study of corporate environmental activity, since a change to environmental policy could be attributed to different economic channels. The detailed production-level data allows us to distinguish among those channels. In particular, observing the costs and benefits of different production processes for each plant is crucial for concluding that the observed environmental policies are actually a by-product of cost-efficient production processes.

Broadly, our paper is part of an emerging finance research that studies the drivers of corporate environmental policies. Past contributions include the effects of limited liability (Akey and Appel, 2020a), legal risk (Ben-David, Kleimeier, and Viehs 2020), shareholder preferences (Naaraayanan, Sachdeva, and Sharmak 2020; Akey and Appel 2020b; Shive and Forster 2019), and financial constraints (Bartram, Hou, and Kim 2019; Xu and Kim 2020; Goetz 2019). We contribute to this literature by examining how product market competition affects corporate environmental decisions.

The rest of the study continues as follows. Section 2 provides a summary of the electric utility industry and its restructuring. Section 3 presents the data and section 4 reports the results. Section 5 examines the findings in light of the different hypotheses and section 6 concludes.

2. The Electric Utility Industry in the US

This section provides a brief summary of the US electric utility industry. It consists of an explanation of how electricity is generated (section 2.1) and how the electricity generation process affects the environment (section 2.2). Section 2.3 describes the restructuring process of electric utilities in the US.

2.1 Electric Generation

The focus of our study is on steam turbine electric plants, powered by fossil fuel. This type of turbines is responsible for generating about 70% of all US electricity during our sample period. The basic process of electricity generation starts with burning of fossil fuels to heat a boiler and create steam which turns a turbine. The rotation of a generator turbine through opposing magnetic fields induces the flow of electricity in the generator, which then travels to its final destination through a network of power grids. The steam that leaves the turbine is cooled and fed into the boiler again.

Plants differ from one another in their mode of operation. Base load power plants usually provide continuous supply of electricity throughout the year with some minimum power generation requirement. Such plants are often larger and tend to be cheaper to operate. Peaking power plants are often smaller and only run during peak hours of demand of electricity.

Three main types of fossil fuels are used to generate heat in steam turbine electric plants: coal, petroleum and gas. These fossil fuels differ from one another in their heat content, measured by the amount of fossil fuel required to generate one unit of heat. Fossil fuels differ also in their prices and their impact on the environment. Among the three, coal is the cheapest, but also has the worst impact on the environment, followed by petroleum and gas.

2.2 Environmental Concerns and Environmental Regulation

The main environmental concern associated with steam generating plants is the hazardous byproducts emitted to the air when burning fossil fuel.[3] One major byproduct is sulfur dioxide (SO_2), which causes acid rain, harmful to plants and animals that live in water. SO_2 also worsens respiratory illnesses and heart diseases in humans. Another hazardous byproduct is nitrogen oxides (NOx), which contributes to ground-level ozone. This byproduct irritates and damages the lungs. The third byproduct is carbon dioxide (CO_2), which contributes to the greenhouse effect. In addition, there is an emission of carbon monoxide (CO) – a poisonous gas and particulate matter (PM), which results in hazy conditions in cities and scenic areas. Coupled with ozone, PM contributes to asthma and chronic bronchitis, especially in children and the elderly. Finally, burning of fossil fuels emits small amounts of heavy metals such as mercury - hazardous to human and animal health.

Among the three fuels used for steam power-plants operation, coal has the worst emission content, followed by petroleum and natural gas. For example, burning of coal to generate one

[3] Other environmental concerns include the use of water resources to produce steam, provide cooling, and serve other functions; discharges of pollution into water bodies, including thermal pollution (water that is hotter than the original temperature of the water body); generation of solid waste, which may include hazardous waste; land use for fuel production, power generation, and transmission and distribution lines; and effects on plants, animals, and ecosystems that result from the air, water, waste, and land impacts above.

billion British Thermal Units (BBTU) of heat is associated with about 2,600 pounds of SO_2.[4] In contrast, burning of petroleum to generate the same amount of heat is associated with 1,122 pounds of SO_2 and burning of natural gas is associated with one pound of SO_2.

To mitigate the effect of burning fuel on the environment, plants can employ three main strategies. First, they can move to less polluting fossil fuel. This can be done either by moving away from coal and petroleum towards natural gas, or by reducing the pollutant content in coals, either by buying coal that is less pollutive, or by pre-treating the coal. Second, they can treat the flue gas from the burning of fuel. Capturing the pollutants can be done in several ways, but the most efficient one requires an apparatus called a flue-gas desulfurization unit (FGD), or *scrubber*. Scrubbers remove about 90% of the pollution in the flue gas, but are expensive (Baasel, 1988). Third, plants can increase efficiency. Newer equipment such as boilers, turbines, and generators are often more efficient than older equipment because they utilize better technologies. Since efficient production implies that less fuel is required to produce the same amount of electricity output, it has positive impact on the environment.

Electric utilities are required to abide the emission standards of the Clean Air Act. In 1990, the US government has made several important amendments to the Clean Air Act. The most relevant amendment for electric utilities is Title IV, which was directed at SO_2 and NOx emissions from utility power plants to control the precursors of acid deposition, (which include acid rain, acid snow, and acid fog). Phase I, which became effective January 1, 1995, required 110 listed power plants of greater than 100 MW electrical capacity and with high levels of emission to considerably reduce their emissions. An additional 182 units joined Phase I of the program as substitution or compensating units.

2.3 Restructuring of the Electric Utility Industry

This subsection briefly summarizes the restructuring process of the electric utility industry in the US. For more detailed explanation see, for example, Warwick (2002) and Joskow (1997).

Historically, electric utilities operated mostly as vertically-integrated regulated monopolies, owning generation, transmission, and distribution of electricity within their localized geographic market. The majority of plants in the US are owned by private investors, and denoted as investor owned utilities (*IOU's*). A minority of the plants are owned by the public government

[4] The median annual heat input for a plant in our sample is 22,000 billion BTU.

or local municipalities, as well as member-owned cooperatives across municipalities (*Muni's*). State regulators set the price of electricity based on utility costs in a process called a *rate case*. This process is complex and lengthy and is needed to determine both the electricity price level and the price design. A rate case can either be initiated by the Public Utility Commission or by the utility itself. A utility generally initiates a rate case only when it needs to increase revenues or believes that it needs a higher rate of return to attract investment capital. The Commission will initiate a rate case if it believes rates are in excess of their cost of service or cost of capital. Rate cases are examined by the regulator on a periodic basis, usually every several years.

By the early 1990s it has become apparent that electric industry regulatory approaches were not working. Demand for electricity has increased, attempts to build new plants faced regulatory constraints, and the process was time consuming and expensive. As a result, states have started to adopt different versions of industry restructuring in the early 1990's. The restructuring involved opening the market for electricity to competition. In the restructured supply system, generation and distribution were unbundled and power plants had to compete with one another through a market mechanism to sell electricity to distributers or customers. Purchasing of power is done via market mechanisms like the power exchange, and transmission scheduling is conducted by an independent body (the Independent System Operator (ISO)).

A total of 23 states plus the District of Columbia restructured their electric utility industry between 1990 and 1999. The regulation affected mostly the IOU's. Muni's were allowed not to take part in the restructuring and to rely on their own production and distribution system to their own localized markets.

3. Data

The main dataset for the analysis consists of annual plant-level data of fossil-fuel generated electric utilities in the U.S. The dataset combines three different sources.

Emission data is obtained from the Environmental Protection Agency (EPA). Electric utilities are required by law to monitor and disclose their emission levels. Within the EPA platform, our emission data comes from two sources. First, we rely on Emissions & Generation Resource Integrated Database (eGRID) data. eGRID is based on plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. government. The information on emissions starts from 1996 and, according to the EPA, is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the United States. Data reported include mass emissions of carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and other chemicals. eGRID reports this information on an annual basis and at different levels of aggregation (plant, state, and grid regions of the country).[5]

While eGRID provides detailed information with respect to plant's emission, it does not cover the pre-restructuring years for most states. Therefore, there is a concern that the resulting time-series is too short to capture emission patterns of utility plants prior to the restructuring in a meaningful way. To extend the time-series, we supplement the eGRID information with historical information on emission from a different platform, Air Market Program Data, also managed by the EPA.[6] Since SO_2 is one of the major byproducts of fossil fuel burning and is considered a major threat to population health and to the environment, the US government has started gathering SO_2 emission data already in the 1980s. The platform provides information on emission levels of SO_2 for the years 1980, 1985, 1990, and starting from 1995, it is reported annually. We therefore combine our eGrid data with information on SO_2 emission for the years 1985, 1990, and 1995.[7] Since complete data is only available for SO_2 emission, we focus on this pollutant in our analysis. However, as we will elaborate in the analysis section, our findings extend also to other chemicals involved in the production of electricity.

We further augment our dataset with information from the US Information Administration (EIA). EIA is a statistical and analytical agency within the U.S. Department of Energy, which collects comprehensive data that covers a full spectrum of elements related to energy generation process, including sources, uses, technologies, and distribution. The information is usually available at a plant level.[8,9]

The majority of the EIA information in our project comes from Form EIA-767. Specifically, the data on capital investment in pollution abatement as well as expenditures associated with the collection and disposal of byproducts during the generation process, are obtained from Form EIA-767 "Plant" files. Information on boilers (installation date and primary

[5] https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid
[6] https://ampd.epa.gov/ampd/
[7] Unfortunately, the data for years prior to 1996 is not available for other pollutants. Air Market Program Data reports statistics on NOx, but the data starts in 1995. We therefore focus our analysis on SO_2 pollution.
[8] Some reports provide more granular information (e.g., at a unit, boiler, or generator level). In these cases, we aggregate information at a plant level.
[9] The data is available online at www.eia.gov, and is categorized into topics (each topic corresponds to a specific form the plant needs to fill out).

fuels type), as well as the information on the use of flue-gas desulfurization (FGD) equipment, including its installation date, are also collected from this form. Next, we include data on quantities of fuel by fuel type (coal, natural gas, or petroleum). This information is collected in form EIA-423, and is available at monthly frequency (we sum up monthly fuel use by each fuel type within each calendar year). Finally, we rely on Form EIA-861 to obtain information on electricity sales and prices, which we also convert into annual frequency. Since plant production and plant emission datasets both rely on the same plant identifier (denoted as ORISPL), the merge of the EPA and EIA databases is straightforward.

The third dataset draws its information from the Utility Data Institute (UDI) O&M Production Cost Database, which, in turn, combines data from the following publicly available resources: Federal Energy Regulatory Commission (FERC), U.S. Energy Information Administration (EIA), and Rural Utilities Service (RUS). The dataset includes basic plant characteristics such as plant ownership, age, location, capacity, as well as some additional production-related factors, including energy output, measured in net Megawatt hours (MWh), energy input, measured in British thermal units (BTUs) of fuel consumption, number of employees, as well as fuel and non-fuel expenses. Non-fuel expenses primarily include operation and maintenance expenses, as well as employee wage bill. Fabrizio, Rose and Wolfram (2007) (henceforth FRW) have combined these variables into one dataset and have made it available for researchers. Their data spans the period 1981-1999 and contains all large fossil-fuel steam and combined-cycle gas turbine generating plants with capacity of 100 megawatt hours (MWh) and higher.[10] Overall, for the 613 facilities that appear in FRW dataset we were able to find data on 589 facilities in the eGRID or Air Market Program datasets.

We do not expand our database beyond 1999 because at the turn of the century several events have stirred the restructuring process in some states. Specifically, electricity prices in California have skyrocketed in 2000-2001, due to market manipulation and the shortage of electricity. As a result, the state of California stepped back and suspended its restructuring. Other states started to debate whether to continue with the restructuring process and five additional states (Oklahoma, Arkansas, New Mexico, Nevada, and Montana) have postponed implementation of the restructuring. Those developments, while interesting on their own, contaminate our difference-

[10] The dataset is available on the website of the American Economic Association at: https://www.aeaweb.org/articles?id=10.1257/aer.97.4.1250.

in-differences setting in the post-1999 period. For example, it is not clear whether a state that has started and postponed restructuring should be assigned into a treated or control group. Also, a delay in the implementation of already initiated restructuring processes raises the question of what the true year of the reform for the treated states should be. It is also not clear whether the states that did not initiate the restructuring process did so because they have already decided against this policy or because they were waiting out to see the resolution of the energy crisis for other states. We therefore restrict our data to the years before 2000, to ensure that we capture the effect of competition on the outcomes of interest in a precise and causal way.

Table 1 summarizes key variables in our sample. An average plant generates around 3.4 terawatt-hours of electricity a year, so that the combined production of our sample plants accounts for close to 60% of total electricity generated in the U.S. during that time. Consistent with the fact that there is only a small fraction of municipal utilities with capacity of 100 MW and higher, 80% of our plants are investor-owned. With regards to emissions, plants allocate on average around $2 million a year on pollution abatement activities; however, there is significant variation across plants. Finally, our plants also differ substantially in the types of input they use. An average plant uses coal as the primary fuel in two-third of its operating boilers, compared to 27% and 11% reliance on gas and petroleum, respectively.

4. Results

In the first set of tests, we ask whether the level of SO_2 emissions has changed following restructuring. Specifically, we take advantage of a series of reforms in the electric utility sector that took place starting from 1993, to form a difference-in-difference test of the effect of restructuring on firms' pollution levels. The reform affected 23 states plus the District of Columbia. The reform in each state started with several rounds of formal hearings, and was culminated with formal laws. The entire process took between two and three years and therefore, it is not immediately clear what year captures the economic impact of the reform. To address this issue, we follow the assignment method proposed by FRW, and use the year of the formal hearing initiation in states that have passed restructuring legislation by the end of our sample period as the reform implementation year. As will be described in further details in section 4.1, our parallel trends test results confirm that plants started to alter their emission activity already at the hearing stage.

Our baseline OLS regression tests the impact of a competition shock on SO_2 output of utility plants using difference-in-differences (DiD) framework. Our specification takes the following form:

$$(1) \qquad Ln(SO_{2i,t}) = \alpha + \beta_1 * Restructure_{i,t} + \beta_2 Scrubber_{i,t} + \beta_3 PhaseI_{i,t} + \alpha_{i,} + \delta_t + \varepsilon_{i,t}$$

where the dependent variable is the natural logarithm of the level of toxic emissions of SO_2 (in tons) by plant i in year t. $Restructure_{i,t}$ is a dummy variable that equals one for every plant in a state that has eventually passed the restructuring law, starting from the year of the first restructuring hearing and onward. We also include a set of control variables, which capture technological and regulatory differences across plants that, in turn, can have a strong effect on the level of emission. The first variable, *Scrubber*, is an indicator variable that takes on a value of one if the plant has at least one FGD unit in operation (operating status "OP") in a given year, and zero otherwise. The second variable, *Phase I*, is a dummy variable for whether the plant was included in the Acid Rain program. As discussed in more details in section 2, the Acid Rain program imposed stringent requirements on a subset of the most polluting plants starting from 1995. About 6% of the plants in our sample were identified under the act.[11]

In designing our empirical specifications, we assume that the variation in control variables and technological differences are unlikely to be driven by the restructuring. We believe this is a plausible assumption. The Clean Air Act, which was passed in 1990 and flagged the facilities which would become subject to the Phase I of the Acid Rain program, was passed several years prior to the first talks of deregulation. Similarly, we find that the majority of variation in the *Scrubber* variable is driven by years prior to restructuring hearings. Specifically, around 84% of the scrubbers in our sample were installed prior to 1993, in which the first state, New York, started its formal restructuring hearings. It is possible that the restructuring has affected decisions of some plants to install scrubbers. We address this argument in the later part of our analysis.

[11] The program also allowed this subset of plants to trade their emission allowances in what was called cap-and-trade program. To ensure that our results are not driven by these confounding rules we also ran all our analysis with the remaining plants. Our results are similar to those for the entire sample. We also note that the Acid Raid program included Phase II, which has targeted smaller plants. Since implementation of Phase II has started in 2000, right after the end of our sample-period, there is no need to include an additional control variable for that phase.

In a variant of specification (1) we also control for the overall level of production, as measured by net electricity generation in MWh, converted into logs.[12] Since SO_2 is highly affected by the amount of output produced, change in output following the restructuring could have been the driver of the results.

Lastly, we include plant-epoch fixed-effects and year fixed-effects. Including plant fixed-effect absorbs unique production characteristics of the plant as well as regional characteristics, such as demand for electricity, weather conditions, proximity to input factors, etc. We follow FRW and use plant-epoch, rather than just plant fixed effects as a more refined way to capture key production characteristics of a facility, as well as the way to neutralize the effect of deregulation on plant-level capacity. Specifically, if a capacity of a plant changes by more than 15%, we consider it a new entity epoch. We also include time fixed-effect to account for common industry factors such as production shocks driven by economic conditions, country-wide weather profile that could affect demand, etc. Errors are clustered by year and plant-epoch.[13]

4.1 Effect of restructuring on pollution levels

We start our analysis with specification (1). The results are presented in Table 2. In our baseline specification, summarized in Column (1), we find that the restructuring has a negative and statistically significant impact on the levels of emission. The impact of the reform is also sizeable: Following the restructuring, the average plant has reduced the levels of SO_2 pollution by roughly exp(-0.33)=28% more compared to changes in pollution in non-affected plants. The comparison of this result to the one in column (2), where we control for the level of production, demonstrates that some of the decline in pollution could be attributed to changes in total production. Yet, the impact of deregulation is still high: After controlling for the level of production, the deregulation lead to roughly exp(-0.2)=18% decrease in SO_2 pollution. Our control variables are also statistically significant and have the expected sign. A plant that installs a scrubber, or flue-gas desulfurization (FGD) technology, reduces its emission by roughly exp(-0.85)=57% on average. The impact of being included in the Phase I program is considerable, reducing the emission of affected plants by close to 40%.

[12] Plants use a small portion of the electricity they produce as part of the operation process. Net generation refers to the electricity generated in excess of the amount of electricity consumed by the plant in the production process.
[13] Clustering instead by state-year does not change any of the results in a material way.

The results of the first two columns show an average percentage decrease in emission across plants. Whether this average plant-level decrease in emission translates into a meaningful economy-wide decrease in emission depends on whether the decrease in emission occurs in large plants or in small plants. Larger plants tend to be base-load plants, which produce larger amounts of electricity overall. We therefore separate our estimation into the groups of large and small plants to examine what type of plants are the drivers of our main results. To measure plant size, we rely on the information about net megawatt (MW) capacity. We use cutoff point of 575 MW, which divides the sample at roughly the median size (575 MW). Columns 3 and 4 show that the decrease in pollution came from larger plants, and suggest that the aggregate effect across all utilities that went through deregulation is likely large.

Next, we ask whether the change in pollution levels differed across other plant characteristics. First, we split our sample into two groups based on plant age. New plants are in general more flexible at changing fuel sources and production procedures, while old plants, built with less sophisticated technology, are often less flexible. Oftentimes, smaller and older plants are also used to provide operating reserves rather than operate full-time (Warwick 2002). We measure plant age based on the year in which the oldest plant unit was installed. Following their methodology, we define new plants as plants built after 1960, which is roughly the median age in our sample. Consistent with our conjecture, in column 5 and 6 we show that old plants have reduced their SO_2 emission by about 15% and the effect is not statistically significant from zero. In contrast, new plants have reduced emission by about 21%, and the effect is statistically different from zero.

Finally, we separate plants by ownership type. In the U.S., some utilities are investor owned (*IOU*s), while others are publicly owned, including utilities owned by the government or local municipality, as well as member-owned cooperatives. For simplicity, we refer to all non-IOU plants as *Muni* plants. State legislation, for the large part, has either exempted *Muni* utilities from complying with restructuring, or has left the decision of whether to participate in the restructuring program with the *Muni* themselves. Thus, we expect the effect of restructuring to be stronger among *IOUs*. Consistent with our conjecture, we find that *IOUs* and *Muni*s were both affected by the restructuring but the effect is twice as large and statistically significant among IOU's (although we cannot reject the hypothesis that the coefficients across the two groups are similar).

One concern with our results is that changes in SO_2 emission may not be related to the restructuring, but rather to other shocks that could have affected both the competitive landscape and pollution policy of the electricity generating industry. For example, a push towards newer electricity generation technologies in some states could have triggered both the restructuring process and the decline in emission. To address this concern, we run our original specification in table 2, except that we replace the restructuring variable with a vector of time dummies for years t-3 to t+3 relative to the first year of restructuring. If indeed pollution levels in restructured states were affected by the deregulation, then we should expect to see significantly negative coefficients only from year t onward. Moreover, we should see the effect occurring only among IOUs (and not Munis, who had the freedom to choose whether to comply with the restructuring or not) and among larger plants, as in Table 2. Table 3 shows that large IOU's have seen a significant reduction in SO_2 emission in year t (the regulation year), but not before. Consistent with Table 2, we also observe no significant change in emission among Munis. We believe these findings alleviate omitted variables concerns.[14]

4.2 Emission Reduction Mechanisms

After establishing the impact of restructuring on plant-level emission output, we turn to exploring the mechanisms that could alter the levels of emissions at the affected plants following restructuring. The spectrum of activities to reduce SO_2 emission at the plant level is dictated by electric generation technology. First, plants can allocate more resources to air cleaning process, both in terms of ongoing labor and material expenses, and in terms of investment in pollution reducing equipment. Second, the composition of fuel used to generate a certain heat level has a large effect on pollution levels (Ellerman and Montero 1998; Kaminski 2003). Lastly, increased efficiency of the plant operation and optimization of existing controls can also achieve reduction in emission rate by reducing the overall amount of heat input needed for electricity generation. In the remainder of the section we analyze the impact of each mechanism on the level of SO_2 at the plant level.

[14] Since the EPA-EIA-FRW dataset has gaps, there may be a concern that parallel trend results could be sensitive to restructuring that took place in certain years. To mitigate this concern, we also perform a parallel trend test for the key emission reduction mechanisms, as described in more details in the next section. The results, presented in Table Appendix-1 show that the reform has a significant impact on the production process only after its first hearing year.

4.2.1 Expenditure on air cleaning

We start by analyzing the effect of restructuring on investment in equipment to reduce pollution, as well as on the level of material and labor expenses. A plant can reduce emission substantially by spending more on emission abatement. This can be achieved by either investing in control technology, such as scrubbers or fluidized bed combustion (FBC) boilers, or by increasing expenses on collection and disposal of the byproducts. In addition, coal pretreatment techniques, such as washing and crushing, help wash out some of the sulfur that exists in tiny specks in coal, and thus, also contribute to reduction in SO_2.

We first focus on capital expenditures. EIA requires plants to report all pollution abatement capital expenditures for new structures and/or equipment, made during the reporting year. We collect this information and examine the effect of restructuring on the level of investment in pollution abatement. The results, reported in Table 4 Column 1, demonstrate that the level of capital expenditure among restructured utilities has dropped considerably following restructuring: an average affected facility has reduced its investment in emission by exp(-0.82)=45%. In Columns 2 we refine the definition of investment by focusing on scrubbers. We estimate an OLS regression since our estimation includes plant-epoch fixed effects, and the logit estimation is not feasible in such setting. The results demonstrate that plants have not increased the reliance on scrubbers following the reform. The only significant variable in this specification is the Phase I dummy, indicating that one way by which facilities subject to the first stage of the acid rain program have reduced their emission was by installing scrubbers.

Next, we look at pollution abatement expenses, as measured by expenditures on material and labor costs, as well as equipment operation and maintenance. In column 3 we consider abatement costs across all categories of chemicals, including ash, flue gas, and other potentially hazardous chemical. In column 4 we consider only expenses associated with the collection and disposal of the sulfur byproducts. In both cases, we find that restructured plants have cut their costs in these categories.

It is possible that the decline in emission collection expenditures was driven by diminishing reliance on coal following restructuring. While we explore the effect of restructuring on fuel mix in more details below, we conclude this subsection by expanding the analysis of pollution abatement expenses to control for the amount of coal used in the electricity generation process. Panel B of Table 4 shows that the reduction of air cleaning expenses is not attributed to the move from coal to cleaner fuel sources, and the impact of deregulation on emission remains negative and statistically significant.

4.2.2 Fuel Mix

We next turn to examining whether, following restructuring, plants have switched to an environmentally-friendly fuel. Overall, there is substantial heterogeneity in the amount of SO_2 pollution across fuel types. Coal burning generates the largest emission of SO_2 per unit of heat generated (about 2,600 lb per BBtu), followed by petroleum (about 1,100 lb/BBtu), whereas natural gas-fired units generate the smallest emission with lonely about 1lb/BBTU. There is also a large heterogeneity across coal types, and the main types available in the U.S. vary dramatically by their sulfur content. For example, bituminous coal, the most prevalent type in the U.S., contains 0.7%–4% of sulfur per mass unit, whereas higher-quality anthracite type generates only 0.6–0.8%, and is almost as high in its heat content.[15] As a result, a plant can reduce SO_2 emission by switching to a less polluting coal.

To examine whether plants have changed their fuel mix following the reform, we first estimate regression quantities of coal, gas, and petroleum used in the production process.[16] To include plants that do not use a certain fuel type in our analysis, we add a value of one before converting the values of each variable into logs. We present the results in Table 5 panel A. We find that affected plants have not changed their use of coal significantly following the restructuring (Column 1), but they have increased their gas quantity relative to non-restructured firms (Column 2, coefficient of 0.59). At the same time, Column 3 shows that restructuring led to a decrease in the use of petroleum in affected firms (coefficient of -0.415) compared to regulated ones. We find similar results when we measure use of coal, gas and petroleum by the fraction of units within a plant whose primary fuel input is coal, gas, and petroleum respectively (Column 4–Column 6).

It is possible that while affected plants have not changed the overall amount of coal used, they have switched to less polluting coal types. To analyze this possibility, in Table 5 panel B we look at sulfur and ash content of the coal used. Both variables are reported by weight (tons), and we add the value of one before converting each variable into logs. We find that plants have

[15]See for example, https://www.purdue.edu/discoverypark/energy/assets/pdfs/cctr/outreach/Basics8-CoalCharacteristics-Oct08.pdf

[16] The quantity of coal is reported in tons; oil – in barrels, and gas – in thousands of cubic ft.

switched to coal with higher sulfur content (Column 1), and the results remain similar when we directly control for the amount of coal used. In columns 3 and 4 we also analyze ash content of coal. Higher ash content implies that after burning the coal, there will be more residue left. While ash emission does not cause acid rain, it is a hazardous waste that can have damaging impact both on human health and environment. We find that following the reform, affected plants saw an increase in ash content in coal, although the effect is not statistically different from zero.

In summary, the overall impact of fuel change on pollution is mixed. The move away from petroleum towards higher reliance on natural gas is consistent with pollution reduction findings. However, while plants, on average, have increased their reliance on natural gas, they also started to use coal with higher level of sulfur. These two findings conflict with one another if the goal of the plant is to reduce pollution.

4.2.3 Efficiency of Operations

Finally, we test whether the change in emission rate could be driven by more efficient production process. FRW find that for a given level of output, the restructuring reform has improved plant efficiency by reducing labor and non-fuel costs. It is therefore also possible that plants have improved fuel efficiency by being able to generate the same amount of electricity with smaller energy input. Plant production efficiency varies with the amount of electricity produced. Plants are often designed to generate base-load electricity continuously at relatively high efficiency levels, and then cover peak load intermittently with less efficient units (Warwick (2002)). Higher efficiency can be achieved by avoiding peak-load operation, as well as by running a plant continuously. Smaller improvements, such as changes to equipment maintenance practices, could also play a role.

We start the analysis of efficiency by examining whether the heat input, measured in log units of heat (BTU), has declined following the restructuring. Table 6 Column 1 demonstrates that controlling for the amount of generated electricity, an affected plant reduces its BTU input by about 1.2%. This implies that efficiency in generating electricity has increased following restructuring.

One of the main reasons for the restructuring across states was the peak electricity demand that could not be met with enough electricity supply (Warwick (2002)). We should therefore expect plants before the restructuring to have been subject to high loads and lower efficiency. Following the restructuring many utilities started to compete across states over electricity, and several states initiated third-party power exchanges, where electric generators submitted bids to sell electricity. Electric utilities that operate at close to maximum capacity cannot compete will have higher costs and will not be able to compete with utilities that have lower capacity. Since peak demands are not fully correlated with one another, electricity restructuring has the potential to smooth out production and improve efficiency. In addition, the entry of non-utility electricity suppliers further increases supply of electricity, and potentially reduces loads across existing utilities.

To test whether, indeed, utilities have reduced their production after the restructuring, we examine plant-level capacity factor in affected plants. To measure capacity factor, we scale total annual generation, *Net MWh*, by overall plant capacity (Gross MWh multiplied by 8,760 -annual number of hours). We then estimate capacity factor as a function of deregulation and control variables.

Consistent with above argument, we find a decrease in the capacity factor of plants in the restructured states of about 2.4% after restructuring (Column 2). In column 3 we use an alternative way to capture capacity and examine whether overall plant-level production has declined following restructuring. We find that the decline in capacity factor translates into a decrease of about 16.6% in amount of electricity produced over time by the utilities (Column 3).

To examine if the change in capacity led to the increase in efficiency, we add the capacity factor variable as an additional explanatory variable in specification (1). We find that indeed, there is a positive relation between capacity factor and BTU use, after controlling for total production – suggesting that higher load is indeed associated with less efficient production.[17] Moreover, once we introduce the capacity factor, the effect of deregulation on efficiency decreases by about 25% (from 1.2% to 0.9%). This means that the change in production output explains at least part of the increase in efficiency.[18]

[17] FRW also analyze fuel efficiency, but their conclusions are mixed. We believe the analysis of capacity factor helps reconcile their findings, and provides evidence in support of increased efficiency argument.

[18] Chan, Fell, Lange and Li (2017) also examine efficiency gains in coal-based plants after the restructuring and found a decrease in capacity factor. However, they did not have the pollution data and could not observe the effect of these gains on pollution reduction.

5. Why Did Firms Change their Emission Policy after Restructuring?

After exploring possible changes in electricity production process, which, in turn, have affected pollution following the restructuring, we now move on to discussing the underlying economic channels through which these patterns could have been established.

5.1 Cost Efficiency Channel

We start with examining the effect of competition on production decisions. These first-order effects are likely to affect pollution outcomes. For example, if a company decides to alter production processes due to competition then pollution will inevitably be changed as well. In this subsection we examine whether the decrease in pollution following restructuring could be driven by plants' desire to reduce overall costs. Past studies, such as FRW, have concluded that restructuring has improved production efficiency. In this section we examine whether reduction in pollution can be a byproduct of efficient production. Economic literature tends to view pollution as negative externality, which is costly to reduce. Therefore, cost-minimizing production policy is often associated with more polluting production process. Our findings that plants' expenses on pollution reduction have gone down are consistent with this idea. However, if supply shocks to less-polluting inputs reduce their costs, cheaper inputs could also give rise to less polluting processes.

We note that fossil-fuel plants employ three inputs: coal, gas, and petroleum. As depicted in Figure 1, coal is the cheapest fuel throughout our sample period (145 cents/mmBTU), followed by natural gas (262 cents/mmBTU), whereas petroleum, at 404 cents/mmBTU on average, is the most expensive. It is therefore possible that reduction in pollution is the outcome of more efficient production process and higher sensitivity of production processes to input prices in particular. Consistent with this idea, Table 5 panel A shows that plants in restructured states started to rely more on natural gas and have reduced their reliance on petroleum.

To test more directly the extent to which pollution-reducing actions could be driven by cost-cutting considerations, we exploit a cross-sectional variation in plants' incentives to become efficient. We hypothesize that the motive to switch to cheaper fuel will be higher among plants that prior to restructuring had especially high production costs. The opening of a state to competition would make these plants more vulnerable to losing their market share to producers of cheaper electricity from out of state, as well as to potential entry by new incumbents. In response to the threat of entry, existing plants in high-operating-cost areas should therefore have higher incentives to reduce production costs by switching to gas from petroleum.

To empirically determine which states had especially high production costs prior to restructuring, we look at state-level electricity prices. Absent restructuring, utility rates are established through a rate of return scheme: Electricity prices are set by regulators in a way that allows utilities to recover their return on investment and operating costs. The higher the cost of production, the higher the electricity cost of MWH set by the regulator. We therefore rank all states by electricity prices every year, so that states with the highest prices receive high ranks, and vice versa. We obtain annual state-level electricity prices from the EIA.[19] We then identify states with particularly high production costs in a year prior to restructuring initiation. To this end, we compare each state's price levels to the rest of the nation. The average ranking among states that were subject to restructuring throughout our sample period is 33.5 (where 50 is the highest and 1 is the lowest). This is consistent with previously established findings that the key motive for deregulation was high prices of electricity in a state (Joskow 1997). We then define a new variable, *High Electricity Price*, which equals the difference between the state rank and 33.5 whenever the state rank is higher than 33.5, and zero otherwise. The intuition behind the variable construction is as follows. When electricity prices in a state are above that of other restructured states, plants will have incentives to reduce costs, and the incentives will increase with the deviation of the state's prices from restructured-states average. Yet, when electricity prices in a state are lower than average, we would expect that plants operating in this state to keep their production function unchanged rather than increase costs.[20] We interact our proxy of production costs, *High Electricity Price*, with restructuring indicator, and re-estimate the equations of input use. The higher the interaction term is, the higher the production costs in restructured state prior to the initiation of deregulation and the stronger is the plants' response through the cost-cutting channel.[21]

Table 7 column (1) shows that overall fuel costs in plants were reduced after the restructuring, but only in those restructured states where production costs were high. The coefficient of -0.006 implies that an increase of 10 positions in state ranking relative to the median

[19] Available at https://www.eia.gov/electricity/data.php

[20] Our results are not sensitive to this assumption. In alternative specifications, we set the threshold at 26 (median rank across all states), as opposed to 33.5, and obtain similar results. We also estimate the regression using the raw rankings, and obtain similar results.

[21] Since our proxy of production costs is time-invariant, we do not need to include it in the regression since it is absorbed in the plant-epoch fixed effect.

ranking of 33.5 is associated with a 6% reduction in log fuel costs. Columns (2)-(4) show that, among restructured plants, there was an increase in the fraction of boilers that are gas operated and a decrease in the percentage of units that are petroleum operated. In both cases the change was only in states where production costs were high before the restructuring. The coefficients of 0.008 and -0.009 imply that an increase in state ranking of 10 positions is associated with an 8% increase in the fraction of boilers operating primarily on gas and 9% decrease in boilers operating primarily on petroleum. We obtain similar results when we examine the annual physical amount of coal, gas, and petroleum used across plants (columns (5)-(7)). The coefficient of 0.09 for gas use (column (6)) implies that an increase in state ranking of 10 positions is associated with 90% increase in the log amount of gas and the coefficient of -0.047 in column 7 implies a similar decrease of 47% for petroleum use. We also find a marginally significant increase in the use of coal after the restructuring (coefficient of 0.011).

5.1.1 The Trade-Off Among Different Fuel Types

Overall, the switch away from petroleum is quite intuitive: It is inferior to gas as it is both costlier and more polluting. When we compare gas and coal, gas is better pollution-wise, but coal is better cost-wise, and the choice between coal and gas is less trivial. It is interesting to note that the sensitivity to output prices had a higher impact on the quantities of gas than quantities of coal. Although we cannot precisely determine the reason behind this pattern, we offer several potential explanations.

First, it is possible that the flexibility of switching to coal is limited due to environmental regulation constraints. Recall that while coal prices are lower, coal emission levels are also much higher. As a result, if a plant switches from petroleum or gas to coal, emission constraints, set as the threshold of pounds of SO_2 per mmBTU, may soon become binding.

Second, higher sensitivity to gas prices following the restructuring could be explained by changes in the nature of the natural gas industry, which was heavily regulated for decades. Continuing problems with pipeline regulation, as well as the lack of open access, have resulted in sub-optimally low supply of natural gas. In the '80s and early '90s a number of the natural gas deregulation orders were issued. The most impactful one (Order 636) was enacted in 1992, and has required that pipeline companies unbundle transportation services and open access capacity, thereby facilitating more efficient distribution and stable supply of natural gas. It is therefore possible that from the standpoint of a power plant, the largest cost efficiency gains could be achieved by higher reliance on natural gas. However, when the natural gas industry was already restructured, electric utilities sector was still regulated, so that electric plants had little incentives to improve cost-efficiency by starting to rely more on natural gas. The electric utility restructuring could have encouraged affected plants to reassess their cost-efficiency considerations, leading to higher sensitivity of production costs to the choice of natural gas.

Finally, it is possible that higher impact of production costs on natural gas compared to coal is determined by the production process of the power plants. Coal-operating units are expensive to start up and to shut down, so they are often used for continuous base-load operations. Units that are used to meet peak demands are often oil and gas-fired units, since they can be started and stopped quickly (Warwick 2002). It is therefore possible that plants have less flexibility to change fuel mix in base-load plants, but higher flexibility in peaking plants. This, in turn, may result in greater substitutability between gas and oil inputs.

To summarize, this section demonstrates that stronger incentives to minimize fuel costs have encouraged affected plants to switch away from more expensive and polluting petroleum to cheaper and more environmentally friendly gas, while economic impact on coal use was fairly modest. Together, these findings demonstrate that efficiency and cost-cutting incentives, brought up by more competitive product market environment, can actually lead to cleaner production.

5.2 Exploring Other Channels

5.2.1 Customer Channel

Existing literature argues that one reason to increase corporate social responsibility is to cater to customers (e.g., Albuquerque, Koskinen, and Zhang, 2019, and Servaes and Tamayo, 2013). To the extent that restructuring has given customers the freedom of choosing electricity consumption by comparing among different utilities, and consumers prefer energy that is less environmentally harmful, it is possible that customers have tilted their consumption towards less polluting utilities.

This argument is consistent with our general findings of SO_2 emission reduction, as well as the findings that firms have increased the use of natural gas at the expense of more polluting petroleum. While our results that firms have increased the level of pollution in coal and have reduced pollution expenditure are inconsistent with the customer explanation, it is nevertheless possible that due to cost constraints, utilities have chosen the more polluting coal to achieve cost efficiency, and at the same time, have increased the use of natural gas to reduce pollution.

To better understand the importance of customer channel in plant decision-making, we perform additional tests. We take advantage of the fact that restructuring occurred both at the wholesale level and at the retail level at different points in time, and only a fraction of the states had implemented retail access by the end of our sample period. At the wholesale level, the restructuring allowed all utilities in the state to compete for sales to wholesale distributors. The retail access allowed retail providers to compete over end users by either buying electricity through the exchange or by buying electricity directly from providers. We expect the retail access to have an environmental impact on utilities, to the extent that end users will prefer providers that rely on less polluting energy. However, since end users have no choice which company to choose under wholesale deregulation, we should not expect the wholesale deregulation to have an impact on customer choice.

To examine the above hypothesis, we re-estimate our regressions of SO_2 pollution after augmenting our specification with an indicator variable for retail-level restructuring. This variable, obtained from FRW dataset, captures retail restructuring (as opposed to wholesale restructuring), and takes a value of one starting from the year in which a state has implemented retail access. If, indeed, retail access led to the use of less polluting fuels, we should expect the variable to have a negative sign. The first column of Table 8 shows that the coefficient of *Retail* is actually positive, and is statistically insignificant. Moreover, it does not weaken the explanatory power of our broader measure of restructuring. In fact, the coefficient on *Restructured* variable has the same magnitude as the case without the retail variable (see Table 2, column 2).

It is still possible that we do not find the effect of retail access on emission because plants have separated themselves to achieve a separating equilibrium. Plants that found it easier to reduce pollution have decreased it further, whereas plants that found it harder to reduce pollution have not changed the level of emissions or even increased it. Therefore, the customer channel argument can be refined to a separating equilibrium, where plants with lower costs of changing into less polluting operations would separate themselves from plants with higher costs (Flammer 2015). To the extent that there may be a product differentiation potential, pollution reduction actions will likely be taken by firms that rely on gas, because it is easier for them to reduce pollution. At the same time, plants that rely on coal but not on gas will be less likely to switch to less-polluting fuels than plants that have already capacity to use gas. To test this conjecture, we separate the plants in our sample into coal operating and gas operating ones. We define a coal- [gas-] operating plant as a plant that has used positive amount of coal [gas] during our overall sample period, but has never used gas [coal] during our sample. Table 8 columns (2) and (3) shows the results. Consistent with the differentiation argument, we find that plants that rely on coal indeed increased pollution, while plants that rely on gas decreased it. However, in both cases, the retail variable is not significant. This suggests that product differentiation is unlikely to be the reason for the different patterns in SO_2 pollution across plants.

5.2.2 Investor Channel

It is possible that our findings are driven by investors of public utilities, who may be interested in protecting the environment. Shareholder activism has been on rise in the past few decades, and Dimson, Karakas and Li (2015) demonstrate that aside from traditional activism, active owners engage target firms in socially responsible practices. Therefore, it is possible that investors responded to restructuring by pushing firms to reduce pollution. We note that this channel, while consistent with our trend in emission as a whole, cannot explain the cross-sectional variations found in our study. For example, we find that coal-based plants have actually increased their emission levels, while gas-based plants have reduced emission. Moreover, this argument relies on the assumption that investors would have had a hard time engaging firms in pollution reducing activities before restructuring. Since restructuring has changed electricity price setting mechanism by abandoning the cost-of-sale process, through which utilities were essentially guaranteed a certain level of profits, the new system has created more risk. It is therefore not clear why investors would find it beneficial to force the utility to increase expenses during a more vulnerable post-restructured time but did not do so before the deregulation when the utility is regulated and is less risky.

Investor channel can also be manifested through clientele effect, when some investors prefer firms to be more protective of the environment than others. Overall, regulated utilities attract long-term, dividend-loving investors (e.g., Brochet, Loumioti, and Serafeim 2012). These investors also tend to focus more heavily on environmental impact (Nguyen, Kecskes, and Mansi 2017; Starks, Venkat, and Zhu 2017). We should therefore expect a stronger push towards environmentally friendly policies before, rather than after the restructuring. We conclude that the investor channel is unlikely to drive our results.

5.2.3 Managerial Entrenchment Channel

Past studies have shown that managers might attempt to become environmentally friendly because of non-pecuniary motives, and these actions are a manifestation of agency conflicts. For example, Chen, Hong, and Shue (2019) show that, consistent with agency channel, passage of shareholder-rights proposals leads to less environmentally friendly policies. Similarly, Masulis and Resa (2015) show that corporate philanthropy is a manifestation of agency conflicts that reduce firm value. If this is the case, then we should expect to find that regulated plants are more susceptible to agency conflicts. However, to the extent that product market competition spurs alignment of incentives (e.g., Hart 1983, Schmidt 1997, Chhaochharia, Grinstein, Grullon, and Michaely 2017), managers of less competitive industries are more likely to be involved in environmentally friendly policies. Therefore, our findings stand in contrast to managerial entrenchment argument, since we find that managers of deregulated utilities have decreased pollution. Instead, our findings are consistent with the agency view that well-governed firms could engage more in CSR (Ferrell, Liang, and Renneboog 2016).

5.2.4 Legal Channel

Finally, we address the possibility that industry restructuring has led to more legal uncertainty. Restructuring, by design, involves changes in rulings that are yet to be challenged in a court of law. Moreover, other types of legislation, such as possible amendments to the Clean Air Act, could interact with restructuring rules in ways that may not be predicted by utilities. As a result, reducing environmental risk may be a value-enhancing strategy in such setting. Consistent with this rational, Sharfman and Fernando (2008) find that reducing environmental risk reduces firms' cost of capital, and Fernando, Sharfman, and Uysal (2017) and Koh, Qian, and Wang (2013) find that a decrease in environmental risk, rather than being green, enhances firm value. In addition, from a legal standpoint, there may be behavioral benefits to environmentally friendly policy. For example, Hong et al. (2019) demonstrate that regulators act favorably towards environmentally friendly firms.

If legal risk considerations are the channel at work, then we should expect an increase in environmentally friendly behavior in a deregulated environment because of legal risk. Indeed, our results are consistent with this argument, because we find that utilities, as a whole, have decreased pollution upon deregulation. However, the legal channel cannot explain the variation in our findings between plants that rely mainly on coal, and plants that rely mainly on natural gas. Table

8 demonstrates that plants that rely on coal have increased their pollution levels (we re-estimate the models without the indicator for retail competition and obtain similar results). If anything, coal plants are likely to be subject to higher scrutiny by the regulator because it is the most polluting agent across all categories of toxic emissions. Consistent with this notion, Phase I of the Acid Rain Program has deliberately targeted the largest polluters – old coal-operating plants and required them to reduce pollution.

6. Conclusion

In this paper we explore the impact of competitive environment on corporate environmental policy, focusing on the effect of electric utility restructuring on SO_2 emission – one of the most harmful byproducts of electricity generation. Our empirical strategy takes advantage of a staggered passage of restructuring legislation in the electric utilities industry across U.S. states during the 1990s. We find that plants in restructured states have decreased pollution relative to plants in non-restructured states.

We explore possible drivers of pollution reduction and find that plants in restructured states have changed their fuel mix and started to rely more heavily on clean gas as a source of energy. In addition, we find that operation efficiency has increased, allowing plants to burn less fuel overall. At the same time, we find that despite the decline in pollution, affected plants have reduced abatement-related capital investment, as well as operations and management expenditures on pollution-reduction activities.

We explore a number of potential economic channels behind these results, while focusing on channels that were previously established in the finance literature. We consider the role of customer preferences and product differentiation; investor clientele and activism, managerial entrenchment incentives, and legal motives. We find little evidence in support of any of these channels. At the same time, we find evidence consistent with the cost efficiency channel.

Broadly, our findings suggest that corporate efficiency and cost-cutting considerations could have positive environmental effects. In our case, regulated utilities were less inclined to move to gas-based production despite the fact that gas was considerably cheaper than petroleum. The lower inclination to move to gas-based production could have been driven by the long regulatory process required for capital investments or by their lack of incentives to alter production processes given that the regulated price of electricity compensated them for their costs regardless how high it was. It is also possible that the lack of product market competition reduced plants' incentives to alter their production and become competitive.

Clearly, incentives to become more efficient and cut costs might not always be beneficial to the environment. Therefore, an attempt to open the market to competition in one industry could have a different effect on the environment than in another industry. Our study delineates the importance of understanding the space of actions that firm take, their costs and benefits, and their environmental impact, in order to predict the effect of consolidation on the environment. To the extent that product market competition in the U.S. has declined in the last two decades, our findings may suggest another channel through which industry consolidation may affect the environment.

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Figure 1:

Average Fuel Prices over Time

The figure depicts average prices of coal, petroleum and gas, all in cents per million BTU, based on information reported in Form EIA-861 for plants in our sample. To aggregate the data across plants, for every fuel type and year we calculate the average of fuel prices, weighted by total MWh generated by each plant.

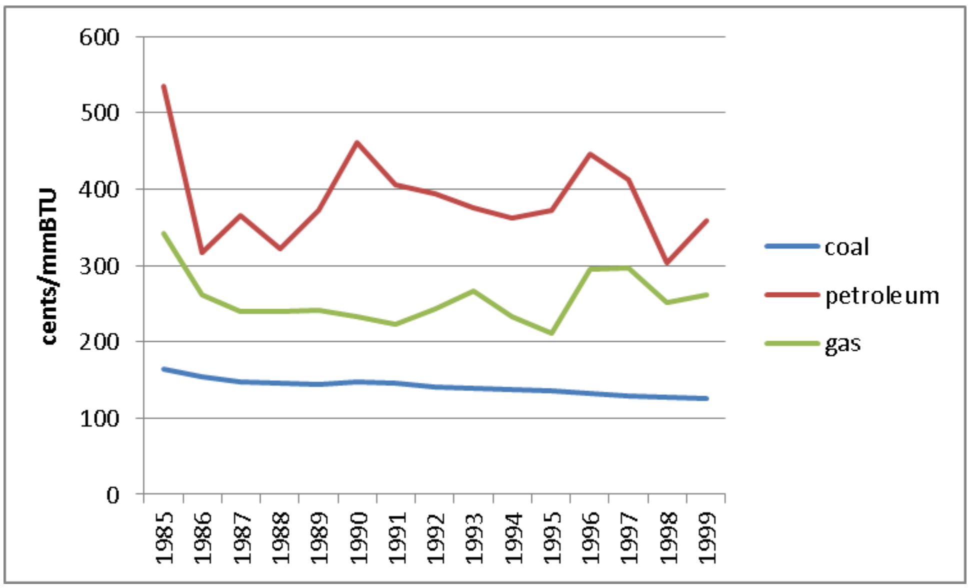

Table 1
Descriptive Statistics

The table presents descriptive statistics for the merged EPA-EIA-FRW plant-year sample for the period of 1985-1999. *Restructured* is an indicator variable that takes on a value of one for every plant in a state that has passed the restructuring legislation starting from the year of the first restructuring hearing and onward. Net annual MWh measures the amount of electric energy produced, in Megawatt hour. *Gross MW Capacity* is the maximum electric power a plant can produce, in Megawatt. *Installation year* is the year when the oldest unit in the plant was installed. *Heat input* is the amount of heating energy used as an input in the generation of electricity and is measured in billion of British thermal units (BBTUs); *Capacity factor* is the ratio of total net energy produced by the plant to its maximal capacity (defined as Gross *MW* Capacity, multiplied by number of hours per year). *IOU* is an indicator variable which equals one if the plant belongs to an investor owned utility firm. SO_2 is the annual emission of sulfur dioxide, in tons. *Scrubber* is an indicator variable that equals 1 if the plant has at least one flue-gas desulfurization (FGD) system in operating status, and zero otherwise. *Phase I* is an indicator variable for whether the plant was subject to Phase I of the Acid Rain program. The indicator takes on the value of 1 for all affected plants starting from 1995 and onward, and zero otherwise. *Abate. Capex* measures all pollution abatement capital expenditures for new structures and/or equipment made during the reporting year, in thousand dollars. *Abate Costs* cover all material and labor costs including equipment operation and maintenance costs (such as particulate collectors, conveyers, hoppers, etc.) associated with the collection and disposal of the byproducts, including fly and bottom ash collection, FGD collection, and other pollution collection. *SO_2 Costs* variable covers all material and labor costs associated with SO_2 collection. Fuel quantities (Coal, Gas, and Petroleum) are total annual amount of each input used, measured in its respective units. %boilers with primary fuel – coal [gas, petroleum] measures the number of boilers that use coal [gas, petroleum] as their primary fuel, divided by the total number of boilers that a plant has in operation.

Table 1 (cont.)

Variable	Obs	Mean	Std. Dev.	Min	p25	Median	p75	Max
Dummy (Restructured=1)	7,940	0.15	0.36	0	0	0	0	1
Plant Characteristics								
Total output (Net annual MWh)	7,940	3,447,705	3,726,115	886	819,218	2,167,528	4,691,988	22,000,000
Gross Capacity (MW)	7,940	807	665	100	304.00	588.96	1,137.60	3,969
Installation year	7,940	1962	12	1918	1953	1960	1972	1997
Heat input (BBTU)	7,940	35,441	37,254	15	9,068	22,706	48,042	229,489
Capacity factor	7,940	0.44	0.22	0.00	0.26	0.45	0.62	0.98
Dummy (IOU=1)	7,940	0.80	0.40	0	1	1	1	1
Pollution and Abatement								
SO_2 emission, ton	3,467	24,345	39,024	0	497	10,847	28,112	374,920
Dummy (Phase I=1)	7,940	0.06	0.24	0	0	0	0	1
Dummy (Scrubber=1)	7,940	0.16	0.37	0	0	0	0	1
Abate. Capex, ($1,000)	7,810	731	6,139	0	0	0	117	304,014
Abate. Costs, total ($1,000)	7,810	1,369	4,163	0	0	17	979	95,656
SO_2 Costs ($1,000)	7,810	643	2,810	0	0	0	149	56,236
Fuel Inputs								
Coal quant. ('000 short tons)	7,788	1,457	2,024	0	0	628	2,116	14,108
Gas quant. ('000 cubic ft.)	7,788	4,509,418	11,000,000	0	0	8,300	2,780,975	107,000,000
Petroleum quant. ('000 barrels)	7,788	282	1,009	0	1	9	44	13,617
% boilers with primary fuel - coal	7,598	0.62	0.46	0.00	0.00	1.00	1.00	1.00
% boilers with primary fuel - gas	7,598	0.27	0.43	0.00	0.00	0.00	0.67	1.00
% boilers with primary fuel - petroleum	7,598	0.11	0.29	0.00	0.00	0.00	0.00	1.00

Table 2
Restructuring and Emission

This table reports estimates of panel regressions of SO_2 emission amounts at the plant level as a function of restructuring and other control variables. The sample consists of all firms in the EPA-EIA-FRW sample over the following years: 1985, 1990, 1995-1999. The dependent variable is defined as one plus annual emission level of SO_2 (in ton), all converted into natural logs. All other variables are as described in Table 1. *Small* [*Large*] plants are plants with gross MW capacity below 575 MW [equal or above 575 MW]. *Old* [*New*] plants are plants in which the oldest unit was installed in 1960 or earlier [after 1960]. *IOU* [*Muni*] is an indicator variable which equals one if the plant belongs to an investor owned utility firm [utility firm owned by government, municipality, or members of a co-op]. The regressions are estimated with an OLS model, and include plant-epoch- and year-fixed effects. Standard errors are double clustered by plant-epoch and year dimensions and are reported in parentheses below coefficient estimates. Significance at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively.

	(1) All	(2) All	(3) Small Plants	(4) Large Plants	(5) Old Plants	(6) New Plants	(7) IOU only	(8) Muni only
Restructured	-0.330***	-0.200*	0.016	-0.396***	-0.162	-0.240**	-0.232*	-0.124
	(0.084)	(0.090)	(0.153)	(0.080)	(0.129)	(0.078)	(0.096)	(0.158)
ln(Net MWh)		0.784***	0.744***	0.904***	0.719***	0.935***	0.807***	0.730**
		(0.087)	(0.107)	(0.093)	(0.090)	(0.119)	(0.081)	(0.218)
Dummy (Scrubber=1)	-0.854***	-0.844***	-0.547*	-1.164**	-0.516	-0.940***	-0.682**	-1.344***
	(0.206)	(0.207)	(0.230)	(0.329)	(0.292)	(0.251)	(0.239)	(0.305)
Dummy (Phase I =1)	-0.494***	-0.452***	-0.486***	-0.436***	-0.345**	-0.593***	-0.420***	-0.509**
	(0.081)	(0.071)	(0.127)	(0.077)	(0.101)	(0.098)	(0.086)	(0.146)
Plant-Epoch FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3467	3467	1691	1776	1785	1682	2787	680
adj.R^2	0.95	0.96	0.94	0.96	0.95	0.96	0.96	0.95
adj.R^2 within	0.04	0.15	0.13	0.20	0.11	0.21	0.15	0.14

Table 3
Examining Parallel Trends

This table reports estimates of panel regressions of SO_2 emission amounts at the plant level as a function of restructuring and other control variables. The sample consists of all firms in the EPA-EIA-FRW sample over the following years: 1985, 1990, 1995-1999. The dependent variable is defined as one plus annual emission level of SO_2 (in ton), all converted into natural logs. The regressions include also the control variables ln(MWH), Phase I, and Scrubber, as in Table 2, as well as an indicator variable that takes on a value of one starting from year t+4 and onward (not shown). *Small* [*Large*] plants are plants with gross MW capacity below 575 MW [equal or above 575 MW]. *IOU* [*Muni*] is an indicator variable which equals one if the plant belongs to an investor owned utility firm [utility firm owned by government, municipality, or members of a co-op]. The regressions are estimated with an OLS model and include plant-epoch- and year-fixed effects. Standard errors are double clustered by plant-epoch and year dimensions and are reported in parentheses below coefficient estimates. Significance at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively.

	IOU		MUNI	
	(1)	(2)	(3)	(4)
	All	Large Plants	All	Large Plants
t-3	0.180	-0.242	0.763	0.587
	(0.160)	(0.134)	(0.819)	(0.910)
t-2	-0.154	-0.372*	-0.153	0.176
	(0.106)	(0.153)	(0.246)	(0.592)
t-1	-0.168	-0.258	0.285	0.245
	(0.140)	(0.185)	(0.319)	(0.603)
t	-0.186	-0.457***	0.067	-0.322
	(0.097)	(0.106)	(0.237)	(0.380)
t+1	-0.302*	-0.408**	-0.208	-0.539
	(0.137)	(0.151)	(0.290)	(0.571)
t+2	-0.236*	-0.458***	-0.332	-1.152
	(0.100)	(0.100)	(0.431)	(1.215)
t+3	-0.260*	-0.459***	-0.104	0.022
	(0.126)	(0.122)	(0.298)	(0.567)
Control Variables	Yes	Yes	Yes	Yes
Plant-Epoch FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	2787	1494	680	282
adj.R^2	0.958	0.961	0.952	0.952
adj.R^2 within	0.152	0.191	0.139	0.237

Table 4
Restructuring and Emission Cleaning Expenditure

This table reports estimates of panel regressions of plant-level capital expenditures, as well as of operations and management costs associated with emission abatement, as a function of restructuring and control variables. The sample in Panel A consists of all plants in the EIA-FRW sample over the period of 1985-1999. The sample in Panel B is refined to include only plants with positive coal input in a given year. All variables are as described in Table 1. Each dependent variable, except *Scrubber* indicator, is converted into natural logs (a value of one is added before the transformation). All regressions are estimated with an OLS model and include plant-epoch- and year-fixed effects. Standard errors are double clustered by plant-epoch and year dimensions and are reported in parentheses below coefficient estimates. Significance at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively.

Panel A: All Plants

	(1) ln(Abate. CapEx)	(2) Dummy (Scrubber=1)	(3) ln(Abate. Costs, total)	(4) ln(SO_2 Costs)
Restructured	-0.823***	-0.005	-0.436*	-0.614**
	(0.217)	(0.010)	(0.224)	(0.232)
ln(Net MWh)	0.216*	0.000	-0.009	0.225*
	(0.116)	(0.004)	(0.111)	(0.115)
Dummy(Scrubber=1)	0.117		4.839***	1.427**
	(0.671)		(0.872)	(0.540)
Dummy(Phase I=1)	-0.323	0.124***	-1.550***	0.732*
	(0.287)	(0.033)	(0.414)	(0.348)
Plant-Epoch FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	7810	7940	7810	7810
adj.R^2	0.42	0.95	0.76	0.59
adj.R^2 within	0.01	0.07	0.06	0.02

Panel B: Coal-Operating Plants

	(1) ln(Abate. CapEx)	(2) Dummy (Scrubber=1)	(3) ln(Abate. Costs, total)	(4) ln(SO_2 Costs)
Restructured	-0.791**	-0.003	-0.619***	-0.588*
	(0.280)	(0.016)	(0.199)	(0.307)
ln(Coal quant.)	0.195	0.003	-0.008	0.264
	(0.203)	(0.010)	(0.167)	(0.196)
Dummy(Scrubber=1)	0.054		5.136***	1.291**
	(0.679)		(0.786)	(0.545)
Dummy(Phase I=1)	-0.503	0.123***	-0.672**	0.488
	(0.321)	(0.034)	(0.301)	(0.364)
Plant-Epoch FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	5169	5169	5169	5169
adj.R^2	0.35	0.94	0.79	0.54
adj.R^2 within	0.01	0.06	0.10	0.01

Table 5
Restructuring and Fuel Type

This table reports estimates of panel regressions of plants' reliance on different fuel types in the production process as a function of restructuring and control variables. The sample consists of all plants in the EIA-FRW sample over the period of 1985-1999, with the exception of specifications (2) and (4) of Panel B, which rely on sample that includes only plants with positive coal input in a given year. All variables are as described in Table 1. In specifications (1)-(3) of Panel A and all specifications in Panel B the dependent variable is converted into natural logs (a value of one is added before the transformation). All regressions are estimated with an OLS model and include plant-epoch- and year-fixed effects. Standard errors are double clustered by plant-epoch and year dimensions and are reported in parentheses below coefficient estimates. Significance at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively.

Panel A: Fuel Mix

	(1) ln(Coal Quant.)	(2) ln(Gas Quant.)	(3) ln(Pet. Quant.)	(4) Prim. Coal	(5) Prim. Gas	(6) Prim. Petrol.
Restructured	0.012	0.590**	-0.415***	0.007*	0.032**	-0.043***
	(0.030)	(0.228)	(0.104)	(0.004)	(0.013)	(0.013)
ln(BTU)	0.359***	0.608***	0.350***	0.003	0.002	-0.008
	(0.039)	(0.124)	(0.074)	(0.002)	(0.009)	(0.009)
Dummy (Scrubber=1)	0.025	-0.191	-0.129	-0.002	-0.006	0.008*
	(0.044)	(0.494)	(0.154)	(0.005)	(0.007)	(0.004)
Dummy(Phase I=1)	0.015	0.232	0.216*	0.000	-0.008	0.008
	(0.027)	(0.240)	(0.112)	(0.006)	(0.007)	(0.006)
Plant-Epoch FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	7788	7788	7788	7598	7598	7598
adj.R^2	0.99	0.94	0.86	0.99	0.94	0.88
adj.R^2 within	0.16	0.01	0.04	0.00	0.01	0.01

Panel B: Coal Quality

	(1) ln(Sulf.Coal)	(2) ln(Sulf.Coal)	(3) ln(Ash)	(4) ln(Ash)
Restructured	0.116**	0.142**	0.067	0.058
	(0.044)	(0.050)	(0.046)	(0.040)
ln(Net MWh)	0.285***		0.323***	
	(0.034)		(0.040)	
ln(Coal Quant.)		0.808***		0.941***
		(0.040)		(0.020)
Dummy(Scrubber=1)	0.417***	0.410***	0.137**	0.117***
	(0.097)	(0.087)	(0.052)	(0.039)
Dummy(Phase I=1)	-0.451***	-0.444***	-0.085**	-0.086**
	(0.063)	(0.067)	(0.035)	(0.031)
Plant-Epoch FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	7788	5169	7788	5169
adj.R^2	0.99	0.94	0.99	0.95
adj.R^2 within	0.13	0.36	0.08	0.44

Table 6
Restructuring and Production Efficiency

This table reports estimates of panel regressions of various measures of plant-level operation efficiency as a function of restructuring and control variables. The sample consists of all plants in the EIA-FRW sample over the period of 1985-1999. All variables are as described in Table 1. Each dependent variable, except *Capacity Factor*, is converted into natural logs. All regressions are estimated with an OLS model and include plant-epoch- and year-fixed effects. Standard errors are double clustered by plant-epoch and year dimensions and are reported in parentheses below coefficient estimates. Significance at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively.

	(1) ln(BTU)	(2) Capacity Factor	(3) ln(Net MWh)	(4) ln(BTU)
Restructured	-0.012**	-0.056***	-0.166***	-0.009
	(0.005)	(0.010)	(0.032)	(0.006)
Capacity Factor				0.151***
				(0.044)
ln(Net MWh)	0.914***			0.885***
	(0.008)			(0.015)
Dummy(Scrubber=1)	0.007	0.009	0.007	0.006
	(0.007)	(0.025)	(0.061)	(0.007)
Dummy(Phase I=1)	-0.002	-0.009	-0.053	-0.002
	(0.005)	(0.011)	(0.036)	(0.005)
Plant-Epoch FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	7940	7940	7940	7940
adj.R^2	0.997	0.853	0.941	0.997
adj.R^2 within	0.947	0.026	0.015	0.948

Table 7
Restructuring, Production Costs, and Fuel Type

This table reports estimates of panel regressions of plant reliance on different fuel types in the production process as a function of restructuring, state-level production costs, and control variables. The sample consists of all plants in the EIA-FRW sample over the period of 1985-1999. *High Electr. Price* is a proxy for high production costs at a state level and is constructed as described in Section 4.2. All variables are as described in Table 1. In specifications (1)-(3) and (7) the dependent variable is converted into natural logs (a value of one is added before the transformation). All regressions are estimated with an OLS model and include plant-epoch- and year-fixed effects. Standard errors are double clustered by plant-epoch and year dimensions and are reported in parentheses below coefficient estimates. Significance at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively.

	(1) ln(Fuel Costs)	(2) %Prim. Coal	(3) %Prim. Gas	(4) %Prim. Pet	(5) ln(Quant. Coal)	(6) ln(Quant. Gas)	(7) ln(Quant. Pet)
Restructured	0.012	0.006	-0.006	-0.001	-0.040	0.153	-0.190
	(0.021)	(0.004)	(0.010)	(0.010)	(0.025)	(0.257)	(0.124)
Restr.*High Electr. Price	-0.006**	0.000	0.008**	-0.009***	0.011*	0.090*	-0.047**
	(0.003)	(0.000)	(0.003)	(0.003)	(0.006)	(0.042)	(0.020)
ln(BTU)	0.849***	0.003	0.008	-0.013	0.366***	0.664***	0.321***
	(0.016)	(0.002)	(0.008)	(0.008)	(0.041)	(0.117)	(0.077)
Scrubber Dummy	0.015	-0.002	-0.009	0.012	0.021	-0.229	-0.109
	(0.032)	(0.005)	(0.009)	(0.008)	(0.044)	(0.495)	(0.150)
Phase I Dummy	-0.061*	0.000	-0.009	0.009	0.015	0.229	0.218*
	(0.029)	(0.006)	(0.007)	(0.006)	(0.027)	(0.239)	(0.114)
Plant-Epoch FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	7937	7598	7598	7598	7788	7788	7788
adj.R^2	0.98	0.99	0.94	0.88	0.99	0.94	0.86
adj.R^2 within	0.71	0.00	0.02	0.03	0.16	0.02	0.04

Table 8
Restructuring, Retail Access and Emission

This table reports estimates of panel regressions of plant-level SO_2 emission amounts as a function of restructuring and other control variables. The sample consists of all firms in EPA-EIA-FRW sample over the following years: 1985, 1990, 1995-1999. The dependent variable is defined as one plus annual emission level of SO_2 (in ton), all converted into natural logs. *Retail* is an indicator variable that takes on a value of one starting from the year in which a state has implemented retail access. All other variables are as described in Table 1. *Coal, no Gas* [*Gas, no Coal*] plants are plants that have used a positive amount of coal input [gas input] but have never used gas [coal] throughout our sample period. Since *Scrubber* is never used in plants with no coal-based operation, the indicator variable is excluded in Specification (3). The regressions are estimated with an OLS model and include plant-epoch- and year-fixed effects. Standard errors are double clustered by plant-epoch and year dimensions and are reported in parentheses below coefficient estimates. Significance at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively.

	(1) All	(2) Coal, no Gas	(3) Gas, No coal
Restructured	-0.200*	0.145**	-0.711**
	(0.089)	(0.051)	(0.234)
Retail	0.018	0.206	-0.242
	(0.164)	(0.110)	(0.336)
ln(Net MWh)	0.784***	0.838***	0.659***
	(0.091)	(0.062)	(0.157)
Dummy (Scrubber=1)	-0.846***	-1.008**	
	(0.209)	(0.274)	
Dummy (Phase I=1)	-0.452***	-0.520***	0.242
	(0.071)	(0.059)	(0.344)
Plant-Epoch FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	3467	1446	1044
adj.R^2	0.96	0.95	0.86
adj.R^2 within	0.15	0.43	0.11

Table Appendix A-1

This table reports estimates of panel regressions of percentage of plant boilers at the plant level that are primarily gas based (columns 1 and 3) and natural log of plant-level heat energy used to generate electricity (in BTU) as a function of restructuring and other control variables (columns 2 and 4). The sample consists of all firms in the EPA-EIA-FRW sample over the following years: 1985-1999. The regressions include also the control variables ln(MWH), Phase I, and Scrubber, as in Table 2, as well as an indicator variable that takes on a value of one starting from year *t*+4 and onward (not shown). *IOU* is an indicator variable which equals one if the plant belongs to an investor owned utility firm. Muni is an indicator variable which equals one if the utility firm is owned by government, municipality, or members of a co-op. The regressions are estimated with an OLS model and include plant-epoch- and year-fixed effects. Standard errors are double clustered by plant-epoch and year dimensions and are reported in parentheses below coefficient estimates. Significance at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively.

	IOU		MUNI	
	(1) Prim. Gas	(2) ln(BTU)	(3) Prim. Gas	(4) ln(BTU)
t-3	-0.001	-0.001	0.033	-0.016*
	(0.011)	(0.005)	(0.026)	(0.007)
t-2	0.027	-0.005	0.035	-0.001
	(0.021)	(0.005)	(0.031)	(0.014)
t-1	0.037	-0.002	0.043	-0.005
	(0.023)	(0.007)	(0.037)	(0.011)
t	0.055**	-0.017***	0.021	-0.039*
	(0.026)	(0.004)	(0.040)	(0.022)
t+1	0.048**	-0.020**	0.023	0.018
	(0.017)	(0.008)	(0.046)	(0.027)
t+2	0.054**	-0.012*	0.011	0.039
	(0.022)	(0.006)	(0.054)	(0.033)
t+3	0.064**	-0.015	-0.046	0.023
	(0.025)	(0.010)	(0.052)	(0.056)
Plant-Epoch FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	6102	6320	1496	1620
adj.R^2	0.937	0.997	0.955	0.995
adj.R^2 within	0.013	0.956	0.011	0.916