Overlapping Environmental and Financial Regulations: The Role of Corporate Governance*

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Abstract

We study the question of whether good corporate governance improves environmental performance. The relationship between governance and environmental performance may depend on the interaction between financial and environmental regulations. To measure these relationships, we develop a unique new panel dataset that matches individual U.S. coal-fired power plant characteristics and emissions rates to the financial information on their corporate parents. We exploit predetermined variation in corporate governance quality prior to the passage of the Sarbanes-Oxley Act—a major federal financial regulation that increased transparency between shareholders and managers—to study the effect of governance improvements on subsequent emissions rates of Nitrogen Oxides (NO_x). We find that the effect of corporate governance on emissions rates differs across environmental regulatory regimes; improvements in corporate governance reduce emissions rates in areas where NO_x emissions are managed by cap-and-trade, but do not affect emissions rates under emissions rate standards. We also find that effects on emissions rates are heterogeneous across different dimensions of governance; increasing CEO accountability causes emissions rates to increase, while increasing shareholder rights has the opposite effect.

Keywords: governance; environmental regulation; emissions; corporate finance

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1. Introduction

Do misaligned managerial incentives that cause firms to perform inefficiently also impact their environmental performance? The separation of ownership and control in public companies can enable executives to mismanage or even appropriate firm resources. Alternatively, it can give managers more power to pursue long-run objectives that are in the firm's interest but are at odds with investors' short-term strategies. In polluting industries, the extent to which shareholders can discipline managers may therefore have large implications for emissions, compliance costs, and environmental investments. This paper investigates how features of corporate governance affect emissions rates and responsiveness to environmental regulation in the electric power industry.

It is well known from a large theoretical and empirical literature that governance mechanisms can influence managers' incentives to work in the firm's interest or in their own personal interest. Managers with poor incentives may divert company resources for their own gain or simply exert substandard effort (Ang et al., 2000; Tirole, 2010; Gogineni et al., 2013). Environmental laws and financial regulations place overlapping constraints on how firms allocate resources and/or monitor managers' performance. The relationship between these constraints is not well understood, however, and both the theoretical and empirical literature find conflicting evidence (Kitzmueller and Shimshack, 2012).

A major hurdle to empirical investigation of the relationship between governance and environmental performance has been that data collected by the U.S. Environmental Protection Agency (EPA) on polluting facilities is not easily matched with financial and governance data from parent companies of these facilities. The empirical literature has been limited to using either the Toxics Release Inventory (TRI), which is one of the only EPA databases to include financial identifiers (Berrone et al., 2010; Cong and Freedman, 2011; Kassinis and Vafeas, 2006), or various proxy variables for environmental performance, such as lawsuits (Kassinis and Vafeas, 2002), participation in voluntary environmental programs (Fisher-Vanden and Thorburn, 2011), third-party ratings (Walls et al., 2012), or green patents (Amore and Bennedsen, 2014).

This paper uses a unique, purpose-developed dataset that matches information on individual power plant facilities from the EPA's Emissions & Generation Resource Integrated Database (eGRID) to financial and governance information on the facilities' corporate owners from the Compustat and RiskMetrics databases. We focus thereby on emissions of nitrogen oxides (NO_x) from coal-fired power plants for the years 1999 through 2010. This period straddles two events that introduce exogenous variation in firm governance and in environmental regulation of NO_x emissions, respectively. The first is the passage in 2002 of the Sarbanes-Oxley Act (SOX),[3] in response to a series of major accounting scandals. SOX imposed a new set of reporting requirements, increased transparency for shareholders, and made executives personally liable for the veracity of financial statements. The second event is the introduction in 2004 of a cap-and-trade program known as the NO_x Budget Program (NBP), which applies to power plants in most eastern and midwestern U.S. states.

We show empirically that the effect of governance on air pollution emissions rates depends on the prevailing approach to emissions regulation. Governance has no statistically significant effect on emissions rates when these are regulated by plant-specific standards. When

[3] Not to be confused with the common use of "SO_x" as an abbreviation for sulfur oxides, which fossil-fuel power plants also emit. In this paper, we limit our attention to nitrogen-oxide emissions, and use SOX to refer to the Sarbanes-Oxley Act.

aggregate emissions are regulated through a cap-and-trade approach, however, governance has economically and statistically significant impacts on emissions rates. Good governance unambiguously reduces emissions rates measured relative to electricity produced, but the effect on emissions rates measured relative to fuel inputs is heterogeneous by governance mechanism. Improved shareholder rights lead to reductions in input emissions rates, whereas increased exposure of executives to legal and financial liabilities can cause increases in input emissions rates. This suggests that good governance better equips firms to adapt to cap-and-trade regulations, but their approach to adaptation differs by corporate governance regime.

2. Background

In this section, we provide further information on NO_x emissions from power plants and on the Sarbanes-Oxley Act. We also briefly review the existing literature on the relationship between environmental performance and firm governance.

2.1. *NO_x emissions from power plants*

Power plant NO_x emissions, which contribute to ground-level ozone formation and can also worsen particulate-matter pollution and acid rain, were initially regulated under the Clean Air Act using command-and-control approaches. Title IV of the 1990 Clean Air Act Amendments (CAAA) imposed standards for input emissions rates—specific limits on pounds of NO_x per million Btu of fuel inputs—that were consistent with specific coal-fired boiler configurations and with NO_x control technologies that were available at the time (Burtraw and Evans, 2003). The standards were phased in between 1996 and 2000, whereby new plants and those undergoing major upgrades were required to meet stricter standards than existing plants. Additionally, plants in areas not in compliance with the National Ambient Air Quality Standards for ozone and in a set of states in the northeast called the Ozone Transport Region (the mid-Atlantic states from Maryland to Maine, plus DC and some counties in Virginia), were required to meet the emissions rate standards earlier and with less flexibility (Burtraw and Evans, 2003).

Starting in 1999, a regional cap on total ozone-season (May-September) emissions was imposed in the Ozone Transport Region, and a cap-and-trade program phased in. In 2004, this program was replaced by the NO_x Budget Trading Program (NBP), which significantly tightened the cap and significantly expanded the number of participating states to include most of the eastern and midwestern United States (Burtraw and Evans, 2003; Fowlie, 2010).

Emissions reductions for coal-fired power plants can be managed in a number of ways, which can be broadly separated into operational improvements and capital investments in emissions control technology. In turn, control-technology options broadly fall into two groups: post-combustion "scrubbers" such as Selective Catalytic Reduction and Selective Non-Catalytic Reduction, and pre-combustion boiler configurations such as various types of low-NO_x burners.

Some operational improvements can simultaneously improve power plant efficiency, although most of these jointly efficiency-enhancing opportunities were likely found and exploited as part of the initial response to the 1990 CAAA. Most operational modifications involve operating the boiler at a lower temperature, which reduces NO_x emissions per unit of fuel input but also reduces the overall operational efficiency of the plant (Burtraw and Evans, 2003).

The extent to which operational modifications harm plant efficiency may not depend solely on fixed factors such as capital quality and age. Bushnell and Wolfram (2009) document systematic skill effects of power plant operational efficiency that depend on the specific identity of the power plant manager on duty at the time of operation. They also report cases in which power plant managers were explicitly incentivized in their compensation contracts to operate power plants at higher efficiencies, and discuss how these managerial practices vary across firms and plants. Fowlie (2010) finds that power plants in states with regulated electricity markets—where utilities were subject to rate-of-return regulation—were more likely to adopt capital-intensive pollution control technologies in order to comply with the NBP than power plants in deregulated states, where power plant financial returns were subject to electricity market risk.

Complying with NO_x emissions limits is costly. Linn (2010) estimates, using an event study, that over the five-year period from 1995–2000, 46 investor-owned utilities in the NBP region lost a combined \$25 billion in market value—about 20% of their combined total market value in 1995—because of investors' projections of lower future profits due to the program. This estimate is broadly consistent with an earlier simulation study by Palmer et al. (2001), which estimated that the NBP program would cost about \$2 billion per year.

2.2. *The Sarbanes-Oxley Act*

The Sarbanes-Oxley Act of 2002, known officially as the Public Company Accounting Reform and Investor Protection Act, introduced major changes to the regulation of corporate governance and financial practice. The law's main objectives are to (i) improve financial reporting quality and (ii) increase investor confidence. There are eleven major sections that cover areas such as additional corporate board responsibilities, auditor independence, corporate governance, enhanced disclosure, and internal control assessments. The Securities and Exchange Commission (SEC) is charged with implementing the rulings on requirements to comply with the law.[4]

SOX and its implications have been the center of a fierce debate among business practitioners, policymakers, and academic researchers. Proponents of the act argue that SOX will bring a variety of long-term benefits, by increasing director responsibility, pushing firms to adopt corporate codes of ethics, and creating an independent Public Company Accounting Oversight Board (PCAOB) to oversee and regulate auditors. As a result of these changes, they argue, investors will face a lower risk of losses from the kinds of corporate and accounting scandals (Enron, Worldcom, Waste Management, Tyco, HealthSouth, Global Crossing, etc.) that prompted the legislation. The resulting increased investor confidence should ultimately benefit firms as well, by lowering their cost of raising capital.

Opponents, on the other hand, view SOX as a regulatory overreaction. The increase in compliance costs associated with SOX hurts public companies, they argue,[5] and gives smaller companies in particular an incentive to go private, in order to bypass SOX's onerous new requirements. In addition, the law hurts the international competitiveness of U.S. stock exchanges, by dissuading foreign firms from getting listed in the U.S.

Given that SOX touches virtually every aspect of a corporation's functions, studying its overall impact has proven to be difficult. In a review of the SOX literature, Coates (2007) discusses the serious problems related to estimating the effects of the law. Importantly,

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[4] A detailed description of the law can be found at http://www.sec.gov/about/laws/soa2002.pdf.

[5] According to a 2011 survey by Protiviti, an audit and risk consultancy, most firms spend around $100,000 to $1 million annually on compliance-related activities. For a full copy of the report, see http://www.protiviti.com/en-US/Documents/Surveys/2011-SOX-Compliance-Survey-Protiviti.pdf.

whereas some changes in governance that haven taken place since 2002 can be traced directly to the SOX legislation itself, others were induced by regulatory changes that occurred around the same time, in response to the same scandals. Coates notes, for example, that criminal prosecutions of corporate managers increased after 2002, but that this was due not to any specific provision in SOX, but rather to decisions by the U.S. Department of Justice and by state attorneys general to adopt more aggressive tactics. He notes also that, even though SOX mandated some new disclosure requirements, many other governance changes were mandated shortly after SOX passed, but independently, by the New York and Nasdaq stock exchanges. Similarly, Maleske (2012) argues that by explicitly banning firms from making loans to their executives (in response to revelations that WorldCom had loaned \$409 million to its CEO Bernie Ebbers) the SOX legislation "shoved issues like executive compensation and board independence into the spotlight" and thereby "laid the cultural roots" of subsequent shareholder activism.

For our purposes, the distinction between direct, indirect, and independent but contemporaneous effects of SOX is immaterial. What matters is that many firms were induced to change their governance practices post-2002, for reasons not driven by their previous environmental performance. When below we discuss such changes as occurring "post" SOX, we do not imply that they necessarily occurred "because of" SOX.

2.3. *Corporate governance and environmental performance*

The finance literature on corporate governance broadly indicates that while poor governance is generally associated with operational inefficiency and lower profitability, in some cases poor governance can empower the CEO to make decisions that are in the long-run interests of the firm, even if they may not pay off in the short run. One confounding feature of the literature is that "governance" is a broad construct, describing many specific policies that may occasionally work in opposing directions.

For example, John et al. (2008) find that strong protection of shareholder rights—one form of good governance—is positively related to firm growth and willingness to take value-enhancing risks. Cuñat et al. (2012) also find that good governance has positive effects on long-term profitability; when a firm's shareholders vote to repeal governance measures that restrict shareholder rights,[6] the firm's stock price tends to increase, and its subsequent (potentially inefficient) corporate acquisitions and capital expenditures tend to fall. Fisman et al. (2013), on the other hand, find that in firms with better governance scores, CEOs with long-term outlooks tend to be ousted sooner. They attribute this to a "board protection" effect: boards of firms with weaker shareholder rights are better able to disregard shareholder whims when deciding whether to fire or retain CEO's.

The main governance measure used by all three above-cited papers (as well as by literally thousands of other papers on corporate governance) is the so-called G-index ("G" for governance) developed by Gompers et al. (2003). This index, described in more detail in Section 3 below, uses a set of 24 governance provisions, each of which restrict shareholder rights in a particular way, and simply counts how many of these 24 a given firm has in place. John et al. (2008) and Fisman et al. (2013) also use the so-called E-index ("E" for entrenchment) subsequently developed by Bebchuk et al. (2009).[7] This index consists of a subset of six provisions found by Bebchuck et al. to drive the widely observed correlation between the

[6] Consistent with the notion of increased post-SOX shareholder activism, Cuñat et al. note that from 2003 onward, the number of such votes increased sharply.
[7] Originally in a widely cited working paper, which John et al. (2008) refer to.

G-index and firm valuation. Other papers have examined other sub- and super-sets of the G-index 24.

Of particularly interest for our purposes is a paper by Bradley and Chen (2011), which focuses on a subset of just three provisions that they label the L-index ("L" for liability). All three provisions protect corporate managers and directors from shareholder lawsuits, either by limiting their liability directly or by committing to indemnify them for litigation expenses. Although this clearly weakens shareholder influence, Bradley and Chen find that firms with these three provisions in place tend to have higher credit ratings and hence lower costs of debt. They argue that this is because the provisions allow corporate managers to adopt more low-risk operating strategies, which ultimately benefits not just bondholders, but possibly shareholders as well. Importantly, they find that, after netting out the effect of their L-index, the remaining G-index provisions are associated with a *higher* cost of debt, contrary to findings in previous studies that used the G-index as a whole. For our purposes, Bradley and Chen's study points to the importance of not blindly lumping all G-index provisions together. Indeed, we find that a subset of eight provisions including Bradley and Chen's three is associated with very different environmental outcomes than the remaining 16.

Perhaps not surprisingly in light of the above, the existing literature on how firm governance is related to environmental performance has tended to find non-monotonic effects as well. As pointed out earlier, the environmental performance measures examined in this literature have generally been limited to toxic releases or various proxy variables. A fairly consistent pattern that emerges is that shareholders appear to reward good environmental performance when there are salient financial risks of poor performance such as lawsuits or enforcement actions, but to punish good environmental performance when the financial benefits are not apparent.

Consistent with this pattern are findings by Hamilton (1995), and Konar and Cohen (2001) that low toxic releases, which firms report to the EPA's Toxics Release Inventory and are generally widely covered in the media, are rewarded by shareholders. Consistent also is the finding by Fisher-Vanden and Thorburn (2011) that in the early 2000s, when there was no immediate prospect of federal climate change regulation, voluntary participation in an EPA carbon dioxide program was punished by shareholders. Interestingly, the study finds that it was more poorly governed firms, as measured by a high G-index (indicating weak shareholder rights), who tended to join the program. Gans and Hintermann (2013) find, in contrast—but again arguably consistent with the pattern—that in 2006 and 2007, during serious congressional debates about climate change regulation, investors rewarded firms participating in the Chicago Climate Exchange, potentially viewing it as a strategic preemption of federal law. Similarly, Kim and Lyon (2011) find that participation in the Carbon Disclosure Project, another voluntary program to report carbon footprint information, was not rewarded by investors until the Kyoto Protocol went into effect.

A different way of describing the pattern is that some firms may voluntarily over-comply with environmental regulations because they are governed poorly: their managers choose to over-comply for non-financial reasons (e.g., a sense of social responsibility or private "warm glow"), and shareholders cannot force these managers to focus on maximizing firm value instead (Fisher-Vanden and Thorburn, 2011). On the other hand, some firms may over-comply because they are governed well: their shareholders do not like the financial risks associated with being out of compliance, and can force managers to reduce that risk

(Arora and Cason, 1995, 1996; Arora and Gangopadhyay, 1995; Khanna and Damon, 1999; Shimshack and Ward, 2008).

For "routine" emissions such as the NO_x emissions of power plants examined in this paper, other factors come into play—factors that reinforce the a priori ambiguity of the governance-environmental performance relationship. If, for example, a firm's emissions are associated mostly with its output, then lower efficiency could translate into lower baseline emissions rates, paradoxically making compliance with environmental regulations easier. If, on the other hand, emissions are associated mostly with the firm's inputs, then the opposite might hold—inefficient use of those inputs (per unit output) could lead to higher emissions rates, and make compliance more difficult. Moreover, most firms have a more complicated transformation surface between multiple polluting and non-polluting inputs and outputs and associated environmental impacts (Agee et al., 2014). Managers tasked with environmental compliance may have different incentives than those tasked with meeting production targets. And these conflicting incentives may be a function of the corporate governance structure.

This discussion leads to a set of opposing hypotheses. Good corporate governance may improve environmental performance because it induces managers to focus on operational efficiency and because environmental compliance is valued by shareholders. Alternatively, good governance may hurt environmental performance because it reduces managers' freedom to engage in costly over-compliance, which is approved of by shareholders only when they see it as an opportunity to avoid legal and regulatory risks.

3. Empirical Methodology

In order to identify the effects of governance on emissions rates, we exploit two dimensions of exposure to the new transparency and reporting requirements that were introduced by the SOX legislation and by the major stock exchanges. First, coal plants with equivalent technology and operations requirements are owned either by publicly traded corporations or by other entities, including privately held firms, cooperatives, and governments or quasi-governmental organizations. Only plants owned by publicly traded corporations are exposed to the governance changes brought on by the new requirements imposed by SOX legislation and the stock exchanges. We use plants owned by other organization types as a control group for the effects of financial regulation on emissions from plants owned by publicly traded corporations.

Second, we exploit firm-level variation in pre-SOX governance quality as a predetermined measure of exposure to the new transparency requirements. Although SOX imposed new reporting and transparency requirements on all publicly traded firms, those with the most severe agency problems would have been most affected by the new rules. Suppose, for example, that in one firm, the corporate charter gives shareholders extensive rights to oversee and discipline managers, the board of directors is not populated by the management team, and the CEO's contract does not protect her against shareholder lawsuits or guarantee her severance pay. Other than having to file more paperwork under SOX, this firm is unlikely to change its management practices because of the transparency requirements in SOX. In another firm, shareholders have limited rights to oust bad managers, there are multiple executives on the board of directors, and the CEO's contract does shield her from liability and does guarantee a severance if she is terminated, regardless of the reason. This firm is more enabled to hide bad behavior and its CEO is more empowered to act against the interest of shareholders than the first firm. As a result, the transparency requirements and executive liability rules in SOX are more likely to induce changes in manager behavior in this second firm.

Using this dimension of predetermined variation allows us to estimate the marginal impact of governance quality in emissions rates. In order to exploit this second source of variation, we take for each plant the average value of the governance measures of its corporate parent in the pre-SOX fiscal years, and interact this regulatory exposure measure with a dummy variable for the post-SOX period. Because we have variation both within affected power plant owners and across affected and unaffected owners, before and after the policy change, we use regression-based difference-in-differences and triple-difference estimators.

The first difference-in-difference specification we estimate is

$$y_{ist} = \mu_i + Post_t + Public_s + \beta T_{st} + \gamma Z_{st} + \delta X_{it} + SIC_I + NERC_R + e_{ist} \qquad (1)$$

where y_{ist} is the emissions rate at unit i, owned by entity s in year t. In some specifications, our data is at the sub-plant, boiler level, while in other specifications it is at the plant level. Emissions rates are measured either as an input emissions rate in pounds per MMBtu, or an output emissions rate in pounds per MWh. We include plant fixed effects, μ_i, as well as industry (SIC_I) and region ($NERC_R$) fixed effects, with regions defined by the National Electric Reliability Council (NERC). $Post_t$ is a dummy variable indicating the post-SOX period, $Public_s$ is a dummy variable that indicates whether or not the plant's owner is a publicly traded corporation, and T_{st} is the interaction between between *Public* and *Post*.

The coefficient β on T_{st} is the average treatment effect of interest. A negative estimate of β would imply that plants owned by publicly traded firms decreased their emissions rates following the passage of SOX, relative to the control group.

We also include firm-level control variables Z_{st} and unit-level control variables X_{it}. Firm-level controls include Total Assets, Capital Expenditures as a share of Total Assets, the Debt-to-Asset Ratio, the Free-Cash-Flow to Asset ratio, Operating Income Before Depreciation as a share of Total Assets, the Market-to-Book ratio, and Firm Age. Unit-level controls include Nameplate Capacity and Capacity Factor at the plant level, and Boiler Age at the boiler (sub-plant) level. When running plant-level regressions, we use age of oldest boiler for multi-boiler plants as a measure of the age of the plant.

We also estimate the marginal effect of governance quality within the set of plants owned by publicly traded corporations. To do so, equation (1) is modified as follows:

$$y_{ist} = \mu_i + Post_t + Gov_s + \beta Gov_s * Post_t + \gamma Z_{st} + \delta X_{it} + SIC_I + NERC_R + e_{ist} \quad (2)$$

In these specifications, Gov_s is the average of the firm's governance scores taken over the pre-SOX years. For each of the governance measures we use, high scores indicate poor governance quality (which is based on the construction of the indices in Gompers et al. (2003)).

A firm with a high pre-SOX governance score is assumed to be most exposed to SOX, and likely to have experienced the largest post-SOX changes in executive behavior and corporate practices because of the increased oversight, liability, and compensation restrictions.[8]

[8] For example, SOX required corporations to hire independent auditors with which they did not have other consulting relationships; held executives personally liable for the certification of financial statements and required them to forfeit compensation for misconduct; banned corporations from making loans to their executives or directors; and banned certain trading activity of company stock by executives. Corporations in which executives acted with the most impunity from shareholder or legal reprisal would have been most affected by these provisions.

Therefore a negative coefficient β in these specifications implies that governance improvements reduce emissions rates, and vice versa.

We also examine whether governance effects on emissions vary across different emissions regulatory regimes. Broadly speaking, governance measures capture managerial autonomy from shareholder oversight, and the degree of shareholder authority. In light of Linn (2010)'s findings that shareholders expected to lose about 20 percent of market value in the NBP region, we test for heterogeneity in governance effects inside versus outside the NO_x Budget Program emissions trading region. We employ a triple-differences framework to test whether the average and marginal governance effects are different in the NBP region. We estimate the following two specifications:

$$y_{ist} = \mu_i + Post_t + Public_s + NBP_i + \beta_1 NBP_i \cdot Post_t + \beta_2 Public_s \cdot Post_t + \beta_3 NBP_i \cdot Public_s + \beta_4 NBP_i \cdot Public_s \cdot Post_t + \gamma Z_{st} + \delta X_{it} + SIC_I + NERC_R + e_{ist} \tag{3}$$

$$y_{ist} = \mu_i + Post_t + Gov_s + NBP_i + \beta_1 NBP_i \cdot Post_t + \beta_2 Gov_s \cdot Post_t + \beta_3 NBP_i \cdot Gov_s + \beta_4 NBP_i \cdot Gov_s \cdot Post_t + \gamma Z_{st} + \delta X_{it} + SIC_I + NERC_R + e_{ist} \tag{4}$$

The variable NBP_i is a dummy variable indicating whether unit i is located in the NBP region. In both of these specifications, β_4, the coefficient on the triple interaction, is the treatment effect of interest.

4. Data

In this section we describe the data sources used in our analysis and the methods we used to match data from various sources. For power plant characteristics and emissions information, we use data from the EPA's Emissions & Generation Resource Integrated Database (eGRID), which includes annual data on almost every electric power generating facility in the United States for a specific set of years. The financial and governance data for corporate owners is drawn from the Compustat and RiskMetrics databases, respectively. We match power plant facilities to their parent companies in Compustat when possible, and use firm-level identifiers in Compustat to match these firms to the governance information in RiskMetrics.

4.1. *eGRID data*

The eGRID database gathers plant characteristics, fuel inputs, and generation and emissions outputs for almost every power plant in the United States for the years 1996-2000, 2004, 2005, 2007, 2009, and 2010, by combining information from several EPA and Energy Information Administration forms. The eGRID database contains some variables, including NO_x emissions, Btu's of fuel inputs, and year brought online, at the individual boiler (sub-plant) level, while most other variables are measured at the plant level.

Importantly, at the plant level, the name of the firm who owns the plant is provided by the plant manager; we use these owner names to search for corporate parent matches in Compustat, as described below. In the analysis reported here, the governance and financial data for the firm with the largest ownership share in an individual plant is used.

Table 1 reports summary statistics of the unit-level variables used in our analysis, both for all plants and for plants whose owners were matched to a corporation in Compustat. The table indicates that the mean size and age of corporate-owned plants are not dramatically different from the full sample, although corporate-owned plants are slightly smaller and more

Table 1. Plant Summary Statistics

	All Plants			Plants with Parent Data		
Variable	**Mean**	**Std. Dev.**	**N**	**Mean**	**Std. Dev.**	**N**
Capacity (MW)	887	837	15082	669	782	1386
Capacity Factor	0.51	0.22	13796	0.55	0.21	1313
Heat Rate	12299	120442	12456	11653	13715	1231
Year Online	1966	17.7	11570	1966	17.1	1031
NO_x Emissions (lbs/MMBtu)	0.38	0.26	11875	0.36	0.26	1127
NO_x Control Technology	0.39	0.49	15172	0.35	0.48	1386

efficient (have lower heat rates), and are used slightly more often (have a higher capacity factor).

4.2. *Corporate finance and governance data*

We use four measures to differentiate the corporate governance quality of the firms in our sample.

As already touched upon above, the most widely used such measure is the G-index developed by Gompers et al. (2003). This index is based on a set of 22 anti-takeover provisions tracked by the Investor Responsibility Research Center (IRRC) as either appearing or not in the charters, bylaws, and other rules of most large corporations, together with data on whether or not the firms are covered under six state takeover laws. The provisions comprise four delay tactics, most notably the "staggered board" tactic of having directors of the firm serve overlapping terms, so that they cannot all be replaced at one time; six manager/director protection provisions, including "golden parachutes" that guarantee them compensation following a takeover; six voting provisions designed to restrict shareholder voting rights; and six other provision, including "poison pill" provisions that make firms unappealing in various ways to hostile bidders. Because the six state takeover laws overlap with four firm-level provisions, Gompers et al. end up with 24 unique provisions. The G-index is then constructed by simply counting the number of these provisions that a firm has in place. It therefore ranges from 0 to 24, with a higher score indicating stronger anti-takeover protections and therefore weaker shareholder rights.

The second measure we use is the E-index constructed by Bebchuk et al. (2009), which has gained popularity because of its ability to explain much of the G-index's association with firm value using only six of its provisions. Four of these—the presence of staggered boards, limits on bylaw amendments, supermajority requirements for mergers, and supermajority requirements for charter amendments—limit shareholders' voting power. The remaining two—golden parachutes and poison pills—make the firm less likely to become a target of hostile takeover bids. The index therefore ranges from 0 to 6, with higher values indicating greater "entrenchment" of directors and executives, suggestive of weak governance.

The third measure we use is a different subset of the G-index. This subset primarily includes the manager/director protection provisions, designed to protect the CEO and other high-level officers from financial or legal consequences of their actions. The eight provisions are compensation plans that allow executives to cash out options or accelerate bonuses in case of a takeover; contracts that indemnify executives from certain legal expenses; provisions in a firm's bylaws or charter that provide similar indemnification; provisions that limit directors' liability; severance pay provisions for high-level executives upon takeover; silver parachutes, which provide similar severance payments for a large number of a firm's employees; unequal voting rights for certain classes of shareholders; and antigreenmail provisions, which make it difficult to accumulate large blocks of stock. These provisions capture the degree of impunity that executives might expect to enjoy. We therefore refer to this index as the "Impunity index" or I-index. The final measure of governance that we use consists of the provisions in the G-index that are not in our I-index. Because these provisions primarily capture limitations on shareholder oversight and authority, we refer to this measure as the "Shareholder oversight index" or S-index.

Importantly, because the provisions in the E-index, I-index, and S-index are subsets of the provisions in the G-index, we can use them to get an idea of the mechanisms by which different dimensions of governance might drive firms' environmental performance. While the E-index is essentially just a reduced version of the overall G-index, the I- and S-indices split the G-index along an important dimension: the I-index is made up of provisions that allow executives to behave without consequences, while the S-index captures provisions that are more aptly described as protecting channels for shareholders to influence executive decision making. The distinction is subtle but important: the I-index is about executive rights, while the S-index is primarily about shareholder rights. As we will see, the distinction affects how coal-plant–owning firms respond to environmental regulations.

Summary statistics for these variables and for additional firm-level control variables are presented in Table 2.

4.3. *Description of the matching process*

Matching of the power plant data in eGRID to firms in Compustat can only be done by name. Doing so is not straightforward, not just because of the numbers involved—the eGRID database contains 8,678 unique plant parent company names, including almost 1,000 unique parent company names for coal plants—but also for other reasons.

Table 2. Firm Summary Statistics

Variable	Mean	Std. Dev.	N
Total Assets ($ millions)	36617	183784	224
Capital Expenditures/Assets	0.053	0.025	223
Free Cash Flow/Assets	0.042	0.034	212
Operating Income Before Depreciation/Assets	0.11	0.043	224
Market-to-Book Ratio	0.66	0.35	227
Firm Age (years)	37.3	21.9	227
Debt/Assets	0.31	0.14	224
G-index	4.0	4.8	227
E-index	0.66	1.0	227
I-index	2.4	2.9	227
S-index	1.7	2.2	227

One problem is that plant owner names listed in eGRID are often spelled somewhat differently from firm names listed in Compustat, in non-systematic ways. For example, business entity identifiers such as “Corporation” may be abbreviated to “Corp” in one database, but abbreviated differently (e.g., to “Cp”), or not abbreviated at all in the other database, and this may vary across companies. The same is true for components of company names: “Electric” may become “Electr,” “Elec,” or “El”; “Power” may become “Pow” or “Pwr”; “Services” may become “Serv” or “Svc”; and so on. To address this problem, we apply an algorithm that (after first removing punctuation and capitalization) systematizes common abbreviations across both databases, and deals with remaining spelling discrepancies by using the so-called Levenshtein distance metric (Levenshtein, 1966). This metric, implemented in the Perl programming language as module Text::Levenshtein,[9] counts the smallest number of single-character edits required to change one string into another, where edits can be either deletions, insertions, or substitutions.[10]

[9] See http://search.cpan.org/dist/Text-Levenshtein/

[10] For example, the Levenshtein distance between “Energy” and “Electric” is five, because transforming the former string to the latter requires at a minimum five edits: three substitutions (“n” to “l,” “g” to “i,” and “y” to “c”)

In principle, one could use this metric directly, treating two names as close matches if their Levenshtein distance is below some cutoff value, possibly after normalizing by the longer name's length. In practice, however, spelling discrepancies tend to be more meaningful, i.e., more likely to indicate a mismatch, if they occur at the beginning of a name than if they occur towards the end. For example, "Nextera Energy Services" is eight edits away from "Nextera Egy Svc" and only five from "System Energy Services." Nevertheless, the first string is much more likely than the second to be a spelling variant of the same company name. To take this into account, our algorithm uses a modified distance metric calculated as

$$d = 1 - \left[\frac{n}{N} + \alpha\left(1 - \frac{n}{N}\right)\left(1 - \frac{L}{N-n}\right)\right]$$

where N is the longer name's length; n is the number of *initial* characters that both names have in common;[11] L is the Levenshtein distance described above, which cannot be larger than $N-n$;[12] and $\alpha \in [0,1]$ is a weighting factor. If $\alpha = 0$, our measure reduces to $1 - n/N$, i.e., to the fraction of the longer string, starting from the left, up to which it exactly matches the shorter one, with no consideration given to subsequent characters. If $\alpha = 1$, our measure reduces to L/N, i.e., to the Levenshtein normalized by the longer name's length. Our algorithm somewhat arbitrarily sets $\alpha = 0.5$.[13] We then conservatively treat names as a potential match (subject to further vetting) if $d < 0.1$.

and two insertions ("c" and "t" before the "r"). The Levenshtein distance between "Energy" and "Egy" is three, because the transformation only requires three deletions ("n," "e," and "r").

[11] So $n = 9$ when comparing "Nextera Energy Services" to "Nextera Egy Svc," while $n = 0$ when comparing the same string to "System Energy Services," with in both cases $N = 23$.

[12] So $L = 8$ when comparing "Nextera Energy Services" to "Nextera Egy Svc," while $L = 5$ when comparing the same string to "System Energy Services."

[13] With $\alpha = 0.5$, $d \approx 0.48$ when comparing "Nextera Energy Services" to "Nextera Egy Svc," while $d \approx 0.61$ when comparing the same string to "System Energy Services." However, the initial stage of our algorithm in fact converts all instances of the string "Energy" in any name to "Egy," and all instances of the string "Services" to "Svc," while also removing capitalization. As a result, for this example, the distance computed in the second stage would actually be that between "nextera egy svc" and "nextera egy svc," yielding $d = 0$, and that between "nextera egy svc" and "system egy svc," yielding $d \approx 0.67$.

A second problem is that the plant owner reported in eGRID may not be listed in Compustat, but may be a subsidiary of a company that *is* listed. To address this problem, we downloaded from the Securities and Exchange Commission's EDGAR website all 120,175 annual reports (Forms 10-K) filed by public companies between the years 1999 and 2010, and extracted from those filings any Exhibit 21 component, which lists subsidiaries of the filer. We then performed the above-described match by distance d on the name of the filer and of all its subsidiaries.[14] If a match with $d < 0.1$ was found, we treated the filer as a potential parent company (again subject to further vetting) of the plant owner listed in eGRID. Because EDGAR provides each filer's Central Index Key (CIK), which is a unique identifier listed also in Compustat, the filer's financial and governance data could then be matched as well. Importantly, in cases where matches were found at multiple levels of ownership (i.e., parent companies of eGRID-listed owners as well as parent companies of those parent companies, etc.), only the lowest level (i.e., that closest to the eGRID-listed owner) was used.

Finally, it is not uncommon for power plants to have multiple owners. In such cases, the eGRID database lists all owners, together with their ownership shares.[15] The above-described procedure was then used for each of these separately. In the analysis reported in this version of the paper, the firm with the largest ownership share was treated as the owner.[16]

[14] Because there is no standard text format for Exhibit 21, extracting the list of subsidiary names itself required a somewhat complex algorithm, which uses so-called "regular expressions" (see http://perldoc.perl.org/perlre.html) to match string patterns.

[15] Typically plants with multiple owners have multiple generating units on site, and the different companies will each own different generating units. The eGRID database then attributes ownership shares of the plant to the capacity shares of the separate generators in the plant's overall capacity.

[16] Of the coal plants in eGRID, 92.5% have a dominant owner with at least 50% ownership share. Over 85% of the coal plants have an owner with at least 75% ownership share, and over 70% of coal plants do not have multiple owners. In some cases, multiple owners are different subsidiaries of the same corporate parent. In future versions

This process matched 1,843 individual coal-fired boilers from 520 coal plants to 241 unique publicly-traded parent firms, resulting in 9,511 boiler-year observations or 3,118 plant-year observations. Of the parent firms, 97 have governance data available, resulting in 1,653 boiler-years and 664 plant-years with governance data for the corporate parent.

5. Corporate Governance and Power Plant NO_x Emissions Rates

In Table 3, we can see by the interaction effect between the Post and Public dummy variables that NO_x emission rates were not significantly lower for plants owned by publicly-traded firms following passage of the 2002 Sarbanes-Oxley Act. Also of interest is that NO_x emissions rates are significantly lower in later years, and that pre-SOX emissions rates by plants at publicly traded firms may have been slightly higher on average than those by plants owned by other entities, although this difference is not statistically significant. It also appears from Table 3 that larger firms, older firms, and firms with more capital expenditures as a share of total assets have lower emissions rates. Importantly, although these estimates condition on the presence of NO_x control technology, this single dummy does not capture variation in the cost and effectiveness of different technological options. Some of the more advanced technologies, with the highest fixed costs, are able to achieve the greatest emissions reductions.

The table also shows that more highly leveraged firms—firms with a larger debt-to-asset ratio—have significantly higher emissions rates. Again, although these estimates are conditional on the presence of NO_x control technology, one possibility is that these firms are

of this paper we will test robustness to different methods of weighting the financial and governance information for multiple owners.

unable to finance capital investment in the most advanced and expensive NO_x control technology, but this is not the only explanation. Alternatively, these firms may be more willing to accept risk, including compliance risk. Lastly, the boiler age variable is only significant at the boiler level. In the plant-level regressions, boiler age refers to the earliest year that one of the plant's boilers came online. This provides an indication of the likely age of the facility. Age variation at the plant level is likely to be much smaller, however, and less directly tied to emissions than at the boiler level. As one should expect, boilers introduced more recently have lower emissions rates at the boiler level.

The specifications reported in Table 4 use variation in governance scores that existed before the passage of the SOX as a measure of exposure to the regulation. The sample in these regressions is limited to publicly traded firms, so the comparison is on the degree of regulatory exposure within the set of affected firms. As explained earlier, firms with higher governance scores are considered to have had "worse" governance and therefore to be more exposed to the new financial regulations. Table 4 reports difference-in-differences estimates of the effect of financial regulatory exposure on emissions rates following the passage of SOX.[17]

We find that the effect of greater exposure to the financial regulation (or worse pre-SOX governance quality) on emissions rates is heterogeneous across different categories of governance and different measures of emissions rates. The first panel of Table 4 shows that the effects of the G-index and E-index on input emissions rates (NO_x emitted per unit of fuel energy input) have opposite signs. The same is true for the effects of I-index and S-index, with an even stronger degree of opposition. Whereas the I-index effect coefficient

[17] Because we use pre-2002 firm-level averages of the governance indices in order to capture pre-determined variation in governance quality and financial regulatory exposure, these measures are collinear with plant fixed effects.

TABLE 3. Simple Difference-in-differences effect of financial regulations on NO_x emissions rates

	Dependent Variable		
	Boiler Level	Plant Level	
	lbs/MMBtu	lbs/MMBtu	lbs/MWh
Total Assets	-2.46e-06**	-7.62e-06***	-.0001992***
	(0.00)	(0.00)	(0.00)
Capital Expenditures/Assets	-.6880535**	-1.053083***	-.4778897
	(0.29)	(0.37)	(6.06)
Debt/Assets	.410672***	.7726396***	8.360431***
	(0.10)	(0.15)	(2.50)
Cash Flow/Assets	.2427079	-.3175673	6.250368
	(0.36)	(0.42)	(7.03)
Income/Assets	.1730977	.244311	9.618113
	(0.39)	(0.53)	(8.87)
Market-to-Book	-.0719033	.0420535	-5.294077***
	(0.06)	(0.11)	(1.81)
Firm Age	-.0017104*	-.0036424***	-.0322673*
	(0.00)	(0.00)	(0.02)
Capacity	-.0000455	-.0000754	-.0008913
	(0.00)	(0.00)	(0.00)
Capacity Factor	-.0434513	-.0352967	-.7313467
	(0.04)	(0.06)	(0.93)
Boiler Age	-.0020969***	.0006825	.012058
	(0.00)	(0.00)	(0.01)
NO_x Control Technology	-.1121042***	-.0801873***	-1.289777***
	(0.01)	(0.02)	(0.26)
Post	-.1481623***	-.1764991***	-1.622522***
	(0.01)	(0.02)	(0.28)
Public	.1235952	.1406959	3.344661
	(0.11)	(0.12)	(2.06)
Post*Public	-.0440205	.0262785	-.9291255
	(0.03)	(0.04)	(0.70)
Intercept	4.665799***	-.6739998	-14.55506
	(0.64)	(1.00)	(16.58)
R^2	.5898285	.7553751	.7493619
N	2944	1166	1166

Notes: Standard errors are in parentheses. NERC region, SIC industry, and plant fixed effects not shown.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

in the first panel of Table 4 corresponds to a *positive* and significant "governance elasticity of emissions rate" at the mean of 0.33, the S-index effect corresponds to a *negative* and significant elasticity of -0.51. In other words, improvements in the executive "Impunity index," indicating reduced ability of CEOs to act with impunity, lead to economically and statistically significant increases in emissions rates. On the other hand, improvements in the "Shareholder oversight index", indicating increases in shareholders' voting rights and oversight role, lead to economically and statistically significant reductions in emissions rates, at least as measured by emissions relative to fuel inputs. This pattern is repeated at the plant level for input emissions rates, as we can see in the second panel of Table 4. Because the G-index and E-index combine variation from all aspects of governance, even ones that might move in opposite directions, their estimated effects are closer to zero.

The third panel of Table 4 shows that improvements in any of our measures of governance quality have a significant negative effect on output emissions rates (NO_x emitted per MWh of electricity produced). We show below that these effects are mainly attributable to reductions in the NBP region. As discussed previously, the NBP represented a switch from plant-specific command-and-control emissions rate standards to a hard, tradeable emissions output cap. In the next subsection, we discuss how this affects the relationship between governance and emissions rates.

5.1. *Corporate Governance and Power Plant NO_x Emissions Rates in the NBP Region*

Starting in 2004, coal plants in 19 eastern and midwestern states were subject to a hard cap with tradeable allowances on summer ozone season NO_x emissions, whereas coal plants in the rest of the country retained their plant-specific emissions rate standards. Whereas emissions constraints in both programs were tightened over time, the NBP plants faced much more strict reductions in emissions allowed. The results in Table 5 show that the SOX financial regulations had differential impacts on emissions depending on whether plants were inside

Table 4. Difference-in-differences effect of financial regulations on NO_x emissions rates

Governance Measure:	G-index	E-index	I-index	S-index
Boiler Level				
Dependent Variable: lbs/MMBtu				
Post	-.2797238***	-.0633249	-.2954515***	.247769***
	(0.08)	(0.08)	(0.06)	(0.09)
Post*Governance	.025864***	-.0185538	.0502035***	-.1070099***
	(0.01)	(0.04)	(0.01)	(0.03)
R^2	.6820502	.6789964	.6881857	.6856919
N	937	937	937	937
Plant Level				
Dependent Variable: lbs/MMBtu				
Post	-.3492643***	-.1361931	-.4024969***	.0921926
	(0.11)	(0.10)	(0.08)	(0.12)
Post*Governance	.0178196	-.051976	.047454***	-.0970206***
	(0.01)	(0.04)	(0.01)	(0.03)
R^2	.8790169	.8783821	.8873531	.8862859
N	230	230	230	230
Plant Level				
Dependent Variable: lbs/MWh				
Post	10.99497***	8.323845***	7.231129***	9.881063***
	(2.89)	(2.67)	(2.40)	(3.38)
Post*Governance	-1.282147***	-3.736909***	-1.393224***	-2.417795***
	(0.31)	(1.10)	(0.39)	(0.85)
R^2	.8227484	.8163566	.8180982	.811885
N	230	230	230	230

Notes: Standard errors are in parentheses. NERC region, SIC industry, and plant fixed effects, as well as plant and firm controls, are not shown.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the cap-and-trade program border or not. Whereas the effects measured earlier in Table 3 were inconclusive, once we allow the financial regulation treatment effect to vary by emissions regime, we see that SOX-affected plants in the emissions trading region significantly reduced their emissions rates.

In Table 6, we see that much of the explanatory power of the corporate governance treatment effect measured previously in Table 4 is showing up in the NBP region, and that there is

Table 5. Financial and cap-and-trade interactions and NO_x emissions rates

	Dependent Variable		
	Boiler Level	Plant Level	
	lbs/MMBtu	lbs/MMBtu	lbs/MWh
Post	-.1381558***	-.1398533***	-1.403751***
	(0.02)	(0.02)	(0.32)
NBP*Post	-.0680021***	-.1607931***	-1.542642***
	(0.03)	(0.03)	(0.56)
Public	-.5279341*	-.4502385*	-10.18076**
	(0.29)	(0.25)	(4.18)
NBP*Public	1.021657***	.9662759***	22.53864***
	(0.34)	(0.35)	(5.76)
Post*Public	.09282**	.0668775	.7139459
	(0.04)	(0.05)	(0.76)
NBP*Post*Public	-.4727326***	-.3659088***	-9.600924***
	(0.06)	(0.09)	(1.46)
R^2	.6004688	.7670476	.7643813
N	2944	1166	1166

Notes: Standard errors are in parentheses. NERC region, SIC industry, and plant fixed effects, as well as plant and firm controls, are not shown.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

a similar pattern of heterogeneous responses depending on the dimension of governance that is captured. In the first and second panels of Table 6, we once again see significant positive effects on input emissions rates of reducing CEO protections, and significant negative effects on input emissions rates of improving shareholder voting rights and oversight; these effects are much stronger economically and statistically within the NBP sample. In the third panel of Table 6, we also see much larger and consistently negative effects of all of our governance measures on output emissions rates.

One explanation for this is that the components of output emissions rates are less flexible and therefore more important to shareholders. Plants have to either meet their emissions limits (measured in pounds) or buy extra permits, and particularly coal plants need to simultaneously meet a baseload electricity demand (measured in MWh). It appears that better-governed firms do a better job satisfying both of these constraints. Input emissions

TABLE 6. Differential effects of governance measures on NO_x emissions rates by NBP region

Governance Measure:	G-index	E-index	I-index	S-index
Boiler Level				
Dependent Variable: lbs/MMBtu				
Post	-.1276431	-.0034642	-.1160764	.0167887
	(0.10)	(0.08)	(0.08)	(0.10)
Post*Governance	.0115534	-.0339122	.0192904	-.0227129
	(0.01)	(0.04)	(0.01)	(0.03)
NBP*Post*Governance	.0519802***	.1338131	.065654***	-.2776769***
	(0.02)	(0.11)	(0.02)	(0.05)
R^2	.6824772	.6759103	.6909358	.6959868
N	947	947	947	947
Plant Level				
Dependent Variable: lbs/MMBtu				
Post	-.2368916*	-.0490775	-.310825***	.0500343
	(0.12)	(0.09)	(0.10)	(0.11)
Post*Governance	.0072674	-.084723**	.0308496*	-.0706352**
	(0.01)	(0.04)	(0.02)	(0.03)
NBP*Post*Governance	.0389392	.0079211	.0533913*	-.2862158***
	(0.03)	(0.15)	(0.03)	(0.06)
R^2	.8484117	.8483041	.8592501	.8747508
N	360	360	360	360
Plant Level				
Dependent Variable: lbs/MWh				
Post	-4.888694*	-2.144603	-5.462181*	2.440318
	(2.80)	(1.79)	(2.81)	(3.19)
Post*Governance	.2255385	-.4049131	.621717	-.7695947
	(0.30)	(0.81)	(0.48)	(0.88)
NBP*Post*Governance	-6.29082***	-46.08678***	-4.509544***	-10.10477***
	(0.60)	(2.89)	(0.74)	(1.76)
R^2	.8345391	.8837061	.7753039	.77393
N	360	360	360	360

Notes: Standard errors are in parentheses. NERC region, SIC industry, and plant fixed effects, as well as plant and firm controls, are not shown.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

rates, on the other hand, are more flexible: operators can meet these in a variety of ways, including adjusting the quality, quantity, and source of fuel inputs, renegotiating fuel procurement contracts, re-optimizing their plant operations, adjusting plant fuel efficiency, or installing pre- or post-combustion technologies that may affect both total emissions and total fuel inputs. So while better-governed firms do a better job of managing output emissions rates, how they achieve this, and how it affects emissions per unit fuel input, depends on the way the company—and by extension the plant—is run.

The specifications in Table 7 restrict the sample to coal plants owned by publicly traded firms in the NBP region, and examine the effect of each governance index separately on their input and output-emissions rates as well as the plant heat rate, which is the inverse of fuel efficiency. For the emissions rate effects we see a similar pattern of signs and magnitudes of governance effects as were estimated in Table 6. However, there are no statistically significant effects of governance on heat rates, indicating that plant managers do not undertake major operational modifications in order to meet the regulations by operating plants more efficiently. There may therefore be heterogeneity in NO_x control technology adoption decisions that is driven by governance quality. This would not be inconsistent with Fowlie (2010)'s findings that NO_x control technology decisions are sensitive to prevailing regulatory incentives; although Fowlie (2010) did not study governance, it may be an important dimension of the investment decision.[18]

6. Discussion and Conclusion

We develop a new dataset that ties power plant attributes and emissions rates to the financial and governance data of their corporate parents. The dataset straddles the passage of the Sarbanes-Oxley Act, which regulated financial oversight of corporations, as well as the

[18] Governance provisions have been shown to be related to capital investments in other contexts, for example, John et al. (2008).

Table 7. Governance effects in the NBP region

Governance Measure:	G-index	E-index	I-index	S-index
Boiler Level				
Dependent Variable: lbs/MMBtu				
Post	-.3604025***	-.2785218**	-.2594092***	.4506614***
	(0.1)	(0.14)	(0.08)	(0.13)
Post*Governance	.055184***	0.115966	.0728041***	-.2750449***
	(0.02)	(0.12)	(0.02)	(0.05)
R^2	0.685341	0.679394	0.692506	0.697901
N	612	612	612	612
Plant Level				
Dependent Variable: lbs/MMBtu				
Post	-.3335699**	-0.14117	-.2512519**	.5763383***
	(0.15)	(0.22)	(0.12)	(0.19)
Post*Governance	.0506953*	-0.03798	.0823761***	-.3421583***
	(0.03)	(0.2)	(0.03)	(0.07)
R^2	0.838656	0.83354	0.849979	0.867048
N	190	190	190	190
Dependent Variable: lbs/MWh				
Post	22.83801***	48.50517***	6.916197*	25.60999***
	(4.11)	(4.78)	(3.93)	(6.77)
Post*Governance	-6.293753***	-49.94015***	-4.017432***	-10.18498***
	(0.78)	(4.31)	(0.83)	(2.49)
R^2	0.846616	0.893784	0.791835	0.779015
N	190	190	190	190
Dependent Variable: Heat Rate				
Post	-595.727	-974.035	62.22077	1108.683
	(1592)	(2349)	(1225)	(2118)
Post*Governance	287.193	1415.398	267.7625	-342.145
	(322)	(2166)	(284)	(790)
R^2	0.860697	0.860098	0.860851	0.859705
N	182	182	182	182

Notes: Standard errors are in parentheses. NERC region, SIC industry, and plant fixed effects, as well as plant and firm controls, are not shown.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

introduction of the NO_x Budget Program, a cap and trade emissions regulation that covered roughly the eastern half of the United States. We use these events to identify the differential effect of governance provisions on emissions rates under different regulatory regimes.

The empirical evidence suggests that firms that, prior to SOX, were most aggressive in shielding their CEOs from the legal or financial consequences of the way they ran their firms, responded to the NO_x Budget Program in a completely different way than firms that had simply been restricting the activism rights of their shareholders. The former firms were those most targeted by the Sarbanes Oxley Act and may have been more affected by the new financial regulations than the latter.

Specifically, we show that there are positive and significant impacts of reducing CEO protections on input emissions rates, but negative and significant impacts of increasing shareholder rights. All of our governance measures have positive and significant effects on output emissions rates. We do not find significant impacts on overall plant operational efficiency, suggesting that emissions rate effects may occur through the NO_x control technology choice or through the permit trading market. Together these results suggest that governance can impact operational efficiency generally and emissions management more specifically through different channels, depending on the category of governance provisions that is changing.

Three explanations are likely for the divergence of effects between CEO protections and shareholder rights. First, if SOX was effective, the required improvement in governance would have been largest for firms that, prior to 2002, had a high "Impunity index", or excessive CEO protections from financial and legal liabilities. Governance quality may have improved the most for these firms, which may have translated into management and operational improvements that allowed them to better optimize the fixed-cost/variable-cost tradeoff in the NO_x control choice, and to better manage any costly over-compliance in a Shimshack and Ward (2008) sense. In addition, they may have become more responsive to shareholder demands; this second point, however, would predict different technology adoption behavior depending on the status of electricity market restructuring in the state of operations, and depending also on the mix of investor types. Both these predictions are testable with available data and are areas of future research.

A second possibility, which conforms to previous finance literature on the impacts of SOX, is that SOX imposed costly new compliance requirements on firms. If SOX imposes compliance costs of as much as $1 million annually, the present value of these costs is on par with the capital costs of NO_x control technology. For those firms most impacted by SOX, this may have left fewer resources available for operations in other parts of the corporation, and in particular fewer resources for large capital investments in NO_x control technology. In order to investigate these two explanations, we need to have a sense of which compliance option was "optimal" for each plant and measure whether deviations from this optimum are systematically related to the pre-SOX governance profile of these firms.

A third possibility relates to risk: firms where CEOs were most protected from risk (prior to SOX) through contract provisions on severance pay and liability were likely to have experienced the greatest increase in CEO risk exposure post-SOX. A key result in Fowlie (2010) is that plants in states with deregulated electricity markets, and thus more exposed to market risk, are less likely to adopt emissions control technology and instead manage emissions through the permit market or through operational modifications which can reduce power plant efficiency. If firms in riskier environments are less likely to invest in NO_x control technology, then exposing the CEO to more of this risk may exacerbate that effect. In future work we can test this hypothesis by examining whether fuel, electricity, and permit price volatility within the NBP region has a different relationship with technology adoption and emissions rates depending on the governance structure of the firm and the restructuring status of the electricity market.

As for our finding that a high pre-SOX S-index (or larger potential improvements in shareholder oversight rights following SOX) is associated with subsequent decreases in both input and output emissions rates, one interpretation is that improved corporate governance helps firms optimize the fixed cost/variable cost tradeoff in emissions control choices, but through different channels depending on the governance mechanism. The finding that stronger shareholder oversight leads to emissions reductions is consistent with the pattern found in the literature that shareholders reward environmental investments when the consequences of noncompliance are more apparent. The NBP permit market was litigated in federal court over several years before it was finally allowed to proceed in 2004; informed investors would have followed these developments and known that the caps would be binding. In this context, more shareholder-responsive firms have a more effective overall response to the environmental regulation.

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