Mergers and Acquisitions as Navigators of Climate Policy Shocks: Evidence from the NOx Budget Trading Program[†]

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Abstract

We examine how mergers and acquisitions (M&As) enable firms to adapt to climate policy shocks. Exploiting the adoption of the Nitrogen Oxides (NOx) Budget Trading Program (NBP) across U.S. states as an exogenous shock, we find that firms with NOx-emitting plants subject to the NBP are more likely to engage in M&As, particularly through vertical integration. The effect is stronger among firms facing larger compliance cost increases, supporting the view that heightened regulatory burdens drive post-NBP acquisitions. Consistent with the cost-saving role of vertical integration, we show that NBP-induced vertical deals reduce production and distribution costs. Overall, our findings provide evidence that M&As serve as a rational response to climate regulation, revisiting the neoclassical view of acquisition motives in the context of environmental policy.

***Keywords**:* Climate change; Climate policy; Mergers and acquisitions (M&As); Vertical integration

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1. Introduction

"Climate Change is the defining issue of our time and we are at a defining moment" (United Nations).[1] To alleviate the adverse effects of climate change, countries worldwide have introduced green policies aimed at controlling emissions.[2] Such regulatory interventions have proven to be beneficial in reducing pollution and improving health (Deschênes et al., 2017; Luo et al., 2020). However, concurrently, they pose tangible challenges for economic actors striving to achieve low-emission levels. In particular, the substantial pollution abatement expenditure resulting from compliance with the climate regulations places the affected firms at a competitive disadvantage in the global economy (Linn, 2010; Curtis, 2018; Krueger et al., 2020). Despite a growing awareness of the effect of climate policy shocks on corporate practices and policies (Nguyen & Phan, 2020; Seltzer et al, 2021; Bartram et al., 2022; Dang et al, 2023), research into merger and acquisition (M&A) behavior is sparse. In this paper, we seek to contribute to the literature by examining the effect of climate policy shocks on firms' M&A activities.

The neoclassical view of M&As presents such activities as a rational response to industry shocks, in a similar way to new structures, new regulations, changes in costs, competition or innovations (Gort, 1969; Mitchell & Mulherin, 1996; Andrade et al., 2001; Harford, 2005). Although a number of high-profile large deals have been associated with value destruction, the broader empirical evidence suggests that, on average, bidder announcement returns are positive (Travlos, 1987; Fuller et al., 2002; Moeller et al., 2004, 2005). One of the most stylized facts is

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[1] United Nations, Global Issues, Climate Change: https://www.un.org/en/global-issues/climate-change.

[2] For instance, the Acid Rain Program, introduced in 1995 in the U.S., successfully reduced the levels of sulfur dioxide (SO_2) and nitrogen oxide (NOx), which are known to cause acid rain. Available at: https://www.epa.gov/acidrain/acid-rain-program-results; The European Union Emissions Trading Scheme (EU ETS) established in 2005, which uses a cap-and-trade system, was an effort to reduce the levels of carbon dioxide (CO_2), nitrous oxide (N_2O), and perfluorocarbons (PFCs). Available at: https://ec.europa.eu/clima/policies/ets_en; The California Cap-and-Trade Program was implemented in 2012 to reduce greenhouse gas emissions. Available at: https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program.

that M&As serve as an effective operational hedging mechanism in response to input price shocks (Fan, 2000) and cash flow uncertainty (Garfinkel & Hankins, 2011). These contrasting perspectives raise an important question: in the context of costly climate regulation, do M&As continue to perform their neoclassical role as tools for navigating climate policy shocks? In this paper, we examine whether and to what extent affected firms respond to climate policy shocks through their M&A involvement.

The Nitrogen Oxides (NOx) Budget Trading Program (NBP) provides an attractive setting to study the effect of climate policy shocks on firms' M&A behavior. As a successful emissions control policy, the NBP worked on a cap-and-trade system to control the regional NOx emissions from more than 2,500 electricity-generating utilities, industrial boilers, and turbines in the Midwestern and Southeastern states of the United States. The NBP was formally implemented in 2003, limiting total annual NOx pollutant emissions in the regulated states. The regional coverage of the NBP, as opposed to the national coverage of other climate regulations, enables the identification of counterfactuals for regulated firms (i.e., firms with NOx-emitting plants in the NBP-participating states) by selecting unregulated firms (i.e., firms with NOx-emitting plants in the non-NBP-participating states). This approach allows us to provide evidence on the effects of NBP implementation on the M&A activities of the firms affected. Furthermore, the NBP is designed to control regional NOx emissions, which are naturally exogenous to firms' M&A activities.

From a theoretical perspective, the effect of the NBP on firms' M&A behavior is ambiguous. The substantial compliance costs imposed by the implementation of the NBP have significantly squeezed the profits of firms with NOx-emitting plants.[3] Specifically, the regulated NOx-emitting plants have to comply with the NBP through costly emission abatement activities or the acquisition of additional emission allowances, resulting in heightened production costs.[4] Our main prediction is that firms with regulated NOx-emitting plants are more likely to engage in M&As in response to the heightened production costs incurred by the NBP implementation. This prediction is motivated by the neoclassical view that M&As represent a rational response to exogenous shocks that reshape the net benefits of integration (Gort, 1969; Mitchell & Mulherin, 1996; Andrade et al., 2001; Harford, 2005). Transactions that may have had a negative expected value (E[NPV] < 0) prior to regulation can become attractive once compliance costs are imposed, as acquisitions that generate synergies may shift expected value into positive territory (Mulherin & Boone, 2000; Jovanovic & Rousseau, 2002; Bhattacharyya & Nain, 2011).

In this context, it remains unclear how M&As enable firms to achieve synergies that offset heightened compliance costs. On the one hand, within vertical M&As, backward integration enables firms to secure access to lower-emission inputs, thereby reducing reliance on costly abatement investments or allowance purchases and generating cost synergies in production. Forward integration enhances financial and operational flexibility, allowing firms to participate more strategically in allowance markets while also realizing distribution cost synergies. On the other hand, horizontal mergers allow firms to spread the substantial fixed costs of abatement technologies across a broader production base, thereby creating economies of scale in compliance

[3] Linn (2010) shows that NBP implementation reduced the profits of firms with regulated electric power plants by as much as $25 billion. Palmer et al. (2001) estimate the total annual costs of the NBP to regulated utilities to be approximately $2.1 billion.

[4] According to a U.S. Environmental Protection Agency (EPA)'s report in 2008, over 70% of regulated NOx-emitting plants had allocated significant capital expenditure for pollution abatement activities, such as transitioning to alternative energy sources, embracing advanced technologies and implementing post-combustion controls. Available at: https://www.epa.gov/sites/default/files/2015-08/documents/2007-nbp-report.pdf.

investments. Accordingly, our study empirically examines whether, and through which channels, affected firms navigate climate policy shocks via M&A activity.

To test these conjectures, we first identify the firms affected by the NBP implementation. Because the firms' headquarters often do not coincide with where the firms' actual economic activities take place, our treatment identification is based on the location of NOx-emitting plants rather than the location of the firms' headquarters. To identify U.S. NOx-emitting plants and retrieve their parent company information, we collect data from the U.S. Environmental Protection Agency's (EPA) Emissions & Generation Resource Integrated Database (eGRID), Clean Air Markets Program Data (CAMPD), and Toxic Release Inventory (TRI) database. As a result, we manually identify 2,328 NOx-emitting plants, whose parent companies are successfully matched to firms in the CRSP/Compustat Merged file. Our final sample consists of 2,028 firm-year observations, representing 228 U.S. listed firms with NOx-emitting plants from 1998 to 2008. Using a difference-in-differences (DiD) approach, our main results show a positive relationship between the implementation of the NBP and the likelihood of firms engaging in M&A activities. On average, firms with NOx-emitting plants in NBP-participating states have approximately 10 percentage points higher likelihood of being acquirors. This evidence is consistent with the view that M&As can serve as tools to navigate climate policy shocks.

We adopt five sets of tests to enhance our identification strategy. First, a potential endogeneity concern is that our main findings may be driven by pre-treatment trends. To address this concern, we investigate the dynamics of the NBP effect in the years before and after its implementation and find that the increase in firms' M&A likelihood occurs only after NBP implementation. Second, to address the concern that systematic differences between the treated and control firms may exist and potentially drive our results, we adopt the propensity score matching (PSM) approach to show that our main findings are not likely to be driven by observable firm-specific heterogeneity. Third, we employ the falsification test to confirm that the NBP effect on firms' M&A likelihood is not driven by random chance. Fourth, we conduct two robustness tests to address concerns that our findings may be confounded by residual effects of earlier electricity industry reforms: (i) excluding firms previously affected by restructuring, and (ii) controlling for time-varying restructuring initiatives. Finally, we examine the value effects of acquisitions by firms facing stronger regulatory pressure and provide evidence that these deals are associated with higher announcement returns and improvements in post-acquisition operating performance.

After providing evidence suggestive of a causal relationship between NBP implementation and firms' involvement in M&As, we turn to the underlying mechanisms of this relationship. First, we show that the positive relationship between the NBP implementation and firms' M&As activities is more pronounced for firms facing larger increases in compliance costs, supporting the notion that heightened compliance costs serve as the primary driver of the post-NBP acquisitions. Second, we document that firms with NOx-emitting plants in the NBP-participating states are more likely to engage in vertical integration rather than horizontal mergers, suggesting that vertical integration represents the dominant channel through which firms adapt to the increased compliance costs following the NBP implementation. Third, we find that vertical acquisitions undertaken after the NBP reduce costs in production and distribution, consistent with the view that vertical integration helps affected firms generate cost synergies that reduce the compliance burden.

Our paper contributes to the literature in several ways. First, we contribute to the M&A literature on the neoclassical theory and provide evidence on how environmental regulation with a cap-and-trade design shapes M&A behavior. The neoclassical literature attributes M&A waves to economic shocks and regards M&As as an effective tool for navigating challenges and regaining financial strength (Gort, 1969; Mitchell & Mulherin, 1996; Andrade et al., 2001; Harford, 2005). Although some high-profile deals have been perceived as empire-building and value-destructive, the broader evidence suggests that bidder announcement returns are, on average, positive (Jensen, 1986; Travlos, 1987; Hanson, 1992; Harford, 1999; Fuller et al., 2002; Moeller et al., 2004, 2005). We revisit the motives of M&As and support the view of the neoclassical theory. We extend this research line and provide evidence that M&As represent a rational response to the NBP, an environmental regulation aimed at reducing NOx emissions. In particular, we provide novel evidence to show that the firms affected pursue vertical integration to achieve cost savings from the production and distribution process, thereby hedging the heightened compliance costs imposed by environmental regulation.

Second, we contribute to the growing literature on the real effects of climate change on firm boundaries. One strand of this literature investigates the economic consequences of climate change for M&A outcomes, such as acquisition likelihood (Xue et al., 2025) and post-acquisition performance (Basu et al., 2024). Another strand of this literature focuses on firms' asset allocation decisions. For example, Duchin et al. (2025) find that firms facing strong environmental pressures often sell polluting plants to buyers subject to weaker scrutiny and with existing supply chain or joint venture links. Similarly, Li et al. (2023) show that mandatory ESG disclosure rules prompt firms to strategically adjust their asset portfolios by acquiring higher-ESG assets and divesting weaker ones, especially after negative ESG incidents. Our study differs from these works by showing that M&As are not merely used for portfolio reshuffling or symbolic ESG improvements but also serve as a strategic response to heightened compliance costs under environmental regulation.

Third, our study is closely related to recent research on corporate strategies in response to climate policy shocks, such as internal capital allocation (Bartram et al., 2022) and conservative financial policies (Nguyen & Phan, 2020; Dang et al., 2023). In particular, Bartram et al. (2022) exploit the adoption of a California cap-and-trade program—designed to control regional greenhouse gas emissions—in a quasi-experimental setting to examine the effect of climate policy on internal resource allocation. They find that financially constrained firms strategically reduce greenhouse gas emissions from plants in California (the regulated state) by shifting emissions to plants in unregulated states. Using the NBP program—structured as a cap-and-trade system to reduce NOx emissions—as an exogenous shock, our study shows that vertical integration helps affected firms hedge heightened compliance costs and maintain operational efficiency.

The remainder of this paper proceeds as follows. Section 2 provides the institutional background for the NBP and develops the hypothesis. Section 3 describes the sample selection, variable definitions, and research design. Section 4 discusses the empirical results of the baseline regression, and the identification tests and their results. Section 5 presents the underlying mechanisms of this paper. Finally, Section 6 concludes the paper.

2. Institutional Background and Hypothesis Development

2.1 The Nitrogen Oxides (NOx) Budget Trading Program

The Clean Air Act (CAA), enacted in 1963 and revised in 1966, 1970, 1977, and 1990, is the primary federal legislation aimed at reducing air pollution in the United States. It proposed the National Ambient Air Quality Standards (NAAQS), imposing rigorous emission restrictions on establishments in regions failing to meet specific air quality criteria compared to those in regions with acceptable air quality. The 1977 CAA Amendments enhanced the NAAQS and authorized the EPA to regulate interstate air pollution and prevent downwind states from being affected by air pollutants transported from upwind states. The CAA Amendments of 1990 were enacted to deal with persistent air quality issues in Northeastern regions, introducing the first cap-and-trade program, which was recognized as the Acid Rain Program. The introduction of the Acid Rain Program reduced sulfur dioxide (SO_2) emissions from power plants and imposed strict restrictions on NOx emissions from the coal-fired power plants.

In 1997, the Northeastern (upwind) states urged the EPA to regulate the NOx emissions in the Southern and Central (downwind) states. This is because wind currents can transport NOx emissions from downwind states to upwind states, leading to adverse health impacts on their residents and hindering compliance with NAAQS ozone non-attainment standards in upwind states. NOx plays a central role in creating ground-level ozone, or smog,[5] which could induce a variety of health issues, such as chest pain, coughing, throat irritation, and congestion. In 1998, the EPA approved the request from the Northeastern states and established the NOx Budget Trading Program (NBP) to control NOx emissions from electricity-generating utilities, large industrial boilers, and turbines located in the Southern and Central states, thereby restricting the potential

[5] Ground-level ozone, or smog, originates when NOx and volatile organic compounds react in sunlight and warmth.

environmental damage that NOx emitters in upwind states could cause to downwind states. Although the Midwest and Southeast states continued to fight the EPA in court, the formal implementation of the NBP was initiated in 2003 in eight states: Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island, along with Washington, DC. After a sequence of legal battles, an additional eleven states, including Alabama, Illinois, Indiana, Kentucky, Michigan, North Carolina, Ohio, South Carolina, Tennessee, Virginia, and West Virginia, complied with the NBP in 2004. This raised the total number of compliant states to nineteen. The NBP was terminated in 2008 and replaced by the ozone season NOx program under the Clean Air Interstate Rule (CAIR) in 2009.

The NBP successfully reduced NOx emissions from more than 2,500 electricity-generating utilities, industrial boilers, and turbines in the Midwestern and Southeastern states of the United States. Specifically, in 2007, the ozone season NOx emissions under the NBP amounted to around 506,000 tons, marking a 60% reduction compared to the levels in 2000 (prior to the NBP implementation). The regulated facilities have various options to reduce NOx emissions. One effective approach is fuel switching, whereby businesses transition from coal to alternative energy sources, such as natural gas, which emit significantly less NOx into the atmosphere. However, opting for alternative energy sources results in higher production costs compared to using coal (Fowlie, 2010).

Furthermore, selective catalytic reduction (SCR) technology is notably the most expensive, albeit highly effective, technology for reducing NOx emissions. Regulated plants that opted for SCR technology faced a significant upfront cost. Specifically, this technology can achieve up to a 90% reduction in NOx emissions; however, it comes at a substantial price, averaging $40 million per plant (Linn, 2010). In addition, several less costly but less effective technologies can also be chosen for installation. For example, selective non-catalytic technologies, costing around $10 million per plant, achieve a 35% reduction in NOx. Other pre-combustion and combustion technologies can lower emissions by 15% to 50% (Fowlie, 2010), depending on plant specifications. Irrespective of the method chosen for emissions reduction, the implementation of the NBP led to an increase in production costs for NOx-emitting plants.

Finally, states could be granted flexibility in allocating allowances (one allowance equals one ton of emissions) to emission sources. Most states were free to allocate allowances in relation to a baseline amount of NOx emissions from facilities. However, certain states (e.g., Virginia and Kentucky) conducted auctions to allocate a proportion of their allowances. Once allowances were allocated, the sources affected could buy and sell allowances on the open market. The purchase of additional emission allowances could impose a substantial financial burden on the regulated plants.

2.2 Electricity Industry Restructuring: Its Relevance to and Distinction from Our Study

Until the early 1990s, electricity prices varied substantially across U.S. states, with particularly pronounced disparities between high-cost and low-cost regions. These differences were largely attributable to the prevailing market structure, which was dominated by vertically integrated investor-owned utilities (IOUs) operating as regulated monopolies within their service territories. Under this system, IOUs—alongside publicly owned utilities and rural electric cooperatives—controlled electricity generation, transmission, and distribution. Their operations were overseen by state public utility commissions (PUCs), which employed a rate-of-return regulatory framework designed to ensure cost recovery and a "fair" return on invested capital.

While this regulatory regime provided stability and guaranteed service provision, it also limited competitive pressures, leading to inefficiencies and persistent price differentials (Fabrizio et al., 2007; Davis & Wolfram, 2012). These price disparities had become a focal point of policy debate, as stakeholders questioned whether the monopolistic structure hindered innovation, suppressed cost reductions, and imposed an undue burden on consumers in high-price states. The widening gap between states' electricity costs galvanized policymakers, regulators, and industry participants to explore electricity industry restructuring. The central aim of these reforms was to replace traditional cost-of-service regulation with competitive wholesale and, in some cases, retail markets, thereby fostering efficiency, encouraging technological adoption, and ultimately reducing prices for end-users.

According to Fowlie (2010), between 1996 and 2001, nineteen U.S. states—predominantly those with relatively high electricity prices—implemented electricity industry restructuring reforms aimed at introducing competition into wholesale and, in some cases, retail electricity markets. Of these, twelve states participating in the NBP—Connecticut, Delaware, Illinois, Massachusetts, Maryland, Michigan, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Virginia—had already undertaken such restructuring prior to the NBP's implementation. This temporal overlap is particularly relevant for empirical identification, as industry restructuring often entails substantial changes in the organization, ownership, and operational boundaries of electric utilities (Davis & Wolfram, 2012). Specifically, deregulation and the unbundling of vertically integrated utilities reshaped firm boundaries, incentivizing strategic market consolidation. Kwoka and Pollitt (2010) and Davis and Wolfram (2012) document that this transition triggered a wave of horizontal mergers among generation companies, driven by the pursuit of economies of scale, broader geographic reach, and enhanced ability to optimize dispatch across larger and more diversified asset portfolios. Consequently, some of the post-NBP outcomes observed in these states could reflect delayed or persistent effects of restructuring rather than the direct causal impact of the NBP itself.

However, beyond the difference in regulatory periods between the NBP and electricity industry restructuring, a key distinction lies in their respective scopes. Electricity industry restructuring centers on regulatory reforms within the electricity sector, whereas the NBP program targets NOx-emitting plants across multiple industries, encompassing not only electricity firms but also manufacturing firms.[6] This industry composition, to some extent, alleviates concerns that the post-NBP effects are primarily driven by the lagged effects of electricity industry restructuring.

2.3 Hypothesis Development

The implementation of the NBP imposed substantial compliance costs on firms operating regulated NOx-emitting plants, thereby reducing profitability under the status quo. These costs include expenditures on emission-abatement activities, purchases of additional allowances, and penalties for exceeding the emissions cap (Fowlie, 2010; Linn, 2010; Curtis, 2018). Estimates place the total annual cost for regulated utilities at approximately $2.1 billion (Palmer et al., 2001), while Deschênes et al. (2017) estimate the aggregate compliance cost for all regulated plants at roughly $4.8 billion. Using stock price reactions, Linn (2010) finds that the NBP reduced the expected profits of firms with regulated electric power plants by as much as $25 billion.

The neoclassical theory of mergers views M&A activity as a rational response to exogenous shocks—whether technological, regulatory, or competitive—that alter the expected net benefits of integration (Gort, 1969; Mitchell & Mulherin, 1996; Andrade et al., 2001; Harford, 2005). Such shocks can enhance the potential for synergies, increase the value of asset redeployment, and shift the distribution of productivity across firms, thereby promoting reallocation through acquisitions

[6] In our sample, firms from the electricity industry account for only 30%, while around 53% are manufacturing firms primarily engaged in Chemicals & Allied Products, Paper & Allied Products, Petroleum Refining & Related Products, and other industrial sectors.

(Jovanovic & Rousseau, 2002; Mulherin & Boone, 2000).[7] Prior to regulation, many potential transactions may have had a negative expected net present value (E[NPV] < 0). The imposition of substantial compliance costs can change this calculus: acquisitions that deliver cost synergies or secure strategic resources can offset these costs, shifting E[NPV] into positive territory (Bhattacharyya & Nain, 2011).

In the NBP setting, such value-enhancing opportunities are most likely for firms with high-cost NOx-emitting plants, particularly when alternative means of cost mitigation are limited. We posit that vertical integration represents a particularly effective M&A strategy in this context. Prior literature suggests that backward integration can secure critical inputs, reduce exposure to volatile input prices, and ensure supply security (Spengler, 1950; Vernon & Graham, 1971; Schmalensee, 1973; Warren-Boulton, 1974; Perry, 1978a). Under the NBP, affected firms could employ backward integration to secure access to lower-emission inputs, such as natural gas, thereby reducing NOx emissions at the source and lowering the need for costly abatement investments or allowance purchases (Fowlie, 2010; Linn, 2010). This strategy is associated with enhanced cost synergies in production. Case evidence from our sample supports this channel. KeySpan Corporation's 2004 acquisition of Seneca-Upshur Petroleum Inc. represents backward vertical integration: by acquiring an upstream natural gas producer, KeySpan gained direct access to a cleaner fuel source, reducing its reliance on higher-emission oil inputs and its exposure to abatement and allowance costs.

[7] We acknowledge that M&As are only one of several strategic responses available to firms facing climate policy shocks. Other options may include going-private transactions, joint ventures or alliances with abatement technology providers, partial equity stakes, or increased R&D in abatement technologies. Nonetheless, our empirical focus on M&As reflects their ability to deliver substantial and immediate operational synergies and strategic repositioning in the wake of regulatory shocks.

On the other hand, forward integration can expand direct market access, eliminate distribution mark-ups, and improve logistics coordination, thereby generating cost synergies in the distribution process (Perry, 1978b; Katz, 1987). Under the NBP, these benefits became particularly valuable because forward integration not only strengthened firms' financial positions to acquire emission allowances, but also enhanced their operational flexibility to participate more strategically in allowance markets—for example, by purchasing permits when prices were favorable or by selling surplus allowances for profit. This strategy thus conferred advantages in allowance trading. Case evidence from our sample supports this channel. International Paper Company's 2007 acquisition of Central Lewmar LLC exemplifies forward vertical integration: by acquiring a downstream distributor, International Paper expanded control over its sales channels, eliminated third-party distribution margins, improved logistics efficiency, and strengthened direct customer relationships.[8]

However, prior literature shows that horizontal mergers can generate gains through multiple channels, including the transfer of wealth from both customers and suppliers (Stigler, 1964; Snyder, 1996; Baker, 2002; Fee & Thomas, 2004; Bhattacharyya & Nain, 2011; Galbraith, 2017; Grullon et al., 2019). By coordinating output, merged firms may exercise greater market power to raise prices or consolidate purchasing to negotiate lower input costs (Robinson, 1969; Snyder, 1996; Galbraith, 2017). In the context of the NBP, horizontal consolidation offers an additional advantage: abatement technologies, such as selective catalytic reduction, entail large fixed costs. Through mergers, affected firms can spread these fixed investments across a larger production base, thereby realizing economies of scale in abatement. The realized economies of scale,

[8] Both cases demonstrate how vertical integration can produce tangible cost synergies that directly mitigate NBP compliance burdens. Appendix B provides further details on these two cases.

combined with enhanced market and input power, could provide affected firms with a competitive advantage by lowering the effective burden of compliance costs under the NBP.

3. Sample and Data

3.1 Sample Selection

We first identify the NOx-emitting plants from the U.S. Environmental Protection Agency's (EPA) Emissions & Generation Resource Integrated Database (eGRID) and Clean Air Markets Program Data (CAMPD) (Shive & Forster, 2020; Grinstein & Larkin, 2021). We start with the eGRID database, which provides NOx emission data starting from 1996, along with other plant-specific details, such as plant names, plant locations, and the parent company information of plants.[9] We then supplement the eGRID information with historical data on NOx-emitting plants from CAMPD, which collects the NOx emission data from all power plants over 25 MW in nameplate capacity in the U.S. and provides the individual power plant details.[10] Considering the NBP was replaced by the ozone season NOx program under the Clean Air Interstate Rule (CAIR) in 2009, we restrict our sample plants to the period between 1998 and 2008, which is five years before and after the first adoption of the NBP in 2003.

Next, we merge these NOx-emitting plants with the CRSP/Compustat Merged file to identify our sample of U.S. public firms. Specifically, the eGRID database discloses parent company information for certain plants. For those plants lacking such information, we merge them with the EPA's Toxic Release Inventory (TRI) database using the unique identifier "FRSID" from the EPA's Facility Registry Service (FRS), thereby supplementing their parent company information.

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[9] According to the EPA, the eGRID database is a comprehensive source of information concerning the environmental characteristics of almost all electricity-generating plants in the United States. The eGRID data are available from the following link: https://www.epa.gov/egrid.

[10] The CAMPD data are available for 1980, 1985, and 1990 and annually starting from 1995. The data are collected from: https://campd.epa.gov/.

We then follow Jing et al. (2022) and employ a fuzzy string-matching algorithm to match the unique parent company name of each NOx-emitting plant with the company name of public firms in the CRSP/Compustat Merged file. To ensure the accuracy of this match, we manually check our sample firms against various identifiers, such as location, company website, 10-K filings, and their DUNS numbers.[11] Our final sample consists of 228 firms with 2,328 unique NOx-emitting plants from 1998 to 2008.

We retrieve data on M&A deals announced between 01/01/1998 and 31/12/2008 from the Thomson Financial SDC Mergers and Acquisitions Database. We retain an M&A deal in the sample only if it fulfils the following criteria. First, it is a U.S. domestic deal, and its status is limited to "Completed" and "Unconditional". Second, the deal value must be disclosed. Overall, 522 deals conducted by our sample firms satisfy these criteria. Our dependent variable, *Acquisition*, is a dummy variable that equals one if a firm conducts at least one acquisition in a given year, and zero otherwise.

3.2 Treatment and Control Groups

The NBP operated a cap-and-trade mechanism for more than 2,500 electricity-generating units and industrial boilers in a proportion of U.S. states from 2003 to 2008 (Palmer et al., 2001; Curtis, 2018). In May 2003, the NBP emissions cap was applied to eight states: Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island, as well as Washington, DC. In May 2004, it was applied to a further eleven states: Alabama, Illinois, Indiana, Kentucky, Michigan, North Carolina, Ohio, South Carolina, Tennessee, Virginia, and West Virginia. Our treatment group is constituted by the firms with NOx-emitting plants located in the

[11] The DUNS number is issued by Dun & Bradstreet (D&B), a unique 9-digit business identifier. The DUNS number of public firms is available at: https://www.dnb.com/duns-number/lookup.html.

above nineteen states and Washington, DC. The firms with plants that are not regulated by the NBP constitute our control group.[12] We construct our main explanatory variable, NBP_{Dummy}, which takes the value of one for the years following when a firm's NOx-emitting plant started being regulated by the NBP, and zero otherwise. When a firm has more than one NBP-affected plant, we define treatment based on its first treated plant.

Treatment intensity varies with the proportion of a firm's NOx-emitting plants located in NBP-regulated states. Within this setting, firms with differing shares of regulated plants face heterogeneous exposure to the NBP. For example, although both Firm A and Firm B operate one NOx-emitting plant within an NBP-regulated state, their overall exposure differs substantially. Firm A operates ten such plants in total, so only 10% (1/10) of its production capacity is subject to the NBP, whereas Firm B operates a single plant, rendering its exposure effectively 100%.

To account for variation in treatment intensity, we implement a continuous-treatment identification strategy (Callaway et al., 2024). Specifically, we first construct the variable $Treat_{Intensity}$, which we define as the ratio of a firm's NOx-emitting plants located in NBP-regulated states to its total number of NOx-emitting plants in 2002—the year immediately preceding the implementation of the NBP.[13] Appendix A lists the 20 largest firms in our sample and their corresponding treatment intensity. *Post* equals one for years in which a firm's NOx-emitting plant

[12] Although these control firms are not directly regulated by the NBP, we cannot entirely rule out the possibility that some firms may have anticipated future regulation and adjusted along other margins. Such indirect effects would likely bias our estimates toward zero, making our results conservative.

[13] Following prior literature that employs continuous-treatment designs (e.g., Yu et al., 2024), we construct $Treat_{Intensity}$ as a time-invariant continuous variable based on each firm's NOx-emitting plants and their geographic distribution prior to the implementation of the NBP. Specifically, we use data from 2002—the year immediately preceding the adoption of the NBP—to more accurately capture firm-level treatment intensity, i.e., exposure to the regulation. As a robustness check, we construct an alternative measure, $Treat_{Intensity(2000–2002)}$, calculated as the average treatment intensity over the three years prior to the NBP (i.e., 2000 to 2002). All results remain robust to this alternative specification. For brevity, we do not report the results, but they are available by request.

was subject to NBP regulation, and zero otherwise. Accordingly, we define our key explanatory variable, $NBP_{Intensity}$, as the interaction between $Treat_{Intensity}$ and *Post*.

3.3 Compliance Costs

Following previous literature (e.g., Shive & Forster, 2020; Duchin et al., 2025), we collect data on compliance costs and enforcement activities, including clean-up costs and fines, from the EPA's comprehensive Enforcement and Compliance History Online (ECHO) database. For each investigation initiated by the EPA or state and local agencies, ECHO records the exact dates, detailed violation information, milestone dates, and final enforcement actions settled. It also reports the costs (in dollars) of compliance actions, recovery, supplemental environmental projects, and federal and local penalties. Following Duchin et al. (2025), we aggregate all these items to assess the total regulatory compliance costs for each case and evaluate the firm-level compliance costs by calculating the dollar amount (in millions) of total regulatory compliance costs incurred by a firm in a given year. Compared to the absolute value of compliance costs, the scaled measure more effectively captures the relative burden of regulatory compliance across firms of different sizes. Accordingly, we construct the variable *CompToAsset* by scaling compliance costs by each firm's total assets.

3.4 Horizontal and Vertical M&As

In line with previous studies (e.g., Shahrur, 2005; Bhattacharyya & Nain, 2011; Herger & McCorriston, 2016), we categorize an acquisition as a horizontal deal if the bidder and target share the same four-digit Standard Industrial Classification (SIC) code.[14] Following the methodology of

[14] As a robustness check, we reclassify horizontal acquisitions based on the three-digit SIC code, as shown in Table D1 of Appendix D. Specifically, an acquisition is classified as horizontal if the bidder and target operate within the same three-digit SIC industry. Among the remaining non-horizontal deals, we classify an acquisition as a vertical deal if the vertical relatedness coefficient exceeds 1%. The results remain robust under this alternative classification.

Fan and Goyal (2006), Garfinkel and Hankins (2011), and Herger and McCorriston (2016), we categorize an acquisition as a vertical deal if the vertical relatedness coefficient between the merging firms' industries exceeds 1%. Specifically, we retrieve data from the Bureau of Economic Analysis (BEA) Input-Output (IO) accounts to identify the vertical relatedness coefficients between any two industries as follows.[15] First, we calculate the dollar value of the output required from industry *i* to produce one dollar's worth of industry *j*'s output ($v_{i,j}$). We then calculate the dollar value of the output required from industry *j* to produce one dollar's worth of industry *i*'s output ($v_{j,i}$). The vertical relatedness coefficient ($V_{i,j}$) is then determined as the maximum of these two input requirement coefficients, indicating the opportunity for vertical integration between these two industries. As the BEA IO tables and the SDC adopt different industry classifications (i.e., the BEA IO tables utilize six-digit IO codes, whereas the SDC uses four-digit SIC codes), we convert the SIC codes to IO codes to merge the measure of vertical relatedness into our SDC sample.[16] The BEA IO tables are updated every five years; therefore, the nearest vertical relatedness measure is chosen for each observation.[17]

3.5 Research Design

Our baseline regressions examine the effect of NBP implementation on the likelihood of being an acquirer for firms with NOx-emitting plants. We employ the following difference-in-differences (DiD) frameworks.

Standard DiD model:

[15] The building blocks for the vertical relatedness coefficients are the Use Table of the Benchmark Input-Output Accounts for the U.S. Economy. The use table comprises a matrix detailing the commodity flow value between each pair of approximately 500 private-sector intermediate IO industries.

[16] We use the IO-North American Industrial Classification System (NAICS) conversion tables provided by the BEA and the NAICS-SIC conversion tables provided by the U.S. Census Bureau to construct a link table between the SIC and IO industry code.

[17] The BEA IO tables are available for 1997, 2002, and 2007 during our sample period. Therefore, for a merger in 1997, 1998, or 1999, the (closest) measure used is the 1997 IO Table. For a merger in 2000, 2001, 2002, 2003, or 2004, the (closest) measure used is the 2002 IO Table. For a merger in 2005, 2006, 2007, or 2008, the (closest) measure used is the 2007 IO Table.

$$Acquisition(1/0)_{i,t} = \beta_0 + \beta_1 NBP_{Dummy\ i,t} + Controls_{i,t-1} + \ Firm\ FE + \ Year\ FE\ (or\ Year \times Industry\ FE)\ + \varepsilon_{i,t} \tag{1}$$

Continuous DiD model:

$$Acquisition(1/0)_{i,t} = \beta_0 + \beta_1 NBP_{Intensity\ i,t} + Controls_{i,t-1} + \ Firm\ FE + \ Year\ FE\ (or\ Year \times Industry\ FE)\ + \varepsilon_{i,t} \tag{2}$$

where *i* indexes the firm and *t* refers to the year. The dependent variable, *Acquisition*, is a dummy variable that equals one if a firm conducts at least one acquisition in a year, and zero otherwise. In standard DiD model, the main explanatory variable, NBP_{Dummy}, takes the value of one for the years following when a firm's NOx-emitting plants started being regulated by the NBP, and zero otherwise. In continuous DiD model, $NBP_{Intensity}$ is the interaction between $Treat_{Intensity}$ and *Post* ($Treat_{Intensity} \times Post$). $Treat_{Intensity}$ is a continuous treatment variable, proxied by the proportion of a firm's NOx-emitting plants located in NBP-regulated states to its total number of NOx-emitting plants prior to the NBP. *Post* is equal to one for the years after a firm's NOx-emitting plant became subject to NBP regulation, and zero otherwise. In both equations, consistent with previous literature (e.g., Harford, 1999; Owen & Yawson, 2010; Uysal, 2011; Elsas et al., 2014; Vermaelen & Xu, 2014; Phalippou et al.,2015; Wu & Chung, 2019; Bose et al., 2021), *Controls* represent a vector of firm characteristics (*Log(Size), Log(Age), ROA, Leverage* and *TBQ*) that may affect a firm's likelihood of engaging in acquisitions. Appendix C describes these variables in more detail. All continuous variables are winsorized at the 1^{st} and 99^{th} percentiles to mitigate the impact of outliers. After requiring non-missing data for the variables of interest and controls, our primary sample comprises 228 firms and 2,028 firm-year observations.

Our model specification also includes two sets of fixed effects. Firm fixed effects account for time-invariant heterogeneity across firms, and Year (Year×Industry) fixed effects control for time-varying differences (across industries).[18] Considering the multitude of fixed effects, using a non-linear model (such as a logit or probit model) is prone to yielding biased estimates due to the incidental parameter problem (Chen et al., 2021). Hence, we employ linear probability regressions in this paper. In an untabulated analysis, we rerun our tests using the probit model and obtain the same inference.

4. Empirical Analysis and Discussion

4.1 Descriptive Statistics

Panel A of Table 1 presents summary statistics for the key variables used in our analysis. Our main dependent variable, *Acquisition*, has a mean (standard deviation) of 0.185 (0.388), indicating that 18.5% of our sample firms conduct at least one acquisition. On average, a firm in our sample exhibits a market capitalization (*Log(Size)*) of 8.034, a *Log(Age)* of 2.388, an *ROA* of 3.9%, a *Leverage* of 31.7% and a *TBQ* of 1.562. Notably, 9.7% of sample firms engage in at least one *Vertical* acquisition, compared to 7.3% that engage in at least one *Horizontal* acquisition. The average firm-year *Vertical Count* (0.119) also exceeds *Horizontal Count* (0.091). These figures suggest that, in this setting, vertical acquisitions are a more common response to the NBP than horizontal acquisitions. The deal-specific characteristics of our cross-sectional dataset are also presented. On average, sample deals experience negative 3-day and 5-day cumulative abnormal returns (CARs) and declines in operating performance. Approximately 41.6% of the transactions are vertical, while 32% are horizontal. Nearly all deals (99%) are classified as friendly, and 32.2%

[18] In particular, Year×Industry fixed effects are incorporated to capture industry-specific shocks and trends, mitigating concerns about industry concentration biasing our estimates.

involve public targets. Regarding payment methods, 34.5% of deals are fully financed with cash, whereas 6.7% are fully financed with stock.

Panel B of Table 1 reports the industry distribution of our sample firms, indicating that the sample is not limited to utilities or electricity firms. Firms operating in the manufacturing sector (SIC 20–39) account for 53% of the sample (120 firms; 1,047 observations), representing the largest share. Within manufacturing, the most represented industries are Chemicals & Allied Products (SIC 28; 27 firms), Paper & Allied Products (SIC 26; 23 firms), and Petroleum Refining & Related Products (SIC 29; 9 firms). The primary NOx sources in these industries include process heaters, boilers, chemical reactors, recovery furnaces, lime kilns, and catalytic crackers.

By contrast, 30% of the sample (69 firms; 610 observations) operate in Electric Services & Other Services Combined (SIC 4911 & 4931), which belong to the Electric, Gas, & Sanitary Services sector (SIC 49). In these firms, NOx emissions primarily originate from electric generation units, boilers, turbines, and other high-temperature combustion processes. The remaining 26 firms (245 observations) are distributed across other industries with smaller representation.

[Insert Table 1 around here]

4.2 Baseline Results

Table 2 reports our empirical results. We start with the standard DiD analysis by regressing *Acquisition* on NBP_{Dummy}, along with control variables, firm and year (year×industry) fixed effects in Columns (1) and (2). Columns (3) and (4) adopt the continuous DiD with the main explanatory variable, $NBP_{Intensity}$. Across all the above specifications, the estimated coefficients on NBP_{Dummy} and $NBP_{Intensity}$ are positive and statistically significant at the 1% level, suggesting that firms with

NOx-emitting plants regulated by the NBP have a significantly higher likelihood of being acquirers than firms with NOx-emitting plants that are not regulated by the NBP. Regarding economic magnitude, in Column (2), for instance, the coefficient on NBP_{Dummy} is 0.1009. This indicates that the implementation of the NBP leads to an increase in firms' likelihood of conducting acquisitions by 10.09%. Given the unconditional rate (0.185) at which firms engage in M&As for our sample firms, this suggests that the relationship between the implementation of the NBP and firms' likelihood of being acquirers is economically meaningful.

These results align with our main conjecture that firms with NOx-emitting plants in the NBP-participating states are more likely to engage in M&As in response to an exogenous increase in compliance costs imposed by the implementation of the NBP. Our findings lend initial support to the neoclassical theory, which posits that M&As are a response to economic, regulatory, and technological shocks (Gort, 1969; Mitchell & Mulherin, 1996; Andrade et al., 2001; Harford, 2005).

[Insert Table 2 around here]

4.3 Enhancing Identification

4.3.1 Dynamics of Treatment Effect

Following Bertrand and Mullainathan (2003) and Serfling (2016), we use a dynamic effect model to validate the parallel trends hypothesis of the DiD method:

Standard DiD model:

$$\begin{aligned} Acquisition(1/0)_{i,t} &= \beta_0 + \beta_1 NBP_{Dummy\,i,t}{}^{-4+} + \beta_2 NBP_{Dummy\,i,t}{}^{-3} + \beta_3 NBP_{Dummy\,i,t}{}^{-2} \\ &+ \beta_4 NBP_{Dummy\,i,t}{}^{-1} + \beta_5 NBP_{Dummy\,i,t}{}^{+1} + \beta_6 NBP_{Dummy\,i,t}{}^{+2} + \beta_7 NBP_{Dummy\,i,t}{}^{+3} \\ &+ \beta_8 NBP_{Dummy\,i,t}{}^{4+} + Controls_{i,t-1} + Firm\ FE \\ &+ Year\ FE\ (or\ Year \times Industry\ FE) + \varepsilon_{i,t} \end{aligned}$$

(3)

where we use the same specifications as those in our baseline models but allow the NBP effect to vary according to the year. We replace the NBP_{Dummy} in Eq. (1) with various timing indicators for the years surrounding the NBP implementation year (i.e., the year when a firm has at least one NOx-emitting plant that starts being regulated by the NBP). These indicators are dummy variables for: four or more years prior to the NBP implementation year (NBP_{Dummy}^{-4+}), the third year prior (NBP_{Dummy}^{-3}), the second year prior (NBP_{Dummy}^{-2}), the first year prior (NBP_{Dummy}^{-1}), the first year after (NBP_{Dummy}^{+1}), the second year after (NBP_{Dummy}^{+2}), the third year after (NBP_{Dummy}^{+3}), and four or more years after (NBP_{Dummy}^{4+}). These treatment windows are benchmarked against the NBP implementation year (NBP_{Dummy}^{0}). Evidence of pre-treatment trends would be indicated by statistically significant coefficients on NBP_{Dummy}^{-4+}, NBP_{Dummy}^{-3}, NBP_{Dummy}^{-2}, or NBP_{Dummy}^{-1}.

Continuous DiD model:

$$\begin{aligned} Acquisition(1/0)_{i,t} &= \beta_0 + \beta_1 NBP_{Intensity\ i,t}{}^{-4+} + \beta_2 NBP_{Intensity\ i,t}{}^{-3} + \beta_3 NBP_{Intensity\ i,t}{}^{-2} \\ &+ \beta_4 NBP_{Intensity\ i,t}{}^{-1} + \beta_5 NBP_{Intensity\ i,t}{}^{+1} + \beta_6 NBP_{Intensity\ i,t}{}^{+2} \\ &+ \beta_7 NBP_{Intensity\ i,t}{}^{+3} + \beta_8 NBP_{Intensity\ i,t}{}^{4+} + Controls_{i,t-1} + Firm\ FE \\ &+ Year\ FE\ (or\ Year \times Industry\ FE) + \varepsilon_{i,t} \end{aligned} \tag{4}$$

where we employ the same specifications as in Eq. (2), but replace the dummy variable *Post*—used to construct $NBP_{Intensity}$ ($=Treat_{Intensity} \times Post$) —with a set of dummy variables representing the years before and after the implementation of the NBP (i.e., the year in which a firm has at least one NOx-emitting plant that becomes subject to NBP regulation). These dummy variables are defined as follows: four or more years prior to the NBP implementation year ($Post^{-4+}$), the third year prior ($Post^{-3}$), the second year prior ($Post^{-2}$), the first year prior ($Post^{-1}$), the first year after ($Post^{+1}$), the second year after ($Post^{+2}$), the third year after ($Post^{+3}$), and four or more years after ($Post^{4+}$). Accordingly, we replace $NBP_{Intensity}$ in Eq. (2) with the corresponding interaction terms, ranging from $NBP_{Intensity}^{-4+}$ (=$Treat_{Intensity} \times Post^{-4+}$) through $NBP_{Intensity}^{4+}$ (=$Treat_{Intensity} \times Post^{4+}$). These treatment windows are benchmarked against $NBP_{Intensity}^{0}$ (=$Treat_{Intensity} \times Post^{0}$). Evidence of pre-treatment trends would be indicated by statistically significant coefficients on $NBP_{Intensity}^{-4+}$, $NBP_{Intensity}^{-3}$, $NBP_{Intensity}^{-2}$, or $NBP_{Intensity}^{-1}$.

Table 3 presents the results. The estimated coefficients on NBP_{Dummy}^{-4+}, NBP_{Dummy}^{-3}, NBP_{Dummy}^{-2}, or NBP_{Dummy}^{-1} in Columns (1) and (2) as well as the coefficients on $NBP_{Intensity}^{-4+}$, $NBP_{Intensity}^{-3}$, $NBP_{Intensity}^{-2}$, or $NBP_{Intensity}^{-1}$ in Columns (3) and (4), are consistently statistically insignificant. This suggests that the parallel trends assumption holds and that there are no significant differences in pre-treatment trends between the treated and control firms. In terms of post-treatment effects, we observe a significant increase in the likelihood of making acquisitions only after the NBP adoption. This finding is consistent with our main results in Table 2 and supports a positive relationship between NBP implementation and firms' acquisition likelihood. Furthermore, Fig. 1 graphically examines the dynamic effects of the NBP on M&A likelihood. The figure reports the estimated coefficients along with 90% confidence intervals. Notably, Fig. 1 provides no evidence of pre-treatment trends in M&A activity, thereby supporting the validity of the parallel trends assumption.

[Insert Table 3 and Fig. 1 around here]

4.3.2 Propensity Score Matching

A related concern is that our results may be driven by systematic differences in firm-specific characteristics between treated and control firms. To address this concern, we adopt the PSM to reconstruct a matched sample (Rosenbaum & Rubin, 1983). Following Serfling (2016), we start by retaining all observations for treated and control firms one year prior to the first adoption of the NBP (i.e., the year 2002). We then estimate a logit model to assess the likelihood of a firm receiving treatment, deriving propensity scores based on firm-level covariates and industry fixed effects. In addition to static firm characteristics—namely *Log(Size), Log(Age), ROA, Leverage, TBQ* and *Log(Sales)*—we incorporate dynamic characteristics such as *Assets Growth* and *Sales Growth* to capture recent performance trends that may affect the probability of treatment. We match each treated firm to a control firm, without replacement, based on the nearest propensity score (within a caliper of 0.01). Next, we exclude all observations, including treated and control firms, that do not meet the common support conditions. Our matching process yields a sample of 37 pairs of treated and control firms.

Panel A and Panel B of Table 4 present the diagnostic statistics comparing the mean differences in covariates before and after matching, respectively. After matching, none of the mean differences in either static or dynamic firm characteristics are significant between the treated and control groups, indicating that our matching procedure is successful. In Panel C, we rerun our main regressions as Eqs. (1) and (2) using the matched sample. Consistent with the findings using the full sample in Table 2, the coefficients on NBP_{Dummy} and $NBP_{Intensity}$ are statistically and significantly positive, suggesting that the positive relationship between NBP implementation and the likelihood of firms being acquirers is robust after controlling for covariate balance.

[Insert Table 4 around here]

4.3.3 Falsification Test

Another potential endogeneity concern is that our main results may be driven by chance. In particular, the observed positive and significant relationship between NBP adoption and the likelihood of affected firms engaging in acquisitions may be driven by other confounding state-level emission trading programs. For example, Renewable Portfolio Standards were implemented in thirty states to control carbon dioxide (CO_2) emissions in the electricity sector during the 1990s and 2000s (Greenstone & Nath, 2020), which could potentially confound our baseline regression results. To further address this concern, we conduct falsification (placebo) tests. Specifically, we re-estimate our baseline regressions using a pseudo-treatment indicator, denoted as *Pseudo* NBP_{Dummy}. This indicator is generated through a two-step randomization procedure. First, we randomly select states in which the NOx-emitting plants of our sample firms are located and assign pseudo-NBP adoption to these states. Second, for each selected state, we randomly assign a treatment year within the sample period to serve as the pseudo-treatment year. We then rerun the baseline regressions using these pseudo assignments and record the resulting coefficients. This procedure is repeated 1,000 times, and Table 5 reports the average estimated coefficients and standard errors of *Pseudo* NBP_{Dummy}. In a similar fashion, we construct *Pseudo* $NBP_{Intensity}$ by randomly assigning both treatment intensity values and treatment years to sample firms. The estimated coefficients for both *Pseudo* NBP_{Dummy} and *Pseudo* $NBP_{Intensity}$ are close to zero and statistically insignificant. These findings provide additional assurance that the treatment effects reported in Table 2 are unlikely to be driven by random chance.

[Insert Table 5 around here]

4.3.4 Electricity Industry Restructuring

To further mitigate the concerns that our findings are driven by the residual effects of prior electricity industry reforms, this section re-estimates our baseline regressions while accounting for the restructuring of the U.S. electricity industry. Panel A of Table 6 reports the results using a restricted sample that excludes firms directly affected by local electricity market restructuring. We classify a firm as affected if it (i) operates at least one plant in a state that underwent electricity industry restructuring and (ii) belongs to the electricity sector, defined by Standard Industrial Classification (SIC) code 4911 (*Electric Services*) or 4931 (*Electric and Other Services Combined*). The results remain robust, indicating that our main findings are not driven by firms impacted by the prior electricity industry restructuring.

Panel B of Table 6 re-estimates the baseline regressions while additionally controlling for time-varying regulations that directly affect firms with plants located in states undergoing electricity market restructuring. The added control variable, *Ind Restructuring*, is an indicator that equals one in the years following the initial restructuring of the electricity industry in the state(s) where a firm's plants are located, and zero otherwise. The electricity industry reforms affect firms operating in the electricity sector—defined by Standard Industrial Classification (SIC) code 4911 (*Electric Services*) or SIC code 4931 (*Electric and Other Services Combined*). For all other firms, the dummy equals zero, as electricity market restructuring is expected to significantly affect only firms in this sector. Our empirical results indicate that, after controlling for *Ind Restructuring*, the estimated effects remain robust and consistent with the main results reported in Table 2. This robustness test suggests that our findings are unlikely to be driven by confounding regulatory changes specific to the electricity sector, thereby reinforcing the interpretation that the observed effects are attributable to the NBP rather.

[Insert Table 6 around here]

4.3.5 CARs and Operating Performance

An important question is whether acquisitions undertaken in response to the NBP are value-enhancing or instead driven by empire-building motives. This section empirically examines the extent to which such acquisitions enhance firm value.

In Panel A of Table 7, we examine the effect of the NBP on cumulative abnormal returns (CARs) surrounding M&A announcements. Specifically, we regress three-day and five-day CARs for acquirers, calculated using the Fama–French three-factor model with a 210-day estimation window (−220 to −11), on NBP adoption (NBP_{Dummy}) or intensity ($NBP_{Intensity}$). The positive and statistically significant coefficients on both NBP_{Dummy} and $NBP_{Intensity}$ indicate that the NBP is associated with value-enhancing effects for acquiring firms. Panel B of Table 7 examines the relationship between the NBP and changes in acquirers' operating performance before and after acquisitions. Following prior research (Francis & Martin, 2010; Chen et al., 2018), we construct two measures of performance change. $\Delta ROA1$ is defined as the change in the acquirer's return on assets (ROA) from year $t-1$ to $t+1$. $\Delta ROA2$ is defined as the difference between the average ROA over years $t+1$ to $t+3$ and the average over years $t-3$ to $t-1$. Across all specifications, the estimated coefficients on NBP_{Dummy} and $NBP_{Intensity}$ are positive and statistically significant, indicating that acquisitions undertaken in response to the NBP ultimately generate cost savings and/or revenue enhancements.

[Insert Table 7 around here]

5. Underlying Mechanisms

5.1 Compliance Costs

The results thus far provide robust evidence that the NBP positively influences the likelihood of affected firms engaging in M&As. In this section, we test the underlying economic mechanisms that drive our main finding. We argue that the primary mechanism through which the NBP exerts its influence is by increasing the compliance costs of affected firms (Fowlie, 2010; Linn, 2010; Curtis, 2018). To validate this proposition, we examine whether increased compliance costs resulting from the NBP affect firms' engagement in M&A activity. Following the methodology outlined by Duchin et al. (2025), we measure firm-level compliance costs by computing the dollar amount (in millions) of total regulatory compliance costs borne by a firm in a year, encompassing the costs of compliance actions, recovery, supplemental environmental projects, and federal and local penalties (see Section 3.3). To better capture the relative burden of regulatory compliance across firms of varying sizes, we construct the variable *CompToAsset* as a firm's compliance costs scaled by its total assets. We then compute the change in this ratio (*ΔCompToAsset*) from the year prior to the NBP implementation (t–1) to the year following it (t+1). Based on this, we create a dummy variable, *High ΔCompToAsset*, which equals one if a firm's *ΔCompToAsset* is above the median level calculated across all firms in the treatment group, and zero otherwise. This variable captures firms that are most exposed to the regulation—i.e., those experiencing a relatively greater increase in compliance burden following the NBP.

Table 8 presents the empirical results. The main explanatory variable is the interaction between NBP adoption (or intensity) and *High ΔCompToAsset*, which captures the heterogeneous treatment effects across firms with different compliance costs. The estimated coefficients on the interaction terms are positive and statistically significant at the 5% level, indicating that firms facing higher increases in compliance costs are more likely to engage in M&A activity following the regulatory change.

[Insert Table 8 around here]

5.2 Types of M&As

Firms affected by the NBP that engage in M&As may benefit from cost synergies or enhanced market power (Spengler, 1950; Stigler, 1964; Vernon & Graham, 1971; Schmalensee, 1973;

Warren-Boulton, 1974; Perry, 1978a; Snyder, 1996; Baker, 2002; Fee & Thomas, 2004; Bhattacharyya & Nain, 2011; Galbraith, 2017; Grullon et al., 2019). For example, vertical integration can potentially optimize both production and distribution operations, resulting in significant cost savings. On the other hand, horizontally merged firms can exert market or buying power more effectively, leading to potential increases in product prices or reductions in input costs. To further nail down the mechanism through which the NBP affects M&As, this section delves into the types of deals prompted by the NBP.

Based on the aforementioned classifications of horizontal and vertical deals (see Section 3.4), we construct the following four dependent variables. *Vertical* is a dummy variable that equals one if a firm conducts at least one vertical acquisition in a given year, and zero otherwise. *Horizontal* is a dummy variable that equals one if a firm conducts at least one horizontal acquisition in a given year, and zero otherwise. *Vertical Count* is the number of vertical deals conducted by a firm in a given year. *Horizontal Count* is the number of horizontal deals conducted by a firm in a given year.

Panel A of Table 9 investigates the relationship between the implementation of the NBP and the likelihood of firms engaging in vertical or horizontal M&A transactions. The coefficients on both NBP_{Dummy} and $NBP_{Intensity}$ are positive and statistically significant at the 5% level in Columns (1) through (4), but become insignificant in Columns (5) through (8). This finding suggests that firms operating regulated NOx-emitting plants are more likely to pursue vertical rather than horizontal deals following NBP implementation. Panel B of Table 9 presents results on the impact of the NBP on the number of vertical and horizontal M&A deals, indicating a positive and statistically significant association between the NBP and the number of vertical acquisitions, whereas no significant relationship is observed for horizontal deals. Taken together, these results imply that vertical integration serves as a primary channel through which the NBP spurs M&A activity.

[Insert Table 9 around here]

5.3 Production and Distribution Costs

The empirical evidence in Section 5.2 shows that the increased likelihood of affected firms engaging in acquisitions after the NBP is primarily driven by vertical integration. Accordingly, this section further examines whether vertical integrations undertaken after the implementation of the NBP indeed lead to cost reductions in the production and distribution processes. Following Hu et al. (2023), we measure production costs using the cost of goods sold (COGS), which captures the costs incurred in manufacturing a firm's products, including expenditures on raw materials and the production process. To enhance comparability and stability across firms, we normalize COGS by total firm assets, consistent with Hu et al. (2023) and Whited (2001), and define the resulting measure as *COGStoAsset*. Further, we define the change in production costs before and after acquisitions, *ΔCOGStoAsset*, as the difference between the average *COGStoAsset* over years t+1 to t+3 and the corresponding average over years t−3 to t−1. Similarly, we use selling, general, and administrative expenses scaled by total assets (*SG&AtoAsset*) to capture a firm's distribution-related costs, including expenditures on selling, distribution, and marketing activities. We define *ΔSG&AtoAsset* as the difference between the average *SG&AtoAsset* from years t+1 to t+3 and the average from t−3 to t−1.

Table 10 presents the empirical results. The dependent variables are the changes in production costs (*ΔCOGStoAsset*) and distribution costs (*ΔSG&AtoAsset*) before and after acquisitions. The key explanatory variable is the interaction between NBP adoption (or intensity) and *Vertical Deal*.

Across all specifications, the interaction terms exhibit negative and statistically significant coefficients, indicating that vertical integrations undertaken following the implementation of the NBP are associated with significant reductions in both production and distribution costs, thereby achieving significant cost savings. This evidence aligns with the view that vertical integration can enhance cost efficiency and thereby reduce affected firms' compliance burden.

[Insert Table 10 around here]

6. Conclusion

Our main contribution lies in providing evidence that M&As serve as an important mechanism through which firms navigate challenges arising from exogenous climate regulation. Exploiting the setting of the NBP, we show that firms with NOx-emitting plants in NBP-regulated states are more likely to engage in M&As in response to the heightened compliance costs imposed by the NBP. These firms primarily rely on vertical integration to achieve cost savings that offset regulatory burdens. The effect is more pronounced for firms facing larger compliance cost increases, underscoring the role of capital frictions in shaping acquisition incentives.

Collectively, our findings support the neoclassical theory of M&As and highlight the role of acquisitions as rational responses to climate policy shocks—a new form of government intervention. In particular, we provide evidence that vertical integration is the dominant channel through which firms adapt to regulatory cost pressures. More broadly, our study contributes to the literature on the economic consequences of climate policies for corporate financing and investment decisions, showing that firms use M&As as a strategic tool to mitigate compliance costs and maintain competitiveness under environmental regulation.

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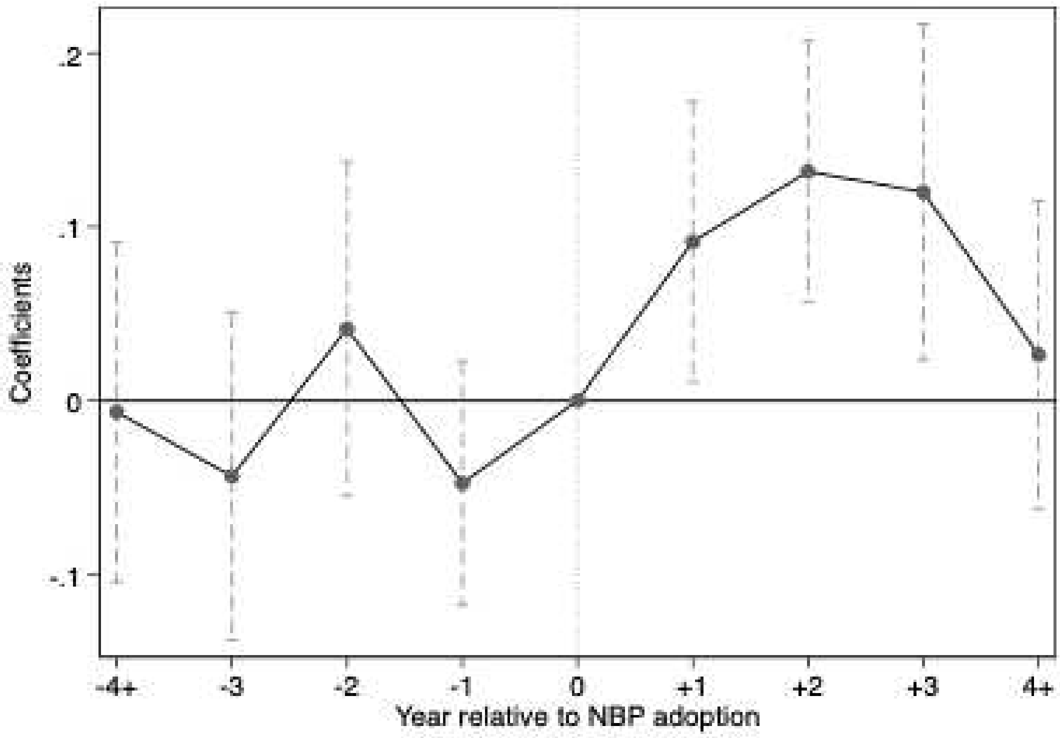

Fig. 1. Dynamics of the treatment effect.

This figure plots the dynamic effect of the adoption of the NBP on M&A involvement. We employ the following equation: $Acquisition(1/0)_{i,t} = \beta_0 + \beta_1 NBP_{Dummyi,t}^{-4+} + \beta_2 NBP_{Dummyi,t}^{-3} + \beta_3 NBP_{Dummyi,t}^{-2} + \beta_4 NBP_{Dummyi,t}^{-1} + \beta_5 NBP_{Dummyi,t}^{+1} + \beta_6 NBP_{Dummyi,t}^{+2} + \beta_7 NBP_{Dummyi,t}^{+3} + \beta_8 NBP_{Dummyi,t}^{4+} + Controls_{i,t-1} + Firm\ FE + Year\ FE + \varepsilon_{i,t}$, as reported in Column (1) of Table 3. *Acquisition* is a dummy variable that equals one if a firm conducts at least one acquisition in a given year, and zero otherwise. The main explanatory variables include various treatment indicators for the years surrounding the NBP implementation year (i.e., the year when a firm has at least one NOx-emitting plant that starts being regulated by the NBP). NBP_{Dummy}^{-4+} is a dummy variable that equals one for four or more years prior to the NBP implementation year, and zero otherwise. NBP_{Dummy}^{-3}, NBP_{Dummy}^{-2}, and NBP_{Dummy}^{-1} are dummy variables that equal one in the third, second, and first year, respectively, prior to the adoption of the NBP, and zero otherwise. NBP_{Dummy}^{+1}, NBP_{Dummy}^{+2}, and NBP_{Dummy}^{+3} are dummy variables that equal one in the first, second, and third year, respectively, following the NBP implementation year, and zero otherwise. NBP_{Dummy}^{4+} is a dummy variable that equals one for four or more years after the NBP implementation year, and zero otherwise. These treatment windows are benchmarked against the NBP implementation year (NBP_{Dummy}^{0}). We report the estimated coefficients along with 90% confidence intervals (dashed lines). Standard errors are adjusted for heteroscedasticity and clustered at the firm level.

Table 1. Descriptive statistics.

This table presents the summary statistics and industry distribution of our sample for the period 1998–2008. Panel A reports the firm-specific variables for the full panel dataset, which comprises 228 firms and 2,028 firm-year observations, as well as the deal-specific variables for the cross-sectional dataset. For each variable, we show the observations (N), mean, standard deviation (Std. Dev), 25th percentiles, median, and 75th percentiles. All variables are defined in Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. Panel B summarizes the distribution of sample firms by industry classification. For each industry, we report the corresponding Standard Industrial Classification (SIC) code range, the primary sources of NOx emissions, the number of sample firms, and the number of firm-year observations.

Panel A: Summary statistics

Variables	N	Mean	Std. Dev	P25	Median	P75
Panel dataset						
Acquisition	2,028	0.185	0.388	0.000	0.000	0.000
NBP_{Dummy}	2,028	0.239	0.427	0.000	0.000	0.000
$NBP_{Intensity}$	2,028	0.200	0.377	0.000	0.000	0.000
Log(Size)	2,028	8.034	1.871	6.830	8.109	9.385
Log(Age)	2,028	2.388	0.432	2.197	2.485	2.708
ROA	2,028	0.039	0.070	0.017	0.035	0.064
Leverage	2,028	0.317	0.160	0.211	0.322	0.412
TBQ	2,028	1.562	0.957	1.117	1.265	1.636
Ind Restructuring	2,028	0.140	0.347	0.000	0.000	0.000
High ΔCompToAsset	2,028	0.094	0.291	0.000	0.000	0.000
Vertical	2,028	0.097	0.296	0.000	0.000	0.000
Horizontal	2,028	0.073	0.261	0.000	0.000	0.000
Vertical Count	2,028	0.119	0.399	0.000	0.000	0.000
Horizontal Count	2,028	0.091	0.361	0.000	0.000	0.000
Cross-sectional dataset						
CAR(-1, 1)	522	-0.001	0.047	-0.019	-0.001	0.018
CAR(-2, 2)	522	-0.000	0.057	-0.026	-0.001	0.026
ΔROA1	519	-0.011	0.064	-0.022	-0.004	0.010
ΔROA2	508	-0.003	0.128	-0.030	-0.008	0.010
NBP_{Dummy}	522	0.299	0.458	0.000	0.000	1.000
$NBP_{Intensity}$	522	0.260	0.413	0.000	0.000	0.500
Deal Size	522	5.115	2.067	3.676	5.155	6.400
Vertical Deal	522	0.416	0.493	0.000	0.000	1.000
Horizontal Deal	522	0.320	0.467	0.000	0.000	1.000
Friendly	522	0.994	0.076	1.000	1.000	1.000
Tender Offer	522	0.077	0.266	0.000	0.000	0.000
Public Target	522	0.322	0.468	0.000	0.000	1.000
Cash	522	0.345	0.476	0.000	0.000	1.000
Stock	522	0.067	0.250	0.000	0.000	0.000
ΔCOGStoAsset	522	-0.025	0.242	-0.071	-0.007	0.044
ΔSG&AtoAsset	381	-0.026	0.059	-0.046	-0.009	0.006
Percentage Stock	522	0.122	0.293	0.000	0.000	0.000
Premium	127	0.398	0.589	0.134	0.333	0.635

Panel B: Industry distribution				
Industry	SIC code (range)	Main NOx Sources	No. Firms	No. Obs.
Manufacturing	***20–39***		***120***	***1047***
	28: Chemicals & Allied Products	Process heaters, boilers, chemical reactors	27	231
	26: Paper & Allied Products	Recovery furnaces, lime kilns, boilers	23	182
	29: Petroleum Refining & Related	Process heaters, catalytic crackers, boilers	9	94
	Others		61	540
Electric, Gas, & Sanitary Services	***49***		***82***	***736***
	4911& 4931: Electric Services & Other Services Combined	Electric generation units, boilers, turbines, high-temperature combustion	69	610
	Others		13	126
Others			***26***	***245***
Total			***228***	***2028***

Table 2. NOx Budget Trading Program (NBP) and acquisition likelihood.

This table examines the effect of the NBP on a firm's M&A likelihood. The dependent variable, *Acquisition*, is a dummy variable that equals one if a firm conducts at least one acquisition in a given year, and zero otherwise. In Columns (1) and (2), the main explanatory variable, NBP_{Dummy}, takes the value of one for the years following when a firm's NOx-emitting plants started being regulated by the NBP, and zero otherwise. In Columns (3) and (4), the main explanatory variable is $NBP_{Intensity}$, which is the interaction term between $Treat_{Intensity}$ and *Post*. $Treat_{Intensity}$ is the ratio of a firm's NOx-emitting plants located in NBP-regulated states to its total number of NOx-emitting plants prior to the NBP. *Post* is equal to one for the years after a firm's NOx-emitting plant became subject to NBP regulation, and zero otherwise. All other variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications use a linear probability model and control for firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable=Acquisition(1/0)				
	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.0864***	0.1009***		
	(0.0305)	(0.0341)		
$NBP_{Intensity}$			0.1086***	0.1229***
			(0.0329)	(0.0365)
Log(Size)	-0.0212	-0.0189	-0.0225	-0.0204
	(0.0169)	(0.0218)	(0.0168)	(0.0219)
Log(Age)	-0.0625	-0.0724	-0.0619	-0.0714
	(0.0491)	(0.0669)	(0.0495)	(0.0666)
ROA	0.3592*	0.3733	0.3599*	0.3702
	(0.2025)	(0.2334)	(0.2028)	(0.2335)
Leverage	-0.0762	-0.1250	-0.0782	-0.1245
	(0.1464)	(0.1471)	(0.1445)	(0.1470)
TBQ	0.0115	0.0177	0.0130	0.0201
	(0.0177)	(0.0243)	(0.0175)	(0.0239)
Constant	0.4543***	0.4394**	0.4615***	0.4478**
	(0.1499)	(0.2189)	(0.1490)	(0.2170)
Year FE	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028
R-squared	0.0242	0.2241	0.0254	0.2249

Table 3 NBP and acquisition likelihood: Dynamics of the treatment effect.

This table examines the pre-treatment trends between the treated and control groups. The dependent variable, *Acquisition*, is a dummy variable that equals one if a firm conducts at least one acquisition in a given year, and zero otherwise. Based on Eq. (3), Columns (1) and (2) include a series of treatment indicators as the main explanatory variables, capturing the years surrounding the NBP implementation year (i.e., the year when a firm has at least one NOx-emitting plant that starts being regulated by the NBP). NBP_{Dummy}^{-4+} is a dummy variable that equals one for four or more years prior to the NBP implementation year, and zero otherwise. NBP_{Dummy}^{-3}, NBP_{Dummy}^{-2}, and NBP_{Dummy}^{-1} are dummy variables that equal one in the third, second, and first year, respectively, prior to the adoption of the NBP, and zero otherwise. NBP_{Dummy}^{+1}, NBP_{Dummy}^{+2}, and NBP_{Dummy}^{+3} are dummy variables that equal one in the first, second, and third year, respectively, following the NBP implementation year, and zero otherwise. NBP_{Dummy}^{4+} is a dummy variable that equals one for four or more years after the NBP implementation year, and zero otherwise. These treatment windows are benchmarked against the NBP implementation year (NBP_{Dummy}^{0}). Based on Eq. (4), Columns (3) and (4) follow the same specification as Eq. (2) but replace the *Post* dummy—used to construct $NBP_{Intensity}$ (=$Treat_{Intensity}\times Post$) —with a set of year-specific dummies around the NBP implementation year. These dummies span from four or more years before ($Post^{-4+}$) to four or more years after ($Post^{4+}$). Corresponding interaction terms ($NBP_{Intensity}^{-4+}$ to $NBP_{Intensity}^{4+}$) replace $NBP_{Intensity}$ in Eq. (2). The benchmark is $NBP_{Intensity}^{0}$ (=$Treat_{Intensity}\times Post^{0}$). *Controls* include *Log(Size), Log(Age), ROA, Leverage* and *TBQ.* All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable=Acquisition(1/0)				
	(1)	(2)	(3)	(4)
NBP_{Dummy}^{-4+}	-0.0066	-0.0173		
	(0.0593)	(0.0661)		
NBP_{Dummy}^{-3}	-0.0435	-0.0148		
	(0.0571)	(0.0665)		
NBP_{Dummy}^{-2}	0.0413	0.0167		
	(0.0582)	(0.0689)		
NBP_{Dummy}^{-1}	-0.0475	-0.0481		
	(0.0426)	(0.0530)		
NBP_{Dummy}^{+1}	0.0914*	0.1204**		
	(0.0489)	(0.0563)		
NBP_{Dummy}^{+2}	0.1318***	0.1641***		
	(0.0456)	(0.0587)		
NBP_{Dummy}^{+3}	0.1201**	0.0604		
	(0.0586)	(0.0631)		
NBP_{Dummy}^{4+}	0.0264	0.0667		
	(0.0536)	(0.0571)		
$NBP_{Intensity}^{-4+}$			0.0072	0.0111
			(0.0682)	(0.0744)
$NBP_{Intensity}^{-3}$			-0.0807	-0.0478
			(0.0667)	(0.0771)
$NBP_{Intensity}^{-2}$			0.0412	0.0212
			(0.0673)	(0.0762)
$NBP_{Intensity}^{-1}$			-0.0624	-0.0678
			(0.0500)	(0.0626)
$NBP_{Intensity}^{+1}$			0.0909	0.1335*
			(0.0597)	(0.0690)
$NBP_{Intensity}^{+2}$			0.1273**	0.1618**
			(0.0496)	(0.0657)
$NBP_{Intensity}^{+3}$			0.1205*	0.0401
			(0.0676)	(0.0719)

$NBP_{Intensity}^{4+}$			0.0553	0.0958
			(0.0628)	(0.0645)
Controls	YES	YES	YES	YES
Year FE	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028
R-squared	0.0302	0.2283	0.0297	0.2281

Table 4. NBP and acquisition likelihood: Propensity score matched (PSM) sample.

This table reports the results from the PSM analysis. Panel A reports diagnostic statistics comparing the mean differences in covariates between treated and control firms before matching. Panel B presents the corresponding statistics after matching. Panel C reports regression results estimated using the matched sample. During the matching procedure, propensity scores are estimated using a logistic regression model that includes a set of control variables, encompassing both static firm characteristics (i.e., *Log(Size), Log(Age), ROA, Leverage, TBQ* and *Log(Sales)*) and dynamic characteristics (i.e., *Assets Growth* and *Sales Growth*). Moreover, each treated firm is matched to a control firm without replacement, using nearest-neighbor matching based on the closest propensity score within a caliper of 0.01. The matching is conducted for the year 2002, which precedes the initial implementation of the NBP. All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Diagnostic statistics — difference in means of covariates before matching

Variables	Treated Group (N=117)	Control Group (N=111)	Mean Difference	p-value
Log(Size)	8.332	7.689	0.643	-0.643***
Log(Age)	2.385	2.392	-0.007	0.007
ROA	0.041	0.036	0.005	-0.005
Leverage	0.333	0.299	0.034	-0.033***
TBQ	1.610	1.507	0.103	-0.103**
Log(Sales)	8.356	7.833	0.523	-0.523***
Assets Growth	0.150	0.146	0.004	-0.004
Sales Growth	0.152	0.154	-0.002	0.001

Panel B: Diagnostic statistics — difference in means of covariates after matching

Variables	Treated Group (N=37)	Control Group (N=37)	Mean Difference	p-value
Log(Size)	7.907	7.996	-0.089	0.487
Log(Age)	2.452	2.414	0.038	0.173
ROA	0.043	0.045	-0.002	0.630
Leverage	0.329	0.318	0.011	0.376
TBQ	1.518	1.567	-0.049	0.391
Log(Sales)	8.063	8.115	-0.052	0.636
Assets Growth	0.135	0.130	0.005	0.889
Sales Growth	0.138	0.135	0.003	0.932

Panel C: Regression results using matched sample

Dependent variable=Acquisition(1/0)

	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.0903**	0.1703***		
	(0.0446)	(0.0549)		
$NBP_{Intensity}$			0.1173**	0.1962***
			(0.0466)	(0.0585)
Controls	YES	YES	YES	YES
Year FE	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES
Observations	774	774	774	774
R-squared	0.0447	0.3207	0.0463	0.3202

Table 5. NBP and acquisition likelihood: Falsification test.

This table presents the results of falsification tests examining M&A involvement following NBP adoption. The dependent variable, *Acquisition*, is a dummy variable that equals one if a firm conducts at least one acquisition in a given year, and zero otherwise. In Columns (1) and (2), the key explanatory variable, *Pseudo* NBP_{Dummy}, is a pseudo-treatment indicator constructed via a two-step randomization procedure: (1) randomly selecting states in which sample firms' NOx-emitting plants are located and assigning pseudo-NBP adoption; and (2) randomly assigning a treatment year within the sample period to each selected state. In Columns (3) and (4), the main explanatory variable, *Pseudo* $NBP_{Intensity}$, is similarly constructed by randomly assigning both treatment intensity values and treatment years to sample firms. Each randomization procedure is repeated 1,000 times, and the table reports the average estimated coefficients on *Pseudo* NBP_{Dummy} and $NBP_{Intensity}$. *Controls* include *Log(Size), Log(Age), ROA, Leverage* and *TBQ.* All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable=Acquisition(1/0)				
	(1)	(2)	(3)	(4)
Pseudo NBP_{Dummy}	0.0006	0.0016		
	(0.0189)	(0.0211)		
Pseudo $NBP_{Intensity}$			-0.0017	-0.0019
			(0.0275)	(0.0305)
Controls	YES	YES	YES	YES
Year FE	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028

Table 6. Electricity industry restructuring.

This table reports robustness tests that account for electricity industry restructuring. In Panel A, we re-estimate our baseline regressions using a sample that excludes firms affected by local electricity industry restructuring. A firm is classified as affected if it operates at least one plant in a state that restructured its electricity industry and belongs to the electricity sector, defined by SIC code 4911 (*Electric Services*) or 4931 (*Electric and Other Services Combined*). Panel B re-estimates the baseline regressions while additionally controlling for time-varying regulations that directly affect firms with plants located in states undergoing electricity market restructuring. The added control variable, *Ind Restructuring*, is an indicator equal to one in the years following the initial restructuring of the electricity industry in the state(s) where a firm's plants are located, provided the firm operates in the electricity sector—defined by Standard Industrial Classification (SIC) code 4911 (*Electric Services*) or SIC code 4931 (*Electric and Other Services Combined*)—and zero otherwise. *Controls* include *Log(Size), Log(Age), ROA, Leverage* and *TBQ.* All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Excluding firms affected by prior electricity industry restructuring

Dependent variable=Acquisition(1/0)				
	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.1428***	0.1476***		
	(0.0344)	(0.0408)		
$NBP_{Intensity}$			0.1543***	0.1671***
			(0.0368)	(0.0439)
Controls	YES	YES	YES	YES
Year FE	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES
Observations	1,679	1,679	1,679	1,679
R-squared	0.0320	0.2536	0.0320	0.2540

Panel B: Controlling for prior electricity restructuring

Dependent variable=Acquisition(1/0)				
	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.0944***	0.1075***		
	(0.0305)	(0.0341)		
$NBP_{Intensity}$			0.1123***	0.1258***
			(0.0331)	(0.0369)
Ind Restructuring	-0.1075**	-0.0818	-0.0948*	-0.0685
	(0.0536)	(0.0598)	(0.0539)	(0.0601)
Controls	YES	YES	YES	YES
Year FE	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028
R-squared	0.0260	0.2252	0.0268	0.2256

Table 7. CARs and operating performance.

This table examines the relationship between NBP implementation and post-acquisition efficiency. Panel A investigates the impact of the NBP on cumulative abnormal returns (CARs) around M&A announcements. The specification is: $CAR_i = \beta_0 + \beta_1 NBP_{Dummy\ i}$ $(or\ \beta_1 NBP_{Intensity\ i})$ + *Deal Controls*$_i$ + *Firm Controls*$_{i,t-1}$ + *Year FE* + *Industry FE* + ε_i. The dependent variables are three-day and five-day CARs for acquirers, computed using the Fama–French three-factor model with a 210-day estimation window (−220 to −11). *Deal Controls* include *Deal Size, Vertical Deal, Horizontal Deal, Friendly, Tender Offer, Public Target, Cash,* and *Stock*. *Firm Controls* include *Log(Size), ROA, Leverage*, and *TBQ*. Panel B explores the relationship between the NBP and improvements in post-acquisition operating performance. The specification is: $\Delta ROA_i = \beta_0 + \beta_1 NBP_{Dummy\ i}$ $(or\ \beta_1 NBP_{Intensity\ i})$ + *Deal Controls*$_i$ + *Firm Controls*$_{i,t-1}$ + *Year FE* + *Industry FE* + ε_i. The change in operating performance is measured using two alternative metrics. First, *ΔROA1* is defined as the change in the acquirer's return on assets from year t−1 to t+1. Second, *ΔROA2* is calculated as the difference between the average return on assets from years t+1 to t+3 and the average from t−3 to t−1. The *Deal Controls* and *Firm Controls* are consistent with those in Panel A. All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include year and industry fixed effects. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Cumulative abnormal returns (CARs)

Dependent variable=	CAR(-1, 1)		CAR(-2, 2)	
	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.0054**		0.0079*	
	(0.0021)		(0.0041)	
$NBP_{Intensity}$		0.0109**		0.0109*
		(0.0040)		(0.0052)
Deal Controls	YES	YES	YES	YES
Firm Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	522	522	522	522
R-squared	0.1594	0.1623	0.1341	0.1353

Panel B: Changes in operating performance

Dependent variable=	$\Delta ROA1_{t-1\rightarrow t+1}$		$\Delta ROA2_{Average(t-3,t-1)\rightarrow Average(t+1,t+3)}$	
	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.0149***		0.0371*	
	(0.0026)		(0.0189)	
$NBP_{Intensity}$		0.0174***		0.0344*
		(0.0031)		(0.0197)
Deal Controls	YES	YES	YES	YES
Firm Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	519	519	508	508
R-squared	0.1506	0.1518	0.1371	0.1357

Table 8. NBP, compliance cost and M&As.

This table investigates the effect of increased compliance costs resulting from the NBP on firms' involvement in M&A activity. The specification is: $Acquisition(1/0)_{i,t} = \beta_0 + \beta_1 NBP_{Dummy\ i,t}$ $(or\ \beta_1 NBP_{Intensity\ i,t}) + \beta_2\ NBP_{Dummy\ i,t} \times High\ \Delta CompToAsset_i\ (or\ \beta_2\ NBP_{Intensity\ i,t} \times High\ \Delta CompToAsset_i) + Controls_{i,t-1} + Firm\ FE + Year\ FE\ (or\ Year \times Industry\ FE) + \varepsilon_{i,t}$. The variable *High ΔCompToAsset* identifies firms most exposed to the policy, i.e., those experiencing greater increase in compliance costs from the pre- to post-NBP period. To construct this variable, we first obtain data from the U.S. Environmental Protection Agency's (EPA) Enforcement and Compliance History Online (ECHO) database. We compute *CompToAsset* as the dollar amount (in millions) of total regulatory compliance costs incurred by the firm—including cleanup expenses and fines—scaled by total assets. We then calculate the change in *CompToAsset* (*ΔCompToAsset*) from the year prior to the NBP implementation (t–1) to the year following it (t+1). *High ΔCompToAsset* is a binary indicator equal to one if a firm's *ΔCompToAsset* is above the median level calculated across all firms in the treatment group, and zero otherwise. The main explanatory variable is the interaction between NBP adoption (or intensity) and *High ΔCompToAsset*, which captures the heterogeneous treatment effect across firms with differing compliance cost burdens. *Controls* include *Log(Size), Log(Age), ROA, Leverage* and *TBQ.* All variables are defined in the Appendix C. All specifications include firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable=Acquisition(1/0)				
	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.0644**	0.0789**		
	(0.0320)	(0.0353)		
NBP_{Dummy}×High ΔCompToAsset	0.1383**	0.1389**		
	(0.0598)	(0.0663)		
$NBP_{Intensity}$			0.0806**	0.0932**
			(0.0361)	(0.0405)
$NBP_{Intensity}$×High ΔCompToAsset			0.1536**	0.1622**
			(0.0660)	(0.0750)
Controls	YES	YES	YES	YES
Year FE	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028
R-squared	0.0271	0.2264	0.0283	0.2273

Table 9. NBP and type of M&As.

This table presents the types of acquisitions undertaken by firms in response to the NBP implementation. Panel A examines the relationship between the implementation of the NBP and the likelihood of firms engaging in vertical or horizontal M&A transactions. The specification is: $Vertical(1/0)_{i,t}$ or $Horizontal(1/0)_{i,t} = \beta_0 + \beta_1 NBP_{Dummy\ i,t}$ (or $\beta_1 NBP_{Intensity\ i,t}$) + $Controls_{i,t-1}$ + *Firm FE + Year FE (or Year×Industry FE)* + $\varepsilon_{i,t}$. *Vertical* is a dummy variable that equals one if a firm conducts at least one vertical acquisition in a given year, and zero otherwise. *Horizontal* is a dummy variable that equals one if a firm conducts at least one horizontal acquisition in a given year, and zero otherwise. Panel B examines the effect of NBP implementation on the number of vertical or horizontal M&A deals conducted by firms. The specification is: $Vertical\ Count_{i,t}$ or $Horizontal\ Count_{i,t} = \beta_0 + \beta_1 NBP_{Dummy\ i,t}$ (or $\beta_1 NBP_{Intensity\ i,t}$) + $Controls_{i,t-1}$ + *Firm FE + Year FE (or Year×Industry FE)* + $\varepsilon_{i,t}$. *Vertical Count* is the number of vertical deals conducted by a firm in a given year. *Horizontal Count* is the number of horizontal deals conducted by a firm in a given year. The classifications of vertical and horizontal deals are based on the four-digit Standard Industrial Classification (SIC) codes. We categorize an acquisition as a horizontal deal if the bidder and target share the same four-digit SIC industry. Among the remaining non-horizontal deals, we categorize an acquisition as a vertical deal if the vertical relatedness coefficient (constructed using the Input-Output (I/O) data from the Bureau of Economic Analysis (BEA)) exceeds 1%. *Controls* include *Log(Size), Log(Age), ROA, Leverage* and *TBQ*. All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Likelihood of vertical or horizontal M&A deals

Dependent variable=	Vertical(1/0)				Horizontal(1/0)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NBP_{Dummy}	0.0576**	0.0587**			0.0071	0.0270		
	(0.0234)	(0.0275)			(0.0237)	(0.0276)		
$NBP_{Intensity}$			0.0750***	0.0744**			0.0086	0.0304
			(0.0263)	(0.0314)			(0.0240)	(0.0265)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	NO	YES	NO	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028	2,028	2,028	2,028	2,028
R-squared	0.0153	0.2153	0.0165	0.2159	0.0163	0.1929	0.0164	0.1928

Panel B: Number (count) of vertical or horizontal M&A deals

Dependent variable=	Vertical Count				Horizontal Count			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NBP_{Dummy}	0.0794**	0.0819**			0.0060	0.0278		
	(0.0307)	(0.0355)			(0.0322)	(0.0353)		
$NBP_{Intensity}$			0.0937**	0.0961**			0.0152	0.0432
			(0.0363)	(0.0433)			(0.0327)	(0.0334)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	NO	YES	NO	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028	2,028	2,028	2,028	2,028
R-squared	0.0188	0.2302	0.0192	0.2304	0.0137	0.1930	0.0138	0.1933

Table 10. NBP, vertical integration, and production and distribution costs.

This table investigates whether vertical integrations following the NBP implementation generate cost savings in the production and distribution process. The specification is: $\Delta Costs_i = \beta_0 + \beta_1 NBP_{Dummy\ i}$ (or $\beta_1 NBP_{Intensity\ i}$) + $\beta_2 NBP_{Dummy\ i,t} \times Vertical\ Deal_i$ (or $\beta_2 NBP_{Intensity\ i,t} \times Vertical\ Deal_i$) + $\beta_3 Vertical\ Deal_i$ + $Deal\ Controls_i$ + $Firm\ Controls_{i,t-1}$ + *Year FE* + *Industry FE* + ε_i. The dependent variable, *ΔCosts,* is the change in production and distribution costs before and after acquisitions, measured by *ΔCOGStoAsset* and *ΔSG&AtoAsset*. In Columns (1) and (2), *ΔCOGStoAsset* is calculated as the difference between the average cost of goods sold scaled by total assets (*COGStoAsset*) from years t+1 to t+3 and the average from t−3 to t−1. In Columns (3) and (4), *ΔSG&AtoAsset* is calculated as the difference between the average selling, general and administrative expenses scaled by total assets (*SG&AtoAsset*) from years t+1 to t+3 and the average from t−3 to t−1. *Vertical Deal* is a dummy variable that equals one for non-horizontal acquisitions with a vertical relatedness coefficient exceeding 1%, and zero otherwise. The main explanatory variable is the interaction between NBP adoption (or intensity) and *Vertical Deal. Deal Controls* include *Deal Size, Friendly, Tender Offer, Public Target, Cash,* and *Stock*. *Firm Controls* include *Log(Size), ROA, Leverage*, and *TBQ*. All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include year and industry fixed effects. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable=	ΔCOGStoAsset		ΔSG&AtoAsset	
	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.0136		-0.0121	
	(0.0802)		(0.0111)	
NBP_{Dummy}×Vertical Deal	-0.0838**		-0.0137*	
	(0.0375)		(0.0063)	
$NBP_{Intensity}$		0.0429		-0.0122
		(0.0902)		(0.0103)
$NBP_{Intensity}$×Vertical Deal		-0.0878**		-0.0142*
		(0.0423)		(0.0066)
Vertical Deal	0.0382	0.0360	0.0090	0.0091
	(0.0263)	(0.0257)	(0.0049)	(0.0049)
Deal Controls	YES	YES	YES	YES
Firm Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Observations	522	522	381	381
R-squared	0.4312	0.4306	0.4106	0.4105

Appendix A: List of the 20 largest firms

This table presents the 20 largest firms in our sample ranked by total assets. For each firm, we report on its four-digit Standard Industrial Classification (SIC) code and industry description, treatment status, and treatment intensity. *Treat* is a dummy variable equal to one if a firm has NOx-emitting plants located in NBP-regulated states and zero otherwise. To capture variation in treatment intensity across firms, we define the continuous variable $Treat_{Intensity}$ as the proportion of a firm's NOx-emitting plants located in NBP-regulated states to its total number of NOx-emitting plants in 2002, the year immediately preceding the initial implementation of the NBP.

Firms	SIC code	SIC description	Treat	$Treat_{Intensity}$
General Motors Co.	3711	Motor Vehicles and Passenger Car Bodies	1	1.00
Ford Motor Co.	3711	Motor Vehicles and Passenger Car Bodies	1	0.50
Exxon Mobil Corp.	2911	Petroleum Refining	1	0.25
BP p.l.c.	2911	Petroleum Refining	1	0.50
Enel S.p.A.	4911	Electric Services	1	0.46
ConocoPhillips	2911	Petroleum Refining	0	0.00
Chevron Corp.	2911	Petroleum Refining	0	0.00
Procter & Gamble Co.	2840	Soap, Detergents, Cleaning Preparations, Perfumes, Cosmetics	1	0.50
ArcelorMittal	3312	Steel Works, Blast Furnaces & Rolling Mills (Coke Ovens)	1	1.00
Pfizer Inc.	2834	Pharmaceutical Preparations	1	1.00
Altria Group, Inc.	2111	Cigarettes	1	1.00
Sanofi	2834	Pharmaceutical Preparations	1	1.00
Rio Tinto Group	1000	Metal Mining	0	0.00
Suez	4911	Electric Services	1	0.60
Novartis AG	2834	Pharmaceutical Preparations	0	0.00
BHP Group Limited	1000	Metal Mining	0	0.00
Roche Holding AG	2834	Pharmaceutical Preparations	1	1.00
BASF SE	2860	Industrial Organic Chemicals	0	0.00
Duke Energy Corp.	4931	Electric & Other Services Combined	1	0.78
Caterpillar Inc.	3531	Construction Machinery & Equipment	1	1.00

Note: For example, according to the CAMPD and eGRID databases, General Motors Co. owned two NOx-emitting plants, Powertrain Warren General Motors and Romulus Operations Powertrain, in Michigan during the sample period 1998–2008. Both facilities became subject to the Michigan NOx Budget Program (NBP) beginning in 2004. Accordingly, General Motors Co. is classified as a treated firm in our sample. Its treatment intensity ratio equals 1 (= 2/2). Also, in 2002, Exxon Mobil Corp. owned eight NOx-emitting plants: Baytown PP3 & PP4 (Texas), Baytown Turbine Generator Project (Texas), Baton Rouge Turbine Generator (Louisiana), Paulsboro Refinery (New Jersey), Beaumont Refinery (Texas), Hawkins Gas Plant (Texas), Joliet Refinery (Illinois), and Chalmette Refinery (Louisiana). Among these, only the facilities in New Jersey and Illinois were subject to the NBP. Accordingly, the firm's treatment intensity ratio is 0.25 (= 2/8).

Appendix B: Examples of M&As

Example: KeySpan Corporation's acquisition of Seneca-Upshur Petroleum Inc.

KeySpan Corporation, operating within the Natural Gas Distribution sector (SIC 4924), engaged in natural gas distribution and energy-related services. The company owned multiple large fossil-fuel-fired plants with significant NOx output in New York—such as Northport, Port Jefferson, Shoreham, and Holtsville—that were subject to regulation under the New York NOx Budget Program (NBP) beginning in 2003. Consequently, KeySpan is classified as a treated firm in our sample. By contrast, Seneca-Upshur Petroleum Inc. was a wholly owned subsidiary of The Houston Exploration Company and operated in the Crude Petroleum & Natural Gas sector (SIC 1311) as an upstream gas producer engaged in oil and gas exploration and production.

Within one year of becoming subject to regulation under the NBP, on May 24, 2004, KeySpan announced its acquisition of Seneca-Upshur Petroleum through a stock exchange transaction with The Houston Exploration Company. The transaction was completed in mid-2004. By acquiring Seneca-Upshur's natural gas reserves and production capacity, KeySpan gained direct access to a cleaner fuel source, thereby reducing reliance on higher-emission oil inputs and mitigating its exposure to costly abatement investments and allowance purchases. This transaction represents a clear instance of backward vertical integration by a regulated firm in the post-NBP period. Although KeySpan continued to source part of its supply externally, the acquisition provided strategic insulation from regulatory compliance costs.

Example: International Paper Company's acquisition of Central Lewmar LLC

International Paper Company, a leading producer of paper and packaging products, operated within the Paper Mills sector (SIC 2621) during our sample period. Its business was organized into four primary segments: Industrial Packaging, Global Cellulose Fibers, Printing Papers, and Consumer Packaging. The company maintained an extensive network of pulp, paper, and packaging mills, as well as converting plants, recycling facilities, and bag manufacturing operations across the United States. Its core manufacturing processes relied heavily on large-scale, high-temperature combustion systems to generate steam, heat, and power. Consequently, these operations were substantial sources of NOx emissions. For instance, plants such as the Georgetown Mill in South Carolina, the Ticonderoga Mill in New York, the Riegelwood Mill in North Carolina, and the Riverdale Mill in Alabama operated fossil-fuel and biomass boilers that reported annual NOx emissions in the hundreds to thousands of tons. These facilities were subject to regulation under the NOx Budget Program (NBP) beginning in 2003–2004. Accordingly, International Paper Company is classified as a treated firm in our sample. Central Lewmar LLC operated in the Industrial and Personal Service Paper sector (SIC 5113) as a wholesale distributor of paper and packaging products. The company served a customer base of more than 6,500 accounts, consisting primarily of commercial printers and publishers.

In August 2007, International Paper Company completed the acquisition of Central Lewmar LLC. The transaction substantially expanded International Paper's downstream distribution network and enhanced its access to printers, publishers, and other end-users of paper products. Strategically, the acquisition advanced International Paper further along the supply chain from manufacturing into integrated distribution and direct customer engagement. This transaction represents a clear case of forward vertical integration by a regulated firm in the post-NBP period. Beyond eliminating third-party distribution margins and improving logistics efficiency, the expanded downstream control also strengthened International Paper's financial and operational flexibility, thereby enhancing its ability to participate more strategically in allowance markets.

Appendix C: Variable definitions

Variable	Definition
Acquisition	Dummy variable that equals one if a firm conducts at least one acquisition in a given year, and zero otherwise.
NBP_{Dummy}	Dummy variable that equals one for the years following when a firm's NOx-emitting plants started being regulated by the NBP, and zero otherwise.
$NBP_{Intensity}$	$Treat_{Intensity} \times Post$, where $Treat_{Intensity}$ is the ratio of a firm's NOx-emitting plants located in NBP-regulated states to its total number of NOx-emitting plants prior to the NBP. *Post* is a dummy variable that equals one for the years after a firm's NOx-emitting plant became subject to NBP regulation, and zero otherwise.
Log(Size)	Natural logarithm of market capitalization.
Log(Age)	Natural logarithm of firm age.
ROA	Net income divided by total assets.
Leverage	The sum of debt in current liabilities plus long-term debts divided by total assets.
TBQ	The sum of equity market value and liability book value, all divided by the book value of total assets.
Log(Sales)	Natural logarithm of sales.
Assets Growth	Annual percentage change in a firm's total assets.
Sales Growth	Annual percentage change in a firm's total sales.
Ind Restructuring	Dummy variable that equals one in the years following the initial restructuring of the electricity industry in the state(s) where a firm's plants are located, provided the firm operates in the electricity sector—defined by Standard Industrial Classification (SIC) code 4911 (*Electric Services*) or SIC code 4931 (*Electric and Other Services Combined*)—and zero otherwise.
High ΔCompToAsset	Dummy variable that equals one if a firm's *ΔCompToAsset* is above the median level calculated across all firms in the treatment group, and zero otherwise. *CompToAsset* is the dollar amount (in millions) of total regulatory compliance costs incurred by the firm due to EPA enforcement actions (including clean-up costs and fines) scaled by firm's total assets. For each firm, *ΔCompToAsset* is the change in *CompToAsset* from the year prior to the NBP implementation (t–1) to the year following it (t+1).
Vertical	Dummy variable that equals one if a firm conducts at least one vertical acquisition in a given year, and zero otherwise.
Horizontal	Dummy variable that equals one if a firm conducts at least one horizontal acquisition in a given year, and zero otherwise.
Vertical Count	The number of vertical deals conducted by a firm in a given year.
Horizontal Count	The number of horizontal deals conducted by a firm in a given year.
CAR(-1, 1)	Three-day CARs for acquirers, computed using the Fama–French three-factor model with a 210-day estimation window (−220 to −11).
CAR(-2, 2)	Five-day CARs for acquirers, computed using the Fama–French three-factor model with a 210-day estimation window (−220 to −11).
ΔROA1	Change in the acquirer's return on assets from year t−1 to t+1.
ΔROA2	Difference between the average return on assets from years t+1 to t+3 and the average from t−3 to t−1.
Deal Size	Natural logarithm of deal transaction value.
Vertical Deal	Dummy variable that equals one for acquisitions that are non-horizontal and have a vertical relatedness coefficient exceeding 1%, and zero otherwise.
Horizontal Deal	Dummy variable that equals one for an acquisition in which the bidder and target share the same four-digit SIC industry, and zero otherwise.
Friendly	Dummy variable that equals one for an acquisition in which the "attitude" of the proposed acquisition is neither hostile nor unsolicited, and zero otherwise.
Tender Offer	Dummy variable that equals one for an acquisition structured as a tender offer, and zero otherwise.
Public Target	Dummy variable that equals one if the target is a public firm, and zero otherwise.
Cash	Dummy variable that equals one for an acquisition that is fully financed by the acquirer's cash, and zero otherwise.

Stock	Dummy variable that equals one for an acquisition that is fully financed by the acquirer's common stock, and zero otherwise.
ΔCOGStoAsset	Difference between the average cost of goods sold scaled by total assets (*COGStoAsset*) from years t+1 to t+3 and the average from t−3 to t−1.
ΔSG&AtoAsset	Difference between the average selling, general and administrative expenses scaled by total assets (*SG&AtoAsset*) from years t+1 to t+3 and the average from t−3 to t−1.
Percentage Stock	Proportion of the total transaction value paid in the form of the acquirer's stock.
Premium	The percentage difference between the offer price and the target share price 20 trading days (four weeks) prior to the announcement date.

Appendix D: Additional Tests

Table D1 presents the robustness checks for Table 8 using an alternative classification scheme for vertical and horizontal acquisitions. Specifically, this classification relies on three-digit Standard Industrial Classification (SIC) codes. An acquisition is classified as horizontal if the bidder and target operate within the same three-digit SIC industry. For the remaining non-horizontal deals, an acquisition is classified as vertical if the vertical relatedness coefficient—constructed using Input-Output (I/O) data from the Bureau of Economic Analysis (BEA)—exceeds 1%. The results remain robust under this alternative classification, consistent with the findings reported in Table 8.

Table D2 presents the robustness test results using a sample that excludes states implementing the NBP in 2003. Following Dang et al. (2023), the 2003 NBP, covering Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island, and the District of Columbia, was introduced as a replacement for the original OTC NBP (1999–2002), which may have been less stringent than the 2004 NBP and exerted a relatively milder policy impact. Furthermore, recent econometric literature shows that in staggered adoption settings, treatment effect heterogeneity can bias DiD estimates because groups adopting at different times may enter comparisons at inappropriate periods (Callaway and Sant'Anna, 2021; Goodman-Bacon, 2021; Sun and Abraham, 2021). Excluding the 2003 adopters helps reduce the influence of timing-related biases. Accordingly, we exclude these states from the analysis and focus solely on the 2004 NBP states. The results remain consistent with those reported in Table 2, indicating a positive association between the NBP and M&A involvement.

Table D3 examines the effect of the NBP on firms' payment method and takeover premium in M&A transactions. Our primary finding in this paper is that NBP implementation increases the likelihood of affected firms becoming acquirers, consistent with the view that firms with regulated NOx-emitting plants pursue acquisitions to hedge rising compliance costs. Prior research shows that financially constrained or distressed firms tend to opt for cash-conserving strategies and use stock rather than cash in M&A deals due to limited access to external financing (Hotchkiss et al., 2008; Faccio & Masulis, 2005; Bruyland et al., 2019; Zhang, 2022). In this context, the NBP's substantial compliance costs may deplete firms' cash reserves and reduce liquidity, incentivizing stock-based payments. Panel A of Table D3 employs a cross-sectional framework to examine how the NBP affects payment choice in acquisitions. The coefficients on NBP_{Dummy} and $NBP_{Intensity}$ are positive and statistically significant, indicating that firms with NOx-emitting plants regulated by the NBP tend to incorporate a higher proportion of stock in acquisition payments. This finding supports our conjecture that, when confronted with increased compliance costs following the NBP's implementation, affected firms face cash constraints that limit their ability to finance acquisitions using cash.

Given that the stocks of financially distressed bidders are more likely to be overvalued (Bruyland et al., 2019), an important question arises as to why target shareholders would accept such a payment method. We posit that affected bidders are more inclined to attract target shareholders by offering higher takeover premiums, thereby compensating for the increased risks associated with bidder overvaluation. To examine this mechanism, Panel B of Table D3 focuses exclusively on deals involving public targets, as stock price information is only available for these firms. The takeover premium is calculated as the percentage difference between the offer price and the target's share price 20 trading days (four weeks) prior to the announcement date. Of the 522 deals in our sample, 127 have historical stock price data available for their targets and are included in our final regression analysis. Across all model specifications, the relationship between NBP exposure and the takeover premium is positive, statistically significant, and economically meaningful. This evidence supports our conjecture that affected bidders offer higher premiums to induce target shareholders to accept stock as the method of payment in M&A transactions.

Table D1. Alternative classifications of vertical and horizontal deals.

This table presents the robustness test using alternative definitions of vertical and horizontal deals. Unlike Table 8, the classifications of vertical and horizontal deals here are based on three-digit Standard Industrial Classification (SIC) codes. We first categorize an acquisition as a horizontal deal if the bidder and target share the same three-digit SIC industry. Among the remaining non-horizontal deals, we classify an acquisition as a vertical deal if the vertical relatedness coefficient (constructed using Input-Output (I/O) data from the Bureau of Economic Analysis (BEA)) exceeds 1%. Panel A shows the relationship between NBP implementation and the likelihood of firms conducting vertical or horizontal M&A deals. The specification is: $Vertical_{Alternative}(1/0)_{i,t}$ or $Horizontal_{Alternative}(1/0)_{i,t} = \beta_0 + \beta_1 NBP_{Dummy\ i,t}$ (or $\beta_1 NBP_{Intensity\ i,t}$) + $Controls_{i,t-1}$ + *Firm FE* + *Year FE (or Year×Industry FE)* + $\varepsilon_{i,t}$. $Vertical_{Alternative}$ is a dummy variable that equals one if a firm conducts at least one vertical acquisition in a given year, and zero otherwise. $Horizontal_{Alternative}$ is a dummy variable that equals one if a firm conducts at least one horizontal acquisition in a given year, and zero otherwise. Panel B examines the effect of NBP implementation on the number of vertical or horizontal M&A deals conducted by firms. The specification is: $Vertical\ Count_{Alternative\ i,t}$ or $Horizontal\ Count_{Alternative\ i,t} = \beta_0 + \beta_1 NBP_{Dummy\ i,t}$ (or $\beta_1 NBP_{Intensity\ i,t}$) + $Controls_{i,t-1}$ + *Firm FE* + *Year FE (or Year×Industry FE)* + $\varepsilon_{i,t}$. $Vertical\ Count_{Alternative}$ is the number of vertical deals conducted by a firm in a given year. $Horizontal\ Count_{Alternative}$ is the number of horizontal deals conducted by a firm in a given year. *Controls* include *Log(Size), Log(Age), ROA, Leverage* and *TBQ*. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Likelihood of vertical or horizontal M&A deals

Dependent variable=	$Vertical_{Alternative}(1/0)$				$Horizontal_{Alternative}(1/0)$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NBP_{Dummy}	0.0460**	0.0494**			0.0166	0.0298		
	(0.0211)	(0.0250)			(0.0257)	(0.0303)		
$NBP_{Intensity}$			0.0576**	0.0596**			0.0209	0.0378
			(0.0236)	(0.0290)			(0.0269)	(0.0310)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	NO	YES	NO	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028	2,028	2,028	2,028	2,028
R-squared	0.0143	0.2317	0.0149	0.2319	0.0227	0.2002	0.0227	0.2004

Panel B: Number (count) of vertical or horizontal M&A deals

Dependent variable=	$Vertical\ Count_{Alternative}$				$Horizontal\ Count_{Alternative}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NBP_{Dummy}	0.0609**	0.0640**			0.0262	0.0408		
	(0.0273)	(0.0315)			(0.0353)	(0.0392)		
$NBP_{Intensity}$			0.0681**	0.0711*			0.0405	0.0622
			(0.0321)	(0.0384)			(0.0363)	(0.0385)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	NO	YES	NO	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES	NO	YES	NO	YES
Observations	2,028	2,028	2,028	2,028	2,028	2,028	2,028	2,028
R-squared	0.0158	0.2517	0.0158	0.2516	0.0197	0.2056	0.0200	0.2062

Table D2. Excluding states that implemented the NBP in 2003.

This table reports a robustness test that excludes states regulated by the NBP in 2003. Specifically, we re-estimate our baseline regressions using a sample that omits firms with NO-emitting plants located in these states, namely, Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island, and the District of Columbia. Applying this exclusion criterion reduces the sample size from 228 to 150 firms. *Controls* include *Log(Size), Log(Age), ROA, Leverage* and *TBQ.* All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include firm and year (or year×industry) fixed effects. The standard errors in parentheses are adjusted for heteroscedasticity and clustering by firm. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable=Acquisition(1/0)				
	(1)	(2)	(3)	(4)
NBP_{Dummy}	0.1704***	0.1738***		
	(0.0435)	(0.0506)		
$NBP_{Intensity}$			0.1680***	0.1736**
			(0.0506)	(0.0666)
Controls	YES	YES	YES	YES
Year FE	YES	NO	YES	NO
Firm FE	YES	YES	YES	YES
Year×Industry FE	NO	YES	NO	YES
Observations	1,301	1,301	1,301	1,301
R-squared	0.0401	0.3073	0.0372	0.3043

Table D3. NBP, payment method and takeover premium.

This table examines the impact of the NBP on firms' choice of payment method and the takeover premium in M&A transactions. Panel A analyzes the relationship between the NBP and the payment method. The specification is: $Percentage\ Stock_i = \beta_0 + \beta_1 NBP_{Dummy\ i}\ (or\ \beta_1 NBP_{Intensity\ i}) + Deal\ Controls_i + Firm\ Controls_{i,t-1} + Year\ FE + Industry\ FE + \varepsilon_i$. The dependent variable, *Percentage Stock,* measures the proportion of the total transaction value paid in the form of the acquirer's stock. *Deal Controls* include *Deal Size, Vertical Deal, Horizontal Deal, Friendly, Tender Offer* and *Public Target*. *Firm Controls* include *Log(Size), ROA, Leverage*, and *TBQ*. Panel B investigates the impact of the NBP on the takeover premiums of transactions involving publicly listed targets. The specification is: $Premium_i = \beta_0 + \beta_1 NBP_{Dummy\ i}\ (or\ \beta_1 NBP_{Intensity\ i}) + Deal\ Controls_i + Firm\ Controls_{i,t-1} + Year\ FE + Industry\ FE + \varepsilon_i$. The dependent variable, *Premium,* is the percentage difference between the offer price and the target's share price 20 trading days (four weeks) prior to the announcement date. *Deal Controls* include *Deal Size, Vertical Deal, Horizontal Deal, Friendly, Tender Offer, Cash,* and *Stock*. *Firm Controls* include *Log(Size), ROA, Leverage*, and *TBQ*. All variables are defined in the Appendix C. Continuous variables are winsorized at the 1st and 99th percentiles. All specifications include year and industry fixed effects. ∗∗∗, ∗∗, and ∗ indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Payment method		
Dependent variable=Percentage Stock		
	(1)	(2)
NBP_{Dummy}	0.0633*	
	(0.0332)	
$NBP_{Intensity}$		0.1012*
		(0.0583)
Deal Controls	YES	YES
Firm Controls	YES	YES
Year FE	YES	YES
Industry FE	YES	YES
Observations	522	522
R-squared	0.3416	0.3438

Panel B: Takeover premium		
Dependent variable=Premium		
	(1)	(2)
NBP_{Dummy}	0.4568**	
	(0.2295)	
$NBP_{Intensity}$		0.5293**
		(0.2511)
Deal Controls	YES	YES
Firm Controls	YES	YES
Year FE	YES	YES
Industry FE	YES	YES
Observations	127	127
R-squared	0.2700	0.2734