Private Equity and Creative Destruction: Evidence from the U.S. Power Sector

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January 30, 2026

Abstract

I study whether private equity (PE) ownership improves allocative efficiency in the U.S. power generation sector by reallocating capital from less efficient to more efficient technologies. Using the staggered expansion of natural gas pipelines from shale-producing regions as plausibly exogenous shocks that shift the relative profitability of fossil fuel power plants, I find that PE owners respond more strongly to these market signals than traditional utilities and other power producers. PE owners are significantly more likely to scale down and retire coal and oil generators once they become uneconomic, while expanding output at more profitable natural gas facilities. I show that PE's advantage stems from lower exposure to local political and labor frictions that constrain traditional utilities. These findings highlight how ownership structure shapes capital reallocation and suggest that financial owners can play an important role in facilitating an efficient transition.

Keywords: creative destruction, energy transition, private equity

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Disclosure statement

The author declares that he has no financial relationships or conflicts of interest that relate to the research described in this paper.

1 Introduction

How efficiently do firms reallocate capital in response to technological shocks? This question is central to economic growth and the process of creative destruction (Schumpeter, 1942; Aghion and Howitt, 1992). In practice, such reallocation is often impeded by regulatory, political, and social frictions, leading firms to maintain unproductive assets while underinvesting in productive ones.[1] This paper studies whether ownership structure affects capital reallocation efficiency by examining the U.S. power generation sector, where the shale gas boom created a stark technological shock that rendered coal and oil-fired generation uneconomic while making gas-fired generation highly profitable.

I find that financial owners such as private equity (PE) firms reallocate capital more efficiently than traditional utilities and power producers in response to this shock. Specifically, PE firms are 4 percentage points more likely than other owners to retire uneconomic coal and oil plants while increasing generation at profitable natural gas plants by 30% after the shock to their profitability. These results stem from PE firms' lower exposure to local political constraints and labor opposition that impede utility decision-making. My results highlight the role of financial markets in improving allocative efficiency in a sector central to economic and environmental outcomes.

Despite the importance of capital reallocation for economic growth and climate goals, there is limited causal evidence on how ownership structure affects this process. The existing literature primarily attributes changes in the electricity market to broad sector-wide forces such as deregulation (Fabrizio, Rose and Wolfram, 2007; Borenstein and Bushnell, 2015). For

[1] For evidence on impediments to creative destruction, see, among many others, studies on regulatory and institutional frictions (La Porta et al., 1998; Djankov et al., 2002); political frictions (Faccio, 2006); and financial frictions and misallocation (Rajan and Zingales, 1998).

example, Andonov and Rauh (2024) show that deregulation explains much of the observed ownership changes and plant retirements and find that, conditional on deregulation, financial owners such as private equity are no more likely than other owners to close power plants.

There are two primary reasons for this gap in the literature. First, measuring asset viability is difficult. Economic viability depends on local market conditions, fuel costs, and competition, factors that typically change gradually, making it hard to identify when assets become uneconomic. Second, ownership is endogenous. Unobserved factors such as managerial slack and poor governance can both attract PE buyers who specialize in addressing these agency problems (Jensen, 1986) and independently raise the probability of closure.

I overcome these challenges by focusing on the power generation sector and exploiting the staggered expansion of natural gas pipelines from shale-producing regions. The power sector provides rich plant-level data on generation, capacity, fuel consumption, and retirement dates, enabling precise measurement of plant-level efficiency and economic viability. More importantly, the sector experienced large, sudden shocks to relative fuel costs. The shale gas boom of the late 2000s sharply reduced natural gas prices, making gas a cheaper substitute for coal and oil in electricity generation. However, adoption of natural gas was initially constrained by limited pipeline capacity to deliver gas to major consuming regions. I exploit the ramp-up of shale production and the staggered construction of major pipelines connecting shale basins to consuming states as exogenous shocks to plant-level profitability, providing sharp, observable variation in asset viability.

I compile data on major pipeline expansions connecting shale-producing regions to consuming states between 2005 and 2020, combining this with comprehensive plant-level data on generation, retirements, and ownership for all U.S. fossil fuel plants. I treat pipeline

arrivals as negative shocks to coal and oil plants and positive shocks to natural gas plants and exploit their staggered timing across states to identify causal effects. The key identifying assumption is that pipeline routes and timing were driven by geographic and infrastructure constraints rather than characteristics of individual plants or owners.

I first confirm that this setting has meaningful economic bite. I show that an exogenous increase in a state's natural gas supply reduces the viability of coal and oil plants: their retirement likelihood increases, and their net generation and profitability decreases. By contrast, gas-fired generators in those states increase their generation. These effects persist after accounting for generator fixed effects and electricity-region–by–year fixed effects, which absorb time-varying shocks common to generators within the same region.

Using this variation, I examine which types of owners are most responsive to these shocks. In particular, I test whether PE owners are more likely than traditional utilities to retire coal and oil plants when profitability falls. I find that PE owners are about 4 percentage points more likely to retire coal and oil units and reduce net generation from these units by more than 60% following the exogenous decline in profitability. In contrast, other owners, such as traditional utilities and local producers, do not respond meaningfully to these shocks, as their plants are no more likely to retire or reduce generation despite economic changes.

These results are robust to plant fixed effects, which absorb all time-invariant plant characteristics, and region-by-year fixed effects, which capture time-varying conditions across different regions. The results are also robust to including deregulated-status-by-year fixed effects, which account for changes in market condition in regulated and deregulated states differently over time, suggesting that PE ownership accelerates inefficient plant retirements over and above any effects of deregulation (e.g., Andonov and Rauh, 2024).

An important question that arises is whether these results reflect selection or treatment effects. In other words, are PE firms simply more likely to acquire plants already on a declining trajectory, or do they behave differently once they own such plants? My empirical setting allows me to separate these channels.

I first document evidence consistent with a selection effect. Following the shale gas boom and the subsequent pipeline expansions, coal and oil units located in treated states, where natural gas became more abundant, are about 0.5 percentage point more likely to be acquired by PE firms, which is rougly a 24% increase from the baseline average of PE ownership of these plants. Event study dynamics show that prior to the shale and pipeline exposure, there is no systematic difference in PE acquisition patterns between treated and untreated states. While I do not observe transaction prices, the revealed preferences implied by these deals suggest that such declining assets are more valuable under PE ownership than non-PE ownership, consistent with the notion that PE firms target underperforming assets with greater scope for value creation (Jensen, 1986).

Next, I ask whether the results are driven entirely by selection or whether there is a treatment effect. To isolate selection from treatment, I re-estimate the effects within a sample restricted to plants acquired by private equity (PE) before the shale gas production started and pipelines were announced and compare their post-shock outcomes to other similar plants in the same local markets that were never PE owned. The identifying assumption is that these acquisitions, which happened even before the pipeline announcement and shale production, were unrelated to subsequent shale or pipeline developments and instead reflected other motives.

Within this restricted sample, PE-owned coal and oil units are about 3.5 percentage

points more likely to retire and reduce generation by over 60% relative to comparable non-PE units. In contrast, PE-owned gas units are about 2.5 percentage points less likely to retire and increase generation by over 60%. This pattern indicates that the results are not driven solely by PE firms targeting already unviable assets but reflect an active role of PE ownership in accelerating retirement of inefficient plants.

Next, I explore the mechanism that drives my results. Traditional utilities and local power producers face several frictions that limit their ability to retire inefficient assets. Power plants are often major local employers and are heavily unionized, creating strong labor and community resistance to shutdowns.[2] In addition, decommissioning power plants exposes owners to litigation risks and reputational damages arising from community challenges over inadequate site remediation, further deterring retirements.[3]

Private equity owners, in contrast, are far less exposed to these social, political, and litigation-related frictions. Their investment horizon is shorter, and their managers are usually geographically detached from the local political environment surrounding the assets. This reduces susceptibility to community and political pressure and allows them to make economically rational shutdown decisions that traditional owners may avoid due to political and local capture. While PE owners remain subject to, and are responsive to, explicit environmental regulations and liabilities (e.g., see Bellon (2025)), they are less exposed to the *implicit* costs that accompany litigation (such as reputational damage), which weigh more heavily on local utilities whose managers and stakeholders live in the affected communities.

I provide several pieces of evidence consistent with this mechanism. First, I test the role of local labor opposition by examining whether utilities find it harder to retire plants in

[2]See these reports of local communities and politicians objecting power plant closures.

[3]See this report on a lawsuit against Alabama Power alleging groundwater contamination from coal ash at one of its retired plants.

states with stronger labor protections. During the sample period, several states adopted right-to-work (RTW) laws that weakened collective bargaining power and reduced union influence. I exploit the staggered adoption of these laws to assess how changes in labor strength affect plant retirements.

I find that stronger pro-labor environments reduce the likelihood of coal and oil unit retirements by about 1.25 percentage points. I do not find a significant effect of these labor law changes on other performance metrics such as net generation or efficiency, which suggests that the mechanism is political and social rather than technological. This evidence highlights the tension between labor policies designed to support local communities and environmental goals that call for the retirement of inefficient assets.

I further examine whether PE ownership mitigates these frictions. I find that PE owners are 3.3 percentage points more likely than traditional utilities to retire coal and oil plants in pro-labor states. In other words, the gap between PE and non-PE retirement outcome is widest in places with strong labor protections. This pattern suggests that PE owners are more resilient to local labor and political pressures and thus more capable of acting on economic signals rather than social constraints.

I next examine whether environmental litigation risk deters traditional utilities from retiring plants and whether PE ownership mitigates this effect. I construct a measure of litigation exposure based on circuit court decisions that expanded citizens' ability to sue firms for environmental violations.[4] In practical terms, these rulings increased expected litigation risk around plant retirements.

[4]From 2010 to 2020, several circuit courts narrowed the "diligent prosecution" bar, which ordinarily limits citizen suits when a government agency is already pursuing enforcement. Courts clarified that weak or noncomprehensive consent decrees, tolerance of ongoing violations, or penalties that fail to deter do not preclude citizen suits (Adelman and Reilly-Diakun, 2021).

Using the staggered timing of these decisions across circuits in a difference-in-differences setting, I find that strengthened citizen-suit rights are associated with fewer coal and oil retirements by non-PE owners in affected areas, consistent with higher expected reputational and legal costs for local utilities. In contrast, PE-owners are 8 percentage points more likely than non PE-owners to retire coal/oil units after these legal shifts. This pattern suggests that the salience of these liabilities binds more for traditional utilities with local community and political exposure than for PE owners.

Overall, my results show that the same environmental and social instruments, such as labor bargaining protections and citizen-suit rights, which are designed to improve environmental and social outcomes, can inadvertently hinder creative destruction. Local and public utilities are more susceptible to these frictions than financial owners such as private equity firms, which are less embedded in local communities and therefore less exposed to political pressures and liability constraints. As a result, PE owners are better able to respond to market signals and reallocate capital toward more efficient technologies.

Literature review:

First, this paper relates to the literature on finance and creative destruction (Schumpeter, 1942; Aghion and Howitt, 1992).[5] My paper adds to this literature and shows that environmental and social policies, which are intended to protect communities and the environment, can also inhibit creative destruction, and that financial owners, such as PE, can help overcome these frictions.

Second, I relate to the literature on the impact of private equity. Prior work have shown

[5]Several seminal work have shown that financial markets and institutions play a key role in alleviating frictions related to market power, financing constraints, and regulations (Rajan and Zingales, 1998; Caballero, Hoshi and Kashyap, 2008; Levine, 2005), which improves allocative efficiency and facilitates growth.

that PE ownership is often associated with increased financial distress and firm default due to higher leverage associated with the PE deals (Kaplan and Stein, 1993; Hotchkiss, Smith and Strömberg, 2021; Axelson et al., 2013). An important but unanswered question is whether PE owners destroy value by closing otherwise viable firms or improve allocative efficiency by accelerating the exit of inefficient assets. I reconcile this debate by showing that the effect of PE ownership on closures is state-dependent: PE owners accelerate retirements and scale back production at assets that become uneconomic, but they also expand production at profitable assets, thereby improving allocative efficiency.

A growing literature studies how PE ownership affects environmental and real outcomes, including pollution (Shive and Forster, 2020; Bellon, 2025), new business formation (Kumar, 2025), innovation (Popov and Roosenboom, 2009; Lerner, Sørensen and Strömberg, 2011), and effects on industry peers (Bernstein et al., 2017; Aldatmaz and Brown, 2020). Bellon (2025) shows that PE effects on pollution are sensitive to environmental liabilities: emissions rise where liability risk is weaker and fall where it is stronger. I complement this result by showing that PE owners are less sensitive than other owners to implicit costs such as local perceptions and political pressure, which allows them to respond more strongly to market signals.

Finally, this paper contributes to the energy finance literature. Prior work attributes much of the sector's changes, such as plant retirements and new plant creation, to deregulation in the 1990s and early 2000s (Borenstein and Bushnell, 2015; Cicala, 2022). For example, Andonov and Rauh (2024) report that while deregulation increases shutdowns of inefficient units, controlling for deregulation they find no additional association between PE ownership and plant retirements. Relatedly, Knittel, Metaxoglou and Trindade (2015) highlight that restructuring altered investment incentives, with regulated utilities more responsive to fuel

prices than independent power producers, whose market exposure weakened their incentives to invest.

I extend this literature by examining forces beyond market restructuring, using a causal design that exploits exogenous variation in plant viability arising from the shale boom and staggered natural gas pipeline expansions. Once endogeneity is addressed, I find that ownership plays a central role: PE owners are significantly more likely to retire plants that become economically unviable, while less likely to retire those that remain viable.

Several papers have used the shale boom as an exogenous shock, including work that exploits shale discoveries and production news to study finance and real outcomes (e.g., Gilje and Taillard, 2016; Gilje, Loutskina and Murphy, 2020). Fewer papers have used pipeline expansions as a shock to natural-gas availability. A notable exception is Scott (2023), who shows that proximity to existing pipelines increased fuel switching from coal to gas after the Mercury and Air Toxics Standards (MATS) rule. I build on this empirical approach by using the introduction of new interstate pipelines, rather than pre-existing lines, as a staggered shock to natural-gas availability across states and years.

2 Institutional background and data

Shale gas: The U.S. witnessed a major shale gas boom in the late 2000s and early 2010s, driven by the rapid adoption of horizontal drilling and hydraulic fracturing technologies, which made large volumes of gas economically recoverable from previously hard-to-extract rock formations. This technology shift led to a steep increase in shale gas production and a large decline in U.S. natural gas prices, with estimates suggesting price levels were roughly

40–50 percent lower than they would have been without the boom (Hausman and Kellogg, 2015; Joskow, 2013). For the power sector, this shock primarily affected the relative operating costs of different technologies: gas-fired units became substantially cheaper to run, while coal and oil units economically uncompetitive in regions where gas supply expanded.

I collect data on shale gas production from the EIA Drilling Productivity Report and Form 914. These sources provide monthly natural gas production by shale region and by state, which I aggregate to the annual state–year level. I focus on the largest shale plays: Marcellus, Haynesville, Utica, Fayetteville, Barnett, and Woodford. These shale plays are importantly 'dry gas', which means they only expanded the natural gas supply and did not meaningfully expand the crude oil supply. This feature allows me to compare natural gas against both coal and oil fuels. Within these regions, I define a state as treated in the first year its shale production exceeds 100 billion cubic feet (Bcf), and it remains treated thereafter. This state-level assignment is also consistent with EIA reports on when states have large production increase of natural gas. My results are also robust to alternative production thresholds and to production per-capita measures.

Pipeline expansions: While the shale boom led to an unprecedented surge in natural gas production, the ability to use this gas for power generation was initially limited by distribution constraints. Much of the interstate pipeline network had been designed around pre-shale production capacity. The sudden increase in large-scale production from new shale basins, such as Marcellus, Utica, and Haynesville, created bottlenecks because these areas lacked sufficient takeaway capacity to deliver gas to consuming regions.[6] In response, many new interstate pipeline projects were initiated in the late 2000s and 2010s to move shale gas

[6]See the 2012 EIA Report that discusses how the growth in Marcellus gas supply outpaced the take-away pipeline capacity from Pennsylvania.

from production basins to major load centers and power markets. These projects expanded the supply of cheap natural gas to new markets and made natural gas generators more competitive than coal and oil units.

To capture this expansion, I compile project-level data from the Energy Information Administration (EIA), including route, capacity, in-service year, and states it services. I keep new pipelines that begin in shale-producing regions and end in non-shale states and exclude small projects with a capacity of less than 500 million cubic feet per day (MMcf/d) to focus on large infrastructure projects that had meaningful effect on the takeaway capacity. I use the first in-service year as the timing of the local gas-availability shock. I also include projects that link shale-producing regions to major existing interstate pipelines that were previously not connected because these connections similarly increased the flow of low-cost shale gas into downstream markets.

This pipeline-based measure provides a novel empirical approach relative to studies that rely solely on shale production measures, because it captures the transmission of gas from producing basins to downstream demand centers rather than production at the wellhead alone. While related work uses the existing pipeline network's proximity to study how infrastructure shapes coal plant outcomes (Scott, 2023), my setting is one of the first, to my knowledge, to exploit the staggered expansion of new interstate pipelines as shocks to local assets viability.

Figure 1 illustrates the evolution of the shale gas boom and the subsequent build-out of major interstate pipelines, highlighting the timing and geographic spread of these shocks. The earliest shale developments occurred in the southern region, beginning with the Barnett Shale in Texas around 2005, followed by Fayetteville in Arkansas in 2007 and Haynesville spanning Louisiana in 2008. A few years later, production surged in the Marcellus formation,

primarily in Pennsylvania and West Virginia in 2010, and subsequently in the Utica formation of Ohio in 2012. The increased gas production in Appalachian basin was highly consequential because of its proximity to large population centers in the northeast and midwest.

This increase in production prompted a wave of large pipeline expansions designed to move cheap shale gas from producing basins to downstream demand centers. The figure highlights several key projects. The Rockies Express (REX) Pipeline began substantial eastbound service in 2010, coinciding with the acceleration of Marcellus output. The TETCO New Jersey-New York expansion increased flows into New Jersey and New York around 2013, easing constraints into the New York City metropolitan region.[7] The Transco Leidy Southeast expansion, placed in service in 2015, connected Marcellus gas to markets throughout the Southeast and significantly increased regional takeaway capacity. Finally, the Algonquin Incremental Market (AIM) project, placed in service in 2016, played a central role in expanding natural gas supply into New England.[8]

I define treatment at the state level based on the staggered timing of the shale gas ramp and major pipeline expansions. For shale states, a state is treated in the first year its shale production exceeds 100 billion cubic feet (Bcf) and remains treated thereafter. For pipeline states, a state is treated beginning in the year the relevant pipeline enters service. I manually verify that this state-level treatment corresponds to meaningful increases in gas supply by cross-checking against EIA reports on shale gas production, and my results are robust to alternative measures based on production per capita.

Generator characteristics: I construct a generator–year panel of fossil-fuel units in the United States from 2000 to 2023 using the U.S. Energy Information Administration

[7] See the 2012 EIA report discussing how the TETCO NJ–NY expansion increased capacity into NYC.
[8] See the full discussion in this 2016 EIA report.

(EIA). Generator characteristics come from EIA Form 860, which reports unit-level fuel type, technology, nameplate capacity, and ownership for electric power plants with at least 1 megawatt (MW) of installed capacity. Operating outcomes come from EIA Form 923, which provides annual electricity generation, fuel consumption, and heat content. I aggregate data from these forms for all units that operate on coal, natural gas, or oil. I exclude commercial and industrial generators that do not sell electricity into wholesale markets.

Ownership: I collect plant-ownership data from S&P Capital IQ, which compiles asset-level ownership for power plants in the US, and supplement this with hand-collected data from news articles, PR newswire, and homepages of private equity firms. A generator is classified as PE-owned in a given year if private equity funds collectively hold more than 25% of the unit's equity. All other units are classified as non-PE–owned, which includes publicly traded electric utilities, privately held independent power producers, and other energy companies.

Summary statistics: Panel A of Table 1 presents summary statistics for all generator-year observations by primary fuel type. Coal units are the oldest in the sample, averaging about 40 years of age, compared with 28 years for oil and 22 years for natural gas generators. Coal plants also tend to be much larger and operate more intensively: the average coal generator has a nameplate capacity of roughly 267 MW and a capacity factor near 0.5, while gas units average 94 MW with a capacity factor of 0.22, and oil units are small peaking units averaging only 14 MW and operating about 3 percent of the time. Coal units generate substantially more electricity (about 1,282 GWh annually) than oil (9 GWh) or gas (194 GWh) units. Retirement rates are low overall but highest among coal generators (3 percent), followed by oil (2 percent) and gas (1 percent). On average, 4 percent of coal, 3 percent of oil, and 11 percent of gas generators are private-equity owned.

Panel B further splits generators by ownership type (PE vs non-PE) and fuel group. Among coal/oil units, PE-owned generators are similar in age to non-PE units (about 31 years) but are somewhat larger on average (92 MW vs. 76 MW) and exhibit slightly higher utilization (capacity factor 0.17 vs. 0.15). Annual output is comparable across ownership types (about 297 vs. 323 GWh), and retirements remain low though marginally higher for PE (3% vs. 2%). In natural gas, PE-owned units are notably younger (17 vs. 22 years) and larger (119 vs. 91 MW), with meaningfully higher utilization (capacity factor 0.29 vs. 0.21). PE-owned gas generators produce nearly double the average annual electricity of non-PE gas units (342 vs. 177 GWh). Retirement rates for gas are uniformly low at roughly 1% for both ownership categories. Overall, PE-owned coal and oil generators exhibit broadly similar characteristics to non-PE-owned ones, whereas PE-owned gas units tend to be somewhat younger, larger, and operate at higher utilization rates.

3 Effect of gas supply shock on coal/oil viability

3.1 Empirical design

I begin my analysis by testing whether my setting has a meaningful economic bite. Specifically, I study the effects of the shale boom and the following pipeline expansions on coal/oil generators relative to natural gas generators. I define states that have expanded natural gas supply due to shale boom and pipeline expansions as treated states after the supply shock.

To estimate the effect of treatment on plant level outcomes, I employ a staggered difference-in-differences design. Recent econometric work has shown that a standard two-way fixed

effects (TWFE) estimators may yield biased estimates when treatment timing is staggered and treatment effects are heterogeneous.[9] To address these concerns, I first balance the panel by restricting the treated sample to six years before and after the treatment. I then follow the methodology proposed by Sun and Abraham (2021), which accounts for cohort-specific and time-varying treatment effects. Specifically, I estimate the following saturated specification:

$$y_{i,t} = \alpha_i + \gamma_t + \sum_g \sum_{k \neq -1} \beta_{g,k}(1\{G_g = g\} \cdot D_{i,t}^k) + Controls_{i,t} + \epsilon_{i,t} \tag{1}$$

where $1G_i = g$ is an indicator for the treatment cohort g and $D_{i,t}^k$ is an indicator for the relative year k since treatment. The coefficients $\beta_{g,k}$ capture cohort-specific average treatment effects at each relative period. I report the weighted average of these cohort-specific estimates, using cohort sample shares as weights. My results are robust to alternative specifications, for example, as suggested in Callaway and Sant'Anna (2021).

I consider several dependent variables to capture different dimensions of economic viability. First, a generator-retirement indicator equals 1 in the year a generator retires and 0 otherwise. Second, I use the log of unit-level net generation (MWh). Third, I use the log of net profits. Net profits are calculated as total revenue from electricity sales minus fuel costs.

3.2 Results

I begin by examining the dynamic effect of the supply shock on coal and oil generator retirements. I estimate Equation 1 with plant and year fixed effects and two-way clustered standard errors at the state and year levels. I present the coefficient estimates and 95% confidence intervals in Figure 2. The figure provides two key pieces of evidence in support

[9] For an overview, see Baker, Larcker and Wang (2022).

of my results. First, the two groups follow parallel trends prior to the shock, alleviating concerns that coal and oil units were already retiring at higher rates than gas units. Second, there is a sharp increase in the retirement likelihood of coal and oil units immediately after the shock, indicating that the shock materially affected these generators' viability.

Table 2 presents estimates from the staggered difference-in-differences specification in Equation 1, reported separately for coal, oil, and gas generators. Columns (1) and (3) show that the gas supply shock raises the probability of retirement within six years by 3.4 percentage points (p.p.) for coal units and 1.44 p.p. for oil units in treated states relative to controls. Columns (2) and (4) indicate a 35% decline in net generation for coal units, with no statistically significant change for oil units. To validate that the shock is positive for natural-gas units, I estimate the same specification for gas-fired generators and find no increase in retirements and, in fact, an increase in net generation of about 14.4% in treated states over the subsequent six years compared with control states.

To further validate that these effects are driven by shale shock to coal and oil fuel viability and not some other geographic shock that affects all fuel generators equally, I run an interacted specification akin to a difference-in-difference-in-differences where I study whether the effect of this shock was differentially higher for coal/oil plants than for gas plants. More specifically, I estimate a specification of the following form:

$$y_{i,t} = Plant_i + Region_r \times Year_t + \beta \times Post\,Shale\,Pipe_{i,t} \times Coal/oil_i + \epsilon_{i,t} \tag{2}$$

where $y_{i,t}$ are generator level outcomes, such as unit retirement likelihood, net generation, and profits for unit i in year t, $Post\,Shale - -Pipe_{i,t} = 1$ if generator i is in treated state in year t and zero otherwise, and $Coal/oil_i$ takes 1 if the generator i is coal or oil powered

and 0 if it is gas-powered. In addition to plant fixed effects, which control for time-invariant plant characteristics, I include a stricter set of NERC-region-by-year fixed effects to absorb time-varying shocks common to generators operating within the same electricity market region. Standard errors are twoway clustered at the state and year level.

Table 3 reports the results. Column (1) shows that, after the gas supply shock, coal and oil generators became 2.33 percentage points more likely to retire than comparable gas units, while there is no statistically discernible post-shock change in retirements among gas units. Columns (2) and (3) indicate that coal/oil units' net generation fell by about 0.95 log points, roughly 60 percent, and their net profits declined by about three-quarters of a log point, roughly one-half, relative to gas generators. The profit result is based on the subsample with coal and gas fuel cost data, so it should be interpreted with that limitation in mind.

Overall, these results show that the shale gas boom and pipeline expansions significantly reduced the economic viability of coal/oil fueled generators, while making gas units more profitable. This serves as a relevant and strong 'first-stage' result that underpins the following analysis.

4 Effect of PE ownership on unit outcomes

4.1 Linear difference-in-differences model

Next, I study whether ownership structure affects the retirement likelihood of plants that are inefficient and unviable. A naive OLS regression of ownership interacted with any measure of efficiency on retirements would yield biased estimates because unobserved factors, such as managerial quality and governance structure would jointly affect both plant's efficiency, its

retirement likelihood, and its likelihood of PE ownership.

To address this endogeneity, I exploit the shale boom and pipeline expansions described above. Shale and pipeline shocks exogenously increased the availability of natural gas and reduced natural gas prices, making it a cheaper substitute for coal and oil in electricity generation. As a result, coal and oil units became a lot less competitive in the electricity market.

I examine whether financial owners of the power plants, such as PE firms respond differently to these exogenous changes in assets viability. Specifically, I estimate the following baseline specification:

$$y_{i,t} = Plant_i + Region_r \times Year_t + \beta \times Post\,Shale\,Pipe_{i,t} \times PE\,owner_{i,t} + \epsilon_{i,t} \qquad (3)$$

where $y_{i,t}$ are generator level outcomes, such as unit retirement likelihood and net generation for unit i in year t and $Plant_i$ and $Region_r \times Year_t$ are plant and electricity-region-by-year fixed effects, respectively, $Post\,Shale\,Pipe_{i,t} = 1$ if generator i is in treated state in year t and zero otherwise, and $PE\,owner_{i,t}$ takes 1 if the unit i is owned by a PE owner in year t. Standard errors are twoway clustered at the state and year level. In my specifications, I include an Electricity-region-by-year fixed effect to take into account time-varying changes happening in different electricity regions during my sample.

Table 4 first reports specifications with NERC-region-by-year fixed effects, which absorb time-varying shocks common to generators in the same electricity market. Columns (1) and (3) show that, after the shale-pipeline shock, PE-owners are about 4 percentage points more

likely to retire their coal and oil units and reduce their net generation by roughly 1.2 log points, relative to comparable non-PE units in the same regions and period. This corresponds to a large drop in output from PE-owned coal/oil capacity, while non-PE owners exhibit no comparable change in retirement or generation.

Columns (5) and (7) repeat the analysis for natural-gas generators and indicate that PE ownership is associated with slightly lower retirement probabilities (around 0.5 percentage points) and somewhat higher generation (about 0.3 log points), while non PE-owners do not respond differently. This suggests that PE owners are more sensitive to market forces and reallocate capital more actively than non-PE owners.

The results are also robust to including deregulated-status-by-year fixed effects, which allow market conditions to evolve differently over time in regulated and deregulated states. Columns (2), (4), (6), and (8) show that the coal/oil retirement and generation effects for PE owners remain very similar in size and significance once this richer set of fixed effects is included. Thus, the findings suggest that the estimated effects are not driven by deregulation, which has been the primary focus of the existing literature (Fabrizio, Rose and Wolfram, 2007; Andonov and Rauh, 2024). Even after accounting for differential trends between regulated and deregulated markets, PE-owned coal and oil units remain substantially more likely to retire following the gas shock.

4.2 Cox proportional hazards model

While the linear specifications above allow for a straightforward interpretation of changes in the likelihood of retirement following the shale-pipeline shock, they treat retirement as a repeated binary outcome and do not fully capture the timing of exit. To alleviate the

limitations of a linear specification, I employ a Cox proportional hazards framework, which explicitly models the timing of retirement, conditions on a generator's survival up to each period, and accommodates right-censoring for units that remain active through the end of the sample. This approach allows me to study whether PE ownership accelerates the timing of exit following the shale-pipeline shock, rather than simply increasing annual retirement probabilities, while accounting for heterogeneity in baseline retirement risk across different market environments.

More specifically, I estimate the following specification:

$$h_i(t \mid X_{i,t}) = h_{0,s}(t) \exp\Big(\beta_1 \, PE_{i,t} + \beta_2 \, PostShalePipe_{i,t} + \beta_3 \, (PE_{i,t} \times PostShalePipe_{i,t}) + Controls_{i,t}\Big), \tag{4}$$

where $h_i(t \mid X_{i,t})$ denotes the hazard that generator i retires at time t, conditional on remaining active up to t, and $X_{i,t}$ denotes the vector of covariates for generator i in year t, including $PE_{i,t}$, an indicator for private equity ownership, $PostShalePipe_{i,t}$, an indicator for exposure to the post–shale-pipeline period, their interaction, and additional controls. The baseline hazard $h_{0,s}(t)$ is allowed to vary flexibly across strata s, so that the underlying timing of retirements can differ across market environments while the covariate effects are identified from within-stratum comparisons over time.

Table 5 reports the results from these hazard specifications. Columns (1)–(3) allow the baseline hazard to vary across three economically meaningful market environments: regulated versus deregulated states, electricity grid regions, defined as NERC, and local operating areas where dispatch and reliability decisions are made, defined as balancing authorities (BAs). This structure absorbs persistent differences in market design, grid conditions, and

operational constraints that can shape the timing of retirements, while identifying the effect of PE ownership and the shale-pipeline shock from within-environment comparisons.

Across all three stratification schemes, the interaction between PE ownership and the post–shale-pipeline period is positive and statistically significant, which indicates that PE-owned coal and oil generators face a substantially higher hazard of retirement following the gas supply shock than comparable non-PE units operating in the same market environments. The estimated hazard ratios imply that, after the shale-pipeline expansion, PE-owned units are roughly 70 to 120 percent more likely to retire in a given year, conditional on survival up to that year. Interpreted in odds terms, the estimate in column (2), which stratifies by NERC region, implies that after the shale-pipeline shock, PE-owned generators face roughly twice the odds of retirement in a given year, conditional on survival up to that year, relative to non-PE generators within the same region.

In contrast, the main effect of PE ownership is small and statistically insignificant across specifications, suggesting that PE-owned units do not exhibit systematically different retirement hazards prior to the shock. The post–shale-pipeline indicator is positive in all specifications but varies significantly across strata, consistent with substantial heterogeneity in retirement dynamics across grid-level market structures.

Overall, these results reinforce the findings from linear model and shows that PE owners respond more aggressively to the economic changes induced by the shale-pipeline expansion by accelerating generator retirements once the shock occurs, and that this pattern is robust to alternative ways of allowing baseline retirement timing to differ across regulatory and grid environments.

4.3 Isolating Treatment from Selection

So far, I have shown that PE firms are more likely to retire coal and oil generators following an exogenous shock to their viability. A natural question is whether this pattern reflects selection, *i.e.*, PE firms acquiring plants already on a declining trajectory, or a treatment effect, whereby PE ownership itself increases retirements. To separate selection from treatment, I exploit variation in the timing of PE acquisitions.

First, I show evidence consistent with selection. Figure 3 plots the share of fossil-fuel plants owned by private equity over time, separately by fuel type and by whether a plant is located in a shale-pipeline state. Across all fuel types, PE ownership rises more sharply in shale-pipeline states beginning in the early 2010s, coinciding with the shale-gas and pipeline expansion period highlighted in the shaded region. The divergence is most pronounced for coal plants, where PE ownership in shale-pipe states increases from less than 5% in 2009 to over 10% by 2016, and remains substantially higher than in other states thereafter. Oil plants show a similar but more modest pattern. Over the same period, PE ownership changes much less in other states. Overall, these trends suggest that PE firms disproportionately acquire coal and oil plants in shale-pipeline states following the shale-pipeline boom.

The descriptive patterns above suggest that PE acquisitions of coal and oil plants increase in shale-pipeline states during this period. I next test this pattern more rigorously in a regression framework that exploits variation in the timing of the shale-pipeline shock across states and over time. Specifically, I estimate Equation 1 with $PE\ acquired_{i,t}$ as the dependent variable, which equals 1 if unit i goes from being non-PE-owned in $t-1$ to PE-owned in year t.

Figure 4 presents the dynamic effect of the supply shock on PE ownership. As the figure

shows, before the supply shock, there is no significant difference between PE acquisition of new plants in treated states and control states relative to the base year, suggesting a parallel pre-trend. Following the shock, however, I find a significant increase in PE acquisition of new plants in treated states relative to control.

I present aggregate treatment effect estimating Equation 1 in Table 6. Across the specifications, I find a roughly 0.5 p.p. increase in the likelihood of a coal/oil plant being acquired by PE firm in the treated states in the next 5 years following the supply shock relative to the pre-shock period. This is an economically significant increase of roughly 24% from the baseline mean of PE ownership.

This piece of evidence shows the presence of a selection effect. While I do not observe transaction prices, the revealed preferences implied by these deals suggest that declining assets are more valuable under PE ownership than non-PE ownership. I hypothesize that these assets were sold at a cheaper price than other similar generators in economically viable states. This evidence is also consistent with the broader notion that PE firms target underperforming assets with greater scope for restructuring or value creation (Jensen, 1986).

As I show above, following shale gas and pipe expansions, PE firms are more likely to acquire plants that become economically unviable. However, before the discovery of shale gas and pipeline announcements, PE acquisitions were likely driven by other motives, such as operational improvements and growth opportunities, and should not have been driven by their relative advantage in owning unviable plants. I exploit this feature to tease out the treatment effect by shutting down the selection channel. More specifically, I restrict the treated sample to fossil fuel plants acquired by PE firms *before shale discoveries and pipeline announcements* in the treated states and compare subsequent retirements of these plants to

the observationally comparable plants in those states that were *never acquired* by a PE firm. The identifying assumption is that PE acquisitions that happened before shale production started or before the pipelines were even announced were motivated by reasons other than handling unviable plants.

I estimate the following difference-in-differences specification:

$$y_{i,t} = Plant_i + Region_r \times Year_t + \beta \times \text{PE Pre shock}_i \times \text{Post shock}_t + \varepsilon_{i,t}, \tag{5}$$

where $y_{i,t}$ measures retirement and net generation of unit i in year t; $Plant_i$ and $Region_r \times Year_t$ are plant and electricity-region-by-year fixed effects, respectively. The coefficient of interest, β, captures the differential change in retirement likelihood after supply shock for plants acquired by PE firms before the shock relative to plants that were never PE-owned.

Table 7 presents results from this analysis. Column (1) shows that even among these pre-existing PE-owned assets, coal and oil units are about 3.5 percentage points more likely to retire after the gas supply shock, relative to comparable non-PE-owned units in the same regions. Column (2) indicates that PE-owned coal and oil units also reduce their net generation by about 1.15 log points, equivalent to roughly a 68% decline, following the shock. In contrast, non-PE owners exhibit no significant change in retirement likelihood or output.

For natural gas generators, which benefited from the shock, the pattern is reversed and remains consistent with the overall sample. Columns (3) and (4) show that PE-owned gas units are about 2.5 percentage points less likely to retire and increase generation by roughly 0.61 log points in treated regions after the positive supply shock, consistent with PE owners reallocating production toward more profitable technologies. Non-PE-owned gas units display no comparable change.

Overall, the evidence suggests that PE owners are more responsive to market conditions, adjusting production and retirement decisions in line with those conditions. In doing so, they improve allocative efficiency by cutting output from plants that are negatively affected and increasing output where the shock is positive.

5 Mechanisms

Next, I explore the mechanisms underpinning these results. Specifically, I focus on several political, social, institutional, and environmental litigation related frictions that make retiring unprofitable assets costlier for traditional utilities and local power producers than for financial owners such as PE.

5.1 Political and social frictions

Power plants serve as major employers within their local communities, often providing high-paying, unionized jobs, and constitute an important source of tax revenue for local governments. Consequently, there is a strong opposition to any plant closure by the local communities, especially by the employees and local politicians.[10]

Private equity owners, in contrast, are far less exposed to these social, political, and litigation-related frictions. Their investment horizons are shorter, and their managers are usually geographically detached from the assets. This reduces susceptibility to community and political pressure and allows them to make economically rational shutdown decisions that traditional owners may avoid due to political or local capture.

[10]See these reports of local communities and politicians objecting power plant closures:

I provide some evidence consistent with this mechanism. First, I test the role of local labor opposition: I examine whether strengthening local labor protections make it more difficult for utilities to retire old assets. Studying this is empirically challenging because it is difficult to find exogenous variations in labor protection rights that leaves other factors, such as the ownership and governance structure, unchanged.

To overcome this challenge, I exploit the staggered adoption of right-to-work (RTW) laws by several states during my sample period. These laws weaken collective bargaining power and reduce union influence. Using the adoption of these acts in a staggered diff-in-diff setting, I ask whether reducing labor's strength to oppose increases the likelihood of plant retirements. More specifically, I test the following specification:

$$Retired_{i,t} = Plant_i + Year_t + \beta \times \text{Pro-ES}_i \times \text{PE owner}_t + Post\,Shale\,Pipe_{i,t} + \varepsilon_{i,t}, \quad (6)$$

where $Retired_{i,t}$ take 1 if unit i retires in year t and zero otherwise; $Plant_i$ and $Year_t$ are plant and year fixed effects, respectively; and $Post\,Shale\,Pipe_{i,t} = 1$ if generator i is in the state affected by shale and pipe-led supply shock. In this analysis, $Pro\text{-}ES_{i,t}$ refers to pro-labor environment of the state that the unit is it: it takes 1 if unit i is in a state that does not have RTW in year t and zero otherwise.

Table 8 reports the results. I first show in Column (1) that stronger pro-labor environments reduce the likelihood of coal and oil retirements: following a shift toward pro-labor policies, these units are about 1.25 percentage points less likely to retire, after controlling for the shale-pipeline supply shock.

I then examine whether private-equity (PE) ownership mitigates these frictions by estimating Equation 6 in Column (2). I find that non-PE owners retire plants less often when a state becomes more pro-labor, whereas PE owners are significantly more likely than traditional utilities to retire inefficient plants in pro-labor states. Column (2) shows that a more pro-labor environment reduces the retirement probability for non-PE owners by about 1.4 percentage points, similar to Column (1). However, the interaction term indicates that PE owners are roughly 3.4 percentage points more likely to retire coal and oil units relative to non-PE owners in pro-labor states, suggesting that these financial owners are less constrained by local labor opposition.

Columns (3) and (4) repeat the analysis for natural gas units and show no significant effects of labor policy changes on retirements, nor any meaningful difference between PE and non-PE ownership. This pattern supports the interpretation that PE-induced responsiveness is concentrated among unviable, inefficient assets, where labor related frictions are higher.

These findings suggest that pro-labor environments, which are intended to protect labor rights, can also impede the process of creative destruction by delaying reitrement of inefficient assets. The presence of financial owners, such as PE firms, can mitigate these frictions, as they are less susceptible to local labor and political pressures and more capable of acting on economic signals rather than social constraints.

5.2 Environmental litigation-related frictions

Decommissioning power plants exposes owners to litigation and reputational risks related to environmental cleanup. When a plant shuts down, owners are responsible for remediating

the site by safely managing waste and hazardous materials.[11] Inadequate remediation can lead to lawsuits from local communities, which not only impose direct litigation costs but also indirect reputational costs to utilities with strong local ties.

Although PE owners remain subject to and responsive to explicit environmental regulations and liabilities (e.g., Bellon (2025)), they are less exposed to the *implicit* litigation-related costs, such as reputational damage, that weigh more heavily on local utilities whose managers, customers, and other stakeholders are more deeply embedded in the affected communities. Consequently, the threat of community backlash and associated reputational loss are more costly for traditional utilities than for PE owners.

I examine whether environmental litigation risk deters traditional utilities from retiring plants and whether PE ownership mitigates this effect. I construct a measure of litigation exposure based on several circuit court decisions, from 2010 to 2020, that expanded citizens' ability to sue firms for environmental violations (Adelman and Reilly-Diakun, 2021). These decisions narrowed the "diligent prosecution" bar, which ordinarily prevents citizen suits when a government agency is already pursuing enforcement. Courts clarified that weak or incomplete government settlements or enforcement that doest not stop ongoing violations do not preclude citizen suits.

In practical terms, these rulings raised the expected threat of private enforcement surrounding retirement decisions, especially in jurisdictions where regulatory settlements are lenient or incomplete. If traditional utilities internalize higher reputational and relational costs from such suits, they may delay or avoid retirements that could trigger litigation, whereas PE owners, who are less exposed to these implicit costs, should be less deterred by

[11] See this report on a lawsuit against Alabama Power alleging groundwater contamination from coal ash at one of its retired plants.

the same increase in expected litigation risk.

I implement a difference-in-differences design that exploits the staggered timing of these circuit court decisions and estimate Equation 6 to test whether PE owners respond differently than non-PE owners to shifts in litigation risk. In this sp ecification, $Pro\text{-}ES_{i,t}$ indicates the pro-litigation environment of unit i in year t: it equals 1 if the unit's relevant court expanded citizens' ability to sue in year t, and 0 otherwise.

Table 9 presents results from this analysis. Column (1) shows that, controlling for the shale-pipeline shock, stronger citizen-suit rights are associated with a modest decline in coal and oil retirements, though the effect is not statistically significant. Column (2) distinguishes by ownership and reveals a clear divergence: a pro–citizen-suit environment reduces the retirement probability of non-PE coal and oil units by about 1.2 percentage point but increases the likelihood of retirement for PE-owned units by roughly 8.4 percentage points relative to non-PE owners. This differential is both statistically and economically significant, suggesting that PE owners are less deterred by potential legal or reputational costs and more willing to exit when environmental scrutiny intensifies. Columns (3) and (4) show no similar effects for natural-gas units.

Overall, the evidence suggests that salience of these liabilities binds more for traditional utilities with local community and political exposure than for PE owners. Local reputational and political pressures raise the shadow cost of litigation for traditional utilities, which reduces their propensity to retire plants, whereas PE owners face weaker implicit costs and therefore retire inefficient plants more readily.

6 Conclusion

I show that PE owners improve allocative efficiency in the power sector by accelerating the exit of uneconomic plants and investing more in efficient ones. To establish causality, I exploit two quasi-natural experiments: the shale gas boom and the staggered expansion of natural gas pipelines, which increased gas availability and made coal and oil less competitive as fuels than gas. In a difference-in-differences framework, I find that coal and oil units owned by PE firms are more likely to retire following these negative shocks than comparable units not owned by PE. This pattern is consistent with PE owners being less constrained by local political pressures and cleanup liabilities that often delay retirement decisions for traditional utilities.

My results have two main policy implications. First, the paper highlights a tension: the same environmental and social instruments, such as labor bargaining protections and citizen-suit rights, which are designed to improve environmental and social outcomes, can inadvertently hinder creative destruction. Therefore, policies supporting energy transition should take into account the political and social costs borne by the local communities.

Second, ownership of the assets undergoing transition matter. Local and public utilities are more susceptible to local, social, and political frictions than financial owners such as private equity firms, which are less embedded in communities and thus less exposed to political pressures and liability constraints. As a result, private equity owners are better able to respond to market signals and reallocate capital toward more efficient technologies. Therefore, regulations that restrict financial investors in the energy sector or promote blanket divestment may unintentionally slow creative destruction and impede the energy transition.

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Figures

Figure 1: Shale production and pipeline expansions map and timeline

This figure illustrates the evolution of the shale gas boom and the subsequent build-out of major interstate pipelines, highlighting the timing and geographic spread of these shocks. The shaded areas represent the shale regions and each solid colored line depicts the major pipelines.

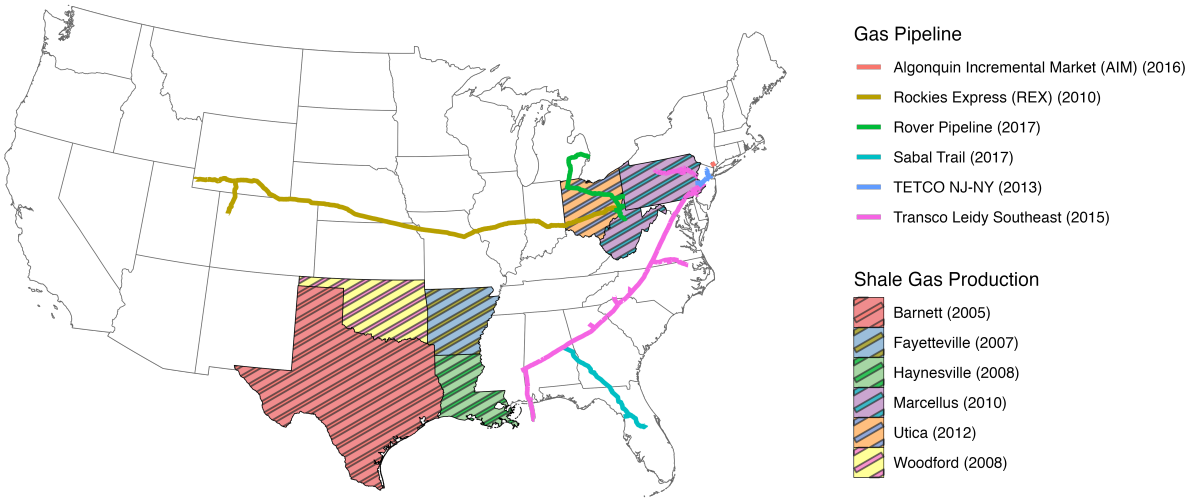


Figure 2: Shale-pipe shock and coal/oil unit retirement

This figure plots the dynamic difference-in-differences estimates of the shale boom and pipeline expansions on the retirement likelihood of coal- and oil-fueled generators, following the difference-in-differences framework of Sun and Abraham (2021). The coefficients represent yearly effects relative to the year immediately before treatment, with 95% confidence intervals shown for six years before and six years after the supply shock. Standard errors are two-way clustered by state and year.

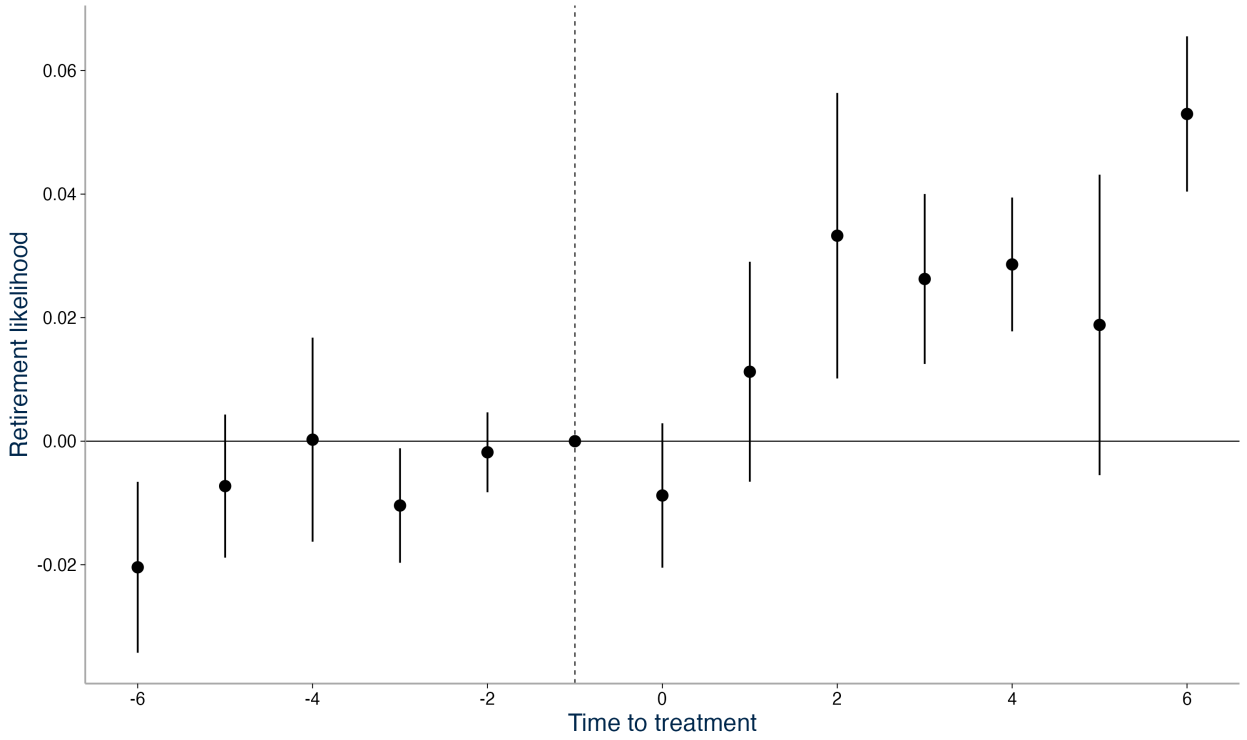


Figure 3: Share of PE-owned fossil-fuel plants by fuel type and shale-pipe exposure

This figure plots the fraction of plants owned by private equity (PE) over time, separately for states exposed and not exposed to shale-gas pipeline expansions. Panels are split by primary fuel type (coal, oil, and gas). The shaded region marks the period 2010–2015, when shale-related infrastructure expanded most rapidly. The y-axis shows the fraction of plants with PE ownership, and the x-axis shows calendar year. The legend distinguishes plants located in states with shale-pipeline exposure from those without exposure.

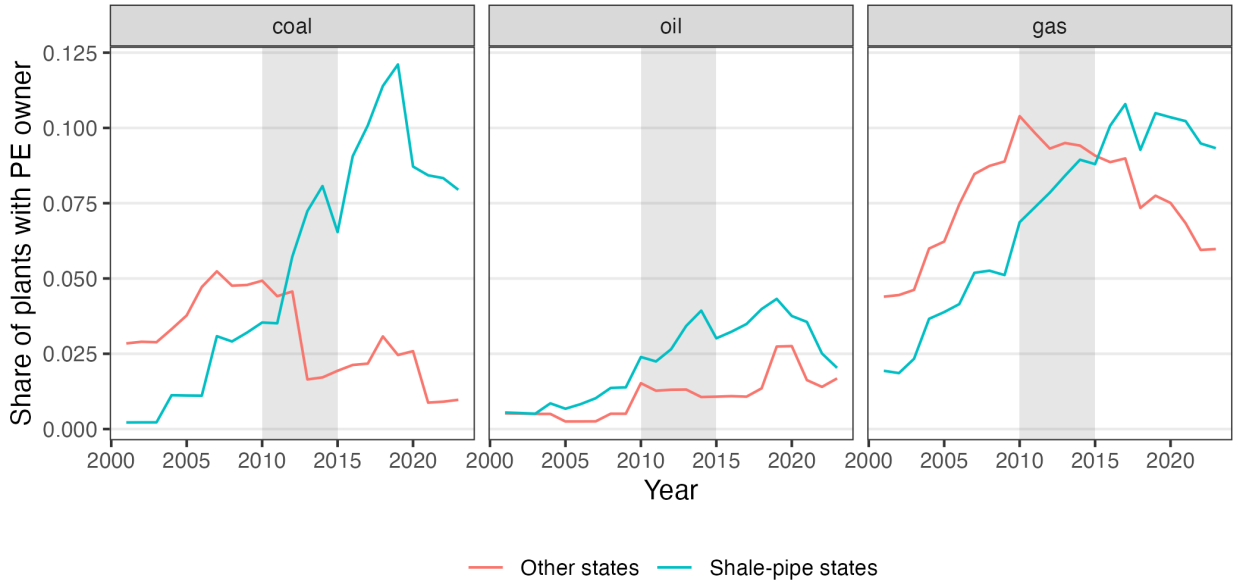
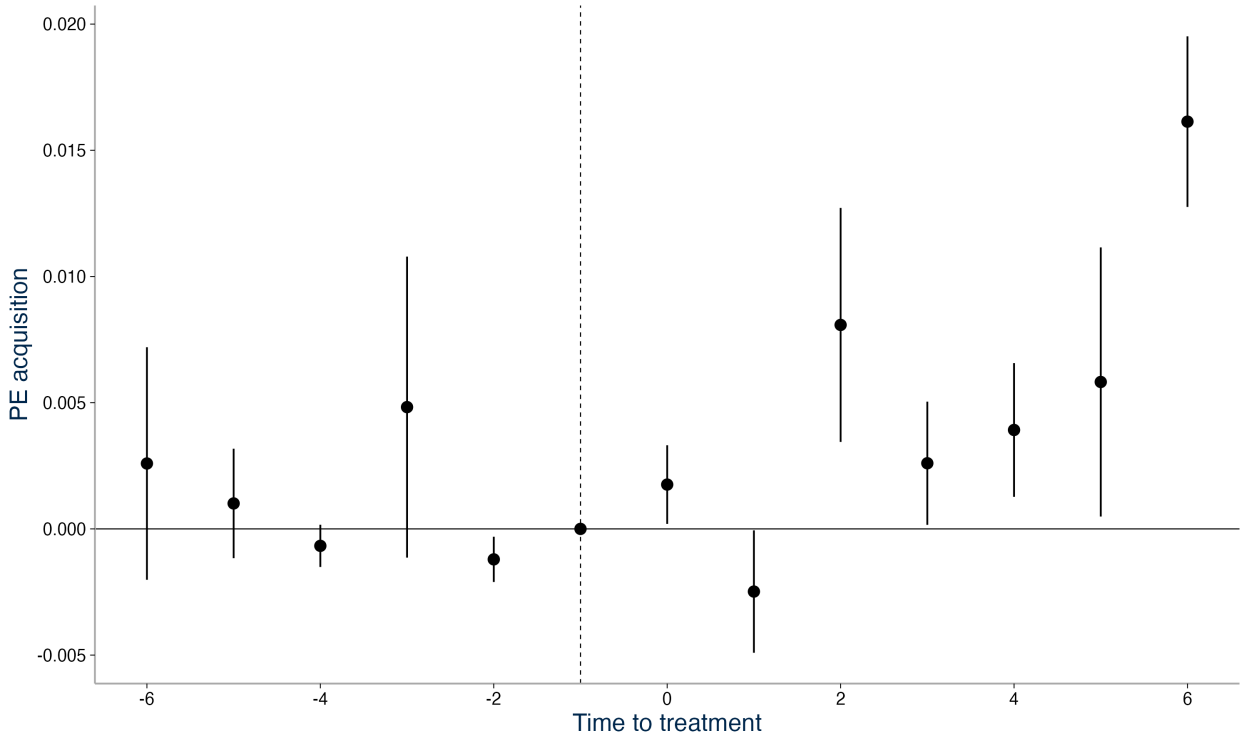


Figure 4: Shale-pipe shock and PE acquisition of coal/oil units

This figure plots the dynamic difference-in-differences estimates of the shale boom and pipeline expansions on the likelihood that coal- and oil-fueled generators are acquired by PE owners, following the event-study framework of Sun and Abraham (2021). The coefficients represent yearly effects relative to the year immediately before treatment, with estimates and 95% confidence intervals shown for six years before and six years after the supply shock. Standard errors are two-way clustered by state and year.



Tables

Table 1: Summary Statistics

This table reports the descriptive statistics of the main variables used in this paper. Panel A presents generator characteristics grouped by fuel type. Panel B further splits the sample by ownership, distinguishing plants owned by private equity (PE) firms from those owned by other investors, and by whether the plant primarily uses coal or oil versus natural gas.

Power plant data comes from the U.S. Energy Information Administration (EIA), and ownership classifications are constructed using S&P Capital IQ supplemented with additional manual sources.

Panel A: By Fuel Type

	Coal			Oil			Gas		
Variable	N	Mean	SD	N	Mean	SD	N	Mean	SD
Age	27,847	40.43	16.10	86,384	28.39	19.19	140,731	21.53	17.82
Cap factor	26,638	0.49	0.26	75,740	0.03	0.09	128,205	0.22	0.27
Capacity (MW)	28,649	266.69	283.50	87,981	14.13	58.21	158,109	93.72	112.38
PE owned	27,860	0.04	0.19	87,071	0.03	0.16	139,640	0.11	0.31
Net gen (GWh)	26,931	1281.56	1622.10	82,573	8.74	92.58	131,961	194.29	396.54
Retired	28,650	0.03	0.17	87,981	0.02	0.13	158,121	0.01	0.11

Panel B: By Owner Type

	Non-PE			PE			Non-PE			PE		
	Coal/Oil						Gas					
Variable	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Age	110,936	31.34	19.25	3,295	30.78	17.36	126,433	22.08	18.21	14,298	16.69	13.01
Cap factor	99,242	0.15	0.25	3,136	0.17	0.27	114,351	0.21	0.27	13,854	0.29	0.27
Capacity (MW)	113,305	75.70	184.19	3,325	92.11	201.15	143,373	91.12	113.21	14,736	118.96	100.52
PE owned	111,606	0.00	0.00	3,325	1.00	0.00	124,899	0.00	0.00	14,741	1.00	0.00
Net gen (GWh)	106,319	322.52	978.38	3,185	296.72	919.66	118,082	176.92	384.06	13,879	342.08	464.47
Retired	113,306	0.02	0.14	3,325	0.03	0.17	143,380	0.01	0.11	14,741	0.01	0.10

Table 2: Shale-pipe exposure and plant outcomes

This Table reports the difference-in-differences estimates of the effect of shale boom and pipeline expansions on several plant outcomes Sun and Abraham (2021) methodology. Columns (1)–(2) present results for coal units; Columns (3)–(4) for oil units; and (5)-(6) for gas units. Columns (1), (3), and (5) use *Retired* as the dependent variable, equal to one if the generator is retired in year t. Columns (2), (4), and (6) use *log net generation*. *Post shale-pipe* equals one in treated states after shale production takeoff and pipeline expansions.

Standard errors are two-way clustered by state and year; t-stats are shown in parentheses.
***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Fuel	Coal		Oil		Gas	
	Retired	Log net gen	Retired	Log net gen	Retired	Log net gen
	(1)	(2)	(3)	(4)	(5)	(6)
Post shale-pipe	0.0343***	-0.3529***	0.0144***	0.0486	-0.0050	0.1444**
	(7.036)	(-4.384)	(3.262)	(0.9449)	(-1.473)	(2.203)
Generator ID FEs	✓	✓	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓	✓	✓
Observations	20,427	19,009	56,855	48,806	112,090	91,194
R^2	0.21	0.77	0.24	0.80	0.23	0.82

Table 3: Effect of shale-pipe exposure on plant outcomes

This Table reports the differential effects of the shale boom and pipeline expansions on coal/oil fueled generators relative to gas powered units. The dependent variable is *Retired* in Column (1), *log net generation* in Column (2), and *log net profit* in Column (3). *Post shale-pipe* is an indicator for years after major shale-related pipeline expansions, and *Coal/oil* is an indicator for coal- or oil-fired generators. The interaction term *Post shale-pipe* × *Coal/oil* captures the differential effect of the shock on coal and oil units relative to gas units.

Standard errors are two-way clustered by state and year; t-stats are shown in parentheses.
***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Retired (1)	Log net gen (2)	Log net profit (3)
Post shale-pipe × Coal/oil	0.0239***	-0.9161***	-0.6743***
	(6.295)	(-5.352)	(-3.516)
Post shale-pipe	-0.0082**	0.4008***	0.1851
	(-2.195)	(3.538)	(1.235)
Coal/oil	-0.0110**	0.7562***	1.593***
	(-2.236)	(3.315)	(5.580)
Generator ID FEs	✓	✓	✓
NERC region-Year FEs	✓	✓	✓
Observations	292,435	245,354	31,799
R^2	0.17	0.88	0.83

Table 4: Differential effect of shale-pipe exposure by PE ownership on plant outcomes

This Table reports difference-in-differences estimates of the effect of the shale boom and pipeline expansions on plant outcomes differentially for PE-owned plants and non-PE-owned plants. Columns (1)–(4) report estimates for coal and oil generators, and Columns (5)–(8) report estimates for natural gas generators. Within each fuel group, Columns (1), (2), (5), and (6) use *Retired* as the dependent variable, while Columns (3), (4), (7), and (8) use *log net generation*. All regressions include generator fixed effects. Odd-numbered columns additionally include NERC region-by-year fixed effects, whereas even-numbered columns instead include regulated-status-by-year fixed effects, where regulated status is an indicator for whether the generator is located in a regulated electricity market. *Post shale-pipe* equals one in treated states after shale production takeoff or pipeline expansion. *PE owner* indicates private equity ownership; the interaction *PE owner* × *Post shale-pipe* captures the differential effect for PE-owned units.

Standard errors are two-way clustered by state and year; t-stats are shown in parentheses.
***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Fuel	Coal/Oil				Natural Gas			
	Retired		Log net gen		Retired		Log net gen	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PE owner × Post shale-pipe	0.0405**	0.0379*	-1.181**	-1.231**	-0.0049*	-0.0045	0.3042*	0.2744
	(2.274)	(1.932)	(-2.419)	(-2.327)	(-1.787)	(-1.582)	(1.738)	(1.455)
Post shale-pipe	0.0013	0.0063	0.0597	0.0071	0.0044	0.0034	-0.0282	0.2230
	(0.2628)	(1.183)	(0.5093)	(0.0798)	(1.546)	(1.013)	(-0.2423)	(1.596)
PE owner	-0.0233***	-0.0166***	0.7918	0.7309	0.0024	0.0027	0.1252	0.1735
	(-3.178)	(-3.272)	(1.263)	(1.052)	(0.6500)	(0.7847)	(0.7100)	(0.9247)
Generator ID FEs	✓	✓	✓	✓	✓	✓	✓	✓
NERC region-Year FEs	✓		✓		✓		✓	
Regulated status-Year FEs		✓		✓		✓		✓
Observations	118,087	118,087	104,906	104,906	151,741	151,741	138,401	138,401
R^2	0.17	0.17	0.93	0.93	0.18	0.18	0.80	0.79

Table 5: Cox proportional hazards models of generator retirement with PE ownership and the shale-pipe post period

The table reports hazard ratios from Cox models estimated on the at-risk generator-year panel (start–stop format). Columns (1), (2), and (3) allow the baseline hazard of retirement to vary flexibly across strata defined by deregulation status, NERC region, and balancing authority, respectively, while constraining the covariate effects to be common within each column. Standard errors are in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Variable	Dereg strata	NERC strata	BA strata
	(1)	(2)	(3)
PE Owner	1.139	1.004	0.862
	(0.228)	(0.228)	(0.298)
Post shale-pipe	1.240***	1.047	1.913***
	(0.065)	(0.078)	(0.080)
PE Owner × Post	1.706*	2.024**	2.220**
	(0.272)	(0.273)	(0.335)
Observations	89745	89745	86870
Events	1816	1816	1504

Table 6: Effect of shale-pipe exposure on PE acquisitions

This table reports difference-in-differences estimates of the effect of post shale-pipeline exposure on the likelihood that a generator is acquired by a private equity owner. The dependent variable is *PE acquired*, which takes one if a generator changes from non-PE ownership to PE ownership in that year.The treatment indicator *Post shale-pipe* equals one in treated states after shale takeoff or pipeline expansions. Columns (1) to (3) include generator fixed effects. Columns (1) and (2) include year fixed effects, while Column (3) replaces year fixed effects with fuel-type-by-year fixed effects. Columns (2) and (3) additionally control for *log(capacity)* and *log net generation*.

Standard errors are two-way clustered by state and year; t-stats are shown in parentheses.
***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	PE acquired		
	(1)	(2)	(3)
Post shale-pipe	0.0050***	0.0053***	0.0054***
	(5.096)	(5.174)	(5.007)
Log (capacity)		0.0046	0.0048
		(0.6614)	(0.6881)
Log net gen		-0.0004	-0.0004
		(-0.7582)	(-0.7399)
Generator ID FEs	✓	✓	✓
Year FEs	✓	✓	
Fuel type-Year FEs			✓
Observations	86,377	76,116	76,116
R^2	0.13	0.14	0.14

Table 7: Differential effect of shale-pipe exposure by pre-exposure PE ownership on plant outcomes

This Table reports difference-in-differences estimates of the effect of the shale boom and pipeline expansions on plant outcomes for plants that were already PE-owned before the shale discovery or pipeline project announcements compared to other plants that are never PE-owned. Columns (1)–(2) report results for coal/oil units; Columns (3)–(4) for natural gas units. Columns (1) and (3) use *Retired* as the dependent variable; Columns (2) and (4) use *log net generation*. *Post shale-pipe* equals one in treated states after shale takeoff or pipeline expansions. *PE owner pre shale-pipe* indicates units owned by PE firms before the shale discovery/pipeline announcement; the interaction *PE owner pre shale-pipe* × *Post shale-pipe* captures the differential effect for those already PE-owned units.

Standard errors are two-way clustered by state and year; t-stats are shown in parentheses.
***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Fuel	Coal/Oil		Natural Gas	
	Retired	Log net gen	Retired	Log net gen
	(1)	(2)	(3)	(4)
PE owner pre shale-pipe × Post shale-pipe	0.0351***	-1.150***	-0.0247***	0.6073***
	(8.679)	(-3.802)	(-4.827)	(5.452)
Post shale-pipe	0.0025	0.0647	0.0077	-0.0345
	(0.4703)	(0.5192)	(1.635)	(-0.2964)
PE owner pre shale-pipe	0.1856	-30.26	-1.619	-0.2287
	(0.0073)	(-0.1462)	(-0.1444)	(-0.0005)
Generator ID FEs	✓	✓	✓	✓
NERC region-Year FEs	✓	✓	✓	✓
Observations	109,901	97,523	111,992	101,182
R^2	0.18	0.93	0.19	0.80

Table 8: Effect of labor rights and PE ownership on plant retirements

This Table reports difference-in-differences estimates of the effect of pro-labor environments on plant retirements, comparing PE-owned and non-PE-owned units. Columns (1)–(2) present results for coal/oil units; Columns (3)–(4) for natural gas units. The dependent variable in all columns is *Retired*, an indicator equal to one in the year a generator retires. *Pro labor* equals one for plants located in non–right-to-work (non-RTW) states, and zero in RTW states. *PE owner* indicates private equity ownership. *Post shale-pipe* equals one in treated states after shale or pipeline exposure. The interaction term *Pro labor* × *PE owner* captures whether private equity owned units respond differently to pro-labor environments than other owners.

Standard errors are two-way clustered by state and year; t-stats are shown in parentheses.
***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Fuel	Coal/Oil		Natural Gas	
	Retired			
	(1)	(2)	(3)	(4)
Pro labor	-0.0125**	-0.0140**	0.0026	0.0015
	(-2.334)	(-2.430)	(0.3464)	(0.1957)
Pro labor × PE owner		0.0337**		-0.0047
		(2.215)		(-0.6475)
PE owner		-0.0177**		0.0035
		(-2.302)		(0.5587)
Post shale-pipe	0.0104*	0.0106*	0.0032	0.0031
	(1.904)	(1.912)	(0.8869)	(0.8480)
Generator ID FEs	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Observations	120,015	118,087	172,420	151,741
R^2	0.17	0.17	0.17	0.18

Table 9: Effect of citizen suit ability and PE ownership on plant retirements

This Table reports difference-in-differences estimates of the effect of citizen-suit friendliness on plant retirements, comparing PE-owned and non-PE-owned units. Columns (1)–(2) present results for coal/oil units; Columns (3)–(4) for natural gas units. The dependent variable in all columns is *Retired*, an indicator equal to one in the year a generator retires. *Pro citizen-suit* equals one for plants in states and years after citizen-suit enforcement rights were expanded. *PE owner* indicates private equity ownership. *Post shale-pipe* equals one in treated states after shale or pipeline exposure. The interaction term *Pro citizen-suit* × *PE owner* captures whether private equity owned units respond differently to these more citizen-suit friendly regimes than other owners.

Standard errors are two-way clustered by state and year; t-stats are shown in parentheses.
***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Fuel	Coal/Oil		Natural Gas	
	Retired			
	(1)	(2)	(3)	(4)
Pro citizen-suit	-0.0017	-0.0122	0.0036	0.0039
	(-0.2067)	(-1.445)	(1.369)	(0.9335)
Pro citizen-suit × PE owner		0.0840***		0.0018
		(4.290)		(0.1763)
PE owner		-0.0105		0.0002
		(-1.133)		(0.0561)
Post shale-pipe	0.0115*	0.0129*	0.0037	0.0037
	(1.831)	(1.904)	(0.9763)	(0.9416)
Generator ID FEs	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Observations	102,488	100,609	162,151	142,108
R^2	0.16	0.16	0.17	0.17