# The Shifting Finance of Electricity Generation*

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**Abstract**

Despite the incentives of incumbent domestic listed corporations (DLCs) in the electricity generation industry, private equity, institutional investors, and foreign corporations have played an outsized role in financing the energy transition. These new entrants are twice as likely to create power plants as incumbents. They owned 58% of wind, 47% of solar, and 34% of natural gas electricity production as of 2020. The ownership changes are concentrated in deregulated wholesale markets which attract more capital from new entrants to create renewable and natural gas plants, acquire existing plants, and accelerate the decommissioning of coal plants. Sales of fossil fuel plants from DLCs to foreign corporations result in some leakage, but private equity has similar decommissioning rates to incumbents. The new ownership types create more efficient power plants with a lower heat rate and improve the efficiency of acquired plants. Our results also highlight an important tradeoff in bringing new financing sources to the electricity sector. When selling electricity, private equity and foreign corporations use contracts with shorter duration, shorter increment pricing, and more peak-period sales, and obtain a $2.59 higher average price per MWh.

**JEL classification**: G23, G24, G32, H54, L51, L71, L94, O13, Q41, Q48.
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# 1 Introduction

Market competition and financing sources can have a profound impact on the implementation of new technologies. Schumpeter (1942) argued that the canonical firm in an environment of perfect competition has fewer incentives and lesser scope to adopt new technologies compared to larger firms in oligopolistic markets. Implementing innovation also requires investors willing to put capital at risk, so if smaller firms are to disrupt larger ones with new technologies, the smaller firms require significant financing. Arrow (1962) in contrast argued that market power stifles innovation, as firms wish to protect their rents and avoid cannibalization of existing assets. The destruction process is also costly as incumbents face legal and regulatory risks associated with legacy technologies and stranded assets. Whether the adoption of new technologies comes more from dominant incumbents or smaller new entrants depends on the competitive and regulatory environment, as well as the availability of capital whose owners are willing to bear risk (Shapiro, 2011).

In the electric power industry, regulated utilities that serve as incumbents generally receive compensation for the fixed costs of building new assets via the regulatory process (Averch and Johnson, 1962; Joskow and Schmalensee, 1986; Joskow, Rose, and Wolfram, 1996). They also have other advantages including size, access to the electrical grid, synergies with existing operations, and the ability to influence government policy.[1] However, incumbents may prefer to delay the implementation of new technology if protected by limited competition and a lack of market discipline (Arrow, 1962; Bertrand and Mullainathan, 2003; Gutiérrez and Philippon, 2017; Cunningham, Ederer, and Ma, 2021). In this paper, we find that in the electricity generation industry, despite the advantages of incumbents, deregulation of wholesale markets has driven the creation of new assets and destruction of old assets by attracting more capital from new entrants, such as private equity (PE) and foreign corporations.

The electricity generation industry is well-suited to examine the role of market regulation and ownership in adopting new technologies for four reasons. First, energy is a capital-intensive sector that has experienced a great deal of innovation, including new renewable technologies using solar and wind energy as well as shale gas (e.g., Gilje, Loutskina, and Strahan, 2016). Second, electricity generation is at the center of government environmental policy and demands for reduced carbon emissions.[2] The industry requires substantial investments if its carbon footprint is to be further

[1] Much of the literature on increasing concentration and rise of large firms has emphasized these advantages of large incumbents more generally (e.g., Chandler, 1994; Autor et al., 2020; Kwon, Ma, and Zimmermann, 2023).

[2] The International Energy Association (2021) calculated that energy investments must rise to $5 trillion per year by 2030 to achieve net zero emissions by 2050.

reduced. Third, energy assets can stimulate economic growth through spillovers to other sectors and the provision of vital services (Glaeser and Poterba, 2020). Fourth, global conflicts have also heightened demands for energy independence across countries, a goal that would require substantial new investments.

To test the extent to which incentives to implement innovation depend on the firm's ownership structure (Aghion, Van Reenen, and Zingales, 2013; Antón, Ederer, Giné, and Schmalz, 2023), we collect data on the ownership of U.S. power plants. We document that over the 2005–2020 period the ownership share of domestic listed corporations (DLCs) has declined from 70% to 54%, while the total U.S. electricity generation has remained roughly constant at 4.1 trillion kWh per year. PE, institutional investors, and foreign listed corporations have gradually replaced DLCs in the ownership of both renewable and fossil fuel power plants. As of 2020, these new entrants together owned 58% of wind, 47% of solar, 34% of natural gas, and 10% of coal electricity production.

We analyze the relative importance of three mechanisms that could drive these ownership changes — creating new power plants, acquiring existing power plants, and decommissioning (shutdown of) power plants — as well as the economic conditions that facilitate ownership transitions. To do this, we compare the role of incumbent owners, which are primarily DLCs, and new entrants which include PE, institutional investors, and foreign corporations, in each of the three mechanisms, as a function of the heterogeneity in local electricity market deregulation.

The market deregulation measures fundamentally capture whether the wholesale electricity market is administered by an independent system operator (ISO) as a balancing authority rather than a traditional vertically integrated utility. The introduction of ISOs with a market dispatch mechanism represents an important source of regional-level variation in competition. In traditional markets, the incumbent utility can potentially exclude new producers from the market by denying transmission access (Fabrizio, Rose, and Wolfram, 2007; Borenstein and Bushnell, 2015; Cicala, 2022). We then consider two more restrictive measures of deregulation to capture subtleties in market structure. First, within deregulated markets organized around ISOs, some producers are utilities still subject to rate-of-return regulation. We therefore construct an indicator that reflects only power plants that are in an ISO balancing market and are owned by an independent power producer (IPP). Around 35.6% of plant-year observations are IPPs participating in ISO balancing markets. Second, we consider a measure of deregulation which captures power plants in ISO-balancing markets where electric utilities were additionally restructured through forced divestitures ("ISO Restructured") comprising approximately 35.0% of the sample.

The ISO-balancing markets were established during the wave of state-level restructurings in the 1990s and early 2000s, so almost exclusively before our sample period and before the expansion of renewable technologies and shale gas, reducing concerns regarding reverse causality. Furthermore, we document that the decision to deregulate is unrelated to the state-level potential for renewable energy generation, nor is it related to how much a state produces natural gas and coal. However, we also address the possibility of omitted variables bias using an instrumental variable (IV) for whether a producer is in a deregulated wholesale market. Our instrument is the difference between the average electricity price in the residential sector and the industrial sector in the plant's state during the 1991−1996 period, established as a determinant of deregulation by White (1996) and Joskow (1997). We find broadly similar results across all of these deregulation measures.

The first mechanism driving ownership changes that we examine focuses on differences in creating new power plants. Deregulated markets exhibit a higher degree of creation of new power plants. Consistent with a strong role for new entrants in implementing new technologies, PE and foreign corporations are disproportionally more likely to finance the creation of renewable solar and wind plants as well as natural gas plants. For instance, conditional on fuel type (i.e., solar, wind, natural gas, coal, and other technologies), state, and time, PE is 1.31 percentage points more likely to own a given power plant in the greenfield stage than DLCs, representing an increase of 80% relative to the baseline greenfield share of 1.63%. However, the difference in creating power plants between DLCs and new entrants is robustly significant only in deregulated markets. Based on the IV analysis, DLCs are 1.57 percentage points less likely to own a greenfield plant in deregulated markets.[3]

The entrance of new ownership types also has implications for existing power plants. The sales of existing plants by incumbent DLCs to PE, institutional investors, and foreign corporations could potentially lead to leakage (reallocation) of older fossil fuel power plants by delaying their decommissioning and extending their operation (Fowlie, Reguant, and Ryan, 2016; Copeland, Shapiro, and Taylor, 2021). Stricter disclosure requirements apply to DLCs, and they are also more likely to be affected by public pressure (e.g., Benthem et al., 2022; Bolton and Kacperczyk, 2022; Duchin, Gao, and Xu, 2024). DLCs might therefore sell their older power plants to ownership types that are subject to more lenient regulatory and disclosure requirements such as PE (see Bernstein (2022) for a review) and foreign corporations.[4]

[3]Our results therefore do not support the Averch and Johnson (1962) argument that regulated utilities engage in more capital investments because they receive an artificially high rate of return on capital.

[4]The leakage hypothesis relates to the concerns about outsourcing pollution in international trade (e.g., Antweiler, Copeland, and Taylor, 2001; Cherniwchan, Copeland, and Taylor, 2017; Shapiro and Walker, 2018; Shapiro, 2021).

Using a competing risks model for power plants owned by DLCs, we analyze DLC decisions to sell or decommission plants. The second mechanism, selling existing plants, is important for the reallocation of assets from DLCs to new entrants and these transactions are twice as likely to occur in deregulated markets. However, there is little evidence that these sales lead to leakage of polluting power plants: the older the plant, the more likely the plant is to be retired by DLCs and the less likely it is to be sold and still operating. In addition, DLCs are *less* likely to sell and more likely to decommission coal plants.

The third mechanism for reallocation is the decommissioning of power plants. Deregulated markets also amplify this mechanism as they exhibit more plant shutdowns. Using hazard models, we examine the differences in decommissioning rates across ownership types which could lead to leakage if the new owners are more likely to continue operating plants for a longer period than DLCs. We find some limited evidence supporting the leakage hypothesis here, as DLCs are more likely to retire power plants than foreign corporations; however there are no differences with PE. The lower decommissioning rates of foreign corporations imply that they would need to double the number of retired plants to remove any leakage relative to DLCs and PE, which translates into 23 additional decommissioned plants during our sample period or 1.43 plants per year. The incumbent DLCs and new entrants do not consistently display different sensitivity to market regulation for all fossil fuel types. Deregulated electricity markets therefore do not exhibit more leakage but rather induce all ownership types jointly to decommission more plants.

Overall, deregulated electricity markets amplify all three mechanisms of ownership changes as they exhibit more creation of new assets, transactions of operational plants, and shutdowns of plants. Deregulated markets attract more capital from PE, institutional investors, and foreign corporations so these new entrants account for 47% of the electricity generated by IPPs in ISO-balancing markets in 2020 as compared to only 9% in traditional markets. In terms of economic factors, the effect of market deregulation on heterogeneity in ownership structures is robust to controlling for climate concerns among the state population, and policy incentives for renewable energy.

The ownership changes we document have implications for the operational performance of power plants, contractual terms of electricity sales, and pricing in electricity markets. Based on the ratio of fuel consumption to electricity generation (heat rate), fossil fuel plants owned by PE, institutional investors, and foreign corporations operate more efficiently than plants owned by DLCs and consume around 5% less fuel per unit of electricity. The lower heat rate automatically implies reduced carbon emissions and pollution. New entrants improve the efficiency of the acquired power plants as well as create new more efficient power plants. Based on a stacked difference-in-difference analysis, we document that the heat rate of the acquired plants declines by 0.44 in the 24 months after the DLCs sell these plants. Using a matched sample of new power plants, we find that plants created by DLCs have a 0.67 higher heat rate than plants created by new entrants. We also reject an alternative version of the leakage hypothesis, namely that the new owners might operate the fossil fuel assets more intensively. If anything, DLCs operate fossil fuel plants at a higher intensity (capacity factor), particularly in traditional markets.

Using Federal Energy Regulatory Commission (FERC) data on wholesale electricity transactions, we show that the new entrants implement shorter electricity contracts, though primarily in non-renewables. PE and foreign corporations enter into contracts with more short-term duration, lower length pricing increments, and more peak-period sales, all conditional on fuel type, location, and time. The greater contractual flexibility enables PE and foreign corporations to obtain higher prices on the wholesale market. For instance, PE-owned power plants sell electricity for $2.59 higher average price per MWh relative to other producers of the same fuel type in the same state and month. These results highlight an important tradeoff: new entrants, such as PE and foreign corporations, create new and more efficient power plants but they also sell electricity through more short-term contracts and at higher prices.

In addition to the literature on the role of new entrants as adopters of technology (e.g., Shapiro, 2011), our findings also relate to research on the role of regulation and market power in the environmental space (Porter, 1996; Jaffe and Palmer, 1997) as we observe that owners with a monopoly on customers, such as incumbent DLCs, cooperatives, and government, are the last to adopt new technology (Aghion, Bergeaud, and Van Reenen, 2021). Our results contribute also to the literature on climate finance (e.g., Hong, Karolyi, and Scheinkman, 2020; Giglio, Kelly, and Stroebel, 2021), as we highlight the role of capital expenditures and greenfield investments from new entrants and competitive markets in accelerating the energy transition. Our results on the limited acquisitions of older fossil fuel power plants by new entrants complement findings that banks also reduce financing of these plants (Green and Vallee, 2022). We show that these reduced financing sources force DLCs to retire older fossil fuel assets, especially in competitive markets.

Our paper relates to the energy economics literature on the deregulation of electricity markets, or more specifically the ceasing of regulating vertically-integrated utilities based on cost-of-service and the impact on market power (e.g., Borenstein, Bushnell, and Wolak, 2002; Borenstein, 2002). The deregulation generally results in efficiency gains through reduced production costs (e.g., Fabrizio, Rose, and Wolfram, 2007; Davis and Wolfram, 2012; Cicala, 2015, 2022; Jha and Wolak, 2023). Demirer and Karaduman (2023) and Bai and Wu (2023) find that acquired power plants experience efficiency increases. Our contribution is to show that as the regulatory status changes, ownership structure also changes, and new participants, such as PE and foreign corporations, potentially drive efficiency improvements in the deregulated electricity markets.

Finally, our paper relates to the literature on the impact of PE on efficiency and productivity.[5] We study the creation of new assets and retirement of existing assets by PE funds, rather than focusing only on changes in ownership through acquisitions and improving existing companies (e.g., Guo, Hotchkiss, and Song, 2011; Gompers, Kaplan, and Mukharlyamov, 2016). PE plays a major role in implementing new technologies and shutting down stranded assets, but this is not necessarily attributable to PE's business model and incentives, since foreign corporations also adopt new technologies. Creation and destruction are primarily affected by market competition, incumbency status, and pressures specific to U.S. listed corporations versus their foreign and private counterparts.

## 2 Data on Power Plants and Electricity Markets

### 2.1 Power Plant Characteristics

Our sample covers all U.S. power plants reporting to the Energy Information Administration (EIA) over the 2005–2020 period. EIA Form 923 provides data on monthly electricity generation at the power-plant-prime-mover level. That is, if a power plant uses multiple prime mover technologies (e.g., a natural gas plant using a steam turbine, combustion turbine, and combined-cycle combustion turbine), it will have multiple observations. EIA Form 860 provides information on the power plant characteristics on a generator level. We aggregate the information from EIA Form 860 for power-plant-generators that use the same prime-mover technology and merge both datasets on a power-plant-prime-mover level. Table 1 shows that our sample contains 11,593 power plants, 13,261 power-plant-prime-mover units, and 1,509,346 monthly observations. Fossil fuel power plants often use multiple prime-mover technologies, while nuclear, hydro, wind, and solar power plants rely only on one prime-mover technology. When we use the term power plant in this paper, we refer to power-plant-prime-mover observations.

[5] Prior research has examined the impact of PE ownership on operational performance, productivity, employment, and profitability (e.g., Davis et al., 2014; Bernstein and Sheen, 2016; Antoni et al., 2019; Davis et al., 2021; Howell et al., 2022); workplace safety, employees health, and employee satisfaction (e.g., Cohn et al., 2021; Lambert et al., 2021); environment and pollution (e.g., Shive and Forster, 2020; Bellon, 2022; Bai and Wu, 2023); customers in regulated industries such as education and healthcare (e.g., Eaton, Howell, and Yannelis, 2020; Liu, 2022).

Table 1 reports summary statistics on the average power plant characteristics weighted by power plant nameplate capacity. We present weighted statistics as the sample contains many small power plants that contribute very little to overall electricity generation.[6] For instance, there are 3,941 solar power plants in the sample, but they account for less than 3% of electricity generation in 2020. The weighted average power plant has a nameplate capacity of 0.98GW and is 30.9 years old.

We construct two measures of power plants' operating performance. First, the capacity factor captures operating intensity and is defined as the ratio of net electricity generation to monthly capacity (the maximum potential output). Power plants differ in the average capacity factor by fuel type. Nuclear plants operate almost continuously and have the highest capacity factor of 0.86, while solar plants depend on the sun hours and have the lowest capacity factor of 0.24. Second, the heat rate captures operating efficiency and is defined as the ratio of fuel consumption in millions of Btu to electricity generation in MWh. We observe the heat rate for fossil fuel and nuclear plants, and lower values imply lower fuel consumption and higher efficiency.

During our sample period, the electricity industry exhibited substantial construction of new plants and decommissioning of old plants. Out of 13,261 unique plants, 6,082 are new greenfield plants, and their first 12 months of operation account for 1.63% of the sample on a capacity-weighted basis. Greenfield plants use either solar and wind energy or natural gas. The decommissioned indicator equals one for the last 12 months of operation before a plant is shut down. 1,949 power plants were shut down during this period, and their last 12 months of operation account for 1.03% of the sample. Decommissioned plants are concentrated in fossil fuels, such as coal and natural gas.

## 2.2 Power Plant Ownership

We manually collect ownership data based on regulatory announcements, Preqin dataset, S&P Global, and newswire articles, and classify the power plant owners into eight categories.[7] The largest category based on ownership stakes is *domestic publicly listed corporations*, (DLCs), which includes both traditional utilities and independent power producers (e.g., Duke Energy, Exelon, PG&E, Southern Company, etc.). The DLC category also includes YieldCo companies, such as NRG Yield and NextEra Energy, that are majority-owned by U.S. corporations. DLCs are the incumbent owners of power plants as the vast majority originated from vertically-integrated electric utilities.

[6] In the regression estimations, we either use the full sample weighted by capacity or limit attention to the subsample of plants with a capacity of at least 20MW. Online Appendix Table A.1 reports summary statistics without weighting the power plants and focuses only on the subsample of power plants with a capacity of at least 20MW.

[7] We do not classify tax equity investors as owners because tax equity investors do not have decision-making power and acquire different share classes (Garrett and Shive, 2022).

The other traditional owners of power plants are industrial firms, government, and cooperatives. The *industry* category captures power plants owned by industrial companies engaged in energy-intensive manufacturing, such as paper, steel, and aluminum (e.g., International Paper Co, Dow Chemical Co, and Alcoa Corporation). These industrial firms consume most of the produced energy for their own factories. The *government* category includes power plants owned by federal, state, and local governmental entities (e.g., Tennessee Valley Authority and U.S. Bureau of Reclamation). The electric *cooperatives* category covers power plants that are built and owned by the communities they serve (e.g., Basin Electric Power Coop and Associated Electric Coop).

The new rising owners of power plants are private equity, institutional investors, and foreign corporations. *Private equity (PE)* includes investments made by PE buyout and infrastructure funds as well as other investment vehicles (e.g., ArcLight, LS Power, and Macquarie). This category also includes a small number of plants owned by private firms (e.g., Caithness Energy, Koch Industries, and Tenaska). *Institutional investors* covers direct investments by pension funds, insurance companies, and sovereign wealth funds in power plants. Almost all direct investments come from foreign institutions, such as Canadian and Dutch pension funds (e.g., CPPIB, OMERS, and APG). The *foreign publicly listed corporations* category covers power plants owned by European, Canadian, and Asian energy companies (e.g., EDP Group, Engie, ITOCHU, and Osaka Gas). The final category is *other* small power plants, which we have not classified in one of the seven categories.

Figure 1 shows that we categorize 99% of electricity generation in any month over the 2005–2020 period into one of the seven ownership categories. If a power plant is owned by multiple ownership types, we divide the ownership stake equally across the ownership types (i.e., if a PE and institutional investor jointly own a power plant, we assume that each ownership type owns 50% of the plant). This adjustment does not matter for most ownership types, as they typically act as sole investors and acquire 100% stake in the power plants. Institutional investors are the exception, they often co-invest with other investors and share ownership in 87% of their observations.[8]

In Figure 1, we observe that the percentage of electricity generated by power plants owned by DLCs declines from 70% in 2005 to 54% in 2020. PE, institutional investors, and foreign corporations replace DLCs as their share jointly increases from 7% in 2005 to 24% in 2020. The generation share of governments, cooperatives, and industrial firms remains constant. The ownership changes while the total electricity production, exports, and imports remain constant. Online Appendix Figure A.1

[8]For instance, Canada Pension Plan Investment Board co-invested with Energy Capital Partners PE fund in the buyout of Calpine Corporation in 2018. Alberta Investment Management Corporation established a joint venture with AES Corporation to acquire Sustainable Power Group LLC in 2017.

shows that the U.S. produced around 4.1 trillion kWh of electricity in 2005 and the total output has remained constant over our sample period. The total imports and exports of electricity also remain stable and account for less than 1.5% of the U.S. electricity market.

The ownership structure of power plants differs across fuel types. Figure 2 depicts ownership shares for the six main fuel types: natural gas, coal, nuclear, hydro, wind, and solar.[9] Over the 2005–2020 period, natural gas became the main fuel and replaced declining coal generation. Wind and solar energy are increasing and account for the majority of newly created plants. The amount of electricity generation from hydro and nuclear power plants stays relatively stable and their ownership structure also does not exhibit significant shifts. The new ownership types (PE, institutional investors, and foreign corporations) controlled 34% of the natural gas, 58% of the wind, and 47% of the solar electricity generation as of 2020. DLCs own a large part of the generation in all fuel types, but they are especially negatively affected by the declining coal generation.

## 2.3 Regulation of Electricity Markets

*ISO Balancing* is our broadest measure of market deregulation, and it is an indicator for power plants that operate in a wholesale market administered by an Independent System Operator (ISO) as a balancing authority. The ISOs were formed after the adoption of the Energy Policy Act of 1992 and Federal Energy Regulatory Commission orders 888 and 889 of 1996 to open the wholesale electricity markets to competition. Our definition classifies the following balancing authorities as ISOs: California ISO, Electric Reliability Council of Texas, Midcontinent ISO, ISO New England, New York ISO, PJM Interconnection, and Southwest Power Pool. The ISOs took over the control of the transmission system from the local utility and conduct auctions to provide non-discriminatory grid access. In the areas that are not serviced by an ISO, vertically integrated local electric utilities own power plants generating electricity as well as the transmission system and delivery network. These utilities do not adopt a market dispatch mechanism and could potentially exclude independent producers from the market by denying transmission access (Borenstein and Bushnell, 2015; Cicala, 2022). The vertically integrated utilities are typically owned by DLCs or the government.

The advantage of *ISO Balancing* measure is that it covers all plants bidding into an ISO wholesale markets, but many of these plants are still subject to rate-of-return regulation, especially in MISO

[9]The hydro category includes only plants using hydraulic turbines, while plants with pumped storage have a separate category. The solar category includes only plants with a photovoltaic prime mover, while plants with steam turbines that can use a solar stream are a separate category. The EIA data covers only utility-scale solar and does not include information on distributed small-scale solar. The capacity of the small-scale solar installations is 50% of the capacity of utility-scale solar, so the EIA data underestimates the importance of solar energy (EIA Table 4.3).

and SPP. Thus, this measure includes also unrestructured utilities that operate in a competitive wholesale market. *IPP ISO Balancing* is our main measure of market deregulation, and it captures only power plants that participate in an ISO Balancing market and are owned by an independent power producer (IPP). This measure captures only IPPs that operate under a market-based pricing model and excludes all plants owned by regulated electric utilities that operate under a cost-of-service model (Borenstein and Bushnell, 2015).

*ISO Restructured* is an alternative more restrictive definition of market deregulation. It captures power plants that participate in a wholesale market administered by an ISO balancing authority and are located in areas with restructured electric utilities.[10] States that have an ISO restructured market required vertically integrated utilities to break up through asset sales. In these cases of forced divestiture, the utilities sold off their power plants or transferred them to unregulated affiliates (Fabrizio, Rose, and Wolfram, 2007; Cicala, 2015). The forced divestitures were completed by 2002, so they did not drive the ownership changes in our sample period, but these measures created relatively more competitive markets.[11]

All three deregulation measures are defined on a power-plant-level, not on a state-level (similar to Cicala, 2022; Jha, 2023). Based on Table 1 Panel D, 61% of the power plants participate in a wholesale market administered by an ISO balancing authority, while only 36% are IPPs in an ISO balancing market. The *ISO Restructured* measure applies to 35% of the plants. The overlap between the IPP ISO Balancing and ISO Restructured measures is substantial and 27% of plants in the sample are classified as deregulated under both measures. Online Appendix Table A.2 shows how many plants in each state operate in a deregulated market. In our analysis, to further bolster the causal interpretation, we use the difference between the average electricity price in the residential sector and the industrial sector as an instrumental variable. We measure the price difference *ResidIndPD* on a state level over the 1991–1996 period and use it to instrument *ISO Restructured* markets. The data on average state prices comes from the EIA State Energy Data System (SEDS). Table 1 shows that the average price difference is $9.78 with a standard deviation of 2.99.[12]

[10] *ISO Restructured* classifies mainly the following balancing authorities as restructured markets: Electric Reliability Council of Texas, ISO New England, New York ISO, and PJM Interconnection.

[11] An alternative measure of the regulatory environment captures areas with restructured retail electricity markets, i.e. selling power to end-use customers (Borenstein and Bushnell, 2015). The state initiatives to offer an electricity provider choice to residential and business customers stopped after the California electricity crisis in 2000–2001. The vast majority of power plants located in an area with retail choice participate in an *ISO Restructured* wholesale market.

[12] In Online Appendix Table A.3, we also show that state-level natural resources, economic, and political factors do not predict electricity market deregulation. The decision to deregulate markets is unrelated to variation in state-level solar and wind energy potential, nor is it related to the production of natural gas or coal in a state normalized by the amount of electricity consumption.

In addition to the market regulation, we also control for climate concerns and renewable energy policy incentives on a state level. The climate concern measure is based on the Yale Climate Opinion Survey (Howe, Mildenberger, Marlon, and Leiserowitz, 2015) which was created in 2014 and then rerun in 2016, 2018, and 2021.[13] The comparison of responses within a state over time is limited by changes in the survey design, but we use it to control for cross-sectional differences across states in the same year. Our *Climate Concern* variable is based on the percentage of the state population who think that global warming is happening and is defined as the percentile ranking of the state where the plant is located. The percentile rankings of states based on climate concern over time are very stable and, therefore, we merge the survey ranking in 2014 with our data on power plants over the 2005–2014 period. We make similar adjustments with the later survey waves.

We use the Database of State Incentives for Renewables & Efficiency from the N.C. Clean Energy Technology Center to collect data on the policy incentives introduced by different states to stimulate the transition to renewable energy. We split the policy initiatives into three types of tax incentives for renewables: Corporate Tax, Property Tax, and Sales Tax; and two types of production incentives for renewables: Production Quantity and Tariffs.[14] Our analysis uses primarily a *Renewables Incentives* index, which aggregates the three tax indicators and the two production indicators. Online Appendix Table A.4 presents the average value of the five indicators and aggregate renewables incentives index by state. The index varies from 0.00 in Arkansas to 3.91 incentive types in Vermont.

## 2.4 Pricing and Contractual Terms of Electricity Sales

We merge the EIA power plant data with information on pricing and contracting of electricity sales from the Federal Energy Regulatory Commission (FERC) Electric Quarterly Reports (EQR). The FERC EQR data is available from July 2013 to December 2020, and we convert the quarterly reports into monthly data. If an electricity transaction in the FERC dataset continues over multiple months, we split the quantity and transaction charges across the months based on the number of days contracted in each month. The FERC regulatory requirements affect larger power plants that are interconnected with plants in other states. The interconnection requirement implies that power plants located in the Electric Reliability Council of Texas, Alaska, and Hawaii are not required to

[13]The Yale Climate Opinion Maps data has been used by Bernstein, Gustafson, and Lewis (2019) and Baldauf, Garlappi, and Yannelis (2020) to examine the relation between climate change beliefs and real estate prices.

[14]Corporate tax incentives capture programs that provide a corporate tax credit, corporate tax deduction, and corporate depreciation. Property tax incentives offer property tax exemption or reduction. Sales tax incentives offer an exemption or reduction from sales and use tax for equipment, generation, etc. Renewables production incentives offer compensation per KWh that can differ by fuel type and plant capacity. Renewable tariffs capture primarily feed-in tariffs, which offer long-term contracts with an above-market price to renewable energy producers.

report to FERC as they are not interconnected with power plants in other states.[15]

The two main products that power plants sell are capacity and electricity. Capacity sales are used in some wholesale markets to pay power plants for being available to meet predicted electricity demand. The objective of capacity markets is to cover the fixed costs of building and maintaining power plants and ensure having sufficient capacity in the future. However, capacity sales do not represent a commitment to produce electricity. Power plants sell electricity using separate contracts.

Table 2 shows that we merge 248,987 monthly observations of plants owned by DLCs, PE, institutional investors, and foreign corporations with FERC data on contractual terms and pricing. We do not analyze electricity transactions of plants owned by government, cooperatives, and industrial firms as they typically do not transact on the wholesale market, but rather use their electricity generation for their own consumption within an area they exclusively serve.[16] The average electricity price is \$33.01, while the median price is \$30.48 per MWh.

We classify electricity transactions based on contractual terms in three ways. First, we distinguish between short-term contracts with a duration of less than one year and long-term contracts. Second, we split the transactions into short, medium, and long based on the increment pricing terms. Short transactions use 5-minute, 15-minute, or hourly increments (up to 6 hours) to determine the price. Medium transactions have daily increments (6 to 168 hours). Long transactions use monthly or yearly increments (longer than 168 hours). Third, we classify transactions into full-period, peak, and off-peak based on the peaking terms. Full-period transactions cover both peak and off-peak periods.

Panel A of Table 2 reports the average percentage of transaction charges for electricity sales by different contractual terms, while Online Appendix Table A.5 presents the average percentage of electricity quantity sold by different contractual terms. Around 59% of the charges are for electricity sales under contracts with short durations and 51% of the transactions use short increments to determine the price. Transactions covering the full period account for 38% of the charges. Peak period sales are more expensive as they account for 31% of the quantity and 36% of the charges, while off-peak sales are smaller and cheaper. Fossil fuel power plants can operate more flexibly so they rely more on short-term contracts, short increment pricing, and peak-term production for electricity sales. Solar and wind power plants have limited flexibility in operating hours, so they use more long-term contracts, long increment pricing, and full-period contractual terms.

[15]The FERC EQR data has been used by Lin, Schmid, and Weisbach (2021) to study the cash holdings and liquidity management of electric utilities.

[16]Sections 205(c) and 201(f) of the Federal Power Act define who must submit EQRs to FERC. The reporting provisions do not apply to the United States, a state, or any political subdivision, as well as electric cooperatives. The reporting requirements also do not apply to utilities that make less than 4,000,000 MWh of annual wholesale sales.

Panel B of Table 2 presents summary statistics on capacity sales. The number of power plants that receive compensation for maintaining available capacity is smaller than the number of power plants selling electricity, as not all wholesale markets have a capacity market and power plants must submit bids on competitive auctions to receive compensation for maintaining capacity. Renewable power plants are less likely to sell capacity than fossil fuel power plants. Around 84% of the capacity sales are made under long-term contracts with a duration of longer than one year. Almost all capacity sales use long-term increments and cover the full period.

## 3 The Mechanisms of Ownership Changes and Market Regulation

As the ownership share of DLCs has declined from 70% in 2005 to 54% in 2020, PE, institutional investors, and foreign corporations have gradually replaced DLCs as power plant owners. These ownership changes can occur through three mechanisms: creating new power plants, selling existing plants, and decommissioning plants. In this section, we examine the relative importance of the three mechanisms and the role of electricity market deregulation in stimulating ownership changes.

Our aim is to examine two key theoretically-motivated questions. First, is the regulation that protects the markets and pricing for incumbents positively (under the Schumpeter view) or negatively (under the Arrow view) related to new capital investments in electricity generation, both for renewable alternatives and for fossil fuels? Documenting the shift in ownership from DLCs to the new ownership types by itself does not address this question, as it does not assess who is actually financing asset creation and under what conditions. To do so, we study the extent to which the ownership shift is driven by differences in asset creation, as opposed to transactions and decommissioning, and consider how action on each of these margins differs between regulated and deregulated markets. Second, we test the leakage hypothesis, the extent to which the ownership shift represents sales of older and more polluting plant types away from incumbents and towards owners with more lenient regulatory and disclosure requirements (Fowlie et al., 2016; Copeland et al., 2021; Benthem et al., 2022; Bolton and Kacperczyk, 2022; Duchin et al., 2024; Bernstein, 2022).

### 3.1 Creating New Greenfield Power Plants

In this section, we study the first mechanism that explains the ownership shift, differences in the financing of new power plants. Creating new power plants is risky as the owners need to connect the new plants to the electric grid and establish sales contracts with customers. A Schumpeter-leaning hypothesis is that DLCs, which are the traditional incumbent owners in our setting, have competitive advantages for creating assets. Their advantages are size, synergies with existing operations, access to the transmission network, and ability to impact government policy. In addition, regulated incumbent utilities generally receive compensation through the rate base for the fixed costs of building new assets (Averch and Johnson, 1962; Joskow and Schmalensee, 1986; Joskow, Rose, and Wolfram, 1996).[17] However, an alternative hypothesis is that DLCs may prefer to delay the adoption of new technology (Arrow, 1962), especially under the protection of market power (Bertrand and Mullainathan, 2003; Cunningham, Ederer, and Ma, 2021). Under this hypothesis, new entrants such as PE and foreign corporations will be more likely to own new power plants, especially in deregulated markets.

Our dataset does not provide information on all potential entries, so we cannot estimate the probability of completing a proposed power plant. We estimate the differences in capacity-weighted conditional probabilities of owning a greenfield plant across ownership types relative to their baseline ownership stakes while controlling for fuel type, location, and regulation. In Table 3, we estimate the following specification, where the unit of observation is at the plant-prime-mover-month level:

$$Greenfield_{i,t} = \beta_1 DLC_{i,t} + \beta_2 ISO_{i,t} + \beta_3 DLC_{i,t} \times ISO_{i,t} + \gamma Z_{i,t} + \delta_{f,s,t} + \varepsilon_{i,t}. \tag{1}$$

The dependent variable $Greenfield_{i,t}$ is binary and equals one for the first 12 months of plant $i$ operation. We measure the ownership of plant $i$ in month $t$ by DLCs, while the omitted categories are PE, institutional investors, and foreign corporations. In the OLS regressions, we weigh the power plants by nameplate capacity, which assigns a higher weight to larger power plants. The weighting in the greenfield specifications enables us to estimate economically more representative results as the new renewable plants tend to have a smaller capacity: 3,630 solar plants were created during our sample period, but they accounted for less than 3% of electricity generation in 2020. Our results are robust to using logit specifications instead of OLS, without weighting the observations.[18]

In terms of economic factors, we focus on market regulation which affects the ability of a power plant to operate and sell electricity. $ISO_{i,t}$ is an indicator whether power plant $i$ operates in month $t$ in a deregulated market. Deregulated markets may attract more capital from new entrants as the transmission is not operated by a monopolist utility that is also involved in electricity generation.

[17] Public Utility Commissions (PUCs) will increase a utility's rate base for new construction, and in some cases include credits for Construction Work in Progress (CWIP).

[18] The OLS regressions are also more suitable for our setting than nonlinear logit regressions as our focus is on the marginal effects rather than the latent index variable (Angrist and Pischke, 2009; Bertrand et al., 2007).

Figure 3 Panel A shows that IPPs in deregulated ISO balancing markets attract more capital to adopt new technologies. At the end of 2020, greenfield plants created during our sample period represent 36% of the total installed capacity owned by IPPs in ISO balancing markets and 20% in traditional markets. Panel B shows that this difference is concentrated in renewable power plants. Newly created solar and wind plants represent 22% of the installed capacity of IPPs in ISO balancing markets and only 7% in traditional markets, and the difference is increasing over time. In the specifications, we include interaction terms between the ownership types and market deregulation indicators (e.g., $DLC_{i,t} \times ISO_{i,t}$) to examine which ownership types drive these differences. Importantly, in Online Appendix Table A.3, we show that state-level natural resources, economic, and political factors do not predict market deregulation. The decision to deregulate markets is unrelated to the variation in solar and wind energy potential, nor is it related to the production of natural gas or coal.

To distinguish how much different ownership types create new assets from what may be a general preference to invest in certain fuel types (e.g., renewable energy), we interact several fixed effects. The 19 fuel type fixed effects capture the baseline level that a solar or natural gas power plant is greenfield, while state fixed effects capture differences in weather conditions or available natural resources affecting plant location. We saturate the specifications by including $\delta_{f,s,t}$, fully interacted fuel-type, state, and year-month fixed effects. When including this saturated set of fixed effects, the estimates rely only on variation in owner type and probability of owning greenfield assets across power plants using the same fuel, located in the same state, and at the same moment of time.

In Table 3, we find that DLCs are significantly less likely to own a greenfield power plant relative to their baseline probability of owning any power plant. Based on Column (1), DLCs have a 0.99 percentage point lower probability of owning a greenfield plant than the omitted ownership types, which are PE, institutional investors, and foreign corporations. This coefficient corresponds to a 61% decrease relative to the baseline unconditional probability of 1.63% to own a greenfield power plant in any given month. The smaller probability of DLC plant creation is significant only in deregulated markets. The interaction term of DLC and ISO balancing authority in Column (3) shows that DLCs are 1.16 percentage points less likely to own a greenfield plant in deregulated markets. The baseline coefficient on DLCs in Column (3) is insignificant which implies that DLCs and new entrants are equally likely to own a greenfield plant in traditional markets.

The *ISO Balancing* measure is broad and would include plants that are subject to rate-of-return regulation but operating in deregulated markets. In our setting, DLCs operate both as regulated electric utilities as well as independent power producers (IPPs), while new entrants operate predominantly as IPPs. To address this concern, our preferred measure of market deregulation examines only power plants owned by IPPs in ISO balancing markets. The *IPP ISO Balancing* measure covers only plants that operate under a market-based pricing model and sell electricity in competitive markets. If the differences between DLCs and new entrants reflect only the differences in the probability of owning greenfield plants between regulated electric utilities and IPPs, we would expect that the baseline coefficient on IPP ISO Balancing should be positive and significant, while the interaction term of DLC $\times$ IPP ISO Balancing should not be significant. However, in Column (4), we document that the baseline coefficient on IPP ISO Balancing is positive, but not statistically different from zero, while the interaction term DLC $\times$ IPP ISO Balancing is negative and significant. This result suggests that ownership structure matters as, within the universe of IPPs operating in ISO markets, DLCs are 1.91 percentage points less likely to own a greenfield plant.

Our identification of the effect of deregulation on the creation of new plants and ownership changes relies on the assumption that power plants in deregulated and traditional markets would have followed parallel trends absent the deregulation conditional on observed plant characteristics. However, states and utilities did not randomly choose whether to restructure their electricity markets and we address the possibility of omitted variables bias in several ways.

First, importantly for our interpretation, the ISO markets were established before our sample period, mostly around 2000, and before the wind and solar technologies became competitive as well as before the shale gas boom. This timeline reduces concerns regarding reverse causality, specifically the alternative hypothesis that ISOs were created to stimulate the adoption of new technologies.

Second, in Online Appendix Table A.3, we show that state-level natural resources, economic, and political factors do not predict market deregulation. The decision to deregulate markets is unrelated to variation in state-level solar and wind energy potential, nor is it related to the production of natural gas or coal in a state normalized by the amount of electricity consumption. In line with prior research, the main factor that predicts wholesale market deregulation is not the average electricity price in a state, but rather the difference between the average electricity price in the residential sector and the average electricity price in the industrial sector (White, 1996; Joskow, 1997).

Third, since the difference between retail and industrial electricity prices on a state level is the main predictor of deregulation, we use it as an instrumental variable for deregulation. The IV is the average residential-industrial price difference *ResidIndPD* on a state level over the 1991–1996 period. We construct the IV over the 1991–1996 period to address the staggered restructuring of electricity markets. The first ISO restructured market, PJM Interconnection, started functioning as a competitive wholesale electricity market in 1997, so the IV is measured before any plants operated in a deregulated market. We use the difference between retail and industrial electricity prices to instrument for power plants operating in *ISO Restructured* markets, which is a more restrictive measure of wholesale market deregulation. The ISO restructurings had to be approved by state legislative bodies and were completed at the end of the 1990s, while some ISO balancing markets (but not restructured), such as MISO and SPP, were formed later without state legislative approval.

Our analysis examines the baseline effect of ISO Restructured and an interaction term of DLCs and ISO Restructured, so we estimate two first-stage regressions to instrument for both variables:

$$ISO_{i,t} = \beta_1 ResidIndPD_i + \beta_2 DLC_{i,t} \times ResidIndPD_i + \beta_3 DLC_{i,t} + \gamma Z_{i,t} + \delta_{f,t} + \varepsilon_{i,t}, \quad (2)$$

$$DLC_{i,t} \times ISO_{i,t} = \beta_1 ResidIndPD_i + \beta_2 DLC_{i,t} \times ResidIndPD_i + \beta_3 DLC_{i,t} + \gamma Z_{i,t} + \delta_{f,t} + \varepsilon_{i,t}. \quad (3)$$

The control variables $\gamma Z_{i,t}$ are the same as in 1, but we include only interacted fixed effected on a fuel-year-month level as the IV does not vary within a state. The second stage uses the predicted values of both variables and examines the effect on ownership of greenfield plants:

$$Greenfield_{i,t} = \beta_1 DLC_{i,t} + \beta_2 \widehat{ISO_{i,t}} + \beta_3 DLC\widehat{_{i,t} \times I}SO_{i,t} + \gamma Z_{i,t} + \delta_{f,t} + \varepsilon_{i,t}. \quad (4)$$

Table 3 Column (5) presents the OLS estimates for the ISO restructured deregulation measure. Using this measure, we document that DLCs are 1.50 percentage points less likely to own a greenfield plant in markets with an ISO balancing authority and restructured electric utilities. Online Appendix Table A.6 reports the first stage estimates of both IV regressions. The difference between retail and industrial electricity prices on a state level over the 1991–1996 period strongly predicts whether a power plant $i$ will operate in an ISO-restructured market in period $t$. In Table 3, the first-stage F-statistic is 94.58, and in most models, we obtain F-statistics well above 100, always passing tests for weak instruments. Column (6) shows that the instrumented coefficient on $DLC_{i,t} \times ISO_{i,t}$ is negative and significant, which implies that DLCs are 1.57 percentage points less likely to own a greenfield plant in deregulated markets, an estimate extremely close to the OLS.

The IV results therefore bolster the causal interpretation that electricity market deregulation is the main economic condition that attracts investments by new ownership types in greenfield power plants. Our results do not support the Averch and Johnson (1962) argument that regulated utilities engage in more capital investments because they receive an artificially high rate of return on capital.

Traditional electricity markets exhibit a lower level of asset creation, potentially because state utility commissions adhere to the "used and useful principle" when permitting new investments. Under this principle, electric utilities need to show that a power plant will be used and useful to current ratepayers to get the regulator's approval to include a corporate investment in the cost of service.

Figure 4 Panel A reports the coefficients of a subsample analysis instead of using interaction terms. PE and foreign listed corporations have a disproportionally higher probability of owning a greenfield power plant and this difference is concentrated almost entirely in deregulated electricity markets. Based on Panel A, PE and foreign corporations have a 2.38 and 1.74 percentage points higher probability of owning a greenfield power plant in IPP ISO balancing markets, respectively.

In Panels B and C of Figure 4, we consider heterogeneity by fuel type in the ownership of greenfield plants, focusing on solar, wind, and natural gas fuel types as they account for the vast majority of newly created power plants.[19] The baseline probability for greenfield solar and wind plants is 13.66%, which is relatively high as these new technologies were not adopted before our sample period and almost all solar and wind plants have 12 months of greenfield stage. The baseline probability for greenfield natural gas plants is 1.47% which is lower as they are added to an already existing capacity of natural gas plants. However, in terms of installed capacity, the newly installed renewable and natural gas plants are equally important as the natural gas plants are larger.

We find that DLCs are significantly less likely to own new renewable as well as new fossil fuel plants. Panel B shows that PE and foreign corporations have a 6.43 and 3.63 percentage points higher probability of owning greenfield solar and wind plants, respectively. The heterogeneity in ownership of new wind and solar farms is economically stronger in deregulated markets but does not seem to be entirely concentrated in these markets. Traditional markets also attract more capital from PE and foreign corporations to finance new renewable plants relative to DLCs. Within the subsample of natural gas power plants, we observe that only PE is more likely to create new plants. The difference in the probability of owning new natural gas plants between DLCs and PE is entirely concentrated in deregulated markets. For instance, in ISO restructured markets, PE firms are 2.04 percentage points more likely to create a new natural gas plant, while in traditional markets the coefficient is $-0.52$ and statistically insignificant.

For institutional investors, we find that they have a lower probability of owning greenfield power plants after controlling for interacted fixed effects, even though Figure 2 shows that they own a

[19] Some natural gas power plants use also biogenic municipal solid waste, landfill gas, wood waste, or other gases as alternative fuels, so we can still include fuel-state-time fixed effects in the specifications. Online Appendix Table A.8 also presents a robustness test with specifications by fuel type that uses interaction terms instead of subsamples.

substantial share of the wind and solar power plants. Thus, institutional investors seem to prefer to co-invest in established operational renewable plants and provide deep pockets for larger transactions or partial exit to other investors (Fang, Ivashina, and Lerner, 2015; Andonov, Kräussl, and Rauh, 2021; Lerner, Mao, Schoar, and Zhang, 2022), but are less willing to create these new power plants. In the analysis, we control but do not report the coefficients on government, cooperatives, and industrial firms. These ownership structures are also less likely to create new power plants.

In Table 3, power plants are considered greenfield only in the first 12 months and later can have multiple observations that are not classified as new assets. This definition implies that owners who create plants at the end of the sample period can appear to be investing relatively more in greenfield compared to owners who create more plants earlier, and this could potentially bias the estimates. To address this limitation, we estimate a robustness test by limiting attention only to the subsample of greenfield observations, so that power plants created at any time during the sample period are equally important. In Table 4, the dependent variables are the ownership stakes of DLCs, PE, and foreign corporations of greenfield plants, and the results confirm that market deregulation affects the types of corporate ownership that create power plants. Based on Panel A, DLCs have a 22.0 percentage point lower probability of owning greenfield plants in IPP ISO balancing markets, while PE and foreign corporations have a 22.3 and 11.9 percentage points higher probability. In IPP ISO Balancing markets, new entrants are more likely to create new renewable and natural gas plants. The IV specifications within the subsample of only greenfield observations also confirm that PE and foreign corporations are more likely to create new power plants in deregulated markets, and this result is driven by natural gas plants. These IV specifications are simpler as we do not use interaction terms and need to instrument only for *ISO Restructured* in the first stage.

In Online Appendix Table A.7, we examine whether the results are driven by a few large newly created plants. In this robustness test, we use logit specifications and do not weigh the observations by capacity. Instead, we analyze the subsample of power plants with a nameplate capacity above 20MW. The unconditional baseline probability in the unweighted sample equals 2.77%, which is higher than 1.63% in the weighted sample because the newly created plants tend to be smaller than the existing plants. The results confirm that DLCs are less likely to own new power plants than PE and foreign corporations, especially in deregulated markets, and the differences are even larger in the unweighted sample.

Overall, PE and foreign listed corporations are significantly more likely to create new power plants and their willingness to finance the capital expenditures to adopt new innovative technologies contributes significantly to the changing ownership structure. The market organization affects the extent to which PE and foreign corporations finance new fossil fuel and renewable power plants as compared to DLCs, which have traditionally dominated electricity markets. We can conclude that the higher degree of creation in deregulated markets is driven by the ability of these markets to attract more capital from PE and foreign corporations for greenfield assets.

### 3.2 Selling and Decommissioning Power Plants

In this section, we jointly consider the second and third mechanisms of ownership transition: selling and decommissioning power plants.[20] One concern frequently raised in the financial press and industry reports regarding the selling mechanism is that DLCs transfer older polluting power plants to the new ownership types, such as PE, institutional investors, and foreign corporations.[21] Based on this leakage hypothesis, DLCs face a higher degree of regulatory pressure and public scrutiny (Benthem et al., 2022; Bolton and Kacperczyk, 2022; Duchin et al., 2024).[22] PE and foreign corporations are subject to more lenient regulation and weaker reporting requirements so they may be willing to own and operate older power plants for longer. Thus, the leakage hypothesis would predict that PE and foreign corporations should be more likely to continue operating older fossil fuel plants and postpone their decommissioning.

To assess the relative importance of these two mechanisms we start by analyzing all power plants that DLCs owned at the beginning of our sample in January 2005 and classifying them into four potential outcomes based on the latest observation in our dataset. The latest observation is either the shutdown date or December 2020 for plants that are still operating. The four potential outcomes are as follows. *Still Own & Operating* covers plants that did not change ownership and are still operated by DLCs; *Owned & Retired* captures plants that did not change ownership, but were retired by DLCs during the sample period; *Sold & Operating* captures plants that DLCs sold to other ownership type and are still operated by the new owners; and *Sold & Retired* covers power plants that DLCs sold to other ownership type and were retired by the new owners.

Figure 5 presents the probabilities for the four outcomes weighted by capacity. DLCs retain

[20] The selling mechanism has received significant attention in prior research on cross-border mergers and acquisitions (see Erel, Jang, and Weisbach (2022) for a review), and private equity buyouts (see Bernstein (2022) for a review).

[21] See for example the Private Equity Stakeholder Project report "Private Equity Propels the Climate Crisis: The Risks of a Shadowy Industry's Massive Exposure to Oil, Gas and Coal" and the New York Times article "Private Equity Funds, Sensing Profit in Tumult, Are Propping Up Oil."

[22] One example of the increased public scrutiny is the 2021 action by activist investor Engine No. 1 in collaboration with several large asset managers to win board seats at Exxon Mobil Corporation. The activist investors then voted to cut oil production at Exxon, and Exxon reportedly sold some oil fields to PetroChina (Rubenfeld and Barr, 2022).

ownership and continue operating 1,085 out of 2,207 power plants or 62% of their initial capacity. The selling and decommissioning mechanisms have similar relevance as DLCs retired 16.5% and sold 21.4% (= 19.2% + 2.2%) of their initial capacity. However, the importance of these two mechanisms differs across fossil fuel types. In the subsample of coal and petroleum plants, DLCs retired 26.2% of initial capacity, which is double the capacity sold to new owners. In the subsample of natural gas plants, DLCs retired only 9.9%, while selling 38.0% of the initial capacity. These statistics highlight that the decommissioning of coal power plants by DLCs is a highly relevant mechanism for the transition to cleaner energy.

In Table 5, we estimate a competing risks model and compare the characteristics of power plants that are sold and retired by DLCs. For each power plant $i$ owned by DLCs, we observe the time to exit $t_i$ and the exiting cause $c$, where $c_1$ is selling and $c_2$ is decommissioning. For each cause, there is a latent duration $T_c$, which is the time elapsed before the plant operation ends via exit cause $c$ in the absence of any other causes. However, other competing causes may end plant operation before this time. Thus, the actual exit time and exit cause can be interpreted as the realizations of variables $T$ and $C$, which are defined as $T = min(T_c, c = 1, 2)$ and $C = argmin_c(T_c, c = 1, 2)$. At each point in time, the hazard function for risk $c$ is:

$$h_c(t) = \lim_{\Delta t \to 0} \frac{Pr(t \leq T_c \leq t + \Delta t | T_c \geq t)}{\Delta t}. \tag{5}$$

The overall hazard function is $h(t) = \sum_{c=1}^{2} h_c(t)$ where $h_1$ and $h_2$ are the cause-specific hazard rates for selling and decommissioning. The cause-specific hazard functions are

$$h_c(t, X) = h_{0c}(t) exp(\beta_c X_{i,c,t}), \tag{6}$$

where $h_{0c}$ is the baseline hazard function for exit cause type $c$ at time $t$, and $X_{i,c,t}$ is a vector of covariates for power plant $i$ specific to hazard $c$ at time $t$. The proportional hazard model allows the effects of the covariates to differ by exit cause type.

Table 5 reports the hazard ratios of the competing risks model. In Columns (1) to (4), the main event is a power plant sale, while the competing event is a plant decommissioning. In Columns (5) to (8), the main event is plant decommissioning, while the competing event is a sale. The results provide very mixed evidence on the leakage hypothesis, as several aspects are inconsistent with this hypothesis. First, focusing on the coal coefficient, DLCs are less likely to sell and more likely to decommission coal power plants, which are the most polluting plants of the six main fuel types.[23] Second, DLCs are much more likely to decommission an older power plant than a younger one, by a factor of five to one for every unit increase in log age.

We also find that DLCs are more likely to sell power plants operating in deregulated markets, controlling for the competing risk of decommissioning them. Based on Column (4) which uses the IV, DLCs are three times more likely to sell a plant in an ISO-restructured market after controlling for fuel type, plant size, and age. DLCs are also less likely to retire power plants in an instrumented ISO-restructured market, but the hazard ratios are not significantly different in IPP ISO-balancing markets. In addition, DLCs are more likely to sell power plants in states where the population displays high climate concerns. These facts could indicate potential leakage and require investigation of the behavior of new owners after they acquire a plant, which we examine below.

The competing risk model has the advantage of including all power plants ever owned by DLCs, as well as taking into account the timing of sales and decommissioning events (earlier or later in the sample period). A simpler model for interpretation is a multinomial logit, which we use to provide a snapshot of outcomes for plants that DLCs owned in January 2005. The advantage of the multinomial logit model is that we can classify separately more potential outcomes and also study the probability that DLCs sell a power plant and the new owner decommissions this plant before the end of the sample period. We show this robustness test in Online Appendix Table A.9 and most of the results are generally similar. One new result is that, in deregulated markets, the new owners are also more likely to retire the acquired power plants. If a plant is located in an IPP ISO balancing market, it has a 4.8 percentage point higher probability of being acquired and decommissioned by the new owners, which is a substantial increase relative to the baseline probability of 4.0% for this outcome. This additional result provides further evidence against the leakage hypothesis.

Overall, the sales mechanism is highly relevant but explains only one-third of ownership transitions and does not have a substantial effect on plants using new renewable technologies or coal plants using older technologies. While in other industries transactions account for the vast majority of ownership changes and privatization reforms (e.g., La Porta and López-de Silanes, 1999; Dinc and Gupta, 2011; Howell, Jang, Kim, and Weisbach, 2022; Duchin, Gao, and Xu, 2024), creation of new power plants as well as decommissioning of older plants are highly relevant in the energy sector.

The competing risks analysis suggests that there is limited leakage of older fossil fuel power plants

[23] In the specifications, we control for all 19 fuel types that are part of the EIA classifications but display the coefficients only for coal, nuclear, hydro, wind, and solar power plants (the omitted category is natural gas plants).

from DLCs through sales, but it does not address the possibility that DLCs decommission power plants sooner than PE, institutional investors, and foreign corporations because they are subject to stricter disclosure requirements and public scrutiny. In Table 6, we estimate the differences in decommissioning power plants across ownership types and market regulation settings using a Cox proportional hazard model:

$$h(t) = h_0(t)exp(\beta_1 DLC_{i,t} + \beta_2 ISO_{i,t} + \beta_3 DLC_{i,t} \times ISO_{i,t} + \gamma Z_{i,t} + \delta_s + \lambda_f). \tag{7}$$

The hazard event of interest is a complete decommissioning of power plant $i$ in month $t$, not a partial retirement of one generator. To exclude the effects of a large number of smaller plants on the results, we estimate this specification only on plants with a capacity of at least 20MW, although as robustness in Online Appendix Table A.10 we conduct an OLS analysis on the full sample with observations weighted by capacity. The specifications include $Z_{i,t}$ controls for plant age and capacity, as larger power plants have greater strategic importance for network stability and security of electricity supply. We also control for $\lambda_f$ fuel and $\delta_s$ state fixed effects.[24] In these specifications, the ownership coefficients can be interpreted as differences in the hazard rate of decommissioning a power plant controlling for differences in profitability and efficiency of different fuels and technologies as well as plant capacity and age, with coefficients greater than one reflecting an increased hazard relative to the baseline.

In terms of the economic conditions that drive decommissioning, our focus is again on the role of market regulation. Figure 3 shows that the decisions to commission new plants and decommission old plants closely follow each other over time. Based on Panel C, IPP owners shut down more power plants in deregulated markets with an ISO balancing authority than do owners under traditional regulation. The cumulative decommissioning hazard rate in deregulated markets is 40% higher than in regulated markets, as reflected by a decommissioning rate of 17.3% in IPP ISO balancing markets versus 12.4% in traditional markets. Panel D shows that this effect is driven by differences in fossil fuel plant retirements. In the hazard models, we include interaction terms between the ownership types and market deregulation indicators (e.g., $DLC_{i,t} \times ISO_{i,t}$) to examine which ownership types drive these differences.

Columns (1) and (2) of Table 6 show that DLCs are more likely to retire power plants than

[24] In the IV specification, we control for time fixed effects in the first stage. The Cox proportional hazard model implicitly accounts for time fixed effects, as it is robust to any baseline hazard function. This feature of Cox proportional hazard models makes it robust to time-specific common factors.

institutional investors and foreign corporations, which is consistent with the leakage hypothesis. There is no difference with PE so the largest and most controversial form of new ownership does not contribute to the leakage of older fossil fuel power plants. The main leakage effect is relative to foreign corporations. For instance, the coefficient of 0.51 implies that foreign corporations need to double the number of retired plants to reach the decommissioning rate of DLCs and PE, which translates into 23 additional decommissioned fossil fuel plants during our sample period or 1.43 plants per year. Institutional investors do almost no retiring of plants, but they also have a very limited baseline exposure to power plants using coal, which is the main fuel type subject to shutdowns. Consistent with our findings on greenfield assets, institutional investors appear to seek stable operating assets and do not want to hold power plants either during the greenfield stage or during the decommissioning stage.[25]

Columns (3) to (6) show that the differences in decommissioning hazard ratios seem to be concentrated in deregulated markets, but they are not robust across the different definitions of market regulation and IV methodology. What is clear from the combination of results in Figure 3 and Table 6 is that there is overall more decommissioning of plants in deregulated markets. Deregulated markets stimulate all owners jointly to decommission more plants and the higher level of power plant shutdowns in these markets is not driven by any particular ownership type.[26]

The coefficients on the control variables show that smaller plants, as proxied by nameplate capacity, and older plants have significantly higher decommissioning rates. These results confirm that decommissioning decisions are affected by the plant's strategic importance and technology profitability over time.

In Figure 6, we examine whether the decommissioning rates across ownership types differ by fuel type, focusing on coal and natural gas plants.[27] Panel A confirms that PE has similar decommissioning rates as DLCs, while foreign corporations have lower decommissioning rates. The difference in decommissioning rates between DLCs and foreign corporations is significant in IPP ISO balancing markets, and appears to be driven by both coal and natural gas plants. The decommissioning rates

[25]When investing directly in power plants, institutional investors seem to reduce their exposure to the creation of new assets as well as shut down of old assets, potentially because these activities are associated with higher liability and litigation risks (e.g., Bellon, 2022). Consequently, we find that institutional investors do not hold almost any plants in the decommissioning stage but have also very limited overall exposure to coal power plants.

[26]In Online Appendix Table A.10, we provide robustness analysis using OLS, defining a dependent variable that equals one for the last 12 months of the plant's operation. These specifications allow for weighting the observations by plant capacity and include fully interacted fuel-type, state, and year-month fixed effects. In line with the hazard results, PE has a similar probability of retiring a power plant as DLCs, while institutional investors and foreign corporations have a significantly lower probability of decommissioning a power plant.

[27]If a power plant is designed to use both coal and natural gas as a fuel, we classify this plant in the sample of coal and petroleum power plants.

of PE relative to DLCs somewhat differ across fuel types: PE seems less likely to retire coal and petroleum plants, particularly in ISO restructured markets, but more likely to retire natural gas plants. However, most coefficients are statistically insignificant so the evidence is not as conclusive as in the greenfield analysis. Online Appendix Table A.11 confirms these results using a robustness test with interaction terms instead of subsample analysis.

### 3.3 Implications of Market Deregulation for Power Plant Ownership

We document that all three mechanisms for ownership changes — creating new power plants, selling existing plants, and decommissioning plants — are stronger in deregulated electricity markets. The creation of greenfield plants has a substantial contribution to the ownership changes as new entrants, such as PE and foreign corporations, are significantly more likely than DLCs to create new renewable and fossil fuel plants in deregulated markets. The sales mechanism also results in a substantial transfer of plant ownership from DLCs to new entrants in deregulated markets. The decommissioning mechanism has a smaller impact on the ownership changes as DLCs and new entrants differ marginally in the probability of retiring power plants, but deregulated electricity markets induce all owners jointly to decommission more plants. Deregulated markets enable a faster transition away from fossil fuels since DLCs are retiring more fossil fuel plants in these markets and, critically, new ownership types are not acquiring these plants on a large scale.[28]

Figure 7 summarizes the implications of market deregulation on power plant ownership. Panel A shows that new entrants generated 47% of the electricity in 2020 in IPP ISO balancing markets, and PE alone contributes 31% to the generation in these markets. In traditional markets, the ownership share of new entrants remains almost constant over time and they account for only 9% of the electricity generation in 2020. These trends are substantial and changed the dominant ownership type of power plants across some deregulated states. For example, over the 2005–2020 period, DLCs reduced their ownership share in Pennsylvania (PJM balancing authority) by 62 percentage points, so PE has become the main corporate form of power plant ownership in this state. In 2020, new entrants also accounted for a larger share of the electricity generation than DLCs in Texas (mainly ERCOT balancing authority), New York (NYISO), and Massachusetts (ISO New England).

[28]This interpretation is in line with the results of Green and Vallee (2022) that banks reduce financing of coal power plants, which implies that DLCs cannot sell the power plants to new entrants or use debt to finance these assets.

### 3.4 Comparing the Role of Market Regulation with Other Economic Factors

Our results highlight the key role of electricity market deregulation in explaining the ownership changes of power plants. If other economic factors drive these results, they would need to have differential effects on DLCs located in deregulated and traditional markets. In this subsection, we discuss several potential alternative economic factors and show that the effect of market deregulation on ownership changes through the three mechanisms is robust to these factors.

**Climate Concerns and Policy Incentives:** States, where the population displays higher climate concerns, may attract more investors through increased demand for new renewable or efficient power plants. The higher climate concern among the population could also incentivize more new investors to commit capital to greenfield projects as they could expect these states to adopt stricter regulation and licensing of old power plants. In addition, states implement various tax and production-based incentives to stimulate the transition to renewable energy and ownership types may respond differently to these incentives.

In the greenfield specifications, we find that the interaction term of DLCs and the climate concern percentile ranking is mostly insignificant suggesting that the differences in the probability of financing new power plants across regulatory regimes are not driven by a stronger sensitivity of PE and foreign corporations to climate concerns among the population. The differences in ownership of greenfield plants are also not captured by differences in the sensitivity of DLCs, PE, and foreign corporations to renewable energy policy incentives. For the sales mechanism, states with higher climate concerns experience more sales of plants from DLCs to the new ownership types, but this relation does not affect the role of market deregulation. We also do not find robust evidence of climate concerns and policy incentives' effects on decommissioning rates. The differences in ownership of decommissioned plants do not merely reflect differences in the sensitivity of DLCs, PE, and foreign corporations to climate concerns or renewable energy policy incentives.

In the main greenfield and decommissioning analyses, we include an interaction term of DLC with *Renewable Incentives* index, which aggregates five separate renewable policy indicators. In Online Appendix Figure A.2, we estimate specifications that include separate interaction terms of DLC with each of the components of this index: with the three indicators if a state has corporate tax, property tax, and sales tax incentives for renewable energy, as well as with the two indicators if a state has production incentives or feed-in tariffs for renewable energy. The specifications in Panel A confirm that DLCs are less likely to own greenfield plants in deregulated markets and these results are robust to controlling separately for individual renewable policy incentives. Panel B presents a similar robustness test for decommissioning of power plants. Our baseline specifications do not find significant and consistent heterogeneity across ownership types in their sensitivity of decommissioning decisions to market regulation. The robustness test with five separate indicators for renewable policy measures documents similar results.

**Credit Ratings and ESG Ratings:** An alternative hypothesis is that electricity market regulation correlates with DLC characteristics so these corporate characteristics explain the ownership changes rather than market competitiveness. We consider whether our results on plant creation and decommissioning could be driven by corporate credit ratings or ESG ratings. Under this hypothesis, firms with weaker credit ratings are more likely to be financially constrained and might engage in less plant creation or more plant destruction. Firms with higher ESG ratings may favor the creation of solar and wind farms and decommissioning of fossil fuel plants. This hypothesis predicts that only low ESG or low credit rating DCLs would be less likely to create greenfield power plants and the differences should be insignificant for high-ranked DLCs regardless of market regulation.

Online Appendix Figure A.3 shows that across all ESG and credit rating categories, DLCs are less likely to own greenfield plants. Importantly, the interaction effects with market deregulation remain robust and significant in almost all ESG rating and credit rating categories. We also find that DLCs of all ESG and credit rating categories are less likely to create new solar and wind plants. Panels B and D provide evidence that DLCs lack of creation of new natural gas plants is more concentrated in firms with lower ESG ratings (counterintuitively) and lower credit ratings. Online Appendix Figure A.4 finds no variation of interest in the decommissioning rates across the ESG or credit rating categories. To the extent that DLCs are more likely to decommission, there is no specific ESG or credit rating category that is more likely to do it in a robust fashion. Online Appendix Table A.12 also shows that the role of market deregulation and plant characteristics in explaining DLCs' selling and decommissioning decisions is robust to ESG and credit rating controls.

# 4 Power Plant Operating Performance

The previous analysis examines only ownership of power plants and does not study the fuel consumption and intensity of power plant operation. In this section, we study two measures of operating performance. On the one hand, if the new ownership types operate fossil fuel power plants with a higher capacity factor or higher heat rate, the increased use or reduced efficiency could represent an alternative form of leakage. On the other hand, if the new ownership types operate their plants at less intensity or more efficiently, then the ownership changes would instead be contributing to improvements in operations, lower fuel consumption, and ultimately lower emissions.

We analyze power plant operating performance using our two $Y_{i,t}$ measures of operating performance as dependent variables in the following specification:

$$Y_{i,t} = \beta_1 DLC_{i,t} + \beta_2 ISO_{i,t} + \beta_3 DLC_{i,t} \times ISO_{i,t} + \gamma Z_{i,t} + \delta_{f,s,t} + \varepsilon_{i,t}. \tag{8}$$

Columns (1) to (4) of Table 7 focus on the power plant's capacity factor, which measures operating intensity and equals the ratio of net electricity generation in MWh to nameplate capacity. In Columns (5) to (8), the dependent variable is the power plant's heat rate, which measures operating efficiency and is the ratio of monthly fuel consumption in millions Btu to net electricity generation in MWh. The specifications include $\delta_{f,s,t}$ interacted fuel-state-year-month fixed effects and effectively limit the analysis to comparing the operating performance of power plants using the same fuel type, located in the same state, and in the same moment of time. This saturated set of fixed effects addresses to a large extent differences in the prices of resources (e.g., coal and natural gas prices) as well as weather conditions (e.g., the number of sunshine hours in different months).

Table 7 shows that power plants differ in operating intensity across ownership types. Based on Column (1), DLC plants have a 0.02 higher capacity factor. As shown in Column (2), the difference is particularly pronounced relative to PE-owned plants, which operate at a capacity factor that is 0.03 lower than DLCs. Column (3) shows that the difference in operating intensity between DLCs and new ownership types is concentrated in traditional markets, where power plants owned by the new entrants depend on the local electric utility serving also as a balancing authority when deciding how much electricity to produce.[29] We see that DLCs operating as IPPs in ISO Balancing regimes do not operate at higher capacity factors, as the negative coefficient on the interaction term DLC × IPP ISO Balancing outweighs the positive coefficient on the non-interacted DLC term.[30] Column (4) uses the instrumented ISO Restructured measure of deregulation and shows similar effects as seen in Column (3). The negative interaction term of DLCs and ISO Restructured once again outweighs the baseline coefficient on DLCs, which suggests that the differences in operating intensity across ownership categories are not significant in deregulated markets. We note that operating a power plant less intensively is not necessarily a sign of weaker operating performance and it can be even

[29]DLCs may in these circumstances of traditional markets have the incentive to utilize power plants at higher capacity in these markets, as they are subject to used-and-useful regulation and to maintain their rate base.

[30]Column (3) also shows that non-DLC IPPs operating in ISO Balancing regimes operate at higher capacity factors.

profit-enhancing if the owner exercises market power or if it is unprofitable to produce in some hours (Jha and Leslie, 2023).

We also observe differences across ownership types in power plant operating efficiency, as measured by heat rates. Based on Column (5), DLC plants have a 0.62 higher heat rate than plants owned by the new entrants. This coefficient implies that power plants owned by DLCs operate less efficiently and use around 5% (= 0.616 / 11.324) more fuel to produce one unit of electricity when we compare plants using the same fuel, located in the same state and in the same moment of time. Power plants owned by PE, institutional investors, and foreign corporations all consume less fuel and operate more efficiently. The differences in operating efficiency between DLCs and new entrants seem to be relatively larger in deregulated markets but the interactions are only statistically significant under the IPP ISO Balancing measure of deregulation and not under the instrumented ISO Restructured measure. Thus, while the capacity utilization of DLCs is significantly higher than that of new owners only in traditional markets where there may be incentives for differential operating intensity, new owners operate across the board at higher levels of efficiency.

In the specifications, we control for whether a plant is in a greenfield or decommissioning stage as power plants in these periods operate under significantly lower capacity factors as well as higher heat rates. Based on Column (1), plants have a 0.14 lower capacity factor in the first 12 months and a 0.13 lower capacity factor in the last 12 months of operation. These coefficients are economically significant as the average capacity factor of all power plants is 0.41. Based on Column (5), power plants have a 1.73 higher heat rate in the first 12 months and 0.48 in the last 12 months of operation, which are significantly lower operating efficiencies relative to the average heat rate of 11.32.[31]

The coefficients on *Greenfield 12m* and *Decommissioned 12m* should be interpreted jointly with the coefficient on plant age when evaluating the lifecycle of power plant operating performance. The negative coefficient on plant age suggests that newer plants operate with a higher capacity factor and lower heat rate than older plants. However, the greenfield and decommissioning stage indicators show that the creation and destruction processes are costly for the owners as power plants in these stages stand idle for a prolonged period, generate less electricity, and consume more fuel to generate electricity. For greenfield plants, we interpret these results as evidence that it takes time to gain

[31] The operating performance seems to be even lower in the first and last month as the coefficients on *Greenfield 1m* and *Decommissioned 1m* indicator variables are negative and significant. A large part of the negative coefficient for the first and last month is likely mechanical as power plants do not always operate for the entire month and could be started or decommissioned in the middle of the month. We include separate indicators for the first and last months to isolate this mechanical effect so we can interpret the indicators for the first 12 and last 12 months as differences in operating performance during the greenfield and decommissioning stages. These coefficients on the 1-month indicators should not be added to the effect estimated for the 12-month indicator variables.

market share, establish contracts with customers, and increase capacity utilization, as well as to gain the experience necessary to operate the power plant efficiently.

Since capacity factor is observed for all fuel types but heat rate only for fossil fuels, Online Appendix Table A.13 examines separately the operating performance of different fuel types. We see that the difference in utilization rate between DLCs and new ownership structures is driven primarily by natural gas power plants, consistent with the interpretation that, in this fuel type, the owners have flexibility as to when to operate a plant, and may face regulatory incentives to increase operating intensity in traditional markets.

To summarize so far, we find that the new ownership types do not operate at either higher capacity factors or higher heat rates, the opposite of the pattern that would be expected under the leakage hypothesis. In fact, PE-owned plants clearly operate at lower capacity utilization and lower (i.e. more efficient) heat rates. Foreign corporations and institutional investors also operate at lower (more efficient) heat rates. The higher capacity factor utilization of DLCs occurs only in those traditionally regulated markets where incumbents would be expected to have incentives to operate at these higher utilization rates.

The previous analysis studied all power plants, not only those that experienced changes in ownership. However, such an analysis may not be sufficient to disentangle whether the new entrants select more efficient power plants (within the same state, fuel type, and time period), or whether their ownership leads to operational improvements. In Table 8 Panel A, we focus only on the power plants that were sold by DLCs and estimate stacked difference-in-difference specifications:

$$Y_{i,t} = \beta Post \times Treated + \gamma Z_{i,t} + \delta_{i,c} + \mu_{s,t} + \nu_{c,t} + \varepsilon_{i,t}. \tag{9}$$

The treatment event is a power plant sale from DLCs to the new ownership types. The analysis focuses on an event window of 48 months, covering two years pre- and post-sale. In the subsample of only treated power plants in Column (1), we observe that the capacity factor does not change after the ownership change, whereas in Column (3) we see that the new owners operate these power plants more efficiently than the previous DLC owners with a 0.31 lower heat rate.

In Columns (2) and (4), we stack each treated power plant with a matched never-treated power plant that has been always owned by DLC during our sample period. We match power plants exactly based on fuel type and prime mover, and nearest-neighbor based on plant capacity and age using the Mahalanobis distance measure. In line with Cengiz, Dube, Lindner, and Zipperer (2019) and

Baker, Larcker, and Wang (2022), we include the following set of fixed effects: $\delta_{i,c}$ are interacted plant-prime-mover and stacked cohort fixed effects, $\mu_{s,t}$ are interacted state and time year-month fixed effects, and $\nu_{c,t}$ are interacted cohort and time fixed effects. The stacked difference-in-difference results in Column (4) show that the new owners improve the plant's operating efficiency. The heat rate of the acquired plants declines by 0.44 in the 24 months after the DLCs sell these plants.

The above results on ownership changes suggest that new owners operate power plants more efficiently when ownership is transferred. They do not show whether new ownership types also create more efficient power plants, which is important given our findings that creation drives a large part of the ownership changes. In Table 8 Panel B, we compare the operating performance of newly created power plants by DLCs with plants created by the new ownership types during our sample period. The greenfield power plants do not differ in terms of operating intensity across the ownership types, but new entrants create more efficient power plants. Based on Column (4), which studies a matched subsample of new plants, power plants created by DLCs have a 0.67 higher heat rate than power plants created by new entrants.

Similar to our findings that new owners operate power plants more efficiently, Demirer and Karaduman (2023) find that high-productivity firms acquire plants and increase their efficiency by 4%. Bai and Wu (2023) focus on a smaller sample of PE acquirers and also document that acquired plants operate with a lower heat rate, which translates into reduced fuel consumption and emissions. We confirm the finding that PE acquisition improves operating efficiency, while at the same time we show the other new ownership types exhibit similar effects. We also show that the new ownership types create more efficient plants, which is important given that the ownership changes are so heavily driven by creation and decommissioning, mechanisms that cannot be picked up in a difference-in-difference model.

Overall, we do not find evidence that new ownership types, which are subject to less strict disclosure requirements and public scrutiny, operate fossil fuel power plants with a higher capacity factor. If anything, our results suggest that DLCs operating more intensely fossil fuel power plants in traditional markets where they face relatively more limited competition from new entrants.

## 5 Electricity Pricing and Contractual Terms

In this section, we examine the implications of the emergence of PE, institutional investors, and foreign corporations as major electricity producers. The new ownership types typically enter electricity markets as independent power producers and have significant flexibility to implement contractual terms of electricity sales and capacity sales in line with their objectives and incentives. First, we study differences in contractual terms across ownership types. Second, we examine differences in electricity pricing. The contracting and pricing analysis is based on the subsample of larger power plants matched with the FERC EQR data over the 2013–2020 period and focuses on power plants owned by DLCs, PE, institutional investors, and foreign corporations.

In Table 9, we examine the contractual terms of electricity transactions, which is the main product sold by power plants. The dependent variables are the percentage of the transaction charges for electricity sales under different contractual terms. Columns (1) and (2) analyze contract duration and distinguish between short contracts with a duration of less than one year and long-term contracts. Columns (3) to (5) split the transactions into short, medium, and long based on increment terms used to determine the price. Columns (6) to (8) classify transactions into full-period, peak, and off-peak based on the peaking terms. The specifications include interacted fuel-state-year-month fixed effects which absorb variation in contracting terms across power plant technologies, location, and time. Online Appendix Table A.14 shows that our results are robust to defining all contractual-term dependent variables as a percentage of the quantity sold instead of the transaction charges.

We find that PE sells electricity under contracts with shorter duration and during peak term periods. Column (1) shows that PE power plants sell 13.5 percentage points more electricity under short-term instead of long-term contracts. Based on Column (3), PE plants also use shorter increment pricing periods as they contract 15.1 percentage points more for electricity sales using increment terms of less than six hours instead of long-term monthly or yearly increment terms. Foreign corporations seem to implement electricity sales contracts with similar short increment pricing terms as PE, but their contractual terms are closer to the terms used by DLCs.

However, institutional investors differ significantly from PE, foreign corporations, and DLCs as they use longer contracts that do not target only peak-period sales. Based on Column (6), institutional investors sell 19.7 percentage points more electricity under contracts that cover the full period instead of separate peak-period and off-peak-period contracts. This result is in line with the objective of institutional investors to obtain stable long-term cash flows from their investments in infrastructure assets like power plants (Andonov, Kräussl, and Rauh, 2021). The largest differences in contractual terms are between institutional investors and PE, which is surprising as institutional investors provide capital commitments to PE funds. These differences indicate potential agency conflicts and misalignment of objectives between institutional investors serving as limited partners and PE funds acting as intermediaries.

Online Appendix Table A.15 shows that the differences in contractual terms of electricity sales between new entrants and incumbent DLCs are entirely driven by fossil fuel power plants. When selling electricity from natural gas and coal power plants, PE and foreign corporations use contracts with a shorter duration and shorter pricing increments, and target peak-period sales. The contractual terms of fossil fuel power plants dominate the aggregate results because we weigh the observations by nameplate capacity and fossil fuel power plants are economically substantially more significant than renewable power plants. Wind and solar power plants owned by PE and foreign corporations seem to sell more electricity actually under long-term contracts and increments.

In Table 10, we analyze capacity sales, the second product sold by most power plants. We start by examining the probability that a power plant receives compensation for selling capacity and the sample covers all power plants reporting electricity sales. The dependent variable equals 0.847, which suggests that almost all large power plants receive compensation for maintaining available generation resources in the future. The probability of receiving compensation for selling capacity differs within the universe of new ownership types. The difference in the probability of selling capacity between DLCs and PE is not significant, while foreign corporations are 10 percentage points less likely to participate in capacity markets.

Conditional on participating in capacity markets, ownership types differ in contract duration. We focus only on contract duration, as the capacity contracts do not differ in the other dimensions and almost all are based on long-term increments and full-period coverage. Column (3) shows that DLCs sell more capacity under long-term contracts. Foreign corporations and PE owners are again more likely to establish short-term contracts for capacity sales. Based on Column (4), PE and foreign corporations sell 10.2 and 13.1 more capacity under contracts with a duration of less than one year. Institutional investors enter almost exclusively long-term contracts for capacity sales. Power plants owned by institutional investors use 25.5 percentage points more long-term capacity contracts which confirms our conclusion that institutional investors look for stable, long-term cash flow streams.

In Panel A of Table 11, we examine the pricing of electricity sales and the dependent variables are the mean and median of monthly electricity price per MWh, and we winsorize these pricing variables at 0.5% and 99.5%. The observations are weighted by the quantity of produced electricity and the specifications include either fuel-type and state-year-month fixed effects or fully interacted fuel-state-year-month fixed effects. We find that PE sells electricity for higher prices than DLCs. Based on Columns (2) and (6), PE obtains a \$4.36 higher average price per MWh and \$4.25 higher median price per MWh of electricity sales. Foreign corporations obtain also higher prices on their electricity sales. The interacted state-year-month fixed effects in this specification absorb variation in electricity prices across states and over time, but they do not absorb variation from power plants using different fuels and selling electricity in the same state and at the same moment in time.

In Columns (4) and (8), we introduce a more saturated set of fixed effects on a fuel-state-year-month level. In these specifications, the difference between PE and DLCs shrinks to $2.59 average and median price per MWh, while the difference between foreign corporations and DLCs becomes insignificant. This reduction in the coefficients suggests that the higher prices obtained by PE and foreign corporations may partly reflect the greater flexibility of their plants to scale up or down the production using different fuels in certain state-months.

Panel B of Table 11 shows a similar analysis for the subsample of plants that were created during our sample period. Columns (1) and (3) include all newly created plants, while Columns (2) and (4) show specifications using matched difference-in-difference, where matching occurs exactly based on fuel type and prime mover technology and then nearest-neighbor based on capacity and age. Panel B shows that for newly created plants the price differences between electricity sold by DLCs and new entrants are similar to the broader analysis and that the results in Panel A are largely driven by newly created plants. Based on Column (2), DLCs sell electricity from newly created plants for $5.98 per MWh less than the new ownership types do, as compared to $3.92 per MWh in Panel A. This is consistent with an interpretation that the first owners of a plant have more flexibility in determining contractual terms and pricing.

We interpret the pricing differences between the new entrants and DLCs jointly with our results on contractual differences. We observe that especially power plants owned by PE have more flexible contractual terms, so they can respond more to short-term signals in the electricity market and have more flexibility to adjust their electricity production. PE owners seem to obtain higher electricity prices on the wholesale market through flexible output that responds to signals in the spot electricity market. For instance, PE could reduce electricity production in periods of low prices, which could result in higher average prices. PE could establish different sales contracts that result in higher average prices, such as short-term contracts that target peak-period sales.

Reflecting on the challenges of adopting new technologies in the electricity sector, we find that greenfield plants obtain significantly lower prices. This result can be interpreted in two ways. First, newer power plants are competitive and can potentially reduce the average prices on wholesale markets, by undercutting incumbents and increasing market competition. Second, new power plants seem to have lower operating performance (measured using the capacity factor and heat rate in Table 7) as well as lower prices. This combination suggests that the owners financing the creation of new plants need time to gain market share, establish contracts with customers, and gain experience with how to operate the new plants efficiently.

Overall, we document that the new ownership types offer different contractual terms and electricity pricing compared to DLCs. PE firms sell electricity for a higher price per MWh, and they sell electricity under contracts with shorter duration, shorter increment pricing, and peak term periods. Institutional investors establish fewer volatile contracts for the power plants that they own directly, thus reducing the volatility of the electricity sales by their power plants.

# 6 Conclusion

Regardless of the exact policy direction, stated national commitments to reduce greenhouse gas emissions and achieve greater energy independence will require substantial capital investments to change the mix of capital assets that produce electricity. Using data on U.S. power plants accounting for 99% of the electricity generation over 2005–2020 period, we find that incumbent DLCs have reduced their ownership from 70% to 54%, while new entrants, such as private equity, institutional investors, and foreign corporations, have increased their ownership stakes from 7% to 24%.

PE and foreign corporations have increased their ownership share largely through the creation of new solar, wind, and natural gas power plants in deregulated wholesale electricity markets with an independent balancing authority. We find limited support for the leakage hypothesis that incumbent DLCs, which are subject to higher disclosure requirements and public scrutiny, are more likely to sell older fossil fuel power plants to the new ownership types. Conditional on fuel type and age, foreign corporations operate power plants for longer than DLCs, while PE has similar decommissioning rates. DLCs operate electricity generating assets with higher intensity in traditional markets with limited competition, but they are less efficient. The new ownership types create more efficient power plants with a lower heat rate and improve the efficiency of acquired plants. Power plants owned by the new entrants consume around 5% less fuel per unit of produced electricity.

The new owners also show differences in contractual terms and electricity pricing compared to the incumbent DLCs. For instance, PE sells electricity for \$2.59 higher average price per MWh. PE and foreign corporations sell electricity under contracts with shorter duration, shorter increment pricing, and more peak-term periods, especially when selling electricity generated from fossil fuels.

PE and foreign corporations appear to obtain higher electricity prices on the wholesale market through flexibility in output that responds to signals in the spot market. Therefore, variation in market regulation affects not only the financiers of capital expenditures and ownership of assets but also pricing in the electricity market.

Recent federal legislation including the Infrastructure Investment and Jobs Act and the Inflation Reduction Act have provided incentives for electric power plant investment, and different owners may respond differently to such incentives. Our results highlight an important tradeoff in bringing new sources of financing to the electricity sector. New entrants, such as PE and foreign corporations, have played an important role in creating new and more efficient power plants, but their electricity also on average tends to be sold more through short-term contracts and at higher prices.

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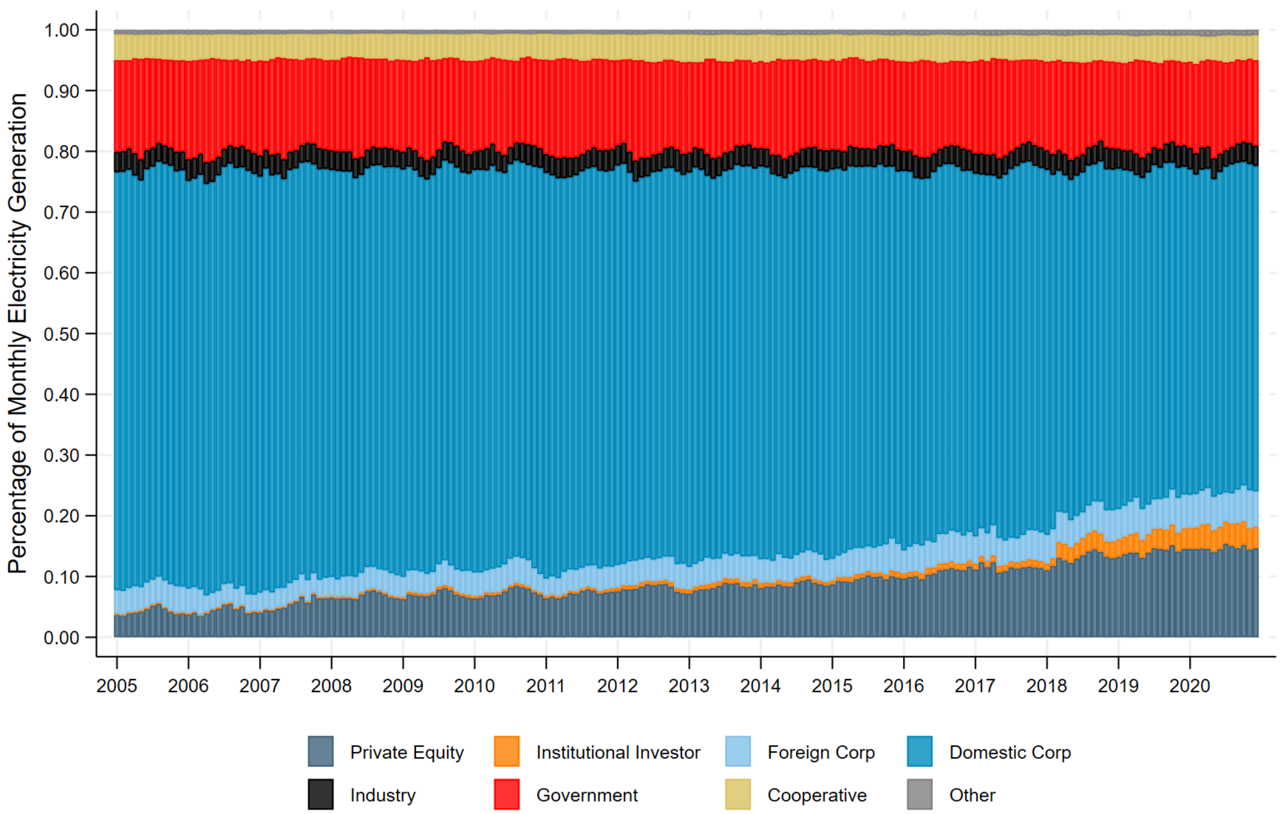
**Figure 1: Ownership and Electricity Generation**

This figure presents the aggregate ownership by the eight categories of owners as a percentage of monthly electricity generation over the 2005–2020 period. Electricity generation is measured as the total electrical output net of the power plant service. If a power plant is owned by multiple ownership types, we divide the ownership and generation equally across the ownership types (i.e., if a private equity and domestic corporation jointly own a power plant, we assume that each ownership type owns 50% of the power plant and accounts for 50% of the electricity output).



## Figure 2: Ownership and Electricity Generation by Fuel Type

This figure presents the ownership by the eight categories of owners for the 6 main fuel types (out of 19 fuel types in the EIA classification) based on the monthly electricity generation. For natural gas, coal, and nuclear, the y-axis is scaled to 200 TWh, while for hydro, wind, and solar the y-axis is scaled to 35 TWh.

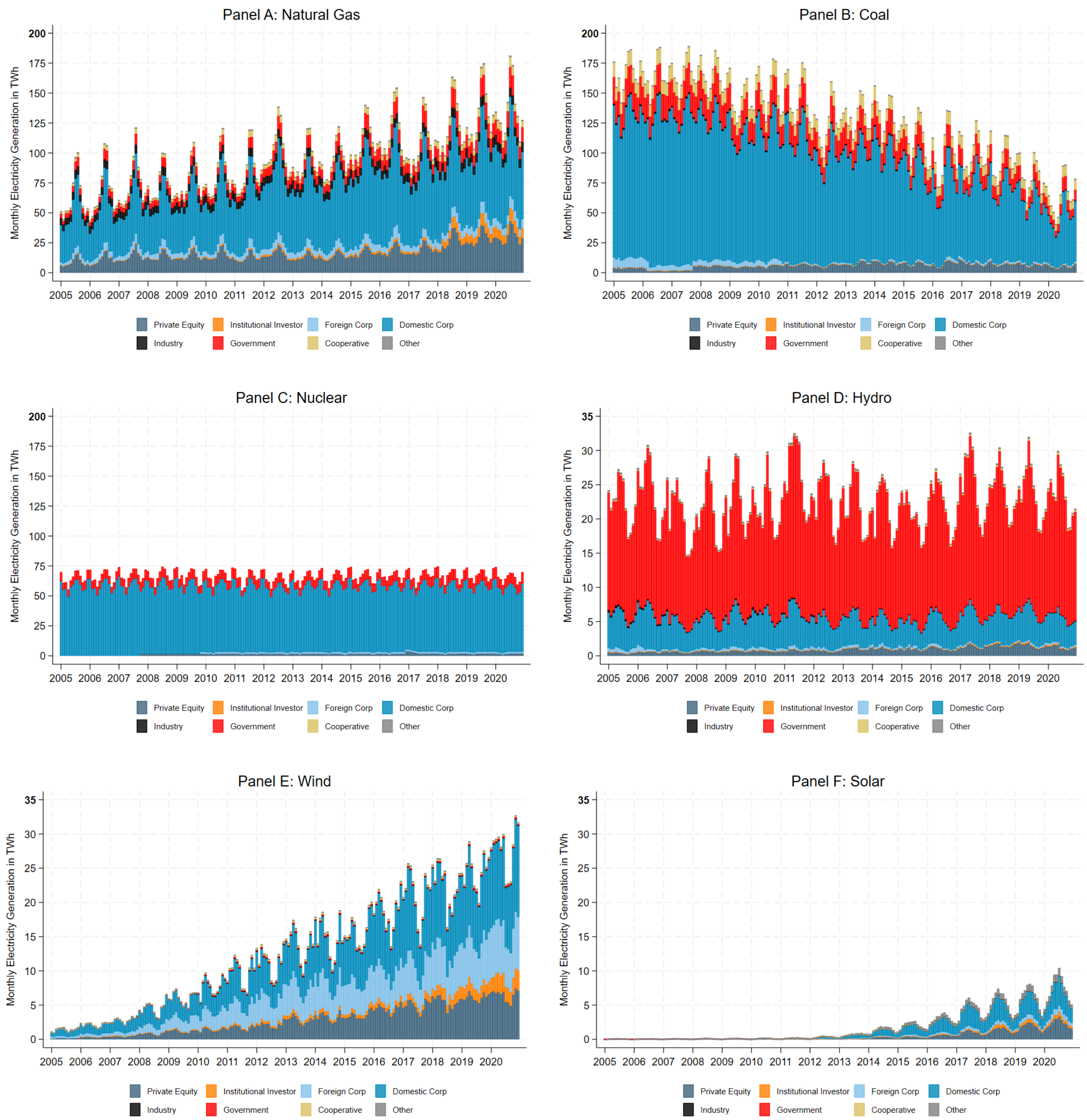
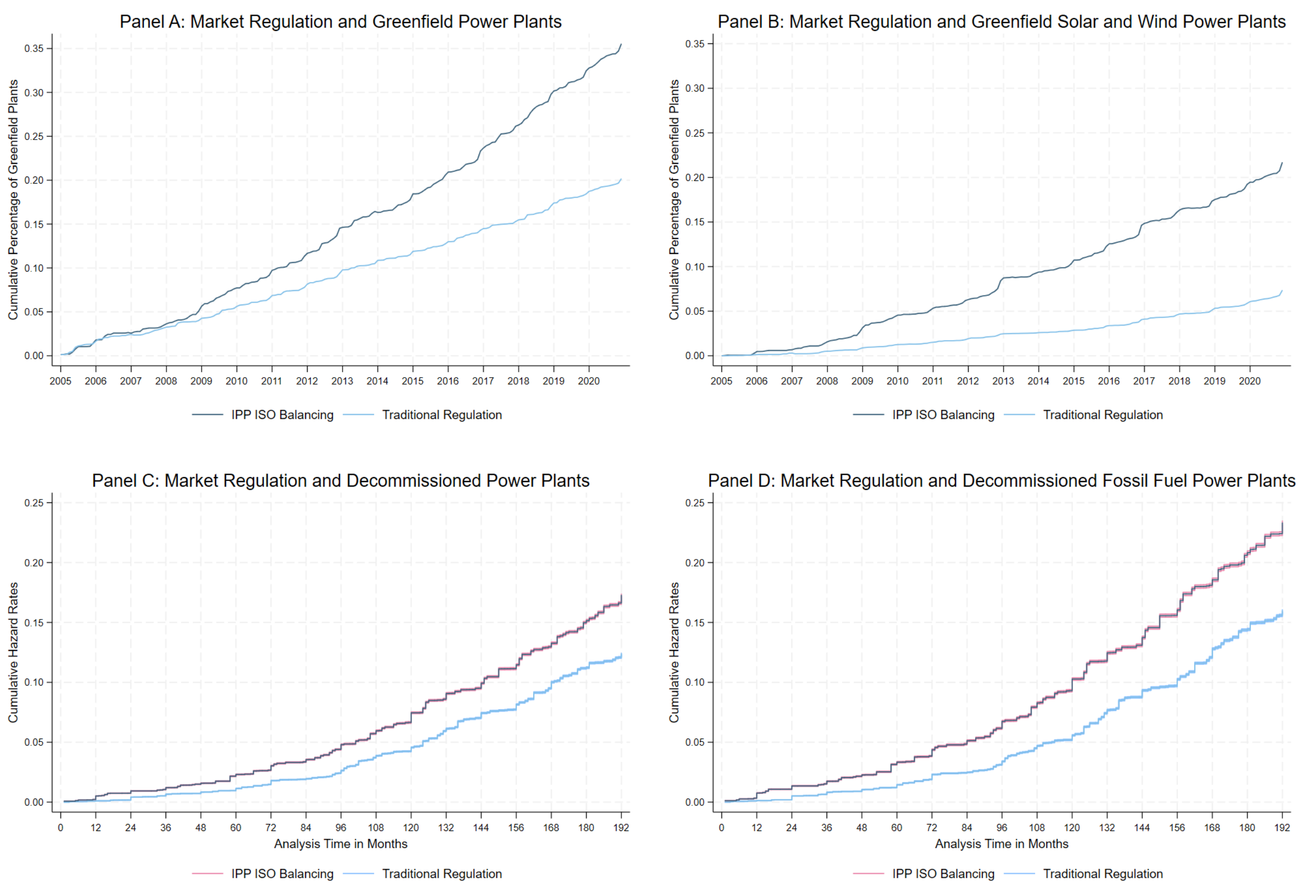


**Figure 3: Market Regulation and Greenfield or Decommissioned Power Plants**

Panel A presents the cumulative capacity of greenfield power plants installed during our sample period as a percentage of the total generating capacity, while Panel B shows the cumulative capacity of solar and wind greenfield power plants installed during our sample period as a percentage of the total capacity. Panel C presents the cumulative hazard rate of decommissioned power plants, while Panel D shows the cumulative hazard rate of fossil fuel decommissioned power plants. In the hazard figures, observations are weighted by nameplate capacity. We split the power plants by market regulation status using the *IPP ISO Balancing* indicator. *IPP ISO Balancing* is an indicator for power plants of independent power producers that participate in a wholesale market administered by an Independent System Operator (ISO) as a balancing authority and electric power transmission system operator.



## Figure 4: Ownership of Greenfield Power Plants by Fuel Type

In Panel A, the dependent variable captures all greenfield power plants. In Panels B and C, we decompose it to capture solar & wind and natural gas greenfield plants. The figures present coefficients for PE and foreign corporations. Observations are at the plant-prime-mover-month level and weighted by capacity. The omitted category in all specifications is DLCs, and we also control for the remaining ownership categories. The baseline coefficients correspond to the estimations in Table 3 Column (2). We estimate separately the role of ownership categories for power plants located in IPP ISO balancing and ISO restructured markets. The specifications include interacted fuel-type, state, and year-month fixed effects. We double-cluster the standard errors by plant-prime-mover and year-month.

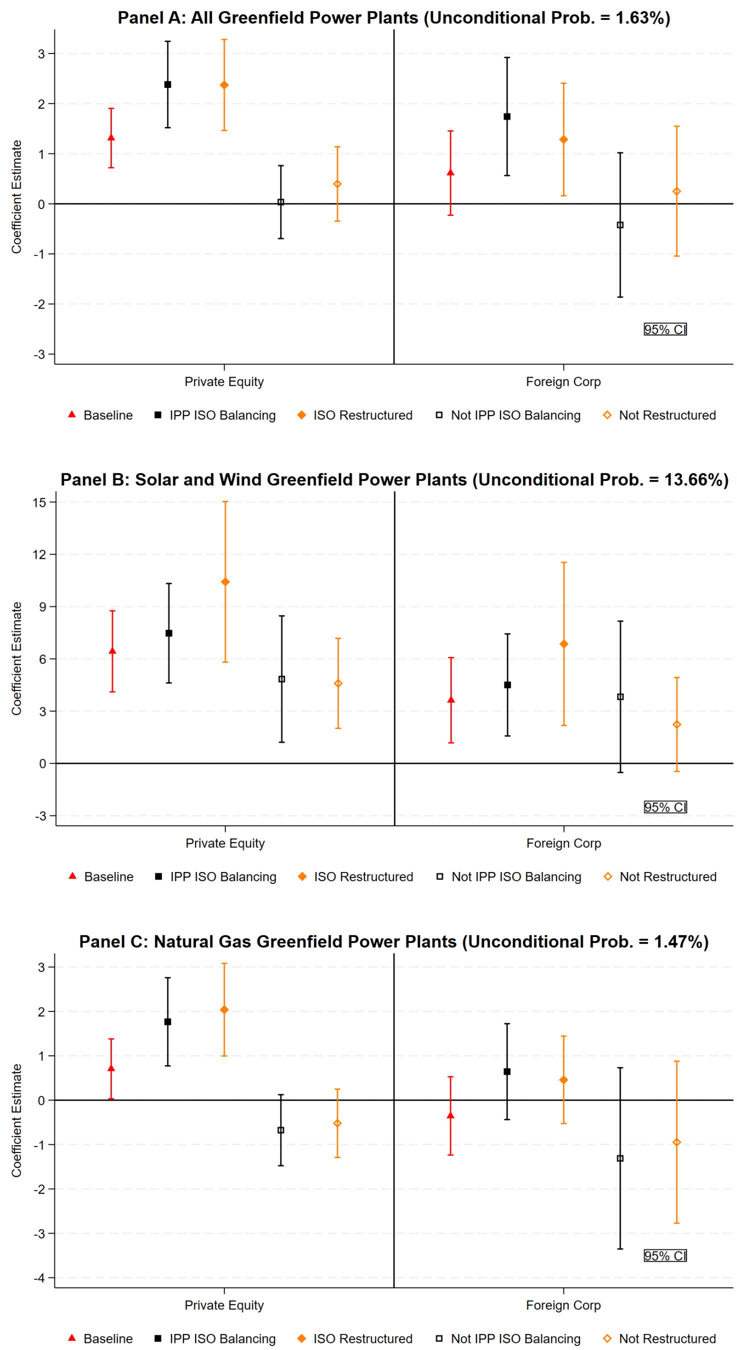


**Figure 5: Transitions of Power Plants Owned Initially by DLCs**

The sample covers power plants that were owned by DLCs at the beginning of our sample, in January 2005. We analyze four potential outcomes based on the latest observation in our dataset (December 2020 for plants that are not retired): *Still Own & Operating* covers plants that are still owned and operated by domestic corporations; *Owned & Retired* covers plants that remained in domestic corporations' ownership, but were retired during the sample period; *Sold & Operating* captures plants that were sold to other ownership types and are still operating; *Sold & Retired* captures plants that were sold to other ownership types and were retired by these other owners during the sample period. The plant-prime-mover observations are weighted by nameplate capacity and we present the percentage of capacity that transitioned to each of the four outcomes. We present the transition outcomes for all power plants, coal & petroleum power plants, and natural gas power plants.

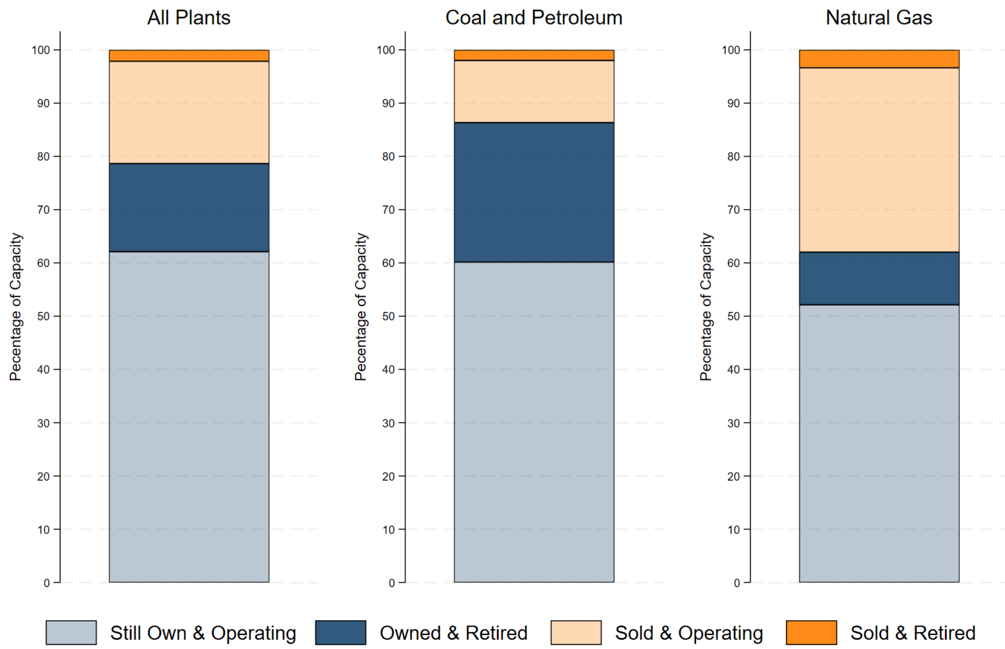
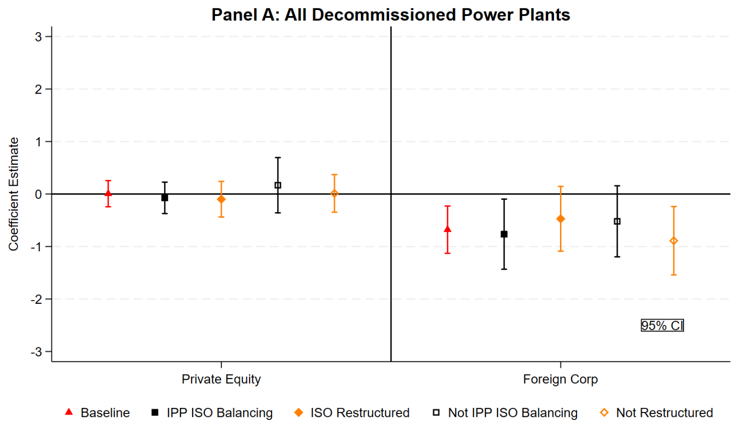
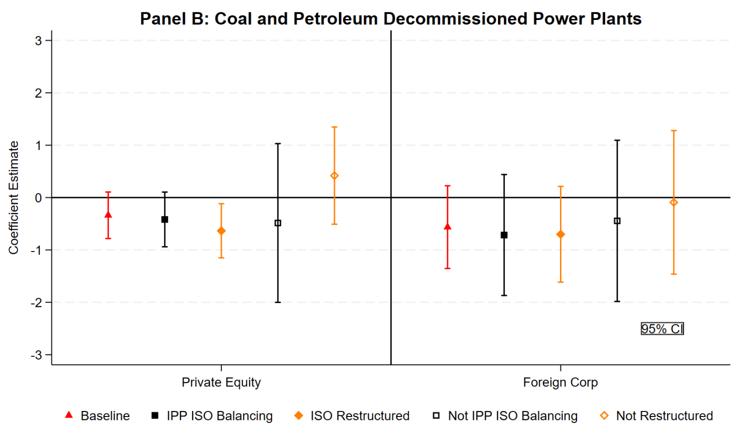


**Figure 6: Ownership of Decommissioned Power Plants by Fuel Type**

In Panel A, the dependent variable captures all decommissioned power plants. In Panels B and C, we decompose it to capture coal & petroleum and natural gas decommissioned plants. The figures present coefficients for PE and foreign corporations in the Cox hazard specifications. Observations are at the plant-prime-mover level and the sample includes plants with a capacity of at least 20MW. The omitted category in all specifications is DLCs, and we also control for the remaining ownership categories. The baseline coefficients correspond to the estimations in Table 6 Column (2). We estimate separately the role of ownership categories for power plants located in IPP ISO balancing and ISO restructured markets. The specifications include fuel-type and state fixed effects. We cluster the standard errors by plant-prime-mover.



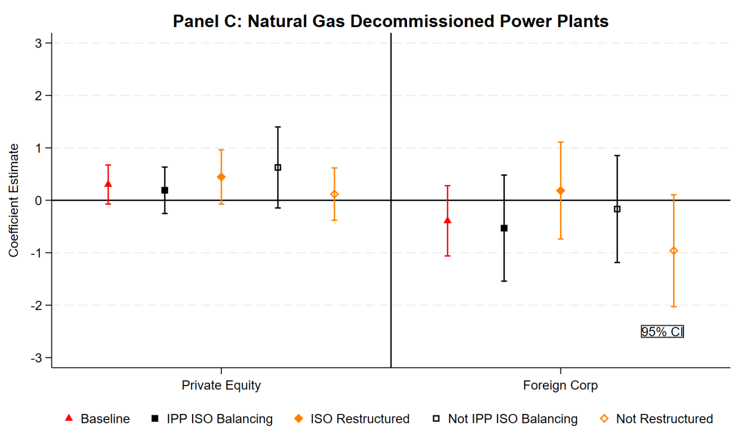
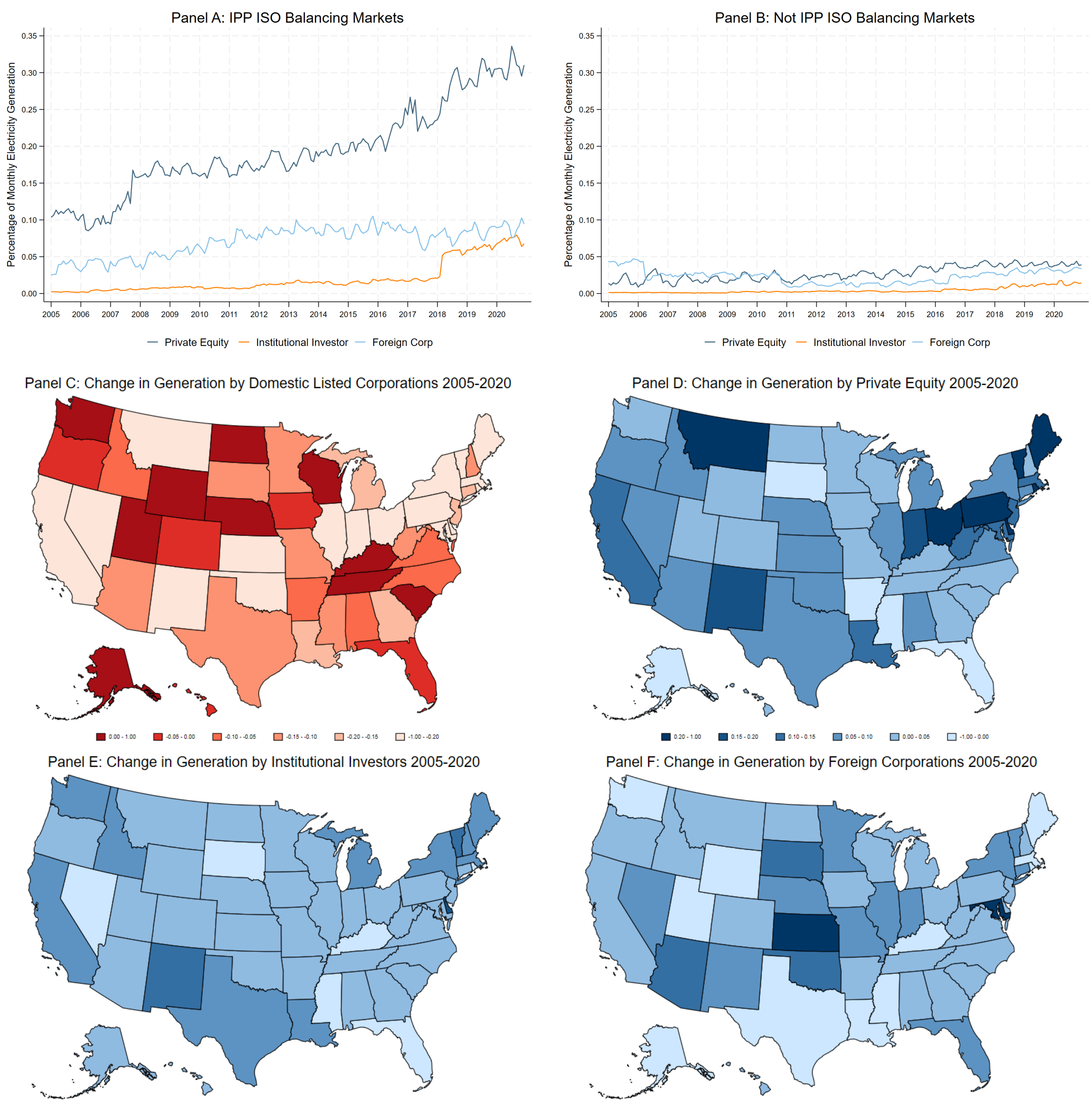



**Figure 7: Ownership and Electricity Generation by Market Regulation and State**

Panels A and B present the aggregate ownership by private equity, institutional investors, and foreign listed corporations as a percentage of monthly electricity generation over 2005–2020 period. Panel A shows the ownership stakes of power plants that participate in an ISO Balancing market and are owned by an independent power producer rather than a regulated electric utility. Panel B shows the ownership stakes in traditional balancing markets. Panels C to F display the changes in the ownership stakes of domestic listed corporations, private equity, institutional investors, and foreign listed corporations by state between 2005 and 2020. The changes are measured in percentage points of the state's electricity generation.



## Table 1: EIA Power Plants

The table presents summary statistics on a plant-prime-mover-month level for all power plants and separately for the main fuel types: natural gas, coal, nuclear, hydro, wind, and solar. All statistics are the weighted means by nameplate capacity. Panel B reports statistics for the power plant characteristics. *Capacity* is the nameplate capacity in GWh. *Capacity Factor* is the ratio of monthly net generation to capacity. *Heat Rate* is the ratio of fuel consumption in millions of Btu to electricity generation in MWh. *Age* presents the plant age in years. *Greenfield 12m* is an indicator for the first 12 months when a plant starts operating. *Decommissioned 12m* is an indicator for the last 12 months when a plant is still operating. Panel C reports the average ownership by the eight categories in percent. If multiple ownership types own a power plant, we divide the ownership equally across the ownership types. Panel D presents statistics on electricity markets. *ISO Balancing* is an indicator for power plants that participate in a wholesale market administered by an Independent System Operator. *IPP ISO Balancing* is an indicator for power plants that participate in an ISO Balancing market and are owned by an independent power producer rather than a regulated electric utility. *ISO Restructured* is an indicator for power plants that participate in a wholesale market administered by an ISO balancing authority and are located in areas with restructured utilities. *ResidIndPD* is the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. *Climate Concern* is the percentile ranking of the state where the plant is located based on the percentage of the state population who think that global warming is happening. *Renewables Incentives* is an aggregate index of three indicators if a state has corporate tax, property tax, and sales tax incentives for renewable energy as well as two indicators if a state has production or feed-in tariffs incentives for renewable energy.

| | **All** | **NatGas** | **Coal** | **Nuclear** | **Hydro** | **Wind** | **Solar** |
|---|---|---|---|---|---|---|---|
| **Panel A: Power Plants Sample** | | | | | | | |
| # Unique Plants | 11,593 | 3,024 | 751 | 66 | 1,500 | 1,294 | 3,941 |
| # Unique Plants-Prime-Mover | 13,261 | 4,142 | 867 | 66 | 1,500 | 1,294 | 3,941 |
| # Unique Greenfield | 6,082 | 752 | 36 | 0 | 53 | 1,031 | 3,630 |
| # Unique Decommissioned | 1,949 | 950 | 311 | 10 | 94 | 94 | 42 |
| Observations | 1,509,346 | 572,867 | 115,426 | 12,215 | 270,290 | 135,683 | 188,066 |
| **Panel B: Power Plant Characteristics** | | | | | | | |
| Capacity (GWh) | 0.980 | 0.584 | 1.426 | 2.037 | 1.090 | 0.176 | 0.100 |
| Capacity Factor | 0.403 | 0.264 | 0.533 | 0.855 | 0.399 | 0.328 | 0.241 |
| Heat Rate | | 11.891 | 10.686 | 10.457 | | | |
| Age (Years) | 30.905 | 21.647 | 41.945 | 33.091 | 58.883 | 6.155 | 2.912 |
| Greenfield 12m | 0.016 | 0.017 | 0.003 | 0.000 | 0.000 | 0.116 | 0.244 |
| Decommissioned 12m | 0.010 | 0.010 | 0.017 | 0.005 | 0.000 | 0.002 | 0.001 |
| **Panel C: Power Plant Ownership** | | | | | | | |
| Domestic Listed Corp (DLC) | 0.591 | 0.547 | 0.706 | 0.843 | 0.209 | 0.421 | 0.472 |
| Private Equity | 0.109 | 0.167 | 0.053 | 0.019 | 0.034 | 0.223 | 0.250 |
| Institutional Investor | 0.011 | 0.017 | 0.002 | 0.000 | 0.003 | 0.049 | 0.046 |
| Foreign Corp | 0.048 | 0.054 | 0.021 | 0.014 | 0.014 | 0.271 | 0.066 |
| Industry | 0.026 | 0.041 | 0.021 | 0.000 | 0.006 | 0.001 | 0.006 |
| Government | 0.159 | 0.112 | 0.132 | 0.124 | 0.716 | 0.014 | 0.007 |
| Cooperative | 0.047 | 0.057 | 0.064 | 0.000 | 0.007 | 0.010 | 0.006 |
| Other | 0.008 | 0.007 | 0.002 | 0.000 | 0.009 | 0.012 | 0.147 |
| **Panel D: Wholesale and Retail Electricity Markets** | | | | | | | |
| ISO Balancing | 0.608 | 0.635 | 0.607 | 0.631 | 0.267 | 0.788 | 0.611 |
| IPP ISO Balancing | 0.356 | 0.423 | 0.241 | 0.444 | 0.064 | 0.686 | 0.583 |
| ISO Restructured | 0.350 | 0.375 | 0.319 | 0.482 | 0.119 | 0.350 | 0.158 |
| ResidIndPD | 9.778 | 10.106 | 9.305 | 10.326 | 8.567 | 9.923 | 10.050 |
| Climate Concern | 0.529 | 0.568 | 0.410 | 0.558 | 0.650 | 0.529 | 0.737 |
| Renewables Incentives | 2.179 | 2.228 | 2.066 | 2.065 | 2.198 | 2.705 | 2.598 |

## Table 2: FERC Electricity Pricing and Contracting

Observations are on a plant-prime-mover-month level weighted by nameplate capacity. The sample includes power plants owned by domestic listed corporations (DLC), private equity, institutional investors, and foreign corporations. Panel A presents summary statistics on electricity prices and reports the average of the mean and median monthly price per MWh. This panel also reports the average percentage of transaction charges for electricity sales by different contractual terms. We split the electricity sales based on three contractual terms. First, we analyze contract duration and distinguish between short contracts with a duration of less than one year and long-term contract duration. Second, we split the transactions into short, medium, and long based on the increment terms. Short transactions use 5-minute, 15-minute, or hourly increments (up to 6 hours). Medium transactions have daily or weekly increments (from 6 hours to 168 hours). Long transactions use monthly or yearly increments (longer than 168 hours). Third, we classify transactions into full-period, peak, and off-peak based on the peaking terms. Panel B presents the average percentage of transaction charges for capacity sales by different contractual terms. We split the capacity sales also based on three contractual terms: contract duration, increment terms, and peak period terms.

| | **All** | **NatGas** | **Coal** | **Nuclear** | **Hydro** | **Wind** | **Solar** |
|---|---|---|---|---|---|---|---|
| **Panel A: Electricity Sales** | | | | | | | |
| #Unique Plants | 3,731 | 1,307 | 355 | 56 | 564 | 654 | 625 |
| Observations | 248,987 | 88,181 | 22,516 | 4,339 | 48,393 | 44,428 | 28,385 |
| Mean Price MWh | 33.014 | 32.514 | 29.909 | 29.541 | 29.777 | 40.674 | 81.271 |
| Median Price MWh | 30.482 | 29.162 | 28.087 | 27.327 | 28.104 | 39.787 | 75.402 |
| Contract Duration - Short | 0.585 | 0.666 | 0.588 | 0.474 | 0.674 | 0.367 | 0.206 |
| Contract Duration - Long | 0.412 | 0.330 | 0.411 | 0.526 | 0.326 | 0.627 | 0.794 |
| Increment Terms - Short | 0.506 | 0.561 | 0.559 | 0.373 | 0.378 | 0.327 | 0.128 |
| Increment Terms - Medium | 0.046 | 0.063 | 0.032 | 0.044 | 0.086 | 0.015 | 0.035 |
| Increment Terms - Long | 0.423 | 0.365 | 0.393 | 0.537 | 0.402 | 0.611 | 0.790 |
| Peaking Terms - Full Period | 0.380 | 0.330 | 0.350 | 0.486 | 0.364 | 0.569 | 0.631 |
| Peaking Terms - Peak | 0.355 | 0.404 | 0.373 | 0.276 | 0.290 | 0.202 | 0.169 |
| Peaking Terms - Off-Peak | 0.195 | 0.203 | 0.214 | 0.177 | 0.179 | 0.140 | 0.060 |
| **Panel B: Capacity Sales** | | | | | | | |
| #Unique Plants | 2,856 | 1,247 | 331 | 53 | 522 | 230 | 350 |
| Observations | 180,816 | 77,551 | 19,778 | 3,870 | 42,740 | 12,794 | 14,027 |
| Contract Duration - Short | 0.158 | 0.178 | 0.122 | 0.151 | 0.283 | 0.149 | 0.119 |
| Contract Duration - Long | 0.841 | 0.821 | 0.877 | 0.849 | 0.717 | 0.850 | 0.881 |
| Increment Terms - Short | 0.010 | 0.015 | 0.007 | 0.003 | 0.017 | 0.008 | 0.011 |
| Increment Terms - Medium | 0.036 | 0.026 | 0.056 | 0.015 | 0.049 | 0.060 | 0.015 |
| Increment Terms - Long | 0.944 | 0.953 | 0.931 | 0.960 | 0.878 | 0.924 | 0.952 |
| Peaking Terms - Full Period | 0.926 | 0.925 | 0.940 | 0.943 | 0.818 | 0.880 | 0.833 |
| Peaking Terms - Peak | 0.015 | 0.018 | 0.012 | 0.003 | 0.036 | 0.052 | 0.048 |
| Peaking Terms - Off-Peak | 0.008 | 0.006 | 0.009 | 0.002 | 0.030 | 0.003 | 0.013 |

## Table 3: Ownership of Greenfield Power Plants

In this table, observations are at the plant-prime-mover-month level and weighted by nameplate capacity. The dependent variable is greenfield power plants and equals one for the first 12 months of plant operation. We measure the ownership by DLCs, PE, institutional investors, and foreign corporations. We also control for the ownership by industry firms, government, cooperatives, and others. *IPP ISO Balancing* is an indicator for power plants in an ISO balancing market that are owned by independent power producers. *ISO Restructured* is an indicator for power plants in an ISO balancing market and located in areas with restructured electric utilities. Column (6) presents the second stage results of an IV model where we instrument the *ISO Restructured* and *DLC* × *ISO Restructured* variables with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. Online Appendix Table A.6 reports the first stage estimates of both IV regressions. *Climate Concern* is the percentile ranking of the state where the plant is located based on the percentage of the state population who think that global warming is happening. *Renewables Incentives* is an aggregate index of three indicators if a state has corporate tax, property tax, and sales tax incentives as well as two indicators if a state has production or feed-in tariffs incentives for renewable energy. *ln Plant Capacity* is the natural logarithm of a plant's monthly capacity. The specifications include interacted fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. For the IV model, we present the Kleibergen-Paap rk Wald F statistic of the first-stage regressions. *$p < .10$; **$p < .05$; ***$p < .01$.

| **All Greenfield Power Plants** (Unconditional Prob. = 1.63%) | | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Domestic Listed Corp (DLC) | -0.990*** | | -0.101 | -0.376 | -0.632 | -0.711** |
| | [0.249] | | [0.437] | [0.434] | [0.437] | [0.335] |
| Private Equity | | 1.312*** | | | | |
| | | [0.300] | | | | |
| Institutional Investor | | -0.779 | | | | |
| | | [0.872] | | | | |
| Foreign Corp | | 0.613 | | | | |
| | | [0.426] | | | | |
| ISO Balancing | | | 0.086 | | | |
| | | | [0.325] | | | |
| DLC × ISO Balancing | | | -1.160*** | | | |
| | | | [0.332] | | | |
| IPP ISO Balancing | | | | 0.458 | | |
| | | | | [0.351] | | |
| DLC × IPP ISO Balancing | | | | -1.913*** | | |
| | | | | [0.419] | | |
| ISO Restructured | | | | | 0.678 | 0.276 |
| | | | | | [0.463] | [0.375] |
| DLC × ISO Restructured | | | | | -1.501*** | -1.571*** |
| | | | | | [0.385] | [0.543] |
| DLC × Climate Concern | | | 0.059 | 0.649 | 0.230 | 0.737* |
| | | | [0.635] | [0.642] | [0.657] | [0.428] |
| DLC × Renewables Incentives | | | -0.044 | 0.005 | 0.067 | 0.065 |
| | | | [0.158] | [0.156] | [0.157] | [0.087] |
| ln Plant Capacity | 0.153** | 0.154** | 0.172*** | 0.174*** | 0.152** | 0.053 |
| | [0.062] | [0.062] | [0.063] | [0.062] | [0.062] | [0.052] |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | Yes | Yes | |
| Fuel-Year-Month FE | | | | | | Yes |
| Observations | 1,410,850 | 1,410,850 | 1,410,850 | 1,410,850 | 1,410,850 | 1,492,665 |
| Adjusted R-squared | 0.200 | 0.200 | 0.200 | 0.201 | 0.200 | |
| K-P rk F-Stat | | | | | | 94.584 |

## Table 4: Greenfield Power Plants Owners and Market Regulation

This table presents the results of OLS specifications using the ownership by domestic listed corporations (*DLC*), private equity, and foreign listed corporations as dependent variables. The analysis is limited to the subsample of greenfield power plants. Observations are at the plant-prime-mover-month level and weighted by nameplate capacity. In Columns (1), (3), and (5), we focus on *IPP ISO Balancing* which is an indicator for power plants in an ISO balancing market that are owned by independent power producers rather than regulated utilities. In Columns (2), (4), and (6), we present the second stage results of an IV model where we instrument the *ISO Restructured* variable with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. Online Appendix Table A.6 reports the first stage estimates of all IV regressions. We also control for *Climate Concern* percentile ranking, *Renewables Incentives* aggregate index, and the natural logarithm of a plant's monthly capacity. The specifications include interacted fuel-type and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. For the IV model, we present the Kleibergen-Paap rk Wald F statistic of the first-stage regression. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **DLCs** | | **Private Equity** | | **Foreign Corp** | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A: All Plants** | Mean Dep. Var. = 0.462 | | Mean Dep. Var. = 0.246 | | Mean Dep. Var. = 0.131 | |
| IPP ISO Balancing | -0.220*** | | 0.223*** | | 0.119*** | |
| | [0.035] | | [0.027] | | [0.018] | |
| ISO Restructured | | -0.374*** | | 0.345*** | | 0.078 |
| | | [0.086] | | [0.071] | | [0.056] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 66,427 | 66,427 | 66,427 | 66,427 | 66,427 | 66,427 |
| Adjusted R-squared | 0.203 | | 0.214 | | 0.193 | |
| K-P F-Stat | | 273.234 | | 273.234 | | 273.234 |
| **Panel B: Solar & Wind** | Mean Dep. Var. = 0.419 | | Mean Dep. Var. = 0.253 | | Mean Dep. Var. = 0.240 | |
| IPP ISO Balancing | -0.217*** | | 0.049* | | 0.173*** | |
| | [0.032] | | [0.027] | | [0.026] | |
| ISO Restructured | | -0.069 | | 0.057 | | 0.004 |
| | | [0.105] | | [0.101] | | [0.105] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 51,501 | 51,501 | 51,501 | 51,501 | 51,501 | 51,501 |
| Adjusted R-squared | 0.138 | | 0.061 | | 0.137 | |
| K-P F-Stat | | 152.365 | | 152.365 | | 152.365 |
| **Panel C: Natural Gas** | Mean Dep. Var. = 0.520 | | Mean Dep. Var. = 0.239 | | Mean Dep. Var. = 0.036 | |
| IPP ISO Balancing | -0.260*** | | 0.463*** | | 0.057*** | |
| | [0.065] | | [0.046] | | [0.019] | |
| ISO Restructured | | -0.653*** | | 0.602*** | | 0.157** |
| | | [0.134] | | [0.101] | | [0.061] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 7,971 | 7,971 | 7,971 | 7,971 | 7,971 | 7,971 |
| Adjusted R-squared | 0.241 | | 0.445 | | 0.082 | |
| K-P F-Stat | | 115.415 | | 115.415 | | 115.415 |

### Table 5: Competing Risks Model: Sales and Decommissioning of Power Plants

Observations are at the plant-prime-mover-month level and the sample includes only power plants with a nameplate capacity of at least 20MW. We present the hazard ratios of a survival analysis using a competing risks model. The sample includes all power plants that have been owned by domestic publicly listed corporations (DLC) at any moment during our sample period. In Columns (1) to (4), the event of interest is a complete sale of a power plant to a new ownership type (not a partial sale or reduced ownership stake), and the competing event is a decommissioning of a plant. In Columns (5) to (8), the event of interest is a complete decommissioning of a power plant (not partial retirement of one generator), and the competing event is a sale of a plant. *IPP ISO Balancing* and *ISO Restructured* are indicators for power plants operating in a deregulated electricity market. In Columns (4) and (8), we present the second stage results of an IV model where we instrument the *ISO Restructured* variable with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. Online Appendix Table A.6 reports the first stage estimates of the IV regression. We also control either for *Climate Concern* percentile ranking and *Renewables Incentives* aggregate index, or for state fixed effects. *ln Plant Capacity* is the natural logarithm of a plant's monthly capacity. *ln Plant Age* is the natural logarithm of plant age in years. The specifications include fuel-type fixed effects and we present the coefficients for coal, nuclear, hydro, wind, and solar power plants (the omitted category is natural gas plants). We cluster standard errors by plant-prime-mover and report standard errors in brackets. For the IV model, we present the Kleibergen-Paap rk Wald F statistic. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

| | **Sold Power Plants** | | | | **Decommissioned Power Plants** | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| #Events of Interest: | 721 | 721 | 721 | 721 | 377 | 377 | 377 | 377 |
| #Competing Events: | 367 | 367 | 367 | 367 | 707 | 707 | 707 | 707 |
| #Total Events: | 1,679 | 1,679 | 1,679 | 1,679 | 1,683 | 1,683 | 1,683 | 1,683 |
| IPP ISO Balancing | 3.654*** | 4.732*** | | | 0.989 | 1.197 | | |
| | [0.379] | [0.769] | | | [0.129] | [0.264] | | |
| ISO Restructured | | | 2.057*** | 3.127*** | | | 0.798* | 0.502* |
| | | | [0.167] | [0.781] | | | [0.097] | [0.201] |
| Climate Concern | 2.021*** | | 4.015*** | 2.859*** | 1.263 | | 1.464 | 1.697* |
| | [0.330] | | [0.663] | [0.551] | [0.332] | | [0.348] | [0.479] |
| Renewables Incentives | 0.870*** | | 0.821*** | 0.831*** | 1.066 | | 1.057 | 1.069 |
| | [0.035] | | [0.034] | [0.035] | [0.062] | | [0.060] | [0.061] |
| ln Plant Capacity | 0.955 | 0.930* | 0.961 | 0.965 | 0.686*** | 0.616*** | 0.686*** | 0.696*** |
| | [0.037] | [0.040] | [0.038] | [0.037] | [0.032] | [0.030] | [0.032] | [0.033] |
| ln Plant Age | 1.138*** | 1.152*** | 1.163*** | 1.156*** | 5.386*** | 5.517*** | 5.404*** | 5.506*** |
| | [0.042] | [0.047] | [0.042] | [0.041] | [0.857] | [0.947] | [0.854] | [0.885] |
| Coal | 0.402*** | 0.463*** | 0.366*** | 0.364*** | 1.805*** | 1.986*** | 1.834*** | 1.808*** |
| | [0.069] | [0.088] | [0.064] | [0.063] | [0.260] | [0.290] | [0.260] | [0.260] |
| Hydro | 0.382*** | 0.339*** | 0.227*** | 0.244*** | 0.010*** | 0.010*** | 0.010*** | 0.008*** |
| | [0.092] | [0.091] | [0.053] | [0.059] | [0.006] | [0.006] | [0.006] | [0.005] |
| Nuclear | 0.053*** | 0.049*** | 0.048*** | 0.045*** | 0.927 | 1.174 | 0.956 | 1.014 |
| | [0.038] | [0.037] | [0.034] | [0.032] | [0.334] | [0.449] | [0.345] | [0.367] |
| Solar | 0.118*** | 0.120*** | 0.153*** | 0.180*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** |
| | [0.031] | [0.033] | [0.041] | [0.049] | [0.000] | [0.000] | [0.000] | [0.000] |
| Wind | 0.495*** | 0.544*** | 0.710*** | 0.692*** | 0.564 | 0.503* | 0.540 | 0.573 |
| | [0.064] | [0.074] | [0.089] | [0.084] | [0.231] | [0.207] | [0.221] | [0.235] |
| Fuel-Type FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Plant State FE | | Yes | | | | Yes | | |
| Observations | 321,117 | 321,117 | 321,117 | 321,117 | 326,312 | 326,312 | 326,312 | 326,312 |
| K-P F-Stat | | | | 408.096 | | | | 408.096 |

## Table 6: Ownership of Decommissioned Power Plants

In this table, observations are at the plant-prime-mover-month level and the sample includes only power plants with a nameplate capacity of at least 20MW. We present the hazard ratios of a survival analysis using the Cox proportional hazard model. The event of interest is a complete decommissioning of a power plant (not partial retirement of one generator). *#Plants* reports the number of unique plant-prime-mover units included in the survival analysis, while *#Decommissioned* reports the number of unique plant-prime-mover units that are retired by the end of the survival analysis. We measure the ownership by domestic publicly listed corporations ($DLC$), private equity, institutional investors, and foreign publicly listed corporations. We also control for the ownership by industry firms, government, cooperatives, and others. *ISO Balancing*, *IPP ISO Balancing*, and *ISO Restructured* are indicators for power plants operating in a deregulated electricity market. In Column (6), we present the second stage results of an IV model where we instrument the *ISO Restructured* variable with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. Online Appendix Table A.6 reports the first stage estimates of both IV regressions. The specifications include fuel-type and state fixed effects. We cluster standard errors by plant-prime-mover and report standard errors in brackets. For the IV model, we present the Kleibergen-Paap rk Wald F statistic. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **All Decommissioned Power Plants** (5,392 Plants; 758 Decommissioned) | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Domestic Listed Corp (DLC) | 1.317** | | 0.814 | 0.997 | 1.103 | 0.704 |
| | [0.156] | | [0.240] | [0.278] | [0.285] | [0.160] |
| Private Equity | | 1.006 | | | | |
| | | [0.128] | | | | |
| Institutional Investor | | 0.002*** | | | | |
| | | [0.004] | | | | |
| Foreign Corp | | 0.507*** | | | | |
| | | [0.117] | | | | |
| ISO Balancing | | | 0.733* | | | |
| | | | [0.138] | | | |
| DLC × ISO Balancing | | | 1.423** | | | |
| | | | [0.248] | | | |
| IPP ISO Balancing | | | | 0.873 | | |
| | | | | [0.145] | | |
| DLC × IPP ISO Balancing | | | | 1.305 | | |
| | | | | [0.264] | | |
| ISO Restructured | | | | | 1.123 | 0.917 |
| | | | | | [0.287] | [0.254] |
| DLC × ISO Restructured | | | | | 0.992 | 0.746 |
| | | | | | [0.165] | [0.336] |
| DLC × Climate Concern | | | 1.278 | 1.103 | 1.234 | 1.856** |
| | | | [0.400] | [0.377] | [0.392] | [0.496] |
| DLC × Renewables Incentives | | | 1.021 | 1.022 | 1.020 | 1.091 |
| | | | [0.067] | [0.066] | [0.066] | [0.059] |
| ln Plant Capacity | 0.606*** | 0.610*** | 0.602*** | 0.606*** | 0.606*** | 0.683*** |
| | [0.023] | [0.023] | [0.023] | [0.023] | [0.023] | [0.025] |
| ln Plant Age | 3.229*** | 3.220*** | 3.250*** | 3.239*** | 3.235*** | 3.160*** |
| | [0.281] | [0.275] | [0.287] | [0.285] | [0.284] | [0.264] |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-Type FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Plant State FE | Yes | Yes | Yes | Yes | Yes | |
| Observations | 753,396 | 753,396 | 753,396 | 753,396 | 753,396 | 753,396 |
| K-P F-Stat | | | | | | 233.985 |

## Table 7: Operating Performance

In this table, observations are at the plant-prime-mover-month level and are weighted by power plant nameplate capacity. In Columns (1) to (4), the dependent variable is the monthly capacity factor, which is the ratio of net electricity generation in MWh to nameplate capacity. We winsorize the capacity factor at 0.5% and 99.5%. In Columns (5) to (8), the dependent variable is the monthly heat rate, which is the ratio of fuel consumption in millions of Btu to electricity generation in MWh. We observe the heat rate for fossil fuel and nuclear power plants. We measure the ownership by domestic publicly listed corporations, private equity, institutional investors, and foreign publicly listed corporations. We also control for the ownership by industry firms, government, cooperatives, and others. *IPP ISO Balancing* and *ISO Restructured* are indicators for power plants operating in a deregulated electricity market. In Columns (4) and (8), we present the second stage results of an IV model where we instrument the *ISO Restructured* variable with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. Online Appendix Table A.6 reports the first stage estimates of the IV regressions. *ln Plant Capacity* is the natural logarithm of a plant's monthly capacity. *ln Plant Age* is the natural logarithm of plant age in years. *Greenfield 1m* is an indicator for the first month when a plant starts operating. *Greenfield 12m* is an indicator for the first 12 months when a plant starts operating. *Decommissioned 1m* is an indicator for the last month when a plant is still operating. *Decommissioned 12m* is an indicator for the last 12 months when a plant is still operating. The specifications include interacted fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. For the IV model, we present the Kleibergen-Paap rk Wald F statistic. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **Capacity Factor** Mean Dependent Variable = 0.412 | | | | **Heat Rate** Mean Dependent Variable = 11.324 | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Domestic Listed Corp (DLC) | 0.016* | | 0.086*** | 0.050** | 0.616*** | | 0.184 | 0.325 |
| | [0.010] | | [0.015] | [0.022] | [0.131] | | [0.164] | [0.221] |
| Private Equity | | -0.029*** | | | | -0.434*** | | |
| | | [0.011] | | | | [0.150] | | |
| Institutional Investor | | 0.097*** | | | | -1.607*** | | |
| | | [0.033] | | | | [0.440] | | |
| Foreign Corp | | -0.014 | | | | -0.873*** | | |
| | | [0.013] | | | | [0.232] | | |
| IPP ISO Balancing | | | 0.085*** | | | | -0.508** | |
| | | | [0.016] | | | | [0.203] | |
| DLC × IPP ISO Balancing | | | -0.108*** | | | | 0.671*** | |
| | | | [0.017] | | | | [0.224] | |
| ISO Restructured | | | | 0.057* | | | | -0.478 |
| | | | | [0.033] | | | | [0.318] |
| DLC × ISO Restructured | | | | -0.108*** | | | | 0.449 |
| | | | | [0.038] | | | | [0.361] |
| ln Plant Capacity | 0.019*** | 0.018*** | 0.019*** | 0.022*** | -0.373*** | -0.373*** | -0.373*** | -0.389*** |
| | [0.003] | [0.003] | [0.003] | [0.004] | [0.059] | [0.059] | [0.059] | [0.059] |
| ln Plant Age | -0.109*** | -0.110*** | -0.108*** | -0.105*** | 1.320*** | 1.329*** | 1.312*** | 1.184*** |
| | [0.006] | [0.006] | [0.006] | [0.006] | [0.099] | [0.098] | [0.099] | [0.090] |
| Greenfield 1m | -0.169*** | -0.169*** | -0.170*** | -0.166*** | 1.882*** | 1.879*** | 1.885*** | 1.841*** |
| | [0.011] | [0.011] | [0.011] | [0.011] | [0.653] | [0.650] | [0.654] | [0.587] |
| Greenfield 12m | -0.141*** | -0.141*** | -0.142*** | -0.122*** | 1.734*** | 1.742*** | 1.739*** | 1.242*** |
| | [0.011] | [0.011] | [0.011] | [0.012] | [0.207] | [0.207] | [0.208] | [0.215] |
| Decommissioned 1m | -0.074*** | -0.074*** | -0.074*** | -0.085*** | 0.486 | 0.481 | 0.489 | 0.250 |
| | [0.017] | [0.017] | [0.017] | [0.016] | [0.453] | [0.454] | [0.454] | [0.446] |
| Decommissioned 12m | -0.125*** | -0.123*** | -0.123*** | -0.130*** | 0.477*** | 0.470*** | 0.467*** | 0.508*** |
| | [0.012] | [0.011] | [0.011] | [0.015] | [0.151] | [0.150] | [0.151] | [0.141] |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | | Yes | Yes | Yes | |
| Fuel-Year-Month FE | | | | Yes | | | | Yes |
| Observations | 1,398,265 | 1,398,265 | 1,398,265 | 1,478,395 | 590,140 | 590,140 | 590,140 | 664,027 |
| Adjusted R-squared | 0.635 | 0.636 | 0.638 | | 0.336 | 0.336 | 0.336 | |
| K-P F-Stat | | | | 199.203 | | | | 156.032 |

### Table 8: Changes in Ownership and Operating Performance

In Columns (1) and (2), the dependent variable is the monthly capacity factor, which is the ratio of net electricity generation in MWh to nameplate capacity. We winsorize the capacity factor at 0.5% and 99.5%. In Columns (3) and (4), the dependent variable is the monthly heat rate, which is the ratio of fuel consumption in millions of Btu to electricity generation in MWh. We observe the heat rate for fossil fuel and nuclear power plants. In Panel A, we focus on the subsample of power plants that experienced an ownership change and were sold by DLCs to PE, institutional investors, and foreign listed corporations. The event window covers 24 months pre and post the ownership change. In Columns (1) and (3) we analyze only the subsample of treated power plants. In Columns (2) and (4), we stack each treated power plant with a matched never-treated power plant that has been always owned by DLC. We match exactly based on fuel type and prime mover, and nearest neighbor based on plant capacity and age. The control variables include *ln Plant Capacity*, *ln Plant Age*, *Greenfield 1m*, *Greenfield 12m*, *Decommissioned 1m* and *Decommissioned 12m*. The specifications include interacted state and year-month fixed effects, and interacted plant-prime-mover and stacked cohort fixed effects. We double cluster standard errors by plant-prime-mover-cohort and time, and report standard errors in brackets. In Panel B, we analyze only the subsample of newly created power plants by DLCs, PE, institutional investors, and foreign corporations during the 2005–2020 period. Columns (1) and (3) examine the operating performance of all new plants, while Columns (2) and (4) create a matched subsample. In this panel, DLC is an indicator if the first-ever owner of a power plant was a domestic listed corporation. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

| | **Capacity Factor** | | **Heat Rate** | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| **Panel A: Power Plants Sold by DLCs** | | | | |
| | Only Treated | Matched DID | Only Treated | Matched DID |
| Post × Treated | -0.005 | 0.000 | -0.309* | -0.441** |
| | [0.006] | [0.006] | [0.181] | [0.176] |
| Controls | Yes | Yes | Yes | Yes |
| State-Year-Month FE | Yes | Yes | Yes | Yes |
| Plant-Prime-Mover FE | Yes | | Yes | |
| Fuel Type FE | Yes | | Yes | |
| Plant-Prime-Mover × Cohort FE | | Yes | | Yes |
| Year-Month × Cohort FE | | Yes | | Yes |
| Observations | 54,064 | 87,003 | 19,822 | 37,952 |
| Adjusted R-squared | 0.805 | 0.812 | 0.738 | 0.733 |
| **Panel B: Power Plants Created by DLCs and New Entrants** | | | | |
| | All | Match | All | Match |
| Domestic Listed Corp (DLC) | 0.008 | 0.006 | 0.387* | 0.666** |
| | [0.006] | [0.007] | [0.224] | [0.295] |
| Controls | Yes | Yes | Yes | Yes |
| State-Year-Month FE | Yes | Yes | Yes | Yes |
| Fuel Type FE | Yes | Yes | Yes | Yes |
| Observations | 197,645 | 86,898 | 30,173 | 8,935 |
| Adjusted R-squared | 0.459 | 0.406 | 0.189 | 0.236 |

## Table 9: Contractual Terms of Electricity Sales

In this table, observations are at the plant-prime-mover-month level and are weighted by power plant nameplate capacity. The dependent variables are the percentages of electricity transaction charges under three different contractual terms. First, we distinguish between short contracts with a duration of less than one year and long-term contracts. Second, we split transactions into short, medium, and long based on the increment pricing terms. Short transactions use 5-minute, 15-minute, or hourly increments (up to 6 hours). Medium transactions have daily or weekly increments (from 6 hours to 168 hours). Long transactions use monthly or yearly increments (longer than 168 hours). Third, we classify transactions into full-period, peak, and off-peak based on the peaking terms. The sample includes power plants owned by domestic publicly listed corporations, private equity, institutional investors, and foreign publicly listed corporations. We focus on the ownership by private equity, institutional investors, and foreign corporations (the omitted ownership category is domestic corporations). *ln Plant Capacity* is the natural logarithm of a plant's monthly capacity. *ln Plant Age* is the natural logarithm of plant age in years. *Greenfield 12m* is an indicator for the first 12 months when a plant starts operating. *Decommissioned 12m* is an indicator for the last 12 months when a plant is still operating. The specifications include interacted fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **Contract Duration** | | **Increment Terms** | | | **Peaking Period Terms** | | |
|---|---|---|---|---|---|---|---|---|
| | Short | Long | Short | Medium | Long | Full | Peak | Off-Peak |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Mean Dependent Variable | 0.585 | 0.412 | 0.506 | 0.046 | 0.423 | 0.380 | 0.355 | 0.195 |
| Private Equity | 0.135*** | -0.140*** | 0.151*** | -0.002 | -0.154*** | -0.035 | 0.092*** | -0.015 |
| | [0.029] | [0.029] | [0.024] | [0.007] | [0.026] | [0.025] | [0.019] | [0.010] |
| Institutional Investor | -0.102 | 0.116* | -0.252*** | 0.069* | 0.184** | 0.197** | -0.130** | -0.032 |
| | [0.062] | [0.063] | [0.061] | [0.040] | [0.083] | [0.083] | [0.050] | [0.032] |
| Foreign Corp | 0.043 | -0.038 | 0.112*** | 0.016 | -0.175*** | 0.012 | -0.002 | -0.034** |
| | [0.039] | [0.040] | [0.036] | [0.010] | [0.038] | [0.035] | [0.023] | [0.014] |
| ln Plant Capacity | 0.020** | -0.023** | 0.006 | -0.003 | 0.002 | -0.017* | 0.011* | 0.005 |
| | [0.010] | [0.010] | [0.009] | [0.003] | [0.009] | [0.009] | [0.006] | [0.003] |
| ln Plant Age | -0.024* | 0.020 | -0.006 | -0.006 | 0.013 | -0.011 | 0.025*** | -0.004 |
| | [0.014] | [0.014] | [0.012] | [0.004] | [0.012] | [0.011] | [0.009] | [0.004] |
| Greenfield 12m | -0.021 | 0.006 | 0.034 | -0.004 | -0.040* | -0.051** | 0.061*** | 0.024*** |
| | [0.025] | [0.024] | [0.022] | [0.006] | [0.022] | [0.022] | [0.016] | [0.008] |
| Decommissioned 12m | 0.049 | -0.047 | 0.021 | 0.005 | -0.004 | -0.016 | 0.014 | 0.004 |
| | [0.035] | [0.035] | [0.033] | [0.004] | [0.031] | [0.033] | [0.024] | [0.014] |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 228,744 | 228,744 | 228,744 | 228,744 | 228,744 | 228,744 | 228,744 | 228,744 |
| Adjusted R-squared | 0.579 | 0.580 | 0.634 | 0.578 | 0.618 | 0.606 | 0.614 | 0.570 |

**Table 10: Contractual Terms of Capacity Sales**

In this table, observations are at the plant-prime-mover-month level and are weighted by power plant nameplate capacity. The sample includes power plants owned by domestic publicly listed corporations, private equity, institutional investors, and foreign publicly listed corporations. In Columns (1) and (2), the dependent variable is an indicator equal to one if a power plant receives compensation for capacity sales. The sample in these specifications includes all power plants reporting in the FERC dataset. In Columns (3) to (6), the dependent variables measure the average percentage of transaction charges for capacity sales by contract length. These specifications limit attention to the subsample of power plants with capacity sales. *ln Plant Capacity* is the natural logarithm of a plant's monthly capacity. *ln Plant Age* is the natural logarithm of plant age in years. *Greenfield 12m* is an indicator for the first 12 months when a plant starts operating. *Decommissioned 12m* is an indicator for the last 12 months when a plant is still operating. The specifications include interacted fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **Probability** | | **Short Contracts** | | **Long Contracts** | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Mean Dependent Variable | 0.847 | 0.847 | 0.158 | 0.158 | 0.841 | 0.841 |
| Domestic Listed Corp (DLC) | 0.034* | | -0.074** | | 0.073** | |
| | [0.020] | | [0.036] | | [0.036] | |
| Private Equity | | -0.001 | | 0.102** | | -0.100** |
| | | [0.024] | | [0.041] | | [0.041] |
| Institutional Investor | | 0.003 | | -0.208** | | 0.209** |
| | | [0.035] | | [0.080] | | [0.080] |
| Foreign Corp | | -0.100*** | | 0.131** | | -0.131** |
| | | [0.031] | | [0.050] | | [0.050] |
| ln Plant Capacity | 0.008 | 0.008 | -0.009 | -0.007 | 0.009 | 0.008 |
| | [0.007] | [0.007] | [0.009] | [0.009] | [0.009] | [0.009] |
| ln Plant Age | 0.011 | 0.013* | 0.014 | 0.017 | -0.015 | -0.018 |
| | [0.007] | [0.007] | [0.011] | [0.011] | [0.011] | [0.011] |
| Greenfield 12m | 0.002 | 0.005 | -0.035 | -0.028 | 0.034 | 0.027 |
| | [0.018] | [0.018] | [0.027] | [0.027] | [0.027] | [0.027] |
| Decommissioned 12m | 0.015 | 0.015 | -0.021 | -0.019 | 0.021 | 0.020 |
| | [0.022] | [0.022] | [0.037] | [0.037] | [0.037] | [0.037] |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 231,097 | 231,097 | 163,001 | 163,001 | 163,001 | 163,001 |
| Adjusted R-squared | 0.586 | 0.589 | 0.520 | 0.526 | 0.519 | 0.525 |

## Table 11: Pricing of Electricity Sales

In Panel A, observations are at the plant-prime-mover-month level and are weighted by the quantity of produced electricity. The dependent variables are the mean and median of monthly electricity prices per MWh. We winsorize the dependent variables at 0.5% and 99.5%. The sample includes power plants owned by domestic publicly listed corporations, private equity, institutional investors, and foreign publicly listed corporations. We focus on the ownership by private equity, institutional investors, and foreign corporations (the omitted ownership category is DLCs). *ln Plant Capacity* is the natural logarithm of a plant's monthly capacity. *ln Plant Age* is the natural logarithm of plant age in years. *Greenfield 12m* is an indicator for the first 12 months when a plant starts operating. *Decommissioned 12m* is an indicator for the last 12 months when a plant is still operating. The specifications include interacted fuel-type, state, and year-month fixed effects. In Panel B, we analyze only the subsample of newly created power plants by DLCs, PE, institutional investors, and foreign corporations during the 2005–2020 period. Columns (1) and (3) examine the operating performance of all new plants, while Columns (2) and (4) create a matched subsample. In this panel, DLC is an indicator if the first-ever owner of a power plant was a domestic listed corporation. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

**Panel A: All Power Plants**

| | **Mean Price** Mean Dependent Variable = 30.836 | | | | **Median Price** Mean Dependent Variable = 28.706 | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Domestic Listed Corp (DLC) | -3.917*** | | -1.213 | | -4.045*** | | -1.294 | |
| | [0.845] | | [0.828] | | [0.815] | | [0.806] | |
| Private Equity | | 4.357*** | | 2.593*** | | 4.252*** | | 2.593*** |
| | | [0.931] | | [0.963] | | [0.867] | | [0.902] |
| Institutional Investor | | -1.646 | | -1.566 | | 0.207 | | -0.426 |
| | | [2.343] | | [1.884] | | [2.242] | | [1.645] |
| Foreign Corp | | 4.929*** | | -0.102 | | 5.300*** | | 0.089 |
| | | [1.774] | | [1.604] | | [1.718] | | [1.556] |
| ln Plant Capacity | -1.013** | -0.977** | -0.093 | -0.096 | -1.281*** | -1.252*** | -0.275 | -0.284 |
| | [0.443] | [0.442] | [0.487] | [0.487] | [0.440] | [0.440] | [0.480] | [0.480] |
| ln Plant Age | 0.977* | 1.002* | 1.343*** | 1.444*** | 0.976* | 0.983* | 1.323** | 1.413*** |
| | [0.512] | [0.513] | [0.487] | [0.487] | [0.527] | [0.529] | [0.526] | [0.526] |
| Greenfield 12m | -4.847*** | -4.852*** | -5.226*** | -5.086*** | -4.554*** | -4.584*** | -4.912*** | -4.795*** |
| | [1.220] | [1.220] | [1.079] | [1.087] | [1.178] | [1.178] | [1.037] | [1.042] |
| Decommissioned 12m | 0.086 | 0.054 | -1.199 | -1.207 | -0.771 | -0.800 | -2.147 | -2.159 |
| | [1.353] | [1.345] | [1.316] | [1.295] | [1.564] | [1.555] | [1.622] | [1.601] |
| State-Year-Month FE | Yes | Yes | | | Yes | Yes | | |
| Fuel FE | Yes | Yes | | | Yes | Yes | | |
| Fuel-State-Year-Month FE | | | Yes | Yes | | | Yes | Yes |
| Observations | 238,201 | 238,201 | 218,746 | 218,746 | 238,201 | 238,201 | 218,746 | 218,746 |
| Adjusted R-squared | 0.497 | 0.498 | 0.647 | 0.647 | 0.458 | 0.459 | 0.617 | 0.618 |

**Panel B: Power Plants Created by DLCs and New Entrants**

| | **Mean Price** | | **Median Price** | |
|---|---|---|---|---|
| | All | Match | All | Match |
| Mean Dependent Variable | 34.252 | 39.106 | 32.083 | 37.244 |
| Domestic Listed Corp (DLC) | -7.723*** | -5.979** | -8.523*** | -6.349*** |
| | [1.799] | [2.275] | [1.663] | [2.157] |
| Controls | Yes | Yes | Yes | Yes |
| State-Year-Month FE | Yes | Yes | Yes | Yes |
| Fuel Type FE | Yes | Yes | Yes | Yes |
| Observations | 82,960 | 33,287 | 82,960 | 33,287 |
| Adjusted R-squared | 0.631 | 0.680 | 0.636 | 0.660 |

# Online Appendix

# The Shifting Finance of Electricity Generation

## A.1 Power Plants and Electricity Generation

The percentage of electricity generated by power plants owned by domestic publicly listed corporations (DLCs) declined from 70% in 2005 to 54% in 2020. Private equity (PE), institutional investors, and foreign corporations replace DLCs as their share jointly increases from 7% in 2005 to 24% in 2020. The generation share of governments, cooperatives, and industry firms remains constant. The ownership changes while the total electricity production remains constant. Online Appendix Figure A.1 Panel A shows that the U.S. produced around 4.1 trillion kWh of electricity in 2005 and the total output has remained constant over our sample period. Panel B plots the total imports and exports of electricity, which also remain stable over our analysis and are economically marginal as they account for less than 1.5% of the U.S. electricity market.

In our main analysis, we present weighted statistics by power plant nameplate capacity as the sample contains many small power plants that contribute very little to overall net generation. One limitation of the nameplate-capacity-weighting is that power plants that use fuels with lower capacity factors receive disproportionately higher weights than power plants that use fuels with higher capacity factors. In our greenfield analysis, we rely primarily on capacity weights with fuel-type-state-time fixed effects, but we also estimate tests without weighting on the subsample of power plants with a capacity of at least 20MW. Online Appendix Table A.1 reports summary statistics without weighting the power plants and focuses only on the subsample of power plants with a capacity of at least 20MW.

Online Appendix Table A.2 shows how many power plants in each state operate under a deregulated wholesale market. *ISO Balancing* is our broadest measure of market deregulation, and it is an indicator for power plants that operate in a wholesale market administered by an Independent System Operator (ISO) as a balancing authority. This table shows that the *ISO Balancing* measure is broader as it covers also states that did not restructure their utilities but agreed to operate in a competitive wholesale market. Thus, this measure includes also many plants that are still subject to rate-of-return regulation, especially in MISO and SPP. *IPP ISO Balancing* is our main measure of market deregulation, and it captures only power plants that participate in an ISO Balancing market and are owned by an independent power producer (IPP). This measure captures only IPPs that operate under a market-based pricing model and excludes all plants owned by regulated electric utilities that operate under a cost-of-service model. *ISO Restructured* is an alternative more restrictive definition of market deregulation. It captures power plants that participate in a wholesale market administered by an ISO balancing authority and are located in areas with restructured electric utilities. In addition to having restructured utilities, the *ISO Restructured* wholesale markets typically also offer a retail choice to residential or business customers. The overlap between the *IPP ISO Balancing* and *ISO Restructured* measures is substantial and 27% of plants in the sample on a capacity-weighted basis are classified as deregulated under both measures.

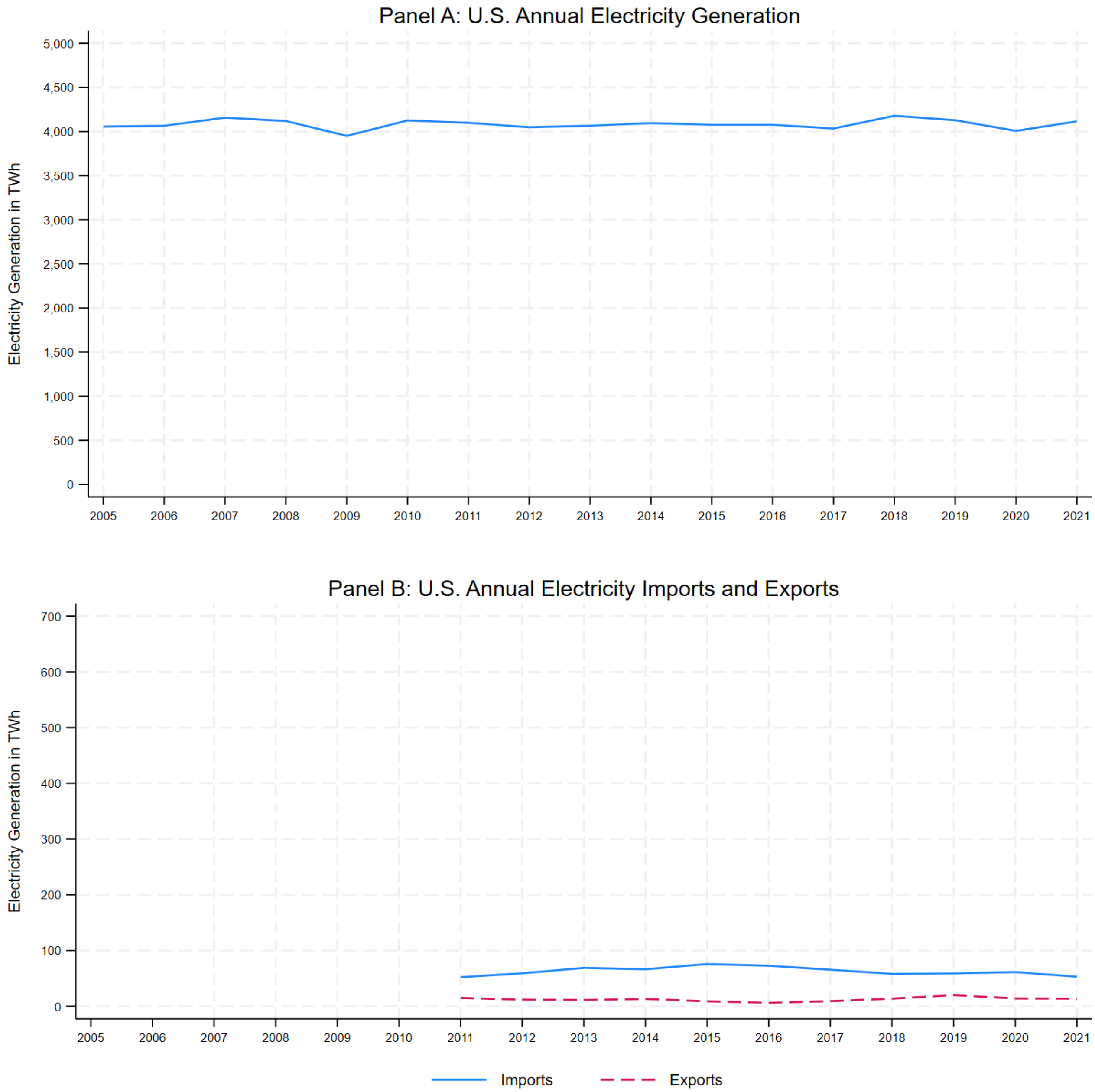
Importantly for our analysis, the ISO markets were established before our sample period, mostly around 2000, and before the wind and solar technologies became competitive as well as before the shale gas revolution. This timeline reduces concerns regarding reverse causality, specifically the alternative hypothesis that ISOs were created to stimulate the adoption of new technologies. In Online Appendix Table A.3, we examine whether state-level energy resources, economic factors, political factors, and electricity prices predict deregulation. Using the Cox proportional hazard model, We estimate a survival analysis on a state level with two dependent variables. In Columns (1) to (4), the event of interest is the year when a deregulated ISO-balancing wholesale market becomes effective and starts operating. In Columns (5) to (8), the event of interest is the year when the state legislation completes the approval and formation of a deregulated ISO-restructured wholesale market.

We find that the decision to establish ISO balancing markets is unrelated to variations in state-level solar and wind energy potential. If anything, the estimates on the approval of ISO-restructured markets suggest that states with higher wind or solar potential scaled by the amount of electricity consumption were less likely to restructure the local utilities and deregulate the electricity markets. The decision to deregulate the electricity markets is also unrelated to the production of natural gas or coal in a state normalized by the amount of electricity consumption. In line with prior research, the main factor that predicts wholesale market deregulation is not the average electricity price in a state, but rather the difference between the average electricity price in the residential sector and the average electricity price in the industrial sector (White, 1996; Joskow, 1997). We document that states with a significantly higher average electricity price in the residential sector than the average electricity price in the industrial sector are more likely to establish an ISO-balancing wholesale market and restructure the local electric utilities. Overall, we show that state-level natural resources, economic, and political factors do not predict electricity market deregulation.

We use the Database of State Incentives for Renewables & Efficiency from the N.C. Clean Energy Technology Center to collect information on the policy incentives introduced by different states to stimulate the transition to renewable energy sources. We split the policy initiatives into three types of tax incentives: Renewables Corporate Tax, Renewables Property Tax, and Renewables Sales Tax; and two types of production incentives: Renewables Production and Renewables Tariffs. Renewables Corporate Tax Incentives capture programs that provide a corporate tax credit, corporate tax deduction, and corporate depreciation. Renewables Property Taxes capture programs offering property tax exemption or reduction. Renewables Sales Taxes incentives offer an exemption or reduction from sales and use tax for equipment, generation, etc. Renewables Production incentives offer monetary compensation per KWh that can differ by fuel type and plant capacity. Renewables Tariffs incentives capture primarily feed-in tariffs, which offer long-term contracts with an above-market price to renewable energy producers. In our analysis, we include a *Renewables Incentives* index, which aggregates the three tax indicators and the two production indicators. Online Appendix Table A.4 presents the average value of the five indicators and aggregate renewables incentives index by state over the 2005–2020 period. The index varies from 0.00 in Arkansas to 3.91 incentive types in Vermont.

**Figure A.1: Total U.S. Electricity Market**

Panel A presents the total U.S. electricity generation over the 2005–2021 period. The data is based on the Energy Information Administration (EIA) Monthly Energy Review Table 7.2a and includes generation from power plants with at least 1 MW electric generation capacity. Panel B shows the total U.S. electricity imports and electricity exports to Canada and Mexico over the 2011–2021 period. The data is based on the Energy Information Administration (EIA) Table 2.14. (Sources: 2016–2021, U.S. Energy Information Administration, Form EIA-111, Quarterly Electricity Imports and Exports Report; 2006–2015 data, National Energy Board of Canada; FERC 714, Annual Electric Balancing Authority Area and Planning Report; California Energy Commission; and EIA estimates.)



## Table A.1: EIA Power Plants (Not Weighted Observations)

**Robustness statistics of Table 1:** We do not weight observations by power plant nameplate capacity, but we limit attention to the subsample of power plants with a nameplate capacity of at least 20MW.

The table presents summary statistics on a plant-prime-mover-month level for all power plants together as well as separately for the main fuel types: natural gas, coal, nuclear, hydro, wind, and solar plants. The sample includes only power plants with a nameplate capacity of at least 20MW. Panel B reports statistics for the power plant characteristics: *Capacity*, *Capacity Factor*, *Heat Rate*, *Age*, *Greenfield 12m*, and *Decommissioned 12m.* Panel C reports the average ownership by the eight categories in percent. If multiple ownership types own a power plant, we divide the ownership equally across the ownership types. Panel D presents statistics on electricity markets. *ISO Balancing* is an indicator for power plants operating in an ISO-balancing wholesale market. *IPP ISO Balancing* is an indicator for power plants that participate in an ISO-balancing market and are owned by independent power producers. *ISO Restructured* is an indicator for power plants that participate in an ISO balancing wholesale market and are located in areas with restructured utilities. *ResidIndPD* is the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. *Climate Concern* is the percentile ranking of the state where the plant is located based on the percentage of the state population who think that global warming is happening. *Renewables Incentives* is an aggregate index of three indicators if a state has corporate tax, property tax, and sales tax incentives for renewable energy as well as two indicators if a state has production or feed-in tariffs incentives for renewable energy.

| | **All** | **NatGas** | **Coal** | **Nuclear** | **Hydro** | **Wind** | **Solar** |
|---|---|---|---|---|---|---|---|
| **Panel A: Power Plants Sample** | | | | | | | |
| # Unique Plants | 4,455 | 1,960 | 651 | 66 | 457 | 879 | 502 |
| # Unique Plants-Prime-Mover | 5,392 | 2,791 | 728 | 66 | 457 | 879 | 502 |
| # Unique Greenfield | 1,883 | 514 | 35 | 0 | 5 | 777 | 501 |
| # Unique Decommissioned | 793 | 528 | 246 | 10 | 5 | 23 | 1 |
| Observations | 753,396 | 420,705 | 102,606 | 12,215 | 86,146 | 87,828 | 21,062 |
| **Panel B: Power Plant Characteristics** | | | | | | | |
| Capacity (GWh) | 0.285 | 0.257 | 0.635 | 1.689 | 0.163 | 0.115 | 0.063 |
| Capacity Factor | 0.318 | 0.263 | 0.478 | 0.857 | 0.373 | 0.321 | 0.257 |
| Heat Rate | | 11.983 | 10.768 | 10.459 | | | |
| Age (Years) | 28.533 | 22.900 | 42.956 | 33.668 | 61.290 | 7.007 | 2.701 |
| Greenfield 12m | 0.028 | 0.015 | 0.003 | 0 | 0.001 | 0.1 | 0.251 |
| Decommissioned 12m | 0.012 | 0.013 | 0.028 | 0.009 | 0.001 | 0.003 | 0.001 |
| **Panel C: Power Plant Ownership** | | | | | | | |
| Domestic Listed Corp (DLC) | 0.420 | 0.392 | 0.505 | 0.864 | 0.345 | 0.414 | 0.533 |
| Private Equity | 0.145 | 0.161 | 0.075 | 0.013 | 0.074 | 0.244 | 0.276 |
| Institutional Investor | 0.016 | 0.018 | 0.003 | 0.000 | 0.006 | 0.039 | 0.055 |
| Foreign Corp | 0.074 | 0.053 | 0.022 | 0.016 | 0.031 | 0.263 | 0.101 |
| Industry | 0.069 | 0.087 | 0.137 | 0.000 | 0.013 | 0.002 | 0.011 |
| Government | 0.198 | 0.193 | 0.170 | 0.106 | 0.512 | 0.015 | 0.002 |
| Cooperative | 0.051 | 0.067 | 0.071 | 0.000 | 0.020 | 0.009 | 0.004 |
| Other | 0.026 | 0.029 | 0.017 | 0.000 | 0.000 | 0.015 | 0.017 |
| **Panel D: State Electricity Markets** | | | | | | | |
| ISO Balancing | 0.637 | 0.668 | 0.642 | 0.701 | 0.400 | 0.774 | 0.555 |
| IPP ISO Balancing | 0.402 | 0.422 | 0.306 | 0.476 | 0.116 | 0.687 | 0.519 |
| ISO Restructured | 0.315 | 0.350 | 0.317 | 0.489 | 0.137 | 0.312 | 0.097 |
| ResidIndPD | 9.935 | 10.189 | 9.514 | 10.507 | 9.134 | 9.877 | 10.189 |
| Climate Concern | 0.572 | 0.592 | 0.442 | 0.560 | 0.573 | 0.534 | 0.738 |
| Renewables Incentives | 2.216 | 2.223 | 2.066 | 2.107 | 2.033 | 2.576 | 2.515 |

## Table A.2: Regulatory Policy by State

We present the number of plant-prime-mover-month observations by state based on the electricity market regulatory status. *ISO Balancing* is an indicator for power plants that participate in a wholesale market administered by an Independent System Operator. *IPP ISO Balancing* is an indicator for power plants that participate in an ISO balancing market and are owned by independent power producers. *ISO Restructured* is an indicator for power plants that participate in an ISO balancing wholesale market and are located in areas with restructured electric utilities. In *traditional* markets, vertically integrated local electric utilities own power plants generating electricity as well as the transmission system and delivery network.

| State | ISO Balancing | IPP ISO Balancing | ISO Restructured | Traditional | Total Plants |
|---|---|---|---|---|---|
| Alabama | 0 | 0 | 0 | 18,554 | 18,554 |
| Alaska | 0 | 0 | 0 | 28,227 | 28,227 |
| Arizona | 261 | 261 | 0 | 22,194 | 22,455 |
| Arkansas | 9,226 | 3,062 | 0 | 3,120 | 12,346 |
| California | 174,277 | 132,665 | 0 | 36,161 | 210,438 |
| Colorado | 162 | 162 | 0 | 30,523 | 30,685 |
| Connecticut | 17,951 | 15,659 | 17,951 | 0 | 17,951 |
| Delaware | 4,988 | 4,611 | 4,988 | 0 | 4,988 |
| District of Columbia | 503 | 491 | 503 | 0 | 503 |
| Florida | 0 | 0 | 0 | 41,808 | 41,808 |
| Georgia | 0 | 0 | 0 | 29,415 | 29,415 |
| Hawaii | 0 | 0 | 0 | 11,976 | 11,976 |
| Idaho | 0 | 0 | 0 | 22,249 | 22,249 |
| Illinois | 40,842 | 28,855 | 40,842 | 893 | 41,735 |
| Indiana | 24,336 | 10,340 | 0 | 408 | 24,744 |
| Iowa | 37,500 | 13,524 | 0 | 5,039 | 42,539 |
| Kansas | 23,031 | 4,168 | 0 | 3,093 | 26,124 |
| Kentucky | 3,298 | 693 | 0 | 6,414 | 9,712 |
| Louisiana | 17,677 | 11,165 | 0 | 2,654 | 20,331 |
| Maine | 18,323 | 17,883 | 18,323 | 1,713 | 20,036 |
| Maryland | 15,587 | 14,449 | 15,587 | 0 | 15,587 |
| Massachusetts | 47,328 | 40,584 | 47,328 | 0 | 47,328 |
| Michigan | 46,433 | 19,542 | 46,433 | 808 | 47,241 |
| Minnesota | 59,905 | 35,626 | 0 | 3,054 | 62,959 |
| Mississippi | 4,787 | 895 | 0 | 7,010 | 11,797 |
| Missouri | 17,677 | 3,570 | 0 | 8,456 | 26,133 |
| Montana | 1,102 | 157 | 0 | 7,815 | 8,917 |
| Nebraska | 14,593 | 2,490 | 0 | 4,900 | 19,493 |
| Nevada | 984 | 720 | 0 | 14,739 | 15,723 |
| New Hampshire | 12,712 | 9,736 | 12,712 | 0 | 12,712 |
| New Jersey | 38,561 | 36,123 | 38,561 | 0 | 38,561 |
| New Mexico | 3,502 | 2,472 | 0 | 11,258 | 14,760 |
| New York | 82,050 | 68,223 | 82,050 | 0 | 82,050 |
| North Carolina | 7,178 | 5,658 | 0 | 56,348 | 63,526 |
| North Dakota | 7,884 | 3,572 | 0 | 563 | 8,447 |
| Ohio | 30,422 | 14,438 | 30,422 | 440 | 30,862 |
| Oklahoma | 17,363 | 6,829 | 0 | 3,193 | 20,556 |
| Oregon | 0 | 0 | 0 | 27,798 | 27,798 |
| Pennsylvania | 42,263 | 41,603 | 42,263 | 192 | 42,455 |
| Rhode Island | 5,590 | 5,398 | 5,590 | 0 | 5,590 |
| South Carolina | 0 | 0 | 0 | 21,841 | 21,841 |
| South Dakota | 3,236 | 1,202 | 0 | 3,262 | 6,498 |
| Tennessee | 368 | 368 | 0 | 12,648 | 13,016 |
| Texas | 84,462 | 66,013 | 68,936 | 3,745 | 88,207 |
| Utah | 0 | 0 | 0 | 15,445 | 15,445 |
| Vermont | 14,051 | 5,268 | 0 | 0 | 14,051 |
| Virginia | 27,395 | 11,985 | 23,575 | 889 | 28,284 |
| Washington | 0 | 0 | 0 | 26,090 | 26,090 |
| West Virginia | 5,970 | 3,196 | 0 | 927 | 6,897 |
| Wisconsin | 36,445 | 13,965 | 0 | 2,066 | 38,511 |
| Wyoming | 0 | 0 | 0 | 11,195 | 11,195 |
| Total | 1,000,223 | 657,621 | 496,064 | 509,123 | 1,509,346 |

## Table A.3: Predicting Deregulation by State

In this table, observations are at the state-year level and the sample covers the 1991–2010 period. We start in 1991 as the first event of approved market deregulation is in 1993, and we stop in 2010 as the last event of effective deregulation is in 2009. We present the hazard ratios of a survival analysis using the Cox proportional hazard model. In Columns (1) to (4), the event of interest is the year when a deregulated ISO-balancing wholesale market becomes effective and starts operating. In Columns (5) to (8), the event of interest is the year when the state legislation completes the approval and formation of a deregulated ISO-restructured wholesale market. The *WindPotential* measures the wind capacity potential in MW at 80 meters and aggregates the capacity across the ten wind TRG classes. The data is provided by the AWS Truepower and National Renewable Energy Laboratory. For AK, DC, and HI, we append the data on wind capacity potential using information from the NREL U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis. The *SolarPotential* measures the urban and rural utility-scale PV solar capacity in GWh and comes from the NREL U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis. *NatGasProduction* is the natural gas dry production in million cubic feet, provided by the EIA Natural Gas Gross Withdrawals and Production data series. The *CoalProduction* measures the aggregate annual coal production in short tons and is reported by the EIA and U.S. Mine Safety and Health Administration. We scale the wind potential, solar potential, natural gas production, and coal production variables by the total electricity consumption (electricity sales to ultimate customers), provided by the EIA State Energy Data System (SEDS). *Electricity Price* is the average electricity price of all sectors in dollars per million Btu. *ResidIndPD* is the difference between the average electricity price in the residential sector and the average electricity price in the industrial sector. The data on average prices comes from the EIA State Energy Data System (SEDS). The state GDP per capita is from the Bureau of Economic Analysis. The annual unemployment rate is the average of the monthly unemployment rates by state, reported by the Bureau of Labor Statistics. *Democratic Control* and *Republican Control* are indicator variables capturing whether both legislative branch levels (house and senate) are controlled by the Democrats or Republicans (the omitted category is split control). We cluster standard errors by state, and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **ISO Balancing Effective** | | | | **ISO Restructured Approved** | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| WindPotential / ElecConsumption | 0.975 | 0.976 | | | 0.716** | 0.733** | | |
| | [0.017] | [0.018] | | | [0.105] | [0.110] | | |
| SolarPotential / ElecConsumption | | | 0.999 | 0.999 | | | 0.984** | 0.987** |
| | | | [0.001] | [0.001] | | | [0.007] | [0.006] |
| NatGasProduction / ElecConsumption | 0.993 | 0.994 | 0.990 | 0.989 | 0.992 | 1.010 | 0.999 | 1.014 |
| | [0.011] | [0.012] | [0.012] | [0.013] | [0.021] | [0.022] | [0.019] | [0.021] |
| CoalProduction / ElecConsumption | 0.974 | 0.969 | 0.961 | 0.960 | 0.938 | 1.251 | 0.734 | 0.994 |
| | [0.056] | [0.065] | [0.062] | [0.069] | [0.200] | [0.247] | [0.174] | [0.146] |
| Electricity Price | 0.995 | 0.983 | 0.995 | 0.982 | 1.029 | 1.059 | 0.999 | 1.038 |
| | [0.030] | [0.034] | [0.030] | [0.033] | [0.047] | [0.059] | [0.046] | [0.060] |
| ResidIndPD | 1.112*** | 1.124** | 1.115*** | 1.130** | 1.273*** | 1.288** | 1.268*** | 1.264** |
| | [0.045] | [0.054] | [0.045] | [0.055] | [0.096] | [0.164] | [0.089] | [0.142] |
| GDP Per Capita | | 1.016*** | | 1.016*** | | 1.024*** | | 1.023*** |
| | | [0.005] | | [0.005] | | [0.008] | | [0.008] |
| Unemployment Rate | | 0.892 | | 0.898 | | 0.707 | | 0.749 |
| | | [0.136] | | [0.134] | | [0.183] | | [0.195] |
| Democratic Control | | 0.923 | | 0.996 | | 0.754 | | 0.626 |
| | | [0.392] | | [0.422] | | [0.734] | | [0.540] |
| Republican Control | | 0.720 | | 0.724 | | 2.095 | | 1.727 |
| | | [0.268] | | [0.274] | | [1.472] | | [1.181] |
| Observations | 766 | 766 | 766 | 766 | 814 | 814 | 814 | 814 |

## Table A.4: Renewable Policy Index by State

We use the Database of State Incentives for Renewables & Efficiency from the N.C. Clean Energy Technology Center to collect information on the renewable policy incentives by state-year-month. We split the policy initiatives into three types of tax incentives: Corporate Tax, Property Tax, and Sales Tax; and two types of production incentives: Production and Tariffs. For each type of incentive, we create an indicator variable equal to one if a state has at least one incentive in that category in a given month. The table presents the average values of these indicators over the 2005–2020 period by state. In our analysis, we include a *Renewables Incentives* index, which aggregates the three tax indicators and the two production indicators.

| State | Corporate Tax | Property Tax | Sales Tax | Production | Tariffs | Renewables Incentives |
|---|---|---|---|---|---|---|
| Alaska | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 |
| Alabama | 0.00 | 0.00 | 0.00 | 0.62 | 0.52 | 1.14 |
| Arkansas | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Arizona | 0.94 | 1.00 | 1.00 | 0.00 | 0.00 | 2.94 |
| California | 0.06 | 0.00 | 0.19 | 1.00 | 0.90 | 2.15 |
| Colorado | 0.37 | 0.84 | 0.91 | 0.93 | 0.00 | 3.04 |
| Connecticut | 0.00 | 0.00 | 0.84 | 0.49 | 0.00 | 1.34 |
| DC | 0.00 | 0.53 | 0.00 | 0.49 | 0.00 | 1.03 |
| Delaware | 0.00 | 0.00 | 0.00 | 0.97 | 0.00 | 0.97 |
| Florida | 0.62 | 0.78 | 1.00 | 0.30 | 0.00 | 2.70 |
| Georgia | 0.40 | 0.00 | 0.00 | 0.58 | 0.00 | 0.98 |
| Hawaii | 1.00 | 0.70 | 0.00 | 0.49 | 0.71 | 2.91 |
| Iowa | 1.00 | 1.00 | 1.00 | 0.00 | 0.56 | 3.56 |
| Idaho | 0.00 | 0.81 | 0.98 | 0.00 | 0.00 | 1.80 |
| Illinois | 0.00 | 0.88 | 0.72 | 0.65 | 0.00 | 2.24 |
| Indiana | 0.00 | 0.68 | 0.00 | 0.67 | 0.36 | 1.71 |
| Kansas | 0.31 | 1.00 | 0.00 | 0.00 | 0.00 | 1.31 |
| Kentucky | 0.81 | 0.00 | 0.81 | 0.62 | 0.00 | 2.24 |
| Louisiana | 0.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.62 |
| Massachusetts | 1.00 | 1.00 | 0.00 | 1.00 | 0.00 | 3.00 |
| Maryland | 0.87 | 1.00 | 0.78 | 0.49 | 0.00 | 3.15 |
| Maine | 0.00 | 0.05 | 0.00 | 0.58 | 0.00 | 0.63 |
| Michigan | 0.00 | 1.00 | 0.00 | 0.71 | 0.37 | 2.08 |
| Minnesota | 0.00 | 1.00 | 1.00 | 0.93 | 0.48 | 3.41 |
| Missouri | 0.00 | 0.59 | 0.00 | 0.00 | 0.00 | 0.59 |
| Mississippi | 0.00 | 0.00 | 0.00 | 0.62 | 0.38 | 0.99 |
| Montana | 0.69 | 1.00 | 0.00 | 0.00 | 0.00 | 1.69 |
| North Carolina | 0.68 | 0.78 | 0.00 | 0.98 | 0.00 | 2.44 |
| North Dakota | 0.62 | 1.00 | 0.34 | 0.00 | 0.00 | 1.96 |
| Nebraska | 0.88 | 0.67 | 0.83 | 0.00 | 0.00 | 2.38 |
| New Hampshire | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| New Jersey | 0.00 | 0.77 | 1.00 | 1.00 | 0.00 | 2.77 |
| New Mexico | 1.00 | 0.69 | 0.84 | 0.67 | 0.00 | 3.20 |
| Nevada | 0.00 | 1.00 | 0.75 | 0.93 | 0.00 | 2.68 |
| New York | 0.37 | 1.00 | 0.96 | 0.07 | 0.21 | 2.61 |
| Ohio | 0.31 | 1.00 | 1.00 | 0.71 | 0.00 | 3.03 |
| Oklahoma | 1.00 | 0.38 | 0.00 | 0.00 | 0.00 | 1.38 |
| Oregon | 0.97 | 0.66 | 0.00 | 0.99 | 0.00 | 2.63 |
| Pennsylvania | 0.00 | 0.88 | 0.00 | 0.49 | 0.00 | 1.37 |
| Rhode Island | 0.63 | 1.00 | 1.00 | 0.60 | 0.00 | 3.23 |
| South Carolina | 0.94 | 0.00 | 0.00 | 0.81 | 0.00 | 1.75 |
| South Dakota | 0.00 | 0.84 | 0.67 | 0.00 | 0.00 | 1.51 |
| Tennessee | 0.00 | 1.00 | 0.66 | 0.58 | 0.00 | 2.24 |
| Texas | 1.00 | 1.00 | 0.00 | 0.66 | 0.52 | 3.18 |
| Utah | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 | 2.00 |
| Virginia | 0.00 | 1.00 | 0.00 | 0.62 | 0.00 | 1.62 |
| Vermont | 0.20 | 1.00 | 1.00 | 0.71 | 1.00 | 3.91 |
| Washington | 0.00 | 0.00 | 0.72 | 0.96 | 0.90 | 2.58 |
| Wisconsin | 0.00 | 0.00 | 1.00 | 0.89 | 0.00 | 1.89 |
| West Virginia | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 2.00 |
| Wyoming | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 |

## A.2 FERC Data on Electricity Transactions

We merge the EIA power plant data with information on pricing and contracting of electricity sales from the Federal Energy Regulatory Commission (FERC) Electric Quarterly Reports (EQR). The FERC EQR data is available from July 2013 to December 2020, and we convert the quarterly reports into monthly data. If an electricity transaction in the FERC dataset continues over multiple months, we split the quantity and transaction charges across the months based on the number of days contracted in each month. The FERC regulatory requirements affect larger power plants that are interconnected with plants in other states. The interconnection requirement implies that power plants located in the Electric Reliability Council of Texas, Alaska, and Hawaii are not required to report to FERC as they are not interconnected with power plants in other states.

Panel A of Table 2 reports the average percentage of transaction charges for electricity sales by different contractual terms, while Online Appendix Table A.5 presents the average percentage of the quantity of electricity sold by different contractual terms. Around 59% of the electricity charges in our sample are for sales under contracts with short durations and 51% of the transactions use short increments to determine the price. Transactions covering the full period account for 38% of the quantity sold and charges. Peak period sales are more expensive as they account for 31% of the quantity and 36% of the charges, while off-peak sales are smaller and cheaper. Power plants using fossil fuels, such as coal and natural gas, are more flexible to adjust operation hours so they rely relatively more on short-term contracts, short increment pricing, and peak-term production for electricity sales. Solar and wind power plants depend on weather conditions and have limited flexibility in operating hours, so they use relatively more long-term contracts, long increment pricing, and full-period contractual terms for electricity sales.

## Table A.5: FERC Electricity Pricing and Contracting

**Robustness statistics of Table 2 Panel A:** We present the average percentage of electricity quantity sold by different contractual terms instead of the average percentage of transaction charges for electricity sales by different contractual terms.

Observations are on a plant-prime-mover-month level weighted by nameplate capacity. The sample includes power plants owned by domestic listed corporations (DLC), private equity, institutional investors, and foreign corporations. The table reports the average percentage of electricity quantity sold by different contractual terms. We split the electricity sales based on three contractual terms. First, we analyze contract duration and distinguish between short contracts with a duration of less than one year and long-term contract duration. Second, we split the transactions into short, medium, and long based on the increment terms. Short transactions use 5-minute, 15-minute, or hourly increments (up to 6 hours). Medium transactions have daily or weekly increments (from 6 hours to 168 hours). Long transactions use monthly or yearly increments (longer than 168 hours). Third, we classify transactions into full-period, peak, and off-peak based on the peaking terms.

| | **All** | **NatGas** | **Coal** | **Nuclear** | **Hydro** | **Wind** | **Solar** |
|---|---|---|---|---|---|---|---|
| **Contractual Terms of Electricity Sales Based on Quantity Sold** | | | | | | | |
| Contract Duration - Short | 0.567 | 0.625 | 0.580 | 0.486 | 0.663 | 0.370 | 0.182 |
| Contract Duration - Long | 0.430 | 0.371 | 0.419 | 0.514 | 0.336 | 0.623 | 0.818 |
| Increment Terms - Short | 0.502 | 0.547 | 0.552 | 0.399 | 0.372 | 0.335 | 0.125 |
| Increment Terms - Medium | 0.042 | 0.054 | 0.033 | 0.047 | 0.087 | 0.013 | 0.032 |
| Increment Terms - Long | 0.430 | 0.387 | 0.399 | 0.509 | 0.408 | 0.604 | 0.797 |
| Peaking Terms - Full Period | 0.388 | 0.351 | 0.354 | 0.476 | 0.361 | 0.563 | 0.644 |
| Peaking Terms - Peak | 0.314 | 0.358 | 0.329 | 0.248 | 0.262 | 0.175 | 0.150 |
| Peaking Terms - Off-Peak | 0.225 | 0.227 | 0.252 | 0.213 | 0.208 | 0.170 | 0.065 |

## A.3 Instrumental Variable Methodology

Our identification of the effect of deregulation on the creation of new plants and ownership changes relies on the assumption that power plants in deregulated and traditional markets would have followed parallel trends absent the deregulation conditional on observed plant characteristics. We address the possibility of omitted variables bias using an instrumental variables (IV) approach. Since the difference between retail and industrial electricity prices on a state level is the main predictor of deregulation (White (1996), Joskow (1997)), we use it as an instrumental variable for deregulation. The IV is the average residential-industrial price difference *ResidIndPD* on a state level over the 1991–1996 period. We construct the IV over the 1991–1996 period to address the staggered restructuring of electricity markets. The first ISO restructured market, PJM Interconnection, started functioning as a competitive wholesale electricity market in 1997, so the IV is measured before any plants operated in a deregulated market. We use the difference between retail and industrial electricity prices to instrument for power plants operating in *ISO Restructured* markets, which is our more restrictive measure of wholesale market deregulation. The ISO restructurings had to be approved by state legislative bodies and were completed at the end of the 1990s, while some ISO balancing markets (but not restructured), such as MISO and SPP, were formed later without state legislative approval.

This is the first-stage regression that we estimate to instrument the *ISO Restructured* markets using the the average residential-industrial price difference *ResidIndPD*:

$$ISO_{i,t} = \beta_1 ResidIndPD_i + \beta_3 DLC_{i,t} + \gamma Z_{i,t} + \delta_{f,t} + \varepsilon_{i,t}. \tag{10}$$

In some specifications, our analysis examines the baseline effect of ISO Restructured and an interaction term of DLCs and ISO Restructured, so we sometimes estimate two first-stage regressions to instrument for both variables:

$$ISO_{i,t} = \beta_1 ResidIndPD_i + \beta_2 DLC_{i,t} \times ResidIndPD_i + \beta_3 DLC_{i,t} + \gamma Z_{i,t} + \delta_{f,t} + \varepsilon_{i,t}, \tag{11}$$

$$DLC_{i,t} \times ISO_{i,t} = \beta_1 ResidIndPD_i + \beta_2 DLC_{i,t} \times ResidIndPD_i + \beta_3 DLC_{i,t} + \gamma Z_{i,t} + \delta_{f,t} + \varepsilon_{i,t}. \tag{12}$$

In the IV specifications, we include only interacted fixed effected on a fuel-year-month level as the IV does not vary within a state. The second stage uses the predicted values of both variables.

Online Appendix Table A.6 presents the coefficient estimates of the first-stage regressions for the IV specification each time it is used in the paper. The difference between retail and industrial electricity prices on a state level over the 1991–1996 period strongly predicts whether a power plant $i$ will operate in an ISO-restructured market in period $t$. The first-stage F-statistics are mostly well above 100 and always pass tests for weak instruments.

## Table A.6: First-Stage Results of the IV Specifications

**We present the first-stage estimates of the multiple IV specifications used throughout the paper.**

We instrument the *ISO Restructured* variable with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period (*ResidIndPD*). Where an interaction term of DLC ownership and ISO restructured markets is included, we instrument the *ISO Restructured* and *DLC* × *ISO Restructured* variables with *ResidIndPD* and the interaction term *DLC* × *ResidIndPD*. The last row presents the Kleibergen-Paap rk Wald F statistic which tests for weak instruments.

| | Table 3 Column 6 | Table 4 Panel A | Table 4 Panel B | Table 4 Panel C | Table 5 Column 4 Column 8 | Table 6 Column 6 | Table 7 Column 4 | Table 7 Column 8 |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **Panel A: First Stage Equation for ISO Restructured** | | | | | | | | |
| ResidIndPD | 0.062*** | 0.062*** | 0.057*** | 0.065*** | 0.056*** | 0.058*** | 0.063*** | 0.062*** |
| | [0.003] | [0.004] | [0.005] | [0.006] | [0.003] | [0.002] | [0.003] | [0.004] |
| DLC × ResidIndPD | 0.010* | | | | | 0.001 | 0.023*** | 0.026*** |
| | [0.006] | | | | | [0.003] | [0.005] | [0.006] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1,492,665 | 66,427 | 51,501 | 7,971 | 326,312 | 753,396 | 1,478,395 | 881,809 |
| Adjusted R-squared | 0.351 | 0.389 | 0.299 | 0.465 | 0.236 | 0.277 | 0.342 | 0.327 |
| **Panel B: First Stage Equation for DLC × ISO Restructured** | | | | | | | | |
| ResidIndPD | -0.001 | | | | | -0.002*** | -0.002 | -0.002 |
| | [0.001] | | | | | [0.000] | [0.001] | [0.001] |
| DLC × ResidIndPD | 0.074*** | | | | | 0.061*** | 0.089*** | 0.091*** |
| | [0.005] | | | | | [0.003] | [0.005] | [0.005] |
| Controls | Yes | | | | | Yes | Yes | Yes |
| Observations | 1,492,665 | | | | | 753,396 | 1,478,395 | 881,809 |
| Adjusted R-squared | 0.436 | | | | | 0.368 | 0.424 | 0.421 |
| K-P rk F-Stat | 94.584 | 273.234 | 152.365 | 115.415 | 408.096 | 233.985 | 199.203 | 156.032 |

## A.4 The Determinants of Ownership Changes

We find that PE and foreign listed corporations are significantly more likely to create new power plants and their willingness to finance the capital expenditures to adopt new innovative technologies contributes significantly to the changing ownership structure. The difference in the probability of owning new natural gas plants between DLCs and PE is concentrated in deregulated markets. Our results suggest that the higher degree of power plant creation in deregulated markets is driven by the ability of these markets to attract more capital from PE and foreign corporations for greenfield assets.

Online Appendix Table A.7 shows that our results are robust to using logit specifications instead of pooled OLS, and without weighting the observations by nameplate capacity. However, we rely more on the OLS specification as the weighted coefficients are economically more relevant for the greenfield analysis, and they include a more saturated set of fixed effects. In Online Appendix Table A.7, we show that the results are not driven by a few large newly created power plants (we also do not include all power plants to avoid that the results are driven by micro solar plants). The unconditional baseline probability in this unweighted subsample equals 2.77% as compared to 1.63% in the weighted broad sample, which shows that the newly created power plants tend to be on average smaller than the existing power plants. The results confirm that DLCs are less likely to create new power plants than PE and foreign corporations. The difference in the probability of creating new electricity-generating assets is concentrated in deregulated wholesale markets.

In the main analysis, we find that DLCs are significantly less likely to own new renewable as well as new fossil fuel plants. Online Appendix Table A.8 supports these results by estimating specifications by fuel type that use interaction terms instead of analyzing subsamples.

When we jointly consider the second and third mechanisms of ownership transition, selling and decommissioning power plants, we rely primarily on competing risks model. The competing risks model has the advantage of including all power plants ever owned by DLCs, as well as taking into account the timing of sales and decommissioning events (earlier or later in the sample period). A simpler model for interpretation is a multinomial logit, which we use to provide a snapshot of outcomes for plants that were owned by DLCs in January 2005. The advantage of the multinomial logit model is that we can classify separately more potential outcomes and also study the probability that DLCs sell a power plant and the new owner decommissions this plant before the end of the sample period. We show this robustness test in Online Appendix Table A.9 and most of the results are generally similar.

In line with our results on the role of market regulation in creating new power plants, we also observe that DLCs are more likely in deregulated electricity markets to sell power plants to the new ownership types. Based on Column (5) of Online Appendix Table A.9, if a power plant operates in an IPP ISO-balancing wholesale market, DLCs have a 23.7 percentage points higher probability to sell this power plant to new owners. One new result in this robustness test is that, in deregulated markets, the new owners are also more likely to retire the acquired power plants. based on Column (7), if a plant is located in an IPP ISO balancing market, it has a 4.8 percentage points higher probability of being acquired and decommissioned by the new owners, which is a substantial increase relative to the baseline probability of 4.0% for this outcome. This additional result provides further evidence against the leakage hypothesis.

In Online Appendix Table 6, we estimate a robustness test on the differences in decommissioning power plants across ownership types using an OLS model instead of Cox proportional hazard model. This robustness test considers the full sample of power plants with observations weighted by capacity. The specifications include also a more saturated set of fully interacted fuel-type, state, and year-month fixed effects. We confirm that DLCs are more likely to retire power plants than institutional investors and foreign corporations, which is consistent with the leakage hypothesis. There is no difference with PE so the largest and most controversial form of new ownership does not contribute to the leakage of older fossil fuel power plants. The differences in decommissioning hazard ratios seem to be concentrated in deregulated markets, but they are not robust across the different definitions of market regulation.

In the main analysis, we examine whether the decommissioning rates across ownership types differ by fuel type using hazard models on the subsamples of coal and natural gas plants. We find that the difference in decommissioning rates between DLCs and foreign corporations is significant in ISO balancing markets, and appears to be driven by both coal and natural gas plants. However, most coefficients are statistically insignificant so the evidence is not conclusive. Online Appendix Table A.11 confirms these results using a robustness test with interaction terms instead of subsample analysis.

Our results highlight the key role of electricity market deregulation in explaining the ownership changes of power plants. If other economic factors drive these results, they need to affect differently DLCs located in deregulated and traditional markets. In terms of economic factors, we find that the effect of market deregulation on heterogeneity in ownership structures is robust to controlling for climate concerns among the state population, and policy incentives for renewable energy.

In the main analysis, we include an interaction term of DLC with *Renewable Incentives* index, which aggregates five separate renewable policy indicators. One potential concern is that the aggregate index is broad and only some specific policy measures explain the heterogeneity across ownership types to create or decommission power plants. In Online Appendix Figure A.2, we estimate specifications that include separate interaction terms of DLC with the three indicators if a state has corporate tax, property tax, and sales tax incentives for renewable energy as well as separate interaction terms of DLC with the two indicators if a state has production incentives or feed-in tariffs for renewable energy. The specifications in Panel A confirm that DLCs are less likely to own greenfield plants in deregulated markets and these results are robust to controlling separately renewable policy incentives. Panel B presents a similar robustness test for decommissioning of power plants. Our baseline specifications do not find significant and consistent heterogeneity across ownership types in their sensitivity of decommissioning decisions to market regulation. The robustness test with five separate indicators for renewable policy measures documents similar results.

An alternative hypothesis is that electricity market regulation correlates with DLC characteristics so these corporate characteristics explain the ownership changes rather than market competitiveness. We consider whether our results on plant creation and decommissioning could be driven by corporate credit ratings or ESG ratings. Under this hypothesis, firms with weaker credit ratings are more likely to be financially constrained and might engage in less plant creation or more plant destruction. Firms with higher ESG ratings may favor the creation of solar and wind farms and decommissioning of fossil fuel plants. This hypothesis predicts that only low ESG or low credit rating DCLs would be less likely to create greenfield power plants and the differences should be insignificant for high-ranked DLCs regardless of market regulation.

Online Appendix Figure A.3 shows that across all ESG and credit rating categories, DLCs are less likely to own greenfield plants. Importantly, the interaction effects with market deregulation remain robust and significant in almost all ESG rating and credit rating categories. We also find that DLCs of all ESG and credit rating categories are less likely to create new solar and wind plants. Panels B and D provide evidence that DLCs lack of creation of new natural gas plants is more concentrated in firms with lower ESG ratings (counterintuitively) and lower credit ratings. Online Appendix Figure A.4 finds no variation of interest in the decommissioning rates across the ESG or credit rating categories. To the extent that DLCs are more likely to decommission, there is no specific ESG or credit rating category that is more likely to do it in a robust fashion.

In Online Appendix Table A.12, we add ESG and credit rating controls to the competing risks model. We find that the role of market deregulation and plant characteristics in explaining the decisions of DLCs to sell or decommission a power plant is robust to these controls. In addition to confirming our main results, we also find that DLCs with low credit ratings are more likely to decommission power plants.

## Table A.7: Ownership of Greenfield Power Plants (Logit Specifications)

**Robustness check of Table 3:** We use logit specifications and do not weight observations by power plant nameplate capacity, but we limit attention to the subsample of power plants with a nameplate capacity of at least 20MW.

In this table, observations are at the plant-prime-mover-month level and the sample includes only power plants with a nameplate capacity of at least 20MW. The dependent variable captures greenfield power plants and equals one for the first 12 months of plant operation. We measure the ownership by domestic publicly listed corporations (*DLC*), private equity, institutional investors, and foreign publicly listed corporations. We also control for the ownership by industry firms, government, cooperatives, and others. *ISO Balancing*, *IPP ISO Balancing*, and *ISO Restructured* are indicators for power plants operating in a deregulated electricity market. Column (6) presents the second stage results of an IV model where we instrument the *ISO Restructured* and *DLC* × *ISO Restructured* variables with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. The specifications include fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| **Greenfield Power Plants with Capacity ≥ 20MW** (Unconditional Prob. = 2.77%) | | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Domestic Listed Corp (DLC) | -0.829*** | | -0.312 | -0.588 | -0.701* | -0.256 |
| | [0.141] | | [0.405] | [0.399] | [0.364] | [0.334] |
| Private Equity | | 1.073*** | | | | |
| | | [0.169] | | | | |
| Institutional Investor | | -1.011* | | | | |
| | | [0.540] | | | | |
| Foreign Corp | | 0.699*** | | | | |
| | | [0.180] | | | | |
| ISO Balancing | | | -0.208 | | | |
| | | | [0.256] | | | |
| DLC × ISO Balancing | | | -0.824*** | | | |
| | | | [0.269] | | | |
| IPP ISO Balancing | | | | -0.027 | | |
| | | | | [0.245] | | |
| DLC × IPP ISO Balancing | | | | -1.070*** | | |
| | | | | [0.279] | | |
| ISO Restructured | | | | | 1.286*** | -0.163 |
| | | | | | [0.449] | [0.432] |
| DLC × ISO Restructured | | | | | -1.436*** | -1.957** |
| | | | | | [0.292] | [0.857] |
| DLC × Climate Concern | | | -0.138 | 0.232 | -0.047 | -0.459 |
| | | | [0.479] | [0.491] | [0.475] | [0.473] |
| DLC × Renewables Incentives | | | 0.063 | 0.085 | 0.134 | 0.156 |
| | | | [0.114] | [0.115] | [0.117] | [0.097] |
| ln Plant Capacity | 0.774*** | 0.781*** | 0.777*** | 0.781*** | 0.771*** | 0.738*** |
| | [0.080] | [0.080] | [0.080] | [0.080] | [0.081] | [0.076] |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | |
| Observations | 741,003 | 741,003 | 741,003 | 741,003 | 741,003 | 741,181 |

### Table A.8: Ownership of Greenfield Power Plants by Fuel Type

**Robustness check of Figure 4:** We present the regression estimates from specifications by fuel type that use interaction terms instead of subsamples.

In this table, observations are at the plant-prime-mover-month level and weighted by plant capacity. In Columns (1) to (3), the dependent variable equals one for the first 12 months of operation for solar and wind greenfield plants. In Columns (4) to (6), the dependent variable equals one for the first 12 months of operation for natural gas greenfield plants. We measure the ownership by domestic publicly listed corporations (*DLC*), private equity, institutional investors, and foreign corporations. *IPP ISO Balancing* and *ISO Restructured* are indicators for power plants located in an area with a deregulated electricity market. In Columns (3) and (6), we present the second stage results of an IV model where we instrument the *ISO Restructured* variable with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. The specifications include interacted fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

| | **Solar & Wind Power Plants** Unconditional Prob. = 13.66% | | | **Natural Gas Power Plants** Unconditional Prob. = 1.47% | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A: Specifications with Baseline Coefficients on Ownership Categories** | | | | | | |
| Domestic Listed Corp (DLC) | -4.209*** | | | -0.478* | | |
| | [0.993] | | | [0.282] | | |
| Private Equity | | 6.432*** | | | 0.706** | |
| | | [1.179] | | | [0.342] | |
| Institutional Investor | | -4.399* | | | 0.754 | |
| | | [2.310] | | | [0.966] | |
| Foreign Corp | | 3.625*** | | | -0.355 | |
| | | [1.241] | | | [0.447] | |
| Plant Capacity | Yes | Yes | | Yes | Yes | |
| Other Owners | Yes | Yes | | Yes | Yes | |
| Fuel-State-Year-Month FE | Yes | Yes | | Yes | Yes | |
| Observations | 322,113 | 322,113 | | 519,011 | 519,011 | |
| Adjusted R-squared | 0.167 | 0.169 | | 0.153 | 0.153 | |
| **Panel B: Specifications with Interaction Terms of DLCs and Market Regulation** | | | | | | |
| Domestic Listed Corp (DLC) | -2.272 | -4.107 | 0.058 | 0.037 | -0.265 | -0.515 |
| | [2.690] | [2.591] | [2.022] | [0.553] | [0.536] | [0.511] |
| IPP ISO Balancing | -1.064 | | | 0.804* | | |
| | [1.639] | | | [0.418] | | |
| DLC × IPP ISO Balancing | -3.025* | | | -2.269*** | | |
| | [1.829] | | | [0.509] | | |
| ISO Restructured | | -1.161 | -0.970 | | 1.097** | 0.784 |
| | | [3.383] | [2.029] | | [0.525] | [0.630] |
| DLC × ISO Restructured | | -5.045** | -5.186 | | -1.993*** | -3.259*** |
| | | [2.448] | [11.133] | | [0.460] | [0.855] |
| Plant Capacity | Yes | Yes | Yes | Yes | Yes | Yes |
| Interaction with Climate | Yes | Yes | Yes | Yes | Yes | Yes |
| Interaction with Incentives | Yes | Yes | Yes | Yes | Yes | Yes |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-State-Year-Month FE | Yes | Yes | | Yes | Yes | |
| Fuel-Year-Month FE | | | Yes | | | Yes |
| Observations | 322,113 | 322,113 | 323,749 | 519,011 | 519,011 | 562,974 |
| Adjusted R-squared | 0.168 | 0.168 | | 0.154 | 0.154 | |

## Table A.9: Multinomial Logit Model: Sales and Decommissioning of Power Plants

**Robustness check of Table 5:** We estimate a multinomial logit model on four outcomes instead of a competing risks model.

In this table, observations are at the plant-prime-mover-month level and the sample includes only power plants with a nameplate capacity of at least 20MW. We present the marginal effects at the means of multinomial logit specifications. The sample covers power plants that were owned by domestic corporations at the beginning of our sample, in January 2005. We analyze four potential outcomes based on the latest observation in our dataset (December 2020 for plants that are not retired): *Still Own & Operating* covers plants that are still owned and operated by domestic corporations; *Owned & Retired* covers plants that remained in domestic corporations' ownership, but were retired during the sample period; *Sold & Operating* captures plants that were sold to other ownership types and are still operating; *Sold & Retired* captures plants that were sold to other ownership types and were retired by these other owners during the sample period. *IPP ISO Balancing* and *ISO Restructured* are indicators for power plants located in an area with a deregulated electricity market. We also control for *Climate Concern* percentile ranking and *Renewables Incentives* aggregate index. *ln Plant Capacity* is the natural logarithm of a plant's monthly capacity. *ln Plant Age* is the natural logarithm of plant age in years. The specifications include fuel-type fixed effects and we present the coefficients for coal, nuclear, hydro, wind, and solar power plants (the omitted category is natural gas plants; the solar indicator is automatically dropped from the specifications). We cluster standard errors by plant-prime-mover and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **Still Own & Operating** | | **Owned & Retired** | | **Sold & Operating** | | **Sold & Retired** | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| # Unique Plants | 840 | 840 | 353 | 353 | 410 | 410 | 66 | 66 |
| Unconditional Prob. | 0.503 | 0.503 | 0.212 | 0.212 | 0.246 | 0.246 | 0.040 | 0.040 |
| IPP ISO Balancing | -0.256*** | | -0.029 | | 0.237*** | | 0.048*** | |
| | [0.029] | | [0.022] | | [0.027] | | [0.016] | |
| ISO Restructured | | -0.218*** | | -0.061*** | | 0.246*** | | 0.032*** |
| | | [0.028] | | [0.021] | | [0.026] | | [0.012] |
| Climate Concern | -0.058 | -0.158*** | 0.032 | 0.030 | 0.021 | 0.091** | 0.004 | 0.038* |
| | [0.050] | [0.047] | [0.042] | [0.039] | [0.044] | [0.042] | [0.023] | [0.020] |
| Renewables Incentives | -0.007 | -0.007 | 0.010 | 0.010 | -0.011 | -0.011 | 0.008* | 0.008 |
| | [0.012] | [0.012] | [0.009] | [0.010] | [0.010] | [0.010] | [0.005] | [0.005] |
| ln Plant Capacity | 0.089*** | 0.089*** | -0.054*** | -0.053*** | -0.021** | -0.022** | -0.013*** | -0.013*** |
| | [0.011] | [0.011] | [0.008] | [0.008] | [0.009] | [0.009] | [0.005] | [0.005] |
| ln Plant Age | -0.038*** | -0.039*** | 0.156*** | 0.157*** | -0.115*** | -0.115*** | -0.003 | -0.003 |
| | [0.015] | [0.015] | [0.014] | [0.014] | [0.010] | [0.010] | [0.006] | [0.006] |
| Coal | -0.093** | -0.077** | 0.108*** | 0.109*** | -0.030 | -0.042 | 0.015 | 0.010 |
| | [0.038] | [0.038] | [0.026] | [0.025] | [0.036] | [0.036] | [0.018] | [0.019] |
| Hydro | 0.505*** | 0.558*** | -0.601*** | -0.596*** | 0.123*** | 0.080* | -0.026 | -0.042 |
| | [0.060] | [0.060] | [0.074] | [0.074] | [0.045] | [0.043] | [0.035] | [0.036] |
| Nuclear | 0.466*** | 0.527*** | 0.152** | 0.175*** | -0.211 | -0.236 | -0.408*** | -0.466*** |
| | [0.112] | [0.114] | [0.062] | [0.062] | [0.144] | [0.144] | [0.055] | [0.061] |
| Wind | 0.215*** | 0.191*** | 0.038 | 0.031 | -0.274*** | -0.253*** | 0.021 | 0.031* |
| | [0.066] | [0.067] | [0.059] | [0.063] | [0.059] | [0.065] | [0.017] | [0.018] |
| Fuel Type FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1,669 | 1,669 | 1,669 | 1,669 | 1,669 | 1,669 | 1,669 | 1,669 |

**Table A.10: Ownership of Decommissioned Power Plants**

**Robustness check of Table 6:** We estimate pooled OLS instead of Cox proportional hazard model.

In this table, observations are at the plant-prime-mover-month level and are weighted by power plant nameplate capacity. The dependent variable captures decommissioned power plants and equals one for the last 12 months of plant operation. We measure the ownership by domestic publicly listed corporations, private equity, institutional investors, and foreign publicly listed corporations. We also control for the ownership by industry firms, government, cooperatives, and others. *ISO Balancing*, *IPP ISO Balancing*, and *ISO Restructured* are indicators for power plants located in an area with a deregulated electricity market. Column (6) presents the second stage results of an IV model where we instrument the *ISO Restructured* and *DLC* × *ISO Restructured* variables with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. The specifications include interacted fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **All Decommissioned Power Plants** (Unconditional Prob. = 1.03%) | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Domestic Listed Corp (DLC) | 0.092 | | -0.793* | -0.329 | -0.374 | -0.838** |
| | [0.212] | | [0.405] | [0.396] | [0.388] | [0.359] |
| Private Equity | | 0.244 | | | | |
| | | [0.277] | | | | |
| Institutional Investor | | -1.055*** | | | | |
| | | [0.229] | | | | |
| Foreign Corp | | -0.698*** | | | | |
| | | [0.205] | | | | |
| ISO Balancing | | | 0.059 | | | |
| | | | [0.277] | | | |
| DLC × ISO Balancing | | | 0.802*** | | | |
| | | | [0.269] | | | |
| IPP ISO Balancing | | | | 0.139 | | |
| | | | | [0.330] | | |
| DLC × IPP ISO Balancing | | | | 0.589 | | |
| | | | | [0.389] | | |
| ISO Restructured | | | | | 0.844** | -0.550 |
| | | | | | [0.414] | [0.478] |
| DLC × ISO Restructured | | | | | 0.356 | 0.418 |
| | | | | | [0.391] | [0.800] |
| DLC × Climate Concern | | | 1.600*** | 1.420** | 1.662*** | 1.440** |
| | | | [0.603] | [0.606] | [0.630] | [0.560] |
| DLC × Renewables Incentives | | | -0.256* | -0.272* | -0.254* | -0.028 |
| | | | [0.148] | [0.147] | [0.150] | [0.099] |
| ln Plant Capacity | -0.647*** | -0.646*** | -0.667*** | -0.666*** | -0.663*** | -0.562*** |
| | [0.077] | [0.077] | [0.077] | [0.077] | [0.076] | [0.068] |
| ln Plant Age | 1.062*** | 1.075*** | 1.045*** | 1.050*** | 1.063*** | 1.038*** |
| | [0.117] | [0.117] | [0.116] | [0.115] | [0.117] | [0.105] |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | Yes | Yes | |
| Fuel-Year-Month FE | | | | | | Yes |
| Observations | 1,410,850 | 1,410,850 | 1,410,850 | 1,410,850 | 1,410,850 | 1,492,665 |
| Adjusted R-squared | 0.169 | 0.170 | 0.170 | 0.170 | 0.170 | |
| K-P rk F-Stat | | | | | | 94.312 |

### Table A.11: Ownership of Decommissioned Power Plants by Fuel Type

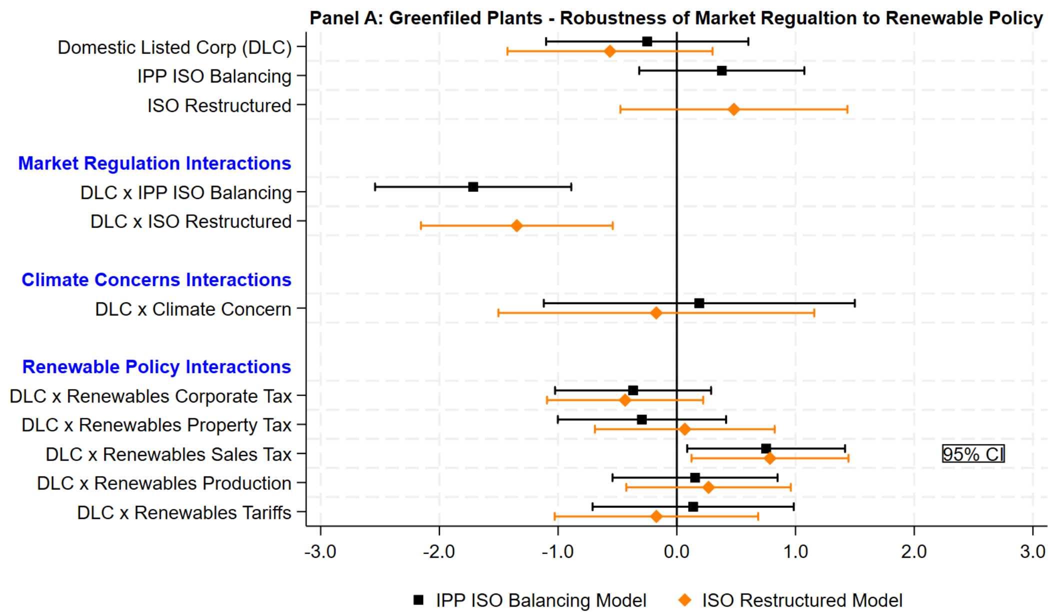
**Robustness check of Figure 6:** We present the regression estimates from specifications by fuel type that use interaction terms instead of subsamples.

Observations are at the plant-prime-mover-month level and the sample includes power plants with a capacity of at least 20MW. We estimate a survival analysis using the Cox proportional hazard model and the event of interest is a complete decommissioning of a power plant. In Columns (1) to (3), the sample covers coal, waste coal, petroleum coke, and residual petroleum plants. In Columns (4) to (6), the sample covers natural gas plants. We measure the ownership by DLCs, private equity, institutional investors, and foreign corporations. *IPP ISO Balancing* and *ISO Restructured* are indicators for power plants operating in a deregulated electricity market. In Columns (3) and (6), we present the second stage results of an IV model where we instrument the *ISO Restructured* variable with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. The specifications include fuel-type and state fixed effects. We cluster standard errors by plant-prime-mover and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **Coal and Petroleum** (989 Plants; 314 Decom.) | | | **Natural Gas** (2,320 Plants; 342 Decom.) | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A: Specifications with Baseline Coefficients on Ownership Categories** | | | | | | |
| Domestic Listed Corp (DLC) | 1.500* | | | 1.035 | | |
| | [0.317] | | | [0.182] | | |
| Private Equity | | 0.713 | | | 1.351 | |
| | | [0.162] | | | [0.256] | |
| Institutional Investor | | 0.000 | | | 0.004*** | |
| | | [0.000] | | | [0.008] | |
| Foreign Corp | | 0.569 | | | 0.676 | |
| | | [0.229] | | | [0.231] | |
| Plant Capacity and Age | Yes | Yes | | Yes | Yes | |
| Other Owners | Yes | Yes | | Yes | Yes | |
| Fuel Type FE | Yes | Yes | | Yes | Yes | |
| State FE | Yes | Yes | | Yes | Yes | |
| Observations | 132,948 | 132,948 | | 344,290 | 344,290 | |
| **Panel B: Specifications with Interaction Terms of DLCs and Market Regulation** | | | | | | |
| Domestic Listed Corp (DLC) | 1.117 | 1.031 | 1.089 | 0.692 | 0.974 | 0.628 |
| | [0.520] | [0.440] | [0.410] | [0.299] | [0.382] | [0.216] |
| IPP ISO Balancing | 1.095 | | | 0.649* | | |
| | [0.304] | | | [0.165] | | |
| DLC × IPP ISO Balancing | 1.511 | | | 1.313 | | |
| | [0.553] | | | [0.414] | | |
| ISO Restructured | | 1.360 | 1.423 | | 1.362 | 0.600 |
| | | [1.012] | [0.432] | | [0.405] | [0.281] |
| DLC × ISO Restructured | | 1.430 | 0.453 | | 0.878 | 1.424 |
| | | [0.432] | [0.302] | | [0.233] | [0.975] |
| Plant Capacity and Age | Yes | Yes | Yes | Yes | Yes | Yes |
| Interaction with Climate | Yes | Yes | Yes | Yes | Yes | Yes |
| Interaction with Incentives | Yes | Yes | Yes | Yes | Yes | Yes |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel Type FE | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | | Yes | Yes | |
| Observations | 132,948 | 132,948 | 132,948 | 344,290 | 344,290 | 344,290 |

**Figure A.2: Renewable Policy Index Split into Five Separate Indicators**

In this robustness test, we include five separate interaction terms with the indicators if a state has corporate tax, property tax, sales tax, production, or feed-in tariffs incentives for renewable energy instead of including an interaction term of DLCs with the aggregate *Renewable Incentives* index. In Panel A, the dependent variable captures greenfield power plants and we present the coefficient estimates of three specifications that replicate Columns (4) and (5) of Table 3. Panel B presents the coefficient estimates from Cox hazard model specifications that estimate survival analysis on power plant decommissioning events and replicate Columns (4) and (5) of Table 6.



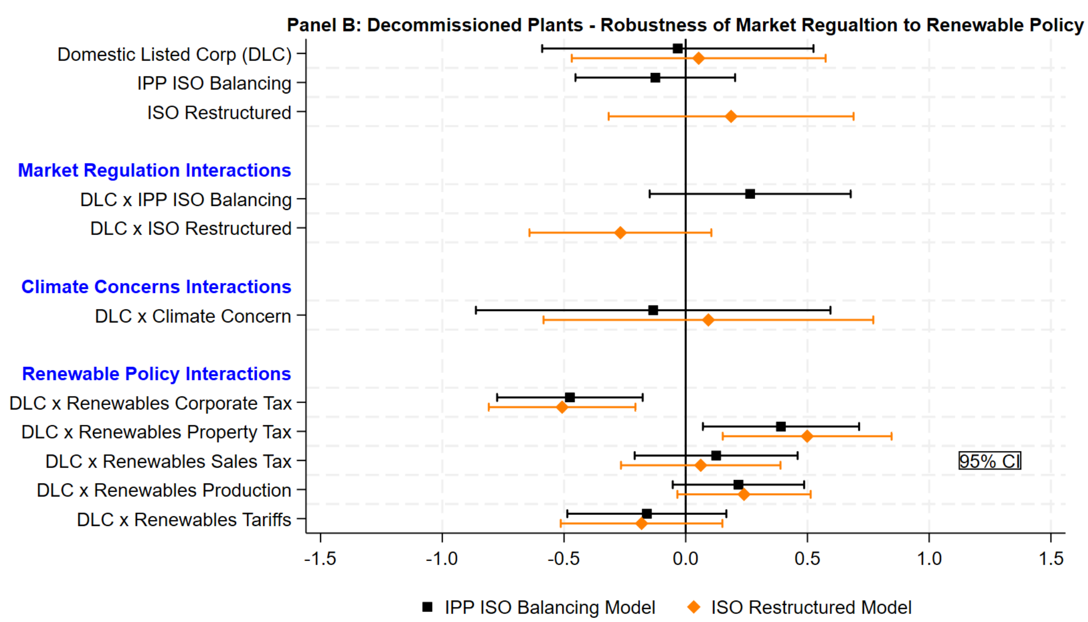



**Table A.12: Competing Risks Model with ESG Ratings or Credit Ratings Controls**

**Robustness check of Table 5:** We control for ESG ratings and financial constraints in the competing risks model.

Observations are at the plant-prime-mover-month level. The sample includes only power plants with a nameplate capacity of at least 20MW that have been owned by domestic publicly listed corporations (DLC) at any moment during our sample period. We present the hazard ratios of a competing risks analysis. In Columns (1) to (4), the event of interest is a complete sale of a power plant to a new ownership type, and the competing event is a decommissioning. In Columns (5) to (8), the event of interest is a complete decommissioning of a power plant, and the competing event is a sale. *IPP ISO Balancing* and *ISO Restructured* are indicators for power plants operating in a deregulated electricity market. In Columns (4) and (8), we present the second stage results of an IV model where we instrument the *ISO Restructured* variable with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. We also control for *Climate Concern* percentile ranking and *Renewables Incentives* aggregate index. *ln Plant Capacity* is the natural logarithm of a plant's monthly capacity. *ln Plant Age* is the natural logarithm of plant age in years. We split the DLCs into tertiles every year based on the Refinitiv ESG ratings and the omitted category is DLCs ranked in the high tertile. We split the DLCs into three groups based on the Fitch credit ratings and the omitted category is DLCs with an investment-grade credit rating higher than BBB+. The specifications include fuel-type fixed effects and we present the coefficients for coal, nuclear, hydro, wind, and solar power plants (the omitted category is natural gas plants). We cluster standard errors by plant-prime-mover and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| | Sold | | | | Decommissioned | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Events of Interest: | 721 | 721 | 721 | 721 | 377 | 377 | 377 | 377 |
| Competing Events: | 367 | 367 | 367 | 367 | 707 | 707 | 707 | 707 |
| No Events: | 1,679 | 1,679 | 1,679 | 1,679 | 1,683 | 1,683 | 1,683 | 1,683 |
| IPP ISO Balancing | 3.335*** | 4.375*** | | | 0.908 | 1.155 | | |
| | [0.376] | [0.737] | | | [0.122] | [0.266] | | |
| ISO Restructured | | | 2.054*** | 2.615*** | | | 0.724*** | 0.449* |
| | | | [0.179] | [0.648] | | | [0.088] | [0.195] |
| Climate Concern | 1.565*** | | 2.572*** | 1.905*** | 1.216 | | 1.353 | 1.552 |
| | [0.258] | | [0.433] | [0.381] | [0.324] | | [0.326] | [0.441] |
| Renewables Incentives | 0.879*** | | 0.838*** | 0.864*** | 1.069 | | 1.065 | 1.076 |
| | [0.036] | | [0.034] | [0.036] | [0.061] | | [0.060] | [0.061] |
| ln Plant Capacity | 0.992 | 0.964 | 0.989 | 1.003 | 0.668*** | 0.605*** | 0.665*** | 0.676*** |
| | [0.040] | [0.042] | [0.040] | [0.040] | [0.031] | [0.029] | [0.030] | [0.032] |
| ln Plant Age | 1.109*** | 1.135*** | 1.118*** | 1.125*** | 5.135*** | 5.371*** | 5.159*** | 5.269*** |
| | [0.044] | [0.049] | [0.043] | [0.043] | [0.807] | [0.914] | [0.804] | [0.840] |
| DLC Med ESG | 0.640*** | 0.600*** | 0.596*** | 0.571*** | 1.169 | 1.177 | 1.180 | 1.184 |
| | [0.081] | [0.076] | [0.074] | [0.071] | [0.169] | [0.171] | [0.170] | [0.171] |
| DLC Low ESG | 0.630*** | 0.630*** | 0.520*** | 0.522*** | 0.778 | 0.916 | 0.772* | 0.755* |
| | [0.083] | [0.088] | [0.069] | [0.069] | [0.120] | [0.151] | [0.121] | [0.118] |
| DLC Miss ESG | 2.476*** | 2.385*** | 1.989*** | 2.034*** | 0.701* | 0.800 | 0.700* | 0.666** |
| | [0.265] | [0.282] | [0.213] | [0.215] | [0.130] | [0.158] | [0.129] | [0.127] |
| DLC Fitch BBB | 0.731** | 0.817 | 0.619*** | 0.607*** | 1.323 | 1.467* | 1.405* | 1.532** |
| | [0.095] | [0.127] | [0.081] | [0.082] | [0.232] | [0.304] | [0.247] | [0.294] |
| DLC Fitch D-BB | 1.272 | 1.244 | 1.708*** | 1.537*** | 1.973*** | 1.970*** | 2.164*** | 2.602*** |
| | [0.199] | [0.212] | [0.246] | [0.241] | [0.418] | [0.462] | [0.461] | [0.699] |
| DLC Fitch Miss | 0.987 | 1.005 | 1.137 | 1.116 | 1.284 | 1.507* | 1.365 | 1.440* |
| | [0.131] | [0.155] | [0.144] | [0.142] | [0.251] | [0.344] | [0.268] | [0.299] |
| Fuel-Type FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Plant State FE | | Yes | | | | Yes | | |
| Observations | 321,117 | 321,117 | 321,117 | 321,117 | 326,312 | 326,312 | 326,312 | 326,312 |

**Figure A.3: Domestic Listed Corp (DLC) Split by ESG Ratings or Credit Ratings and Greenfield Plants**

This figure presents coefficient estimates and confidence intervals of multiple specifications. In all models, observations are at the plant-prime-mover-month level and weighted by power plant nameplate capacity. The dependent variable captures greenfield power plants and equals one for the first 12 months of plant operation.

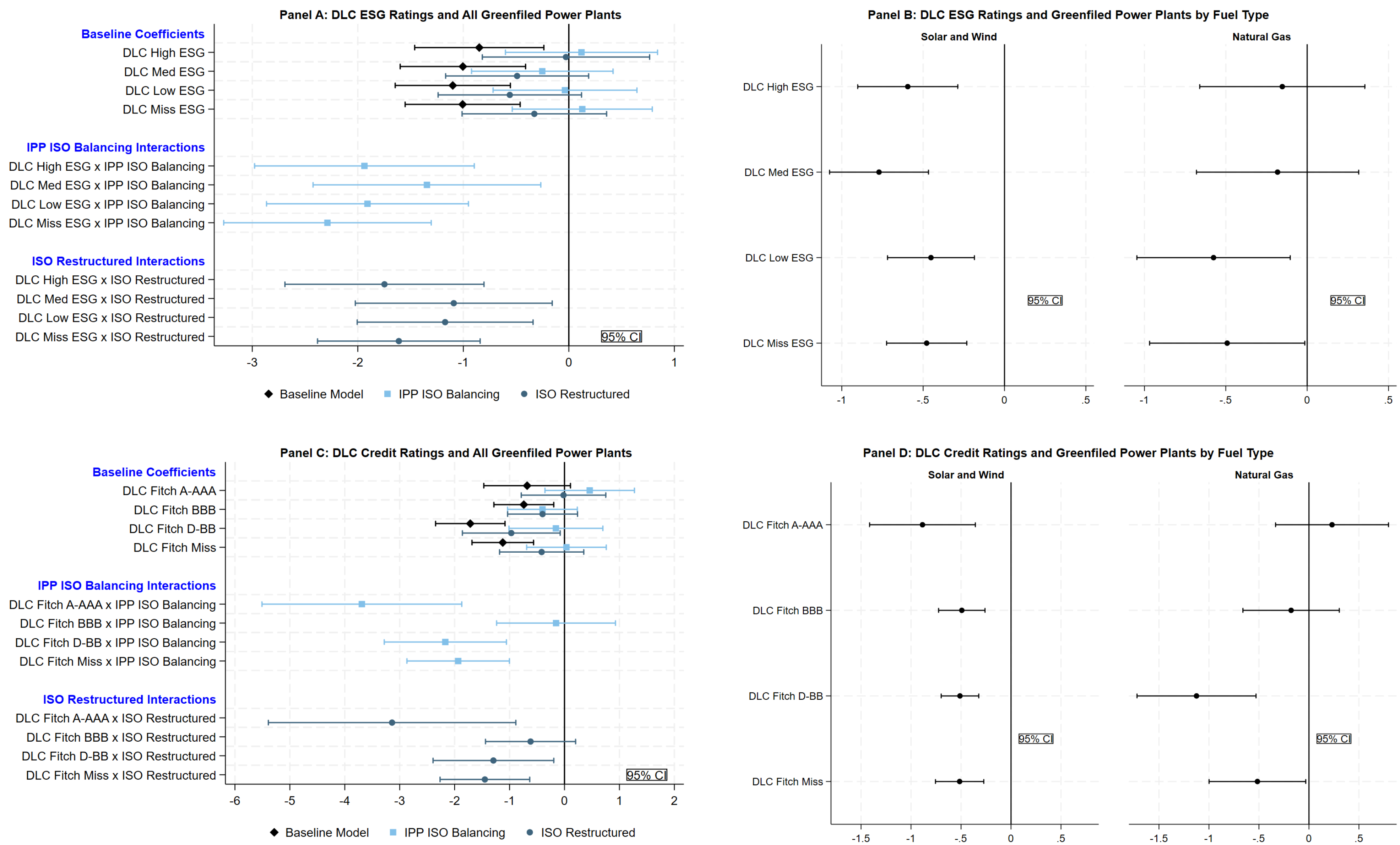
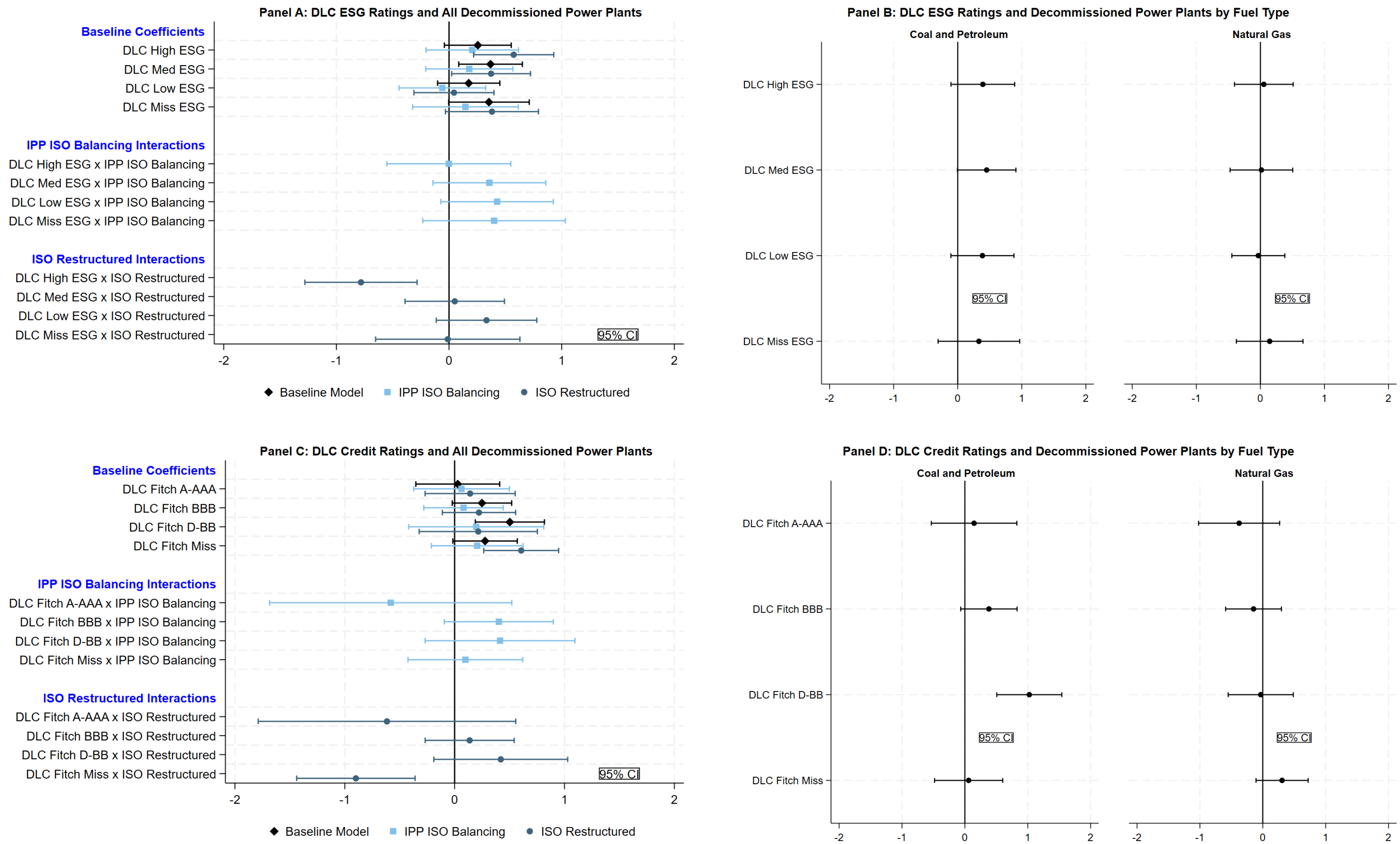


**Figure A.4: Domestic Listed Corp (DLC) Split by ESG Ratings or Credit Ratings and Decommissioned Plants**

This figure presents coefficient estimates and confidence intervals of multiple hazard models. In all models, observations are at the plant-prime-mover-month level and the sample includes only power plants with a nameplate capacity of at least 20MW. The event of interest is a complete decommissioning of a power plant.



## A.5 Operating Performance, Electricity Pricing and Contractual Terms

We observe that new entrants operate power plants more efficiently than DLCs. Their plants have a lower heat rate and consume less fossil fuel to produce one unit of electricity. This result suggests that the ownership changes are accompanied by operational improvements. Online Appendix Table A.13 examines separately the operating performance of different fuel types. We see that the difference in utilization rate between DLCs and new ownership structures is driven primarily by natural gas power plants, consistent with the interpretation that, in this fuel type, the owners have flexibility as to when to operate a plant, and may face regulatory incentives to increase operating intensity in traditional markets.

In Table 9, we examine the contractual terms of electricity transactions. The dependent variables are the percentage of the transaction charges for electricity sales under different contractual terms. Online Appendix Table A.14 shows that our results are robust to defining all contractual-term dependent variables as a percentage of the quantity sold instead of the transaction charges.

Online Appendix Table A.15 shows that the differences in contractual terms of electricity sales between new entrants and incumbent DLCs are entirely driven by fossil fuel power plants. When selling electricity from natural gas and coal power plants PE and foreign corporations use contracts with a shorter duration and shorter pricing increments, and target peak-period sales. The contractual terms of fossil fuel power plants dominate the aggregate results because we weigh the observations by nameplate capacity and fossil fuel power plants are economically substantially more significant than renewable power plants. Panel C shows that wind and solar power plants owned by PE and foreign corporations seem to be selling more electricity actually under long-term contracts and increments than wind and solar power plants owned by DLCs.

## Table A.13: Operating Performance by Fuel Type

**Robustness check of Table 7:** We estimate the analysis of operating performance by fuel type.

In this table, observations are at the plant-prime-mover-month level and weighted by nameplate capacity. In Panel A, the dependent variable is the capacity factor, which is the ratio of electricity generation in MWh to nameplate capacity. We winsorize the capacity factor at 0.5% and 99.5%. In Panel B, the dependent variable is the heat rate, which is the ratio of fuel consumption in millions of Btu to electricity generation in MWh. We do not observe the heat rate for wind, solar, and hydro power plants. Columns (1) to (3) examine the subsample of natural gas plants, Columns (4) to (6) examine the subsample of coal, waste coal, petroleum coke, and residual petroleum plants, and Columns (7) to (9) examine the subsample of solar and wind power plants. We focus on the ownership by DLCs and also control for the ownership by industry firms, government, cooperatives, and others (the omitted ownership categories are private equity, institutional investors, and foreign publicly listed corporations). *IPP ISO Balancing* and *ISO Restructured* are indicators for power plants operating in a deregulated electricity market. Columns (3), (6), and (9) present the second stage results of an IV model where we instrument the *ISO Restructured* and *DLC* × *ISO Restructured* variables with the difference between the average residential and industrial electricity prices in a state over the 1991–1996 period. We control for *ln Plant Capacity*, *ln Plant Age*, *Greenfield 1m*, *Greenfield 12m*, *Decommissioned 1m*, and *Decommissioned 12m*. The specifications include interacted fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

| | **Natural Gas** | | | **Coal & Petroleum** | | | **Solar & Wind** | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| **Panel A: Capacity Factor** | Mean Dep. Var. = 0.276 | | | Mean Dep. Var. = 0.481 | | | Mean Dep. Var. = 0.314 | | |
| Domestic Listed Corp (DLC) | 0.031** | 0.126*** | 0.063** | -0.025 | -0.007 | 0.050 | 0.006 | -0.000 | 0.023* |
| | [0.013] | [0.020] | [0.027] | [0.024] | [0.030] | [0.037] | [0.004] | [0.005] | [0.012] |
| IPP ISO Balancing | | 0.137*** | | | -0.022 | | | 0.006 | |
| | | [0.022] | | | [0.030] | | | [0.006] | |
| DLC × IPP ISO Balancing | | -0.142*** | | | -0.051* | | | 0.011* | |
| | | [0.024] | | | [0.030] | | | [0.006] | |
| ISO Restructured | | | 0.040 | | | 0.041 | | | -0.020 |
| | | | [0.039] | | | [0.047] | | | [0.013] |
| DLC × ISO Restructured | | | -0.136** | | | -0.085 | | | -0.033 |
| | | | [0.053] | | | [0.055] | | | [0.037] |
| Plant Age and Capacity Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-State-Year-Month FE | Yes | Yes | | Yes | Yes | | Yes | Yes | |
| Fuel-Year-Month FE | | | Yes | | | Yes | | | Yes |
| Observations | 463,576 | 463,576 | 480,665 | 100,407 | 100,407 | 140,237 | 322,113 | 322,113 | 323,749 |
| Adjusted R-squared | 0.378 | 0.386 | | 0.610 | 0.613 | | 0.672 | 0.673 | |
| **Panel B: Heat Rate** | Mean Dep. Var. = 11.816 | | | Mean Dep. Var. = 10.913 | | | | | |
| Domestic Listed Corp (DLC) | 0.857*** | 0.254 | 0.827** | -0.132 | -0.232 | -0.836*** | | | |
| | [0.161] | [0.208] | [0.353] | [0.174] | [0.243] | [0.300] | | | |
| IPP ISO Balancing | | -0.864*** | | | 0.172 | | | | |
| | | [0.272] | | | [0.283] | | | | |
| DLC × IPP ISO Balancing | | 0.856*** | | | 0.340 | | | | |
| | | [0.302] | | | [0.278] | | | | |
| ISO Restructured | | | -0.296 | | | -0.983** | | | |
| | | | [0.524] | | | [0.458] | | | |
| DLC × ISO Restructured | | | 0.275 | | | 1.110** | | | |
| | | | [0.710] | | | [0.482] | | | |
| Plant Age and Capacity Controls | Yes | Yes | Yes | Yes | Yes | Yes | | | |
| Other Owners | Yes | Yes | Yes | Yes | Yes | Yes | | | |
| Fuel-State-Year-Month FE | Yes | Yes | | Yes | Yes | | | | |
| Fuel-Year-Month FE | | | Yes | | | Yes | | | |
| Observations | 322,377 | 322,377 | 340,029 | 86,581 | 86,581 | 122,811 | | | |
| Adjusted R-squared | 0.273 | 0.275 | | 0.349 | 0.351 | | | | |

## Table A.14: Contractual Terms of Electricity Sales

**Robustness check of Table 9:** The dependent variables capture the percentage of electricity quantity sold instead of the percentage of transaction charges under various contractual terms.

In this table, observations are at the plant-prime-mover-month level and are weighted by power plant nameplate capacity. The dependent variables are the percentages of electricity quantity sold under three different contractual terms. First, we distinguish between short contracts with a duration of less than one year and long-term contracts. Second, we split transactions into short, medium, and long based on the increment pricing terms. Short transactions use 5-minute, 15-minute, or hourly increments (up to 6 hours). Medium transactions have daily or weekly increments (from 6 to 168 hours). Long transactions use monthly or yearly increments (longer than 168 hours). Third, we classify transactions into full-period, peak, and off-peak based on the peaking terms. The sample includes power plants owned by domestic publicly listed corporations, private equity, institutional investors, and foreign publicly listed corporations. We focus on the ownership by private equity, institutional investors, and foreign corporations (the omitted ownership category is domestic corporations). *ln Plant Capacity* is the natural logarithm of plant's monthly capacity. *ln Plant Age* is the natural logarithm of plant age in years. *Greenfield 12m* is an indicator for the first 12 months when a plant starts operating. *Decommissioned 12m* is an indicator for the last 12 months when a plant is still operating. The specifications include interacted fuel-type, state, and year-month fixed effects. We double cluster standard errors by plant-prime-mover and time, and report standard errors in brackets. *$p < .10$; **$p < .05$; ***$p < .01$.

| | **Contract Duration** | | **Increment Terms** | | | **Peaking Period Terms** | | |
|---|---|---|---|---|---|---|---|---|
| | Short | Long | Short | Medium | Long | Full | Peak | Off-Peak |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Mean Dependent Variable | 0.567 | 0.430 | 0.502 | 0.042 | 0.430 | 0.388 | 0.314 | 0.225 |
| Private Equity | 0.140*** | -0.145*** | 0.155*** | -0.007 | -0.153*** | -0.039 | 0.099*** | -0.019 |
| | [0.028] | [0.029] | [0.024] | [0.008] | [0.025] | [0.024] | [0.018] | [0.012] |
| Institutional Investor | -0.116* | 0.129** | -0.257*** | 0.050 | 0.209*** | 0.203** | -0.135*** | -0.056 |
| | [0.060] | [0.061] | [0.058] | [0.039] | [0.077] | [0.079] | [0.041] | [0.034] |
| Foreign Corp | 0.053 | -0.048 | 0.117*** | 0.011 | -0.173*** | -0.001 | 0.008 | -0.036** |
| | [0.040] | [0.041] | [0.036] | [0.011] | [0.038] | [0.036] | [0.022] | [0.017] |
| ln Plant Capacity | 0.015 | -0.017 | 0.003 | -0.003 | 0.005 | -0.013 | 0.008 | 0.005 |
| | [0.010] | [0.010] | [0.009] | [0.003] | [0.009] | [0.010] | [0.006] | [0.004] |
| ln Plant Age | -0.016 | 0.013 | -0.006 | -0.004 | 0.011 | -0.015 | 0.026*** | -0.001 |
| | [0.013] | [0.013] | [0.012] | [0.003] | [0.011] | [0.011] | [0.008] | [0.004] |
| Greenfield 12m | -0.012 | -0.002 | 0.035 | -0.002 | -0.040* | -0.052** | 0.056*** | 0.033*** |
| | [0.024] | [0.023] | [0.021] | [0.005] | [0.022] | [0.022] | [0.014] | [0.009] |
| Decommissioned 12m | 0.030 | -0.029 | 0.006 | 0.002 | 0.013 | 0.003 | 0.003 | -0.005 |
| | [0.034] | [0.034] | [0.032] | [0.004] | [0.030] | [0.032] | [0.021] | [0.016] |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 228,841 | 228,841 | 228,841 | 228,841 | 228,841 | 228,841 | 228,841 | 228,841 |
| Adjusted R-squared | 0.602 | 0.603 | 0.647 | 0.558 | 0.634 | 0.618 | 0.621 | 0.589 |

## Table A.15: Contractual Terms of Electricity Sales by Fuel Type

**Robustness check of Table 9:** The dependent variables capture contractual terms of electricity sales by fuel type.

In this table, observations are at the plant-prime-mover-month level and are weighted by power plant nameplate capacity. The dependent variables are the percentages of electricity transaction charges under three different contractual terms. The contractual terms focus on the contract duration, increment pricing, and peaking period. Panel A examines the subsample of natural gas plants, Panel B examines the subsample of coal, waste coal, petroleum coke, and residual petroleum plants, and Panel C examines the subsample of solar and wind power plants. The sample includes power plants owned by domestic corporations, private equity, institutional investors, and foreign corporations. We focus on the ownership by private equity, institutional investors, and foreign corporations (the omitted ownership category is domestic corporations). We include the same control variables for plant size, age, greenfield stage, and decommissioning stage. The specifications include interacted fuel-type, state, and year-month fixed effects. We cluster standard errors by plant-prime-mover, and report standard errors in brackets. $^{*}p < .10$; $^{**}p < .05$; $^{***}p < .01$.

| | **Contract Duration** | | **Increment Terms** | | | **Peaking Period Terms** | | |
|---|---|---|---|---|---|---|---|---|
| | Short | Long | Short | Medium | Long | Full | Peak | Off-Peak |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **Panel A: Natural Gas Power Plants** | | | | | | | | |
| Private Equity | 0.176*** | -0.177*** | 0.182*** | -0.002 | -0.178*** | -0.055* | 0.140*** | -0.029** |
| | [0.037] | [0.038] | [0.029] | [0.011] | [0.032] | [0.033] | [0.026] | [0.015] |
| Institutional Investor | -0.172** | 0.196** | -0.347*** | 0.016 | 0.340*** | 0.360*** | -0.243*** | -0.089*** |
| | [0.074] | [0.076] | [0.072] | [0.046] | [0.083] | [0.078] | [0.050] | [0.032] |
| Foreign Corp | 0.044 | -0.039 | 0.151*** | 0.040** | -0.185*** | -0.015 | 0.039 | -0.045** |
| | [0.060] | [0.060] | [0.052] | [0.017] | [0.056] | [0.049] | [0.039] | [0.019] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 69,522 | 69,522 | 69,522 | 69,522 | 69,522 | 69,522 | 69,522 | 69,522 |
| Adjusted R-squared | 0.462 | 0.464 | 0.604 | 0.525 | 0.555 | 0.578 | 0.553 | 0.511 |
| **Panel B: Coal and Petroleum Power Plants** | | | | | | | | |
| Private Equity | 0.374*** | -0.374*** | 0.349*** | 0.010 | -0.331*** | -0.006 | 0.023 | 0.012 |
| | [0.079] | [0.079] | [0.077] | [0.008] | [0.085] | [0.036] | [0.036] | [0.015] |
| Institutional Investor | -2.321*** | 2.319*** | -1.867*** | -0.117*** | 2.199*** | 2.181*** | -0.837*** | -0.589*** |
| | [0.227] | [0.227] | [0.221] | [0.039] | [0.224] | [0.153] | [0.100] | [0.056] |
| Foreign Corp | 0.507*** | -0.507*** | 0.440*** | 0.055* | -0.484*** | -0.025 | -0.031 | 0.051** |
| | [0.112] | [0.112] | [0.120] | [0.032] | [0.114] | [0.021] | [0.026] | [0.021] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 17,648 | 17,648 | 17,648 | 17,648 | 17,648 | 17,648 | 17,648 | 17,648 |
| Adjusted R-squared | 0.647 | 0.649 | 0.699 | 0.789 | 0.728 | 0.712 | 0.671 | 0.635 |
| **Panel C: Solar and Wind Power Plants** | | | | | | | | |
| Private Equity | -0.162*** | 0.139*** | -0.114*** | -0.010 | 0.057 | 0.010 | -0.013 | 0.005 |
| | [0.050] | [0.051] | [0.043] | [0.007] | [0.048] | [0.054] | [0.027] | [0.018] |
| Institutional Investor | -0.040 | 0.039 | -0.157** | 0.129** | -0.020 | -0.061 | 0.028 | 0.055 |
| | [0.094] | [0.094] | [0.064] | [0.049] | [0.094] | [0.108] | [0.053] | [0.041] |
| Foreign Corp | -0.109** | 0.110** | -0.106** | -0.015** | -0.017 | 0.112** | -0.101*** | -0.063*** |
| | [0.051] | [0.051] | [0.042] | [0.006] | [0.049] | [0.051] | [0.025] | [0.017] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Fuel-State-Year-Month FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 71,772 | 71,772 | 71,772 | 71,772 | 71,772 | 71,772 | 71,772 | 71,772 |
| Adjusted R-squared | 0.268 | 0.258 | 0.307 | 0.260 | 0.235 | 0.193 | 0.273 | 0.303 |