# Do Mergers and Acquisitions Improve Efficiency: Evidence from Power Plants

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# Motivation

Remarkably little evidence on how M&A a ect e ciency

Literature primarily focused on market power e ects of mergers

Important for

- Antitrust: Trade-o between **increased market power** and **efficiency**
- Productivity Growth: Do ownership changes allocate assets to more e cient rms?

**Why little evidence?** Primarily data limitations

- Typically, **revenue productivity** is observed, not **physical productivity**
- Hard to separate true e ciency from **market power**, **buyer power** and **quality** changes

**This paper**: Evidence from Power Plants

# Research Questions

- **Do mergers increase efficiency?**
  - What predicts e ciency gains?
  - What are the mechanisms?
- **How do mergers reallocate assets between firms?**
  - Do mergers transfer assets to more productive uses?
  - Are buyers more e cient than sellers?
- **What do firms do?**
  - Process improvements or capital upgrades?

# Our Approach

Evidence from **fossil fuel power plant** acquisitions in the US

- Retrospective study (2000-2020) using all US power plant acquisitions
- A cumulative 95% of total capacity changed hands in the sample period
- About 4000 majority ownership changes of production units

Di erence-in-di erences in a **data-rich environment**

- High-frequency data: hourly input, production and productivity
- Estimation at the production unit level

**Universe of ownership changes** during the study period

- Minority and Majority Share Ownership Changes
- Corporate Structure: Parent level, subsidiary level

# Why Power Plants?

**The data does not have the revenue-is-output problem**

- Physical output and input quantities observed, not revenues and expenditures
- Homogeneous product: No quality changes
- Clearly de ned e ciency measure: Fuel e ciency
- High-Frequency Data: Hourly Input and Output
- Actual input/output, not survey-based

**Important Industry**

- Contributes to around 5 percent of GDP
- Positive Externalities: increasing e ciency reduces $CO_2$ emissions

# Main Findings

- How do mergers a ect e ciency: Increase by 4 percent
  - 75% of e ciency gain is explained by increase in productive e ciency
  - 25% is explained by improved capacity utilization and portfolio e ects

- How do mergers reallocate resources: E ciently
  - High productive rms buy from low productive rms
  - Target rms are selling their under-performing assets

- What do rms do: Operational Improvements
  - After the acquisitions, 55% power plants get a new plant manager
  - No evidence for increase in capital expenditures or labor

# Outline

# Outline

# Electricity Generation

Power plants turn one form of energy into electricity. In 2019

- Natural Gas (33%), Coal (32%), Nuclear (19%), Renewables (16%)

I We focus on thermal (gas and coal- red) power plants

Electricity generation

- A power plant includes multiple generators

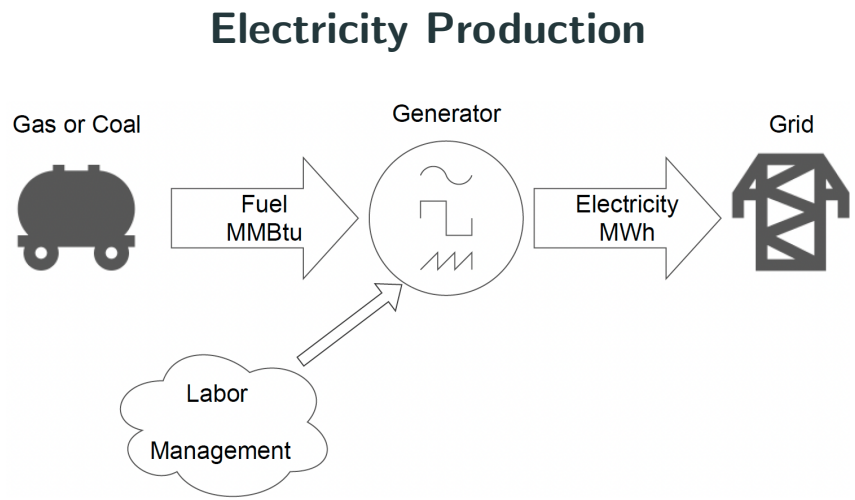
I Our unit of observation is generator

Electricity released to the grid

- Priced through a competitive bidding market: two-thirds of the market
- Regulated return: third of the market

# Production Process

Generator is the unit of production




E ciency is measured by **inverse heat rate**: $\frac{\text{Energy Output (MWh)}}{\text{Energy Input (MMBtu)}}$

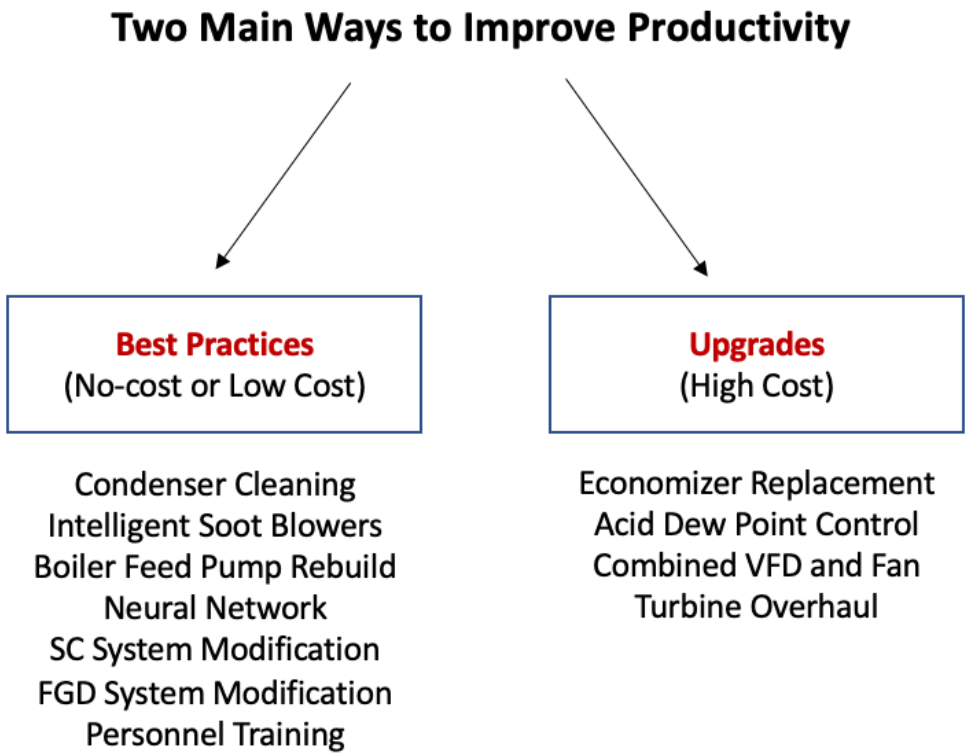
Fuel is 80 percent of operational cost

**Advantage:**

Physical output/physical input: Not confounded by buyer/market power changes

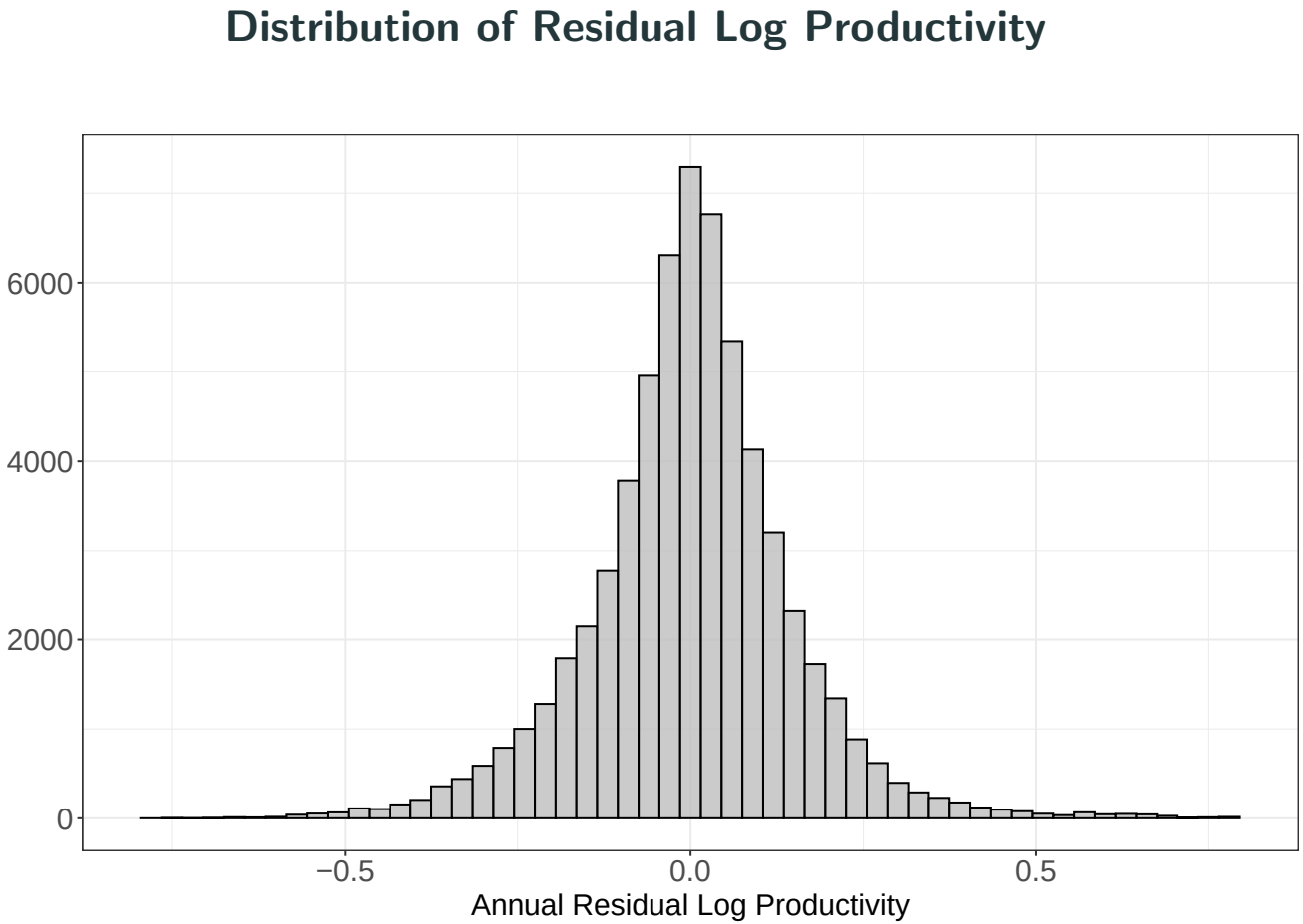
# What Firms do to Improve Heat Rate

\I have never visited a power plant where signi cant improvements in energy e ciency could not be made" (Industry Expert, Power Magazine (2015))




▸ Case Studies

# Large Productivity Dispersion Across Plants




- Controls for plant age, fuel type, technology, capacity, generator manufacturer, generator model, emission controllers

# Efficiency in Power Plants

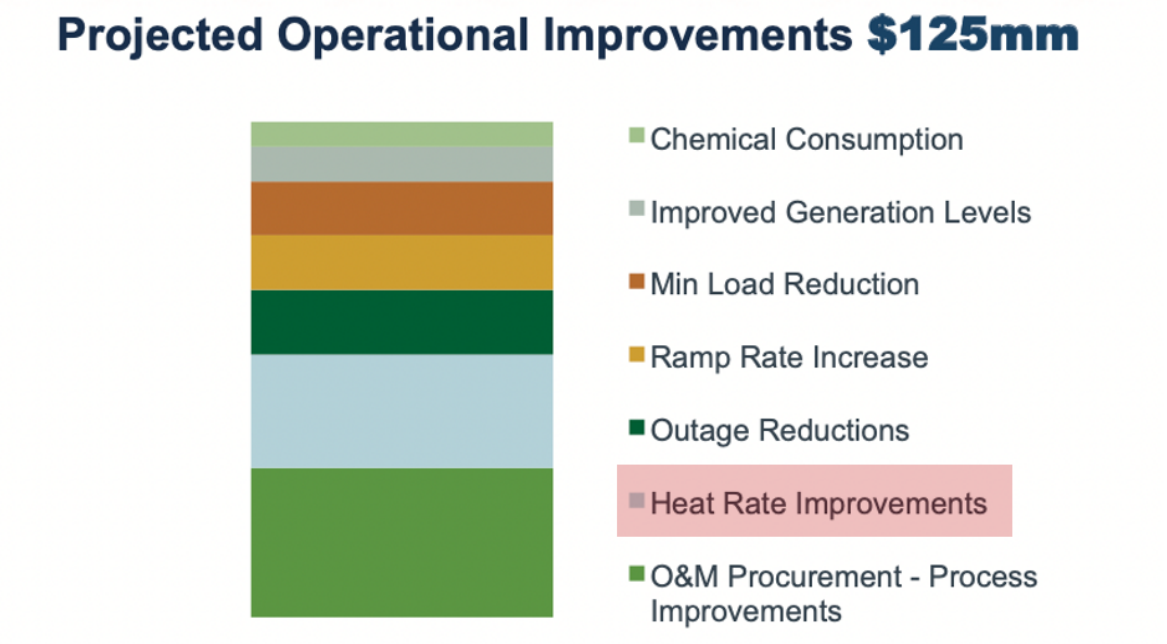
- Productivity changes with the production level
- E cient Scale
- Ramp-up and ramp-down e - ciency loss

**Some Sources of Efficiency Gain**

- Change in the cost curve
- Operating close to the e cient scale (less ramp-up and ramp-down)
- Portfolio E ects (Synergies)

# Acquirers often Make Claims about Heat Rate Improvements

A slide from investor presentation of Dynergy and Vista Energy Merger




Acquisition of Dynergy by Vista Energy (2018, $1.74 billion deal)

- Heat Rate Improvement of 50 million dollars

# Outline

# Production Data (2000-2020)

Data Source: Environmental Protection Agency (EPA), Energy Information Administration (EIA), Velocity Suite and S&P Global for 2000-2020

**Input-Output Data**

- Hourly Input, Output, Emissions

**Generator Data**

- Age, Model, Manufacturer, Fuel Type, Capacity, Location

**Personnel Changes**

- Plant Managers, Engineers, Regulation Compliance Managers

**Input Data**

- Input Types, Suppliers, Prices, Transportation Mode, Quality (Coal)

**Industry and Market Data**

- Prices, Regulation Status, Demand, Market Shares

# Universe of Mergers and Acquisitions (2000-2020)

Data Source: S&P Global and Capital IQ

**Deal Data**

- All transactions that involve power plants
- Deal Size, Buyer, Seller, Announcement and Close Date, Conference Call Transcripts, Deal Description

**Ownership Data**

- Time series data on all shareholders of power plants

**Corporate Structure**

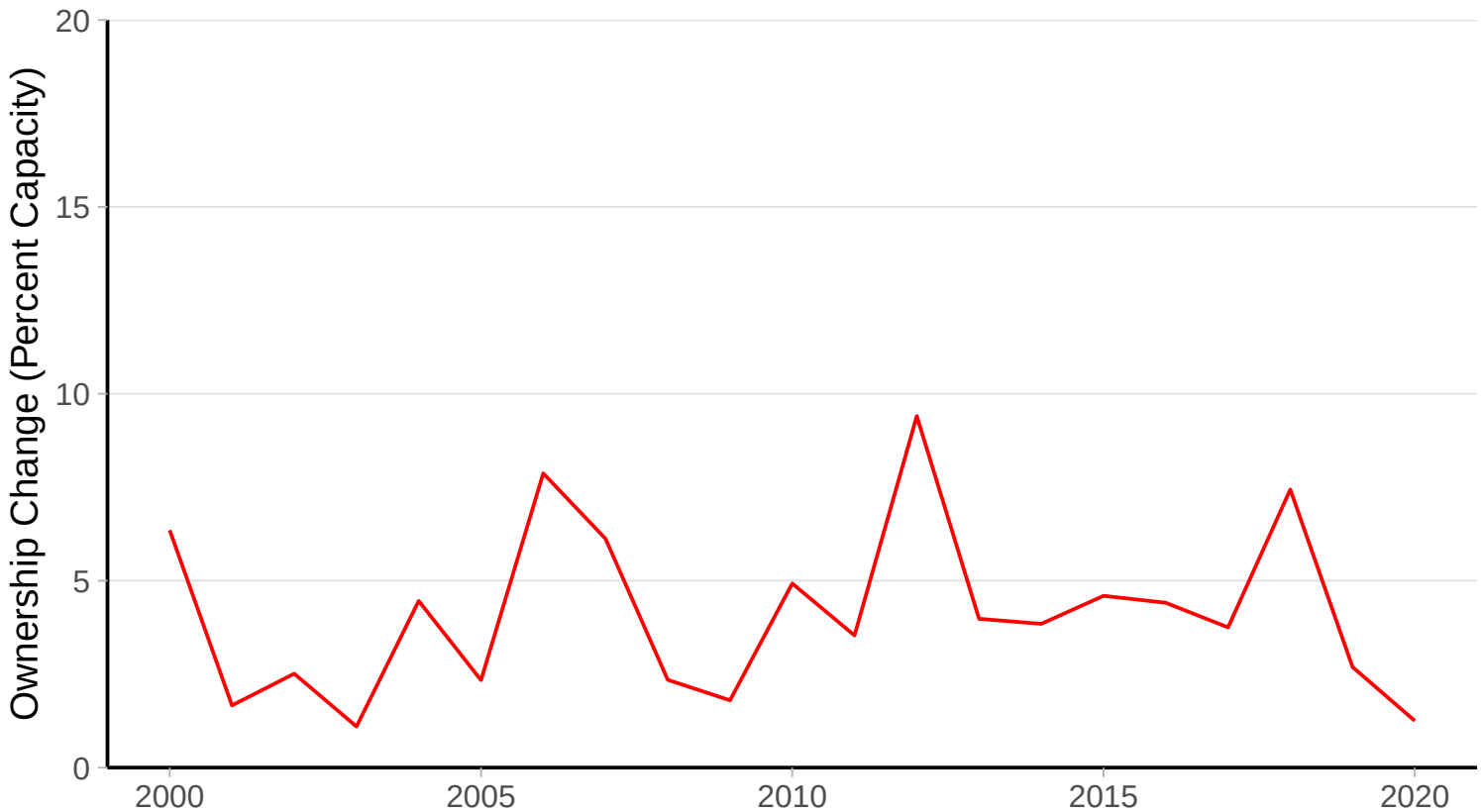
- Parent Company and Subsidiaries

**Company Financials**

- Asset Size, Sales, Pro t, Assets Composition

# Outline

# Ownership Change




- 95% of industry capacity changed ownership (50% distinct)

# Summary Statistics: Mergers and Acquisitions

| | All | Change in Majority Owner |
|---|---|---|
| | Unit Characteristics | |
| # of Units | 4834 | 4030 |
| # of Plants | 1567 | 1264 |
| # of Acquirer Firms | 267 | 234 |
| # of Target Firms | 266 | 229 |
| | Firm Characteristics | |
| Acquirer Capacity (MW) | 5459 | 5055 |
| Target Capacity (MW) | 7025 | 6912 |
| | Transaction Characteristics | |
| # of Deals | 689 | 532 |
| Deal Size in # of Units | 7.0 | 7.6 |

- Entry and exit in the market
- 64 percent of transactions are between incumbent firms

▸ Capacity Decrease

▸ Capacity Increase

# Distribution of Deal Sizes

Distribution of Capacity that Changes Ownership in Transactions

Concentration

# Types of Acquisitions

Ownership can change

- At the parent company level only
- At the parent company and owner level

Classi cation of M&A

- Asset Acquisitions (Power Plant)
- Acquisitions of a subsidiary of another (parent) company
- Merger/Acquisitions of Entire Company

# Plant Acquisitions

Pre-merger

Post-merger

# Subsidiary Acquisitions

Pre-merger

Post-merger

# Mergers

Pre-merger

Post-merger

# Types of Ownership Change

Change in Ownership
at the Subsidiary Level
(Percent of Shares)

Change in Ownership
at the Parent Company Level
(Percent of Shares)

# Outline

# Empirical Strategy: Difference-in-differences

DiD: Estimate how productivity changes after the acquisition

$$\log(y_{it}) = \beta_1 pre\_late_{it} + \beta_2 early\_post_{it} + \beta_3 late\_post_{it} + \gamma X_{it} + \alpha_t + \alpha_i + \varepsilon_{ijt}$$

- $y_{it}$ productivity (inverse heat rate)
- Weekly data, at the unit level (i:unit, t:week)
- pre_late: 1-5 months before the merger, early_post: 1-5 months after the merger, late_post: 6-10 months after the merger
- Controls: generator characteristics, state-month and week fixed effects
- pre_early_acq is normalized to zero
- Only use the first acquisition if a unit is acquired multiple times

Concern: Mergers might be endogenous

- Ownership change is discrete
- Any productivity trend that might lead to selection is gradual
- Rich set of controls and placebo tests

# Empirical Results

Table: Regression Results

| Dep Var: | Log Productivity |
|---|---|
| | All M&A |
| Late pre-acquisition | 0.002 |
| | (0.006) |
| Early post-acquisition | 0.000 |
| | (0.005) |
| Late post-acquisition | 0.017 |
| | (0.006) |
| # of Obs. | 1.79M |
| Adj. $R^2$ | 0.622 |
| # of Acq. | 1760 |

- Comparison: Avg. within-unit annual efficiency increase: 0.2 percent

Table: Regression Results

| Dep Var: | Log Productivity | | |
|---|---|---|---|
| | All M&A | Owner/Parent Company Change | Only Parent Company Change |
| Late pre-acquisition | 0.002 | -0.003 | -0.003 |
| | (0.006) | (0.008) | (0.007) |
| Early post-acquisition | 0.000 | 0.005 | -0.002 |
| | (0.005) | (0.007) | (0.007) |
| Late post-acquisition | 0.017 | 0.039 | -0.006 |
| | (0.006) | (0.012) | (0.007) |
| # of Obs. | 1.79M | 1.38M | 1.4M |
| Adj. $R^2$ | 0.622 | 0.635 | 0.622 |
| # of Acq. | 1760 | 897 | 921 |

- Only Parent and Owner Company change is e ective

# Dynamic E ects

Change in Log Productivity

# Robustness Checks and Placebo Tests

- Placebo Tests
  - Zero Effects of Minority Acquisitions
  - Zero Effects of Company Name Changes

- Robustness Checks
  - Matching Estimator
  - Estimation with daily and hourly data
  - Callaway and Sant'Anna (2021) estimator

- Other important changes without mergers
  - Manager changes without a merger $\rightarrow$ only 0.6 percent efficiency increase

# What Merger Attributes Predicts E ciency Gains?

E ciencies are di cult to evaluate ex ante but factor into merger decisions

Identifying the sources of e ciency gains is important for potential merger evaluations

What merger attributes predict e ciency gains?

- Plant Characteristics
- Acquirer and Target Firm Characteristics
- Deal Characteristics

Estimate:

$$\log(y_{it}) = {}_1\text{treated}_{it} + {}_2\text{treated}_{it} \quad Z_{it} + X_{it} + {}_t + {}_i + {}_{ijt}$$

# Plant Characteristics

# Firm Characteristics

# Deal Characteristics

# How do Mergers Reallocate Resources?

- Important feature of acquisitions: Asset reallocation between incumbent rms
  - 64 percent of transactions target rms sell part of their portfolio and acquiring rm has existing assets

- Questions: (i) Who acquires whom, (ii) What assets do target rms sell?

- Goal: Around the time of acquisition, compare the productivity levels of
  - Existing Assets of Acquirers
  - Existing Assets of Targets
  - Acquired Assets

- Estimate DiD with three sets of treatment dummies

# E ciency of Acquirer and Target

- More e cient rms buy from less e cient rms

# E ciency of Acquirer, Target and Acquired Assets

- Target rm is selling under-performing assets

# E ciency of Acquirer, Target and Acquired Assets

- E ciency of Acquired Assets Increase

# Outline

- Industry
- Data
- M&A
- Empirical Model and Results
- Mechanisms
  - Sources of E ciency Gains
  - What Do Acquirer Firms Do?
- Conclusion

Three Sources of E ciency Gains

- Productive E ciency
- Improved Capacity Utilization
- Portfolio E ects (Synergies)

- Develop predictions and test these sources of e ciency gains
  - Prediction 1: Cost curve shifts down at every production level
  - Prediction 2: Standard deviation of heat rate goes down
  - Prediction 3: E ciency of the existing plants of the acquirer rm in the same market will improve

# Cost Curve

Estimate cost curve pre- and post-merger (one year) nonparametrically

Controlling for ramp-up and ramp-down (production in previous two hours)

- Average 2.9 percent gain through productive e ciency (75% of total)

▸ Cost Curve for Control

# Improvements in Capacity Utilization

Improved in capacity management implies a decline in volatility of heat rate

Focus on acquisitions where acquirer has no existing plants in the market to rule out synergies

E ects of M&A on Standard Deviation of Heat Rate

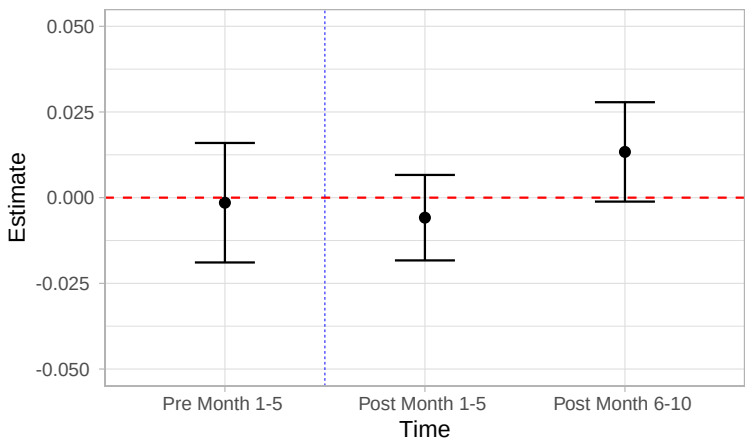
# Synergies: Portfolio Effects

Portfolio e ects implies for the existing generators of the acquirer

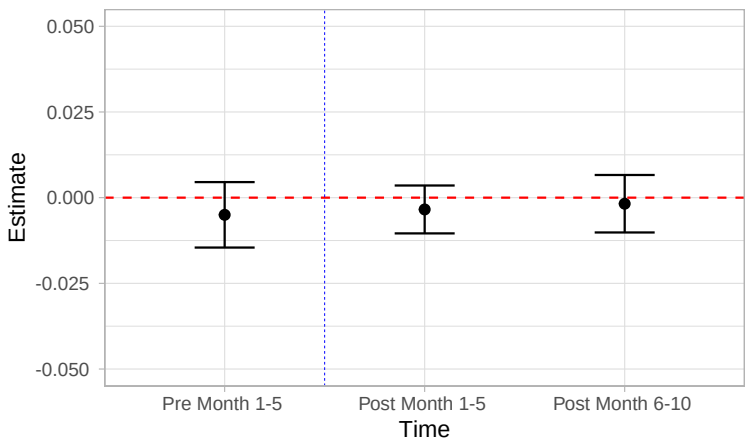
- E ciency improvements of the portfolio in the **same market**
- No change in **different markets**

Di -in-di : Existing portfolio of the acquirer rms is treated

**(a) Same Market**




**(b) Different Market**



# What do firms do?

What increases productive e ciency? Two potential hypotheses

- Process Improvements: **knowledge transfer**
- Capital Upgrades: **liquidity constraints**

Additional data on operation and production

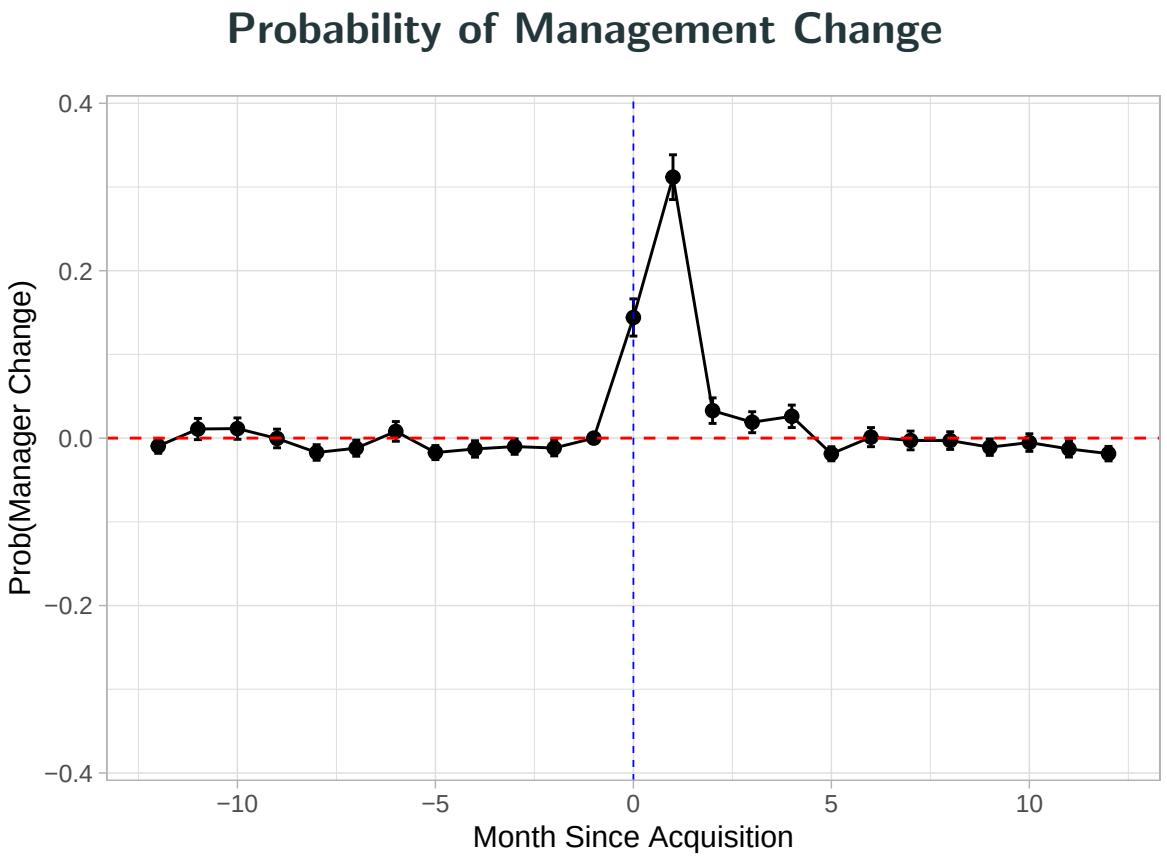
- Manager changes (name and date)
- Annual non-fuel costs, labor and capital expenditure

**Question:** How do management and other costs change after the acquisition?

Di erence-in-di erences estimation with outcomes:

- (i) Manager changes, (ii) Non-fuel cost, labor and capital expenditures

# Manager Change




- 55% of acquirers replace plant manager within three months

# Labor and Capital Change After the Merger

Di -in-di estimation. Outcome variables are the logarithm of

- Non-fuel variable cost per MWh
- Number of Employees
- Capital Expenditures

Annual data for a sample of plants reporting to FERC

| | Non-fuel Cost | Number of Employees | Capital Expenditures |
|---|---|---|---|
| Post-Merger | -0.068 | -0.054 | -0.020 |
| S.E | (0.053) | (0.031) | (0.032) |
| # of Acq | 655 | 584 | 678 |
| # of Obs | 29325 | 26866 | 29418 |
| $R^2$ | 0.62 | 0.92 | 0.86 |

# Conclusion

**Evidence of efficiency gains from power plant M&A**

- 4 percent e ciency gains 5-7 months after acquisition

**Who Acquires What Assets from Whom?**

- E cient rms buy assets from less e cient rms.
- Sellers sell under-performing assets

**What mechanisms generate efficiency gains?**

- Productive E ciency: 75 percent
- Evidence for adopting best practices rather than costly investment