Do Mergers and Acquisitions Improve Efficiency: Evidence from Power Plants

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Motivation

Remarkably little evidence on how M&A affect efficiency

Literature primarily focused on market power effects of mergers

Important for

- Antitrust: Trade-off between **increased market power** and **efficiency**
- Productivity Growth: Do ownership changes allocate assets to more efficient firms?

Why little evidence? Primarily data limitations

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

This paper: Evidence from Power Plants

Research Questions

1. **Do mergers increase efficiency?**
   - What predicts efficiency gains?
   - What are the mechanisms?

2. **How do mergers reallocate assets between firms?**
   - Do mergers transfer assets to more productive uses?
   - Are buyers more efficient than sellers?

3. **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

Difference-in-differences 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 defined efficiency measure: Fuel efficiency
- 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 efficiency reduces CO_2 emissions

Main Findings

- How do mergers affect efficiency: Increase by 4 percent
  - 75% of efficiency gain is explained by increase in productive efficiency
  - 25% is explained by improved capacity utilization and portfolio effects
- How do mergers reallocate resources: Efficiently
  - High productive firms buy from low productive firms
  - Target firms are selling their under-performing assets
- What do firms do: Operational Improvements
  - After the acquisitions, 55% power plants get a new plant manager
  - No evidence for increase in capital expenditures or labor

Outline

1. Industry Overview
2. Data
3. Mergers and Acquisitions
4. Empirical Model and Results
5. Mechanisms
6. Conclusion

Outline

1. **Industry Overview**
   - Industry Overview
   - Measurement of Productivity
   - Sources of Productivity Gains
2. **Data**
3. **Mergers and Acquisitions**
4. **Empirical Model and Results**
5. **Mechanisms**
6. **Conclusion**

Electricity Generation

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

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

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

Electricity generation

- A power plant includes multiple generators

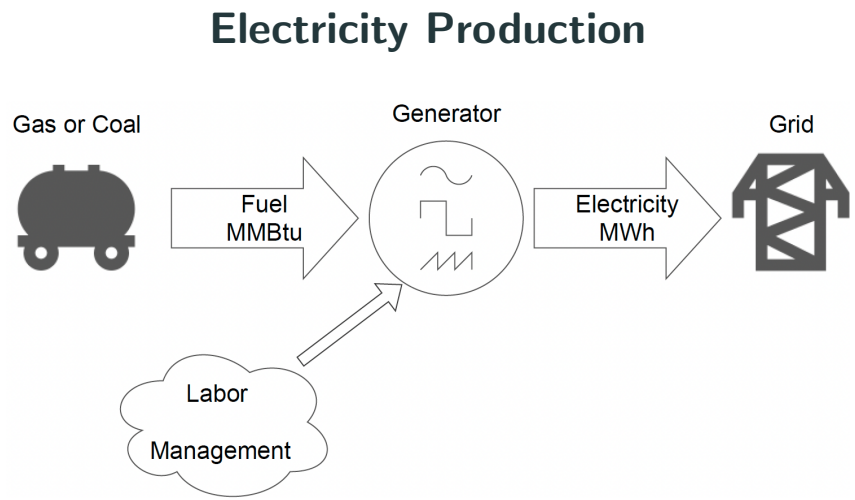
- Our unit of observation is generator

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



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

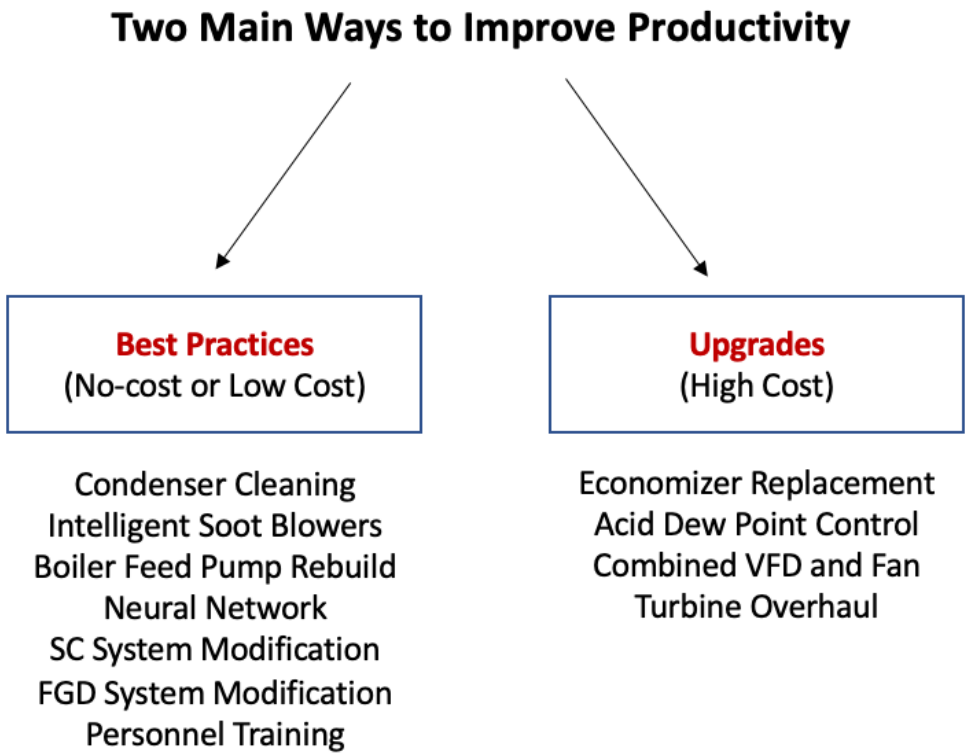
Fuel is 80 percent of operational cost

Advantage:

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

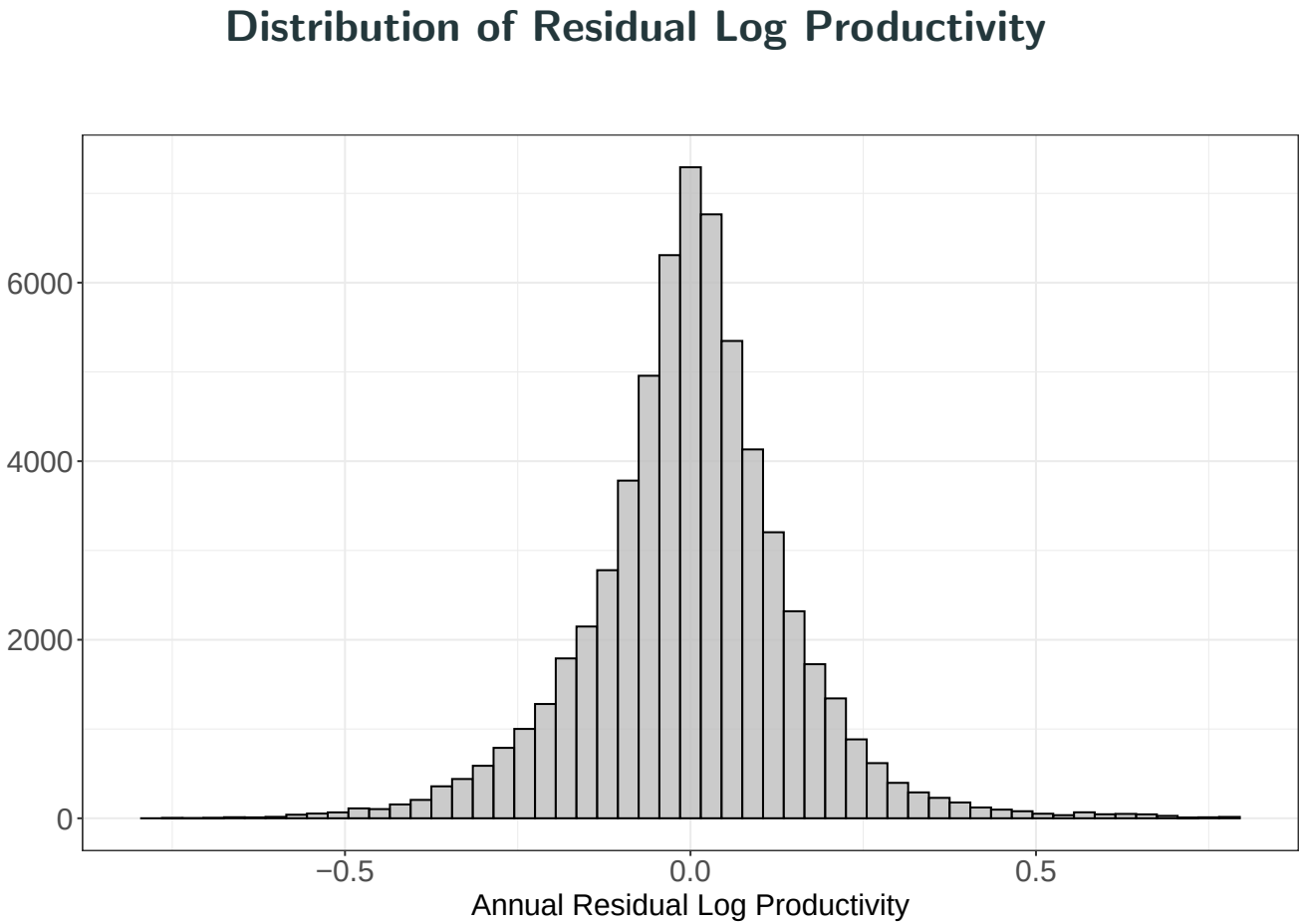
What Firms do to Improve Heat Rate

"I have never visited a power plant where significant improvements in energy efficiency could not be made" (Industry Expert, Power Magazine (2015))



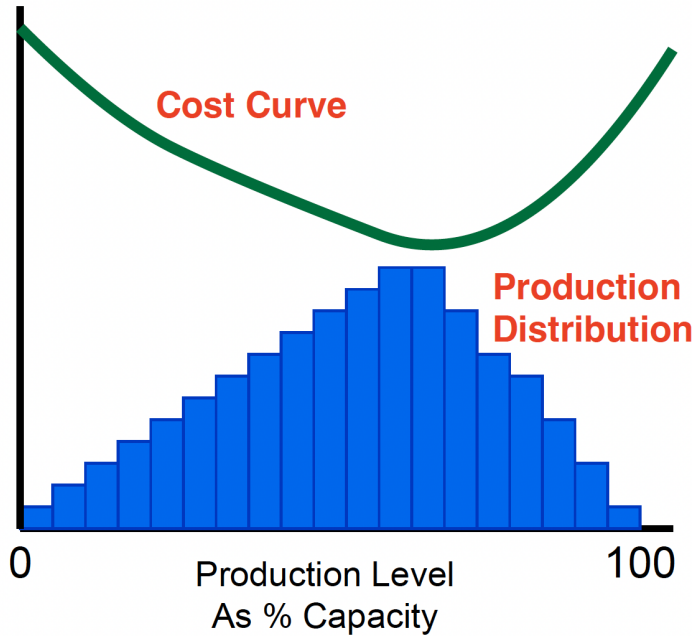
▸ Case Studies

Large Productivity Dispersion Across Plants



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

Efficiency in Power Plants



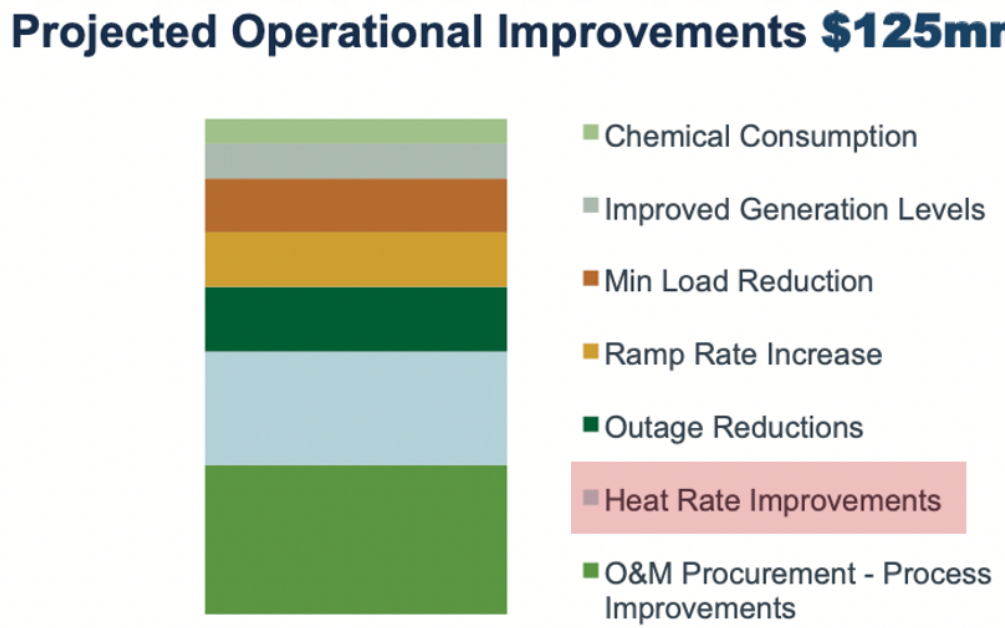
- Productivity changes with the production level
- Efficient Scale
- Ramp-up and ramp-down efficiency loss

Some Sources of Efficiency Gain

- Change in the cost curve
- Operating close to the efficient scale (less ramp-up and ramp-down)
- Portfolio Effects (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 $\approx$ 50 million dollars

Outline

1. **Industry**
2. **Data**
   - Data Sources
   - Production and M&A Data
3. **Mergers and Acquisitions**
4. **Empirical Model and Results**
5. **Mechanisms**
6. **Conclusion**

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

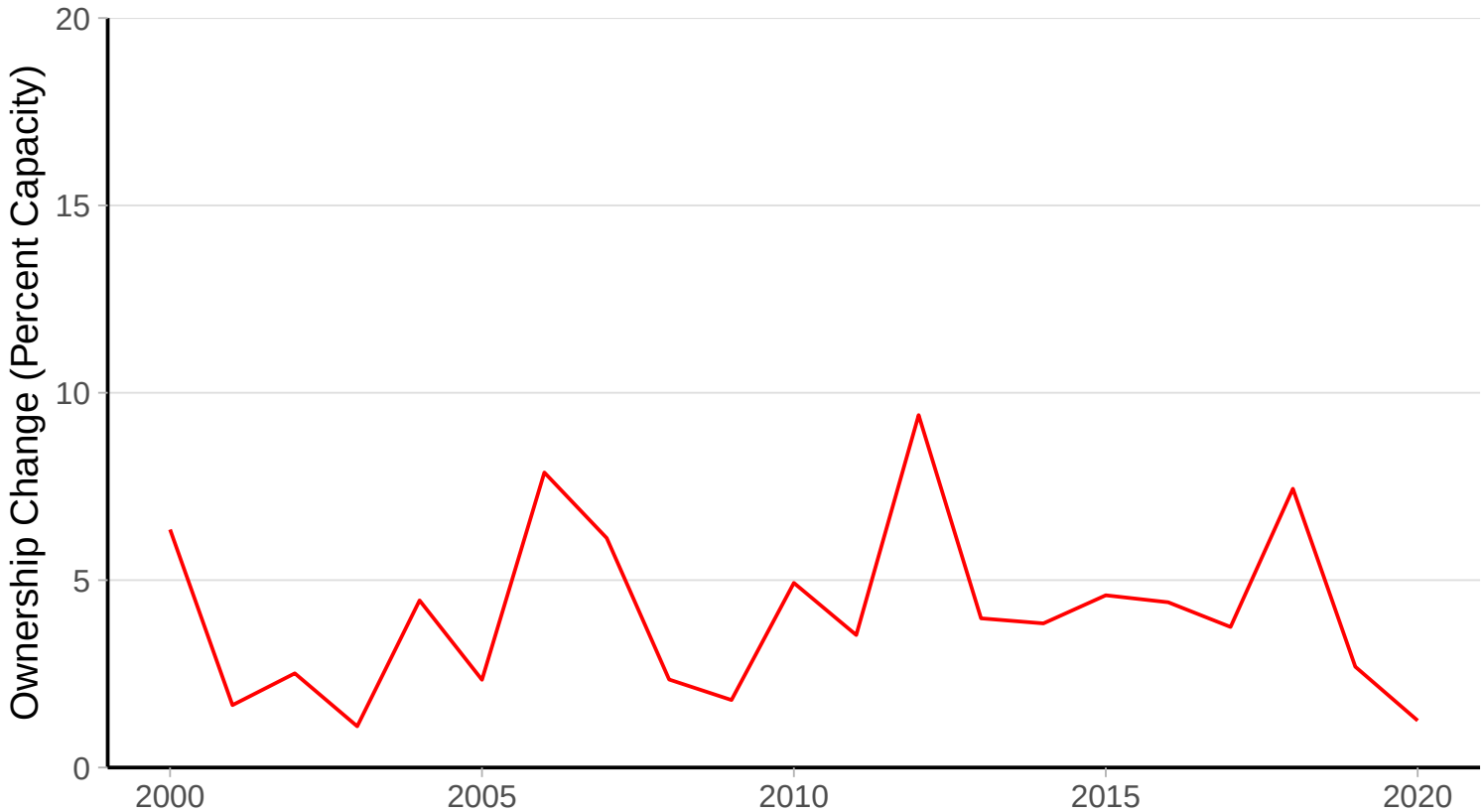
Company Financials

- Asset Size, Sales, Profit, Assets Composition

Outline

1. **Industry**
2. **Data**
3. **Mergers and Acquisitions**
   - Summary Statistics
   - Mergers and Acquisition Types
4. **Empirical Model**
5. **Mechanism**
6. **Conclusion**

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

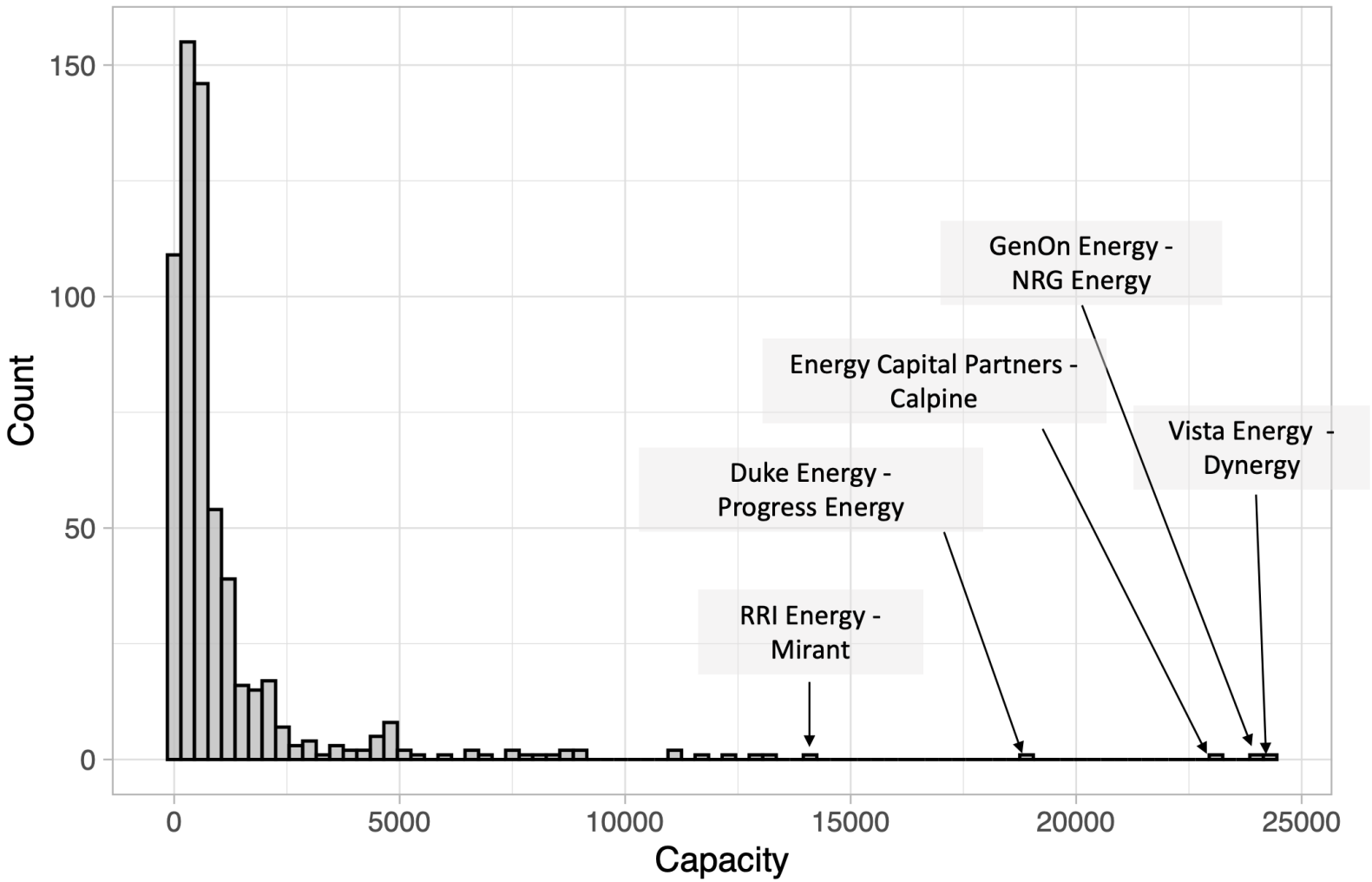
- Entry and exit in the market
- 64 percent of transactions are between incumbent firms

▸ Capacity Decrease

▸ Capacity Increase

Distribution of Deal Sizes

Distribution of Capacity that Changes Ownership in Transactions



▸ Concentration

Types of Acquisitions

Ownership can change

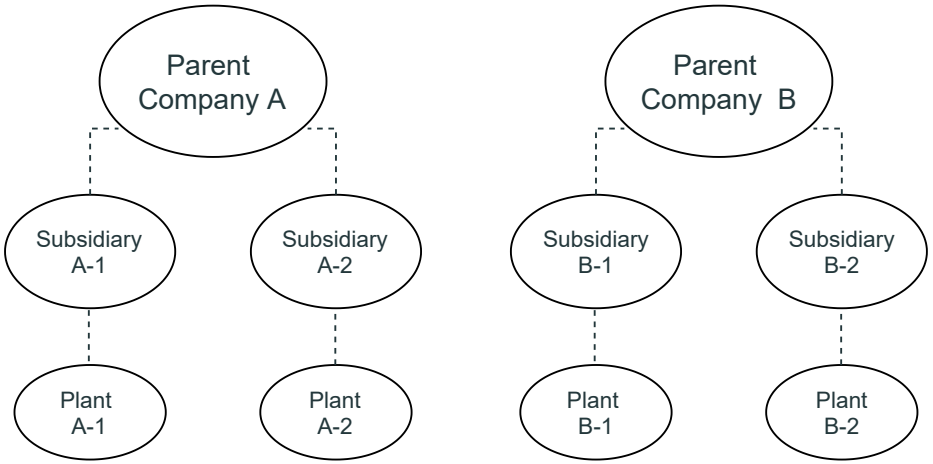
- At the parent company level only
- At the parent company and owner level

Classification of M&A

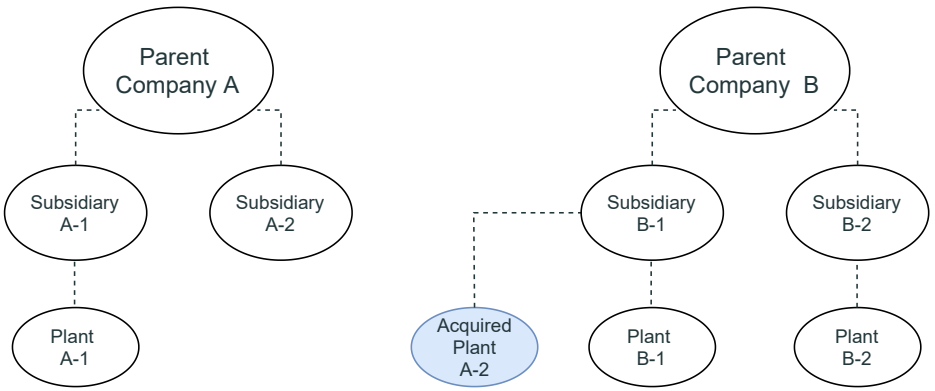
1. Asset Acquisitions (Power Plant)
2. Acquisitions of a subsidiary of another (parent) company
3. Merger/Acquisitions of Entire Company

Plant Acquisitions

Pre-merger

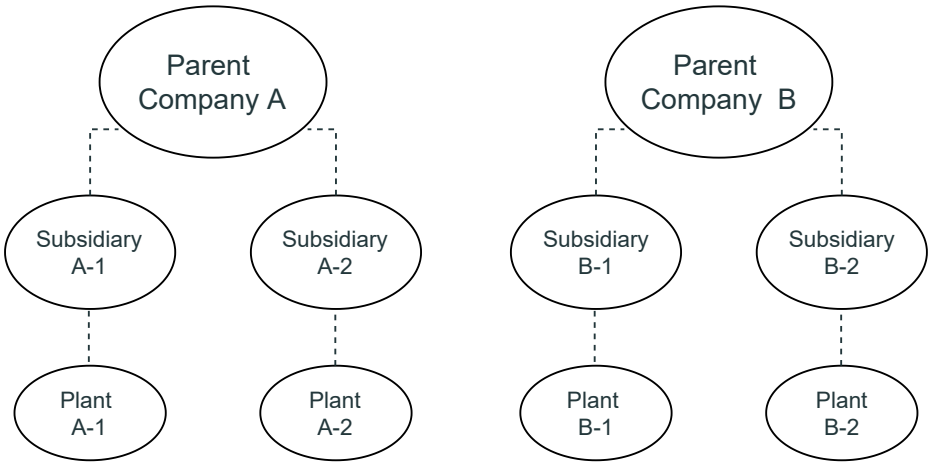


Post-merger

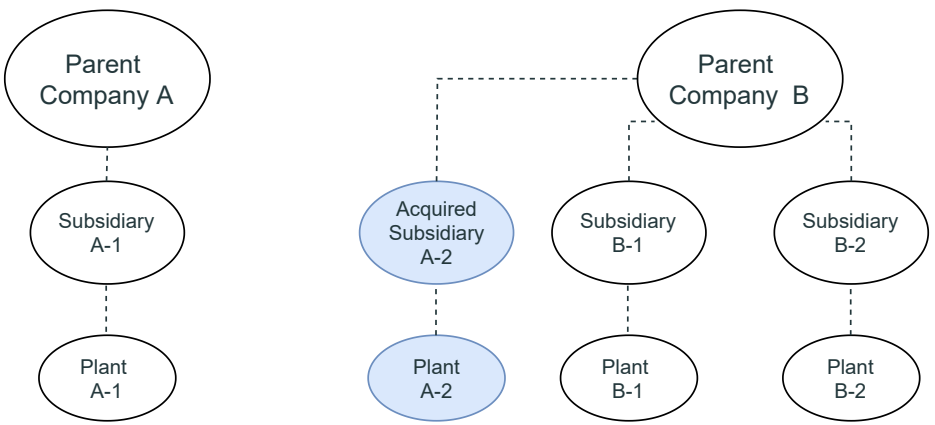


Subsidiary Acquisitions

Pre-merger

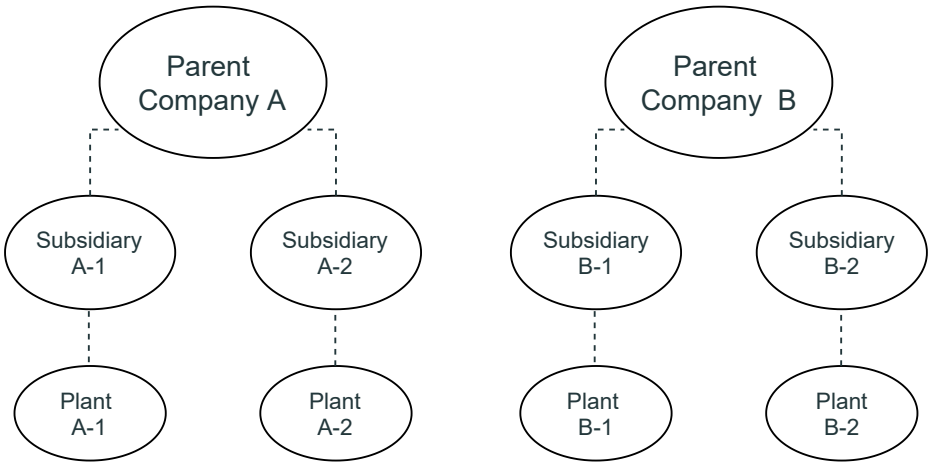


Post-merger

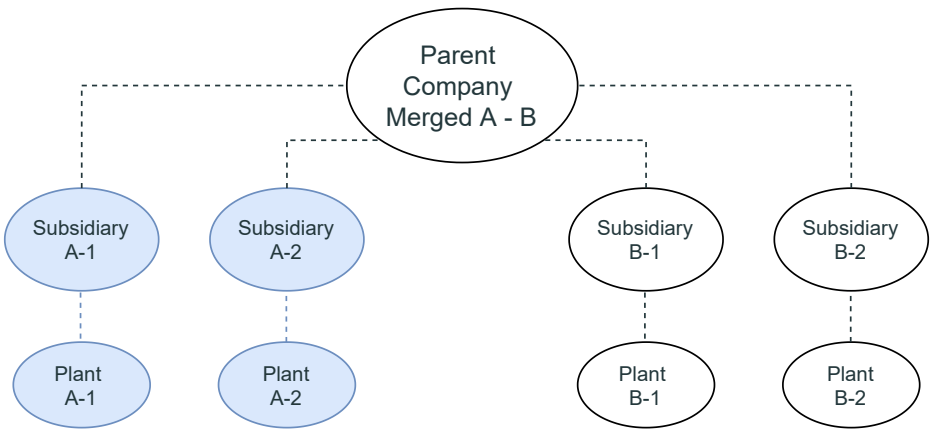


Mergers

Pre-merger

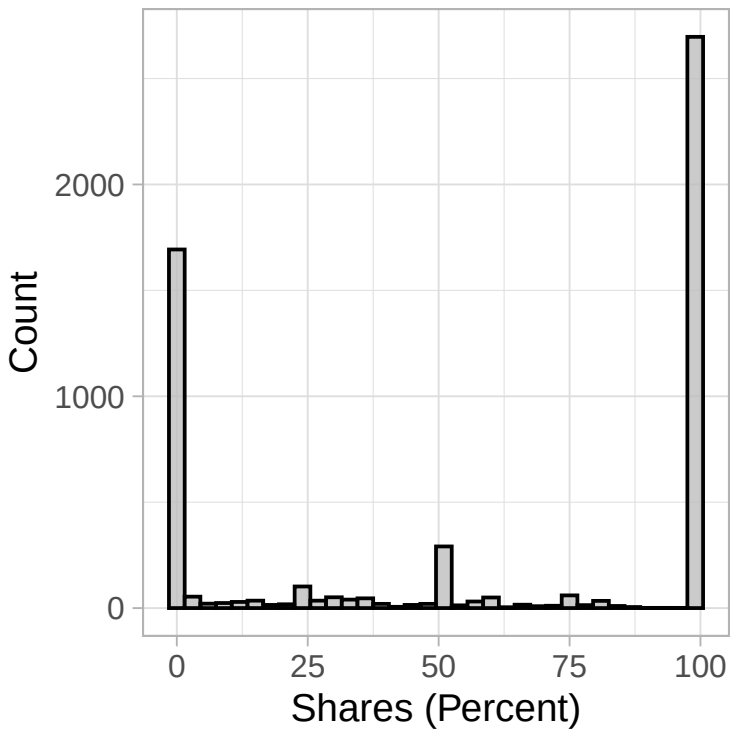


Post-merger

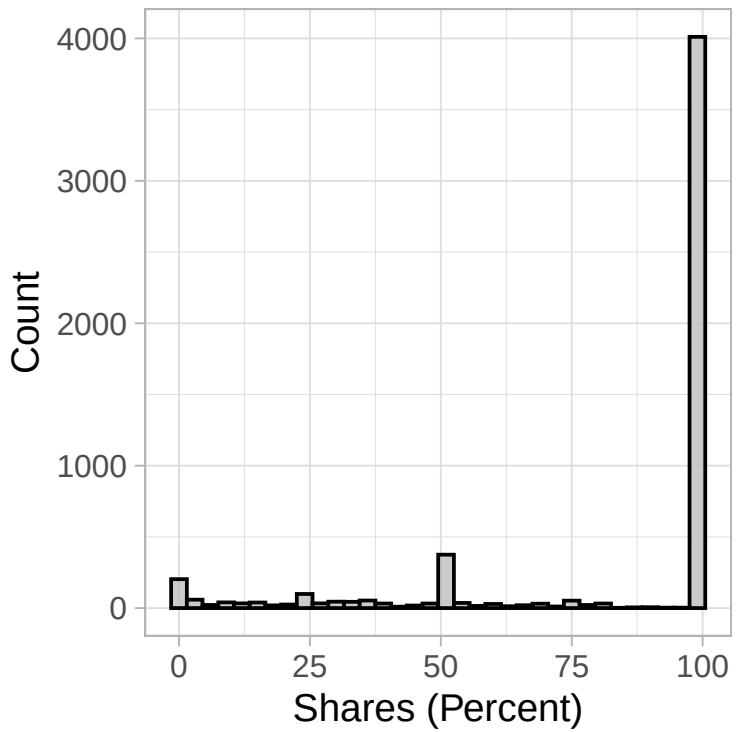


Types of Ownership Change

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



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



Outline

1. **Industry**
2. **Data**
3. **Mergers and Acquisitions**
4. **Empirical Model and Results**
   - Difference-in-differences Estimation
   - What Predicts Efficiency Gains
   - Who Acquires Whom?
5. **Mechanisms**
6. **Conclusion**

Empirical Strategy: Difference-in-differences

DiD: Estimate how productivity changes after the acquisition

$$log(y_{it}) = \theta_1 \text{pre_late}_{it} + \theta_2 \text{early_post}_{it} + \theta_3 \text{late_post}_{it} + \beta X_{it} + \mu_t + \alpha_i + \eta_{ijt}$$

- 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

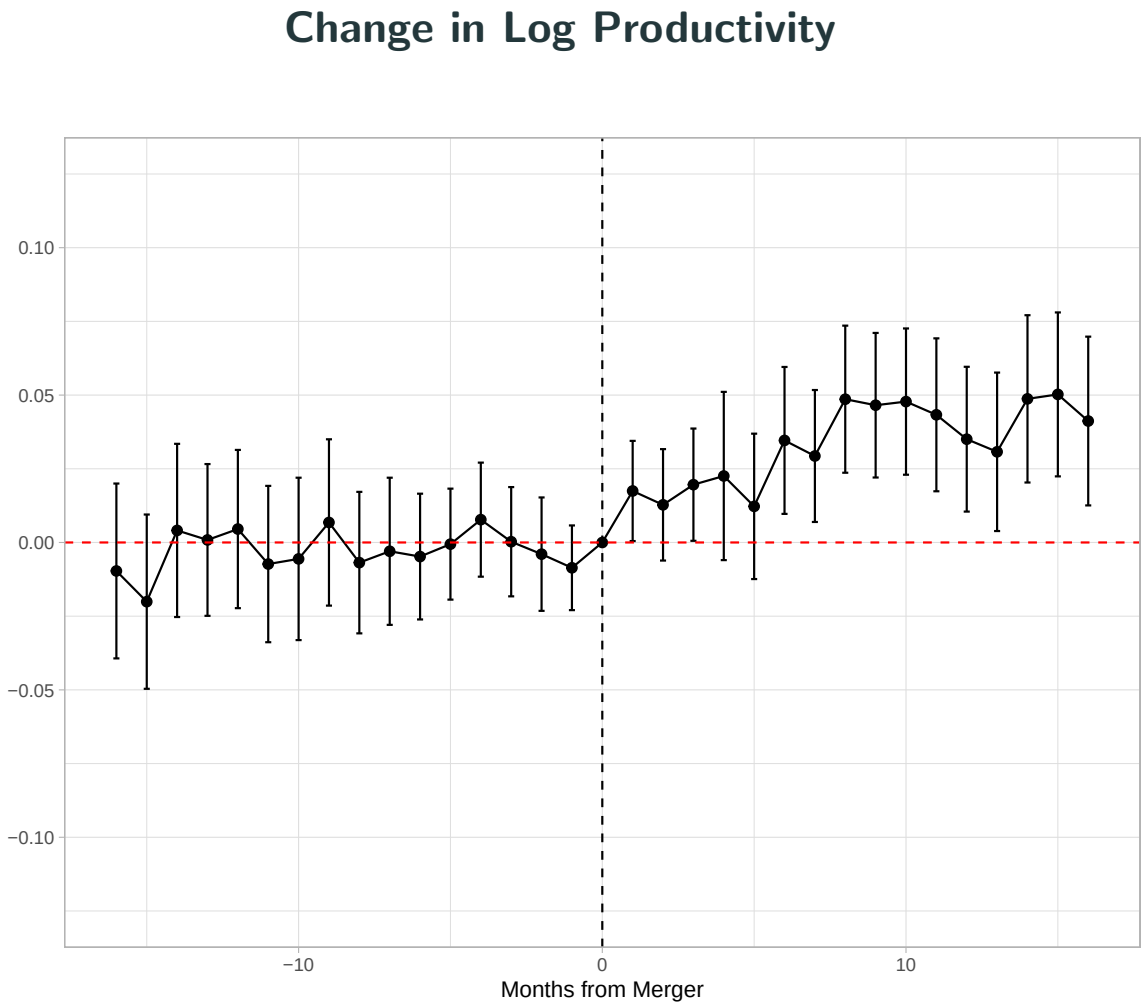
- Comparison: Avg. within-unit annual efficiency increase: 0.2 percent

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 effective

Dynamic Effects



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 Efficiency Gains?

Efficiencies are difficult to evaluate ex ante but factor into merger decisions

Identifying the sources of efficiency gains is important for potential merger evaluations

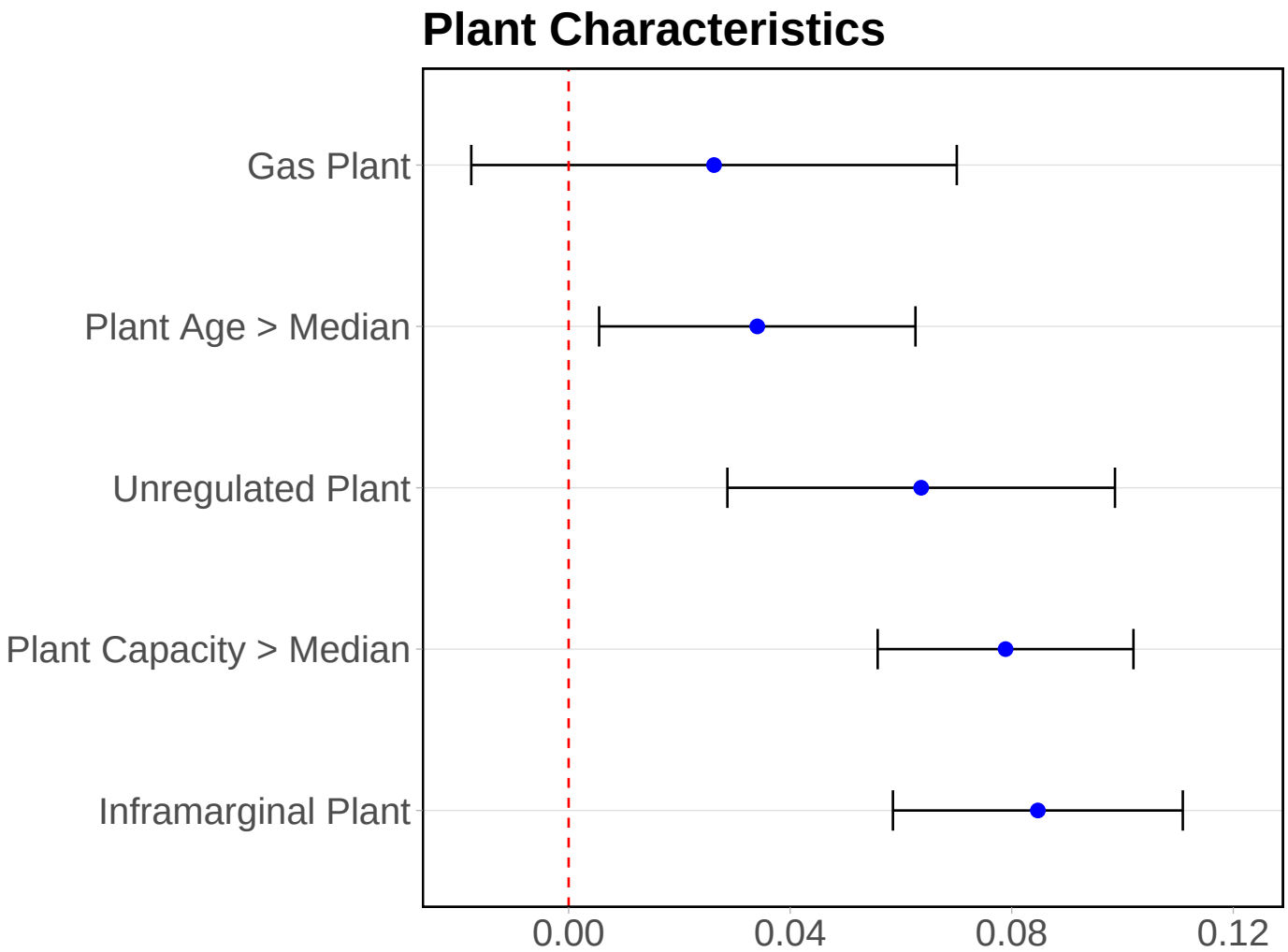
What merger attributes predict efficiency gains?

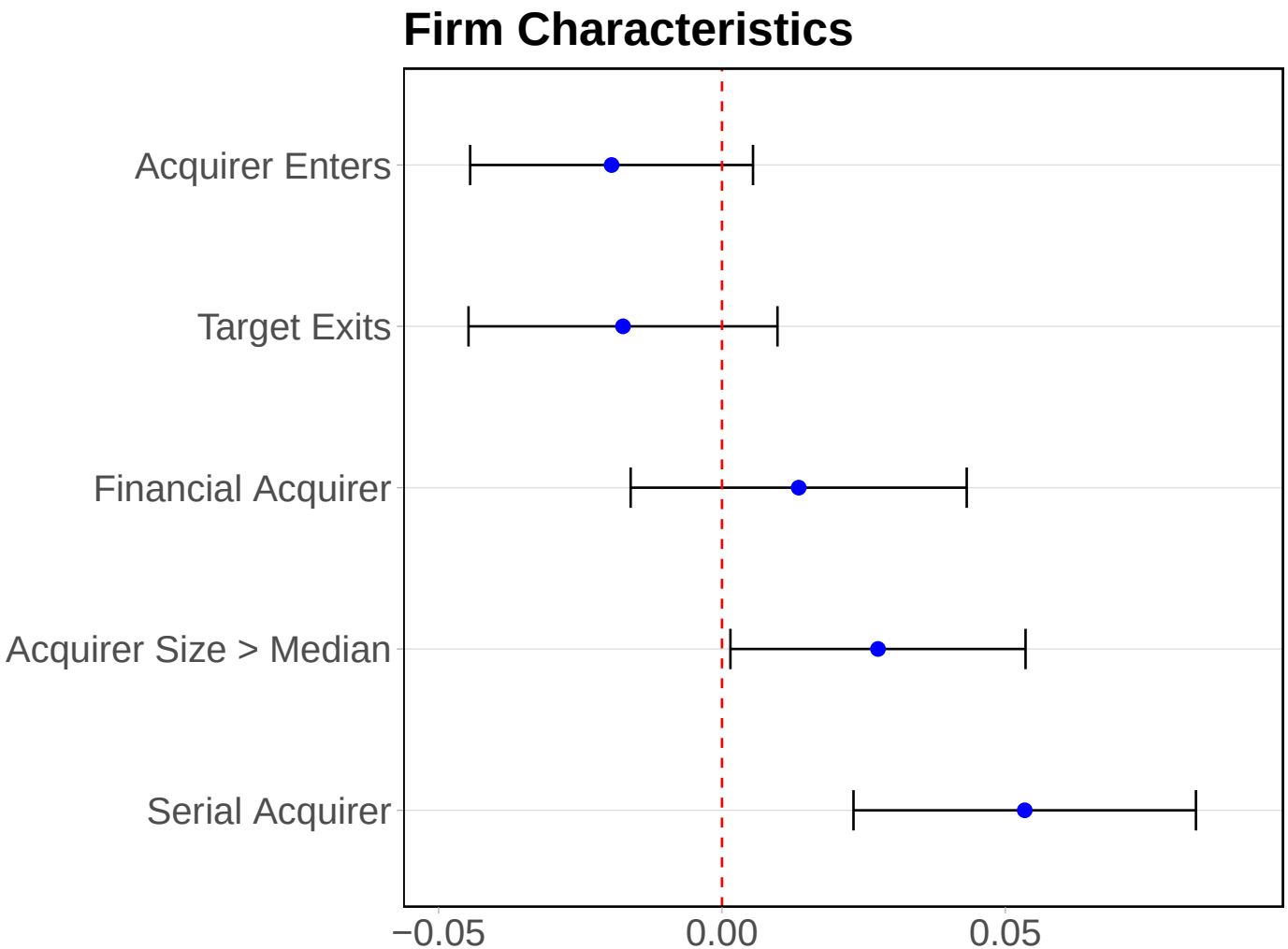
- Plant Characteristics
- Acquirer and Target Firm Characteristics
- Deal Characteristics

Estimate:

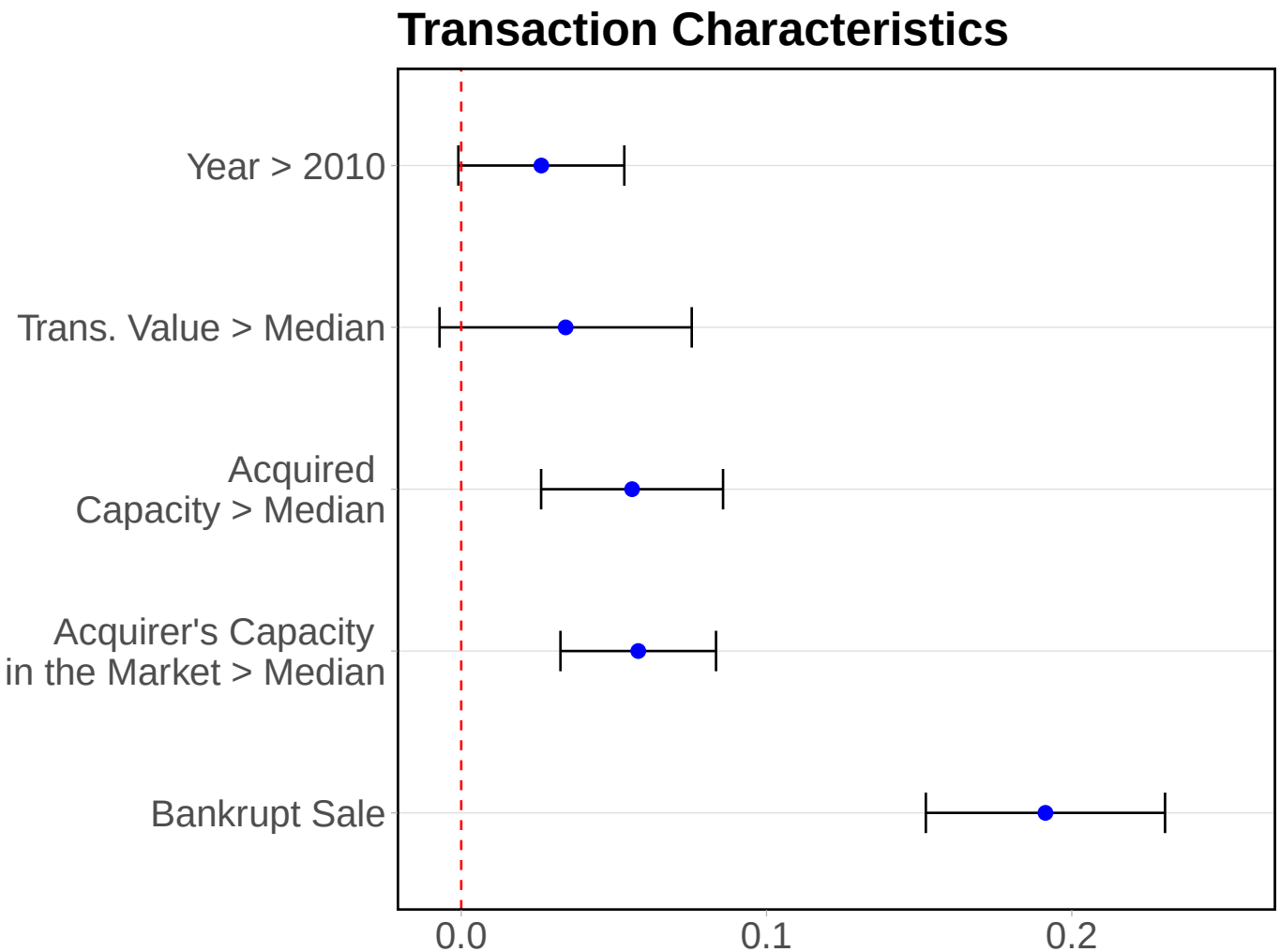
$$log(y_{it}) = \theta_1 \text{treated}_{it} + \theta_2 \text{treated}_{it} \times \mathbf{Z_{it}} + X_{it} + \mu_t + \alpha_i + \eta_{ijt}$$

Plant Characteristics




Firm Characteristics
Acquirer Enters
Target Exits
Financial Acquirer
Acquirer Size > Median
Serial Acquirer
−0.05
0.00
0.05

Deal Characteristics



How do Mergers Reallocate Resources?

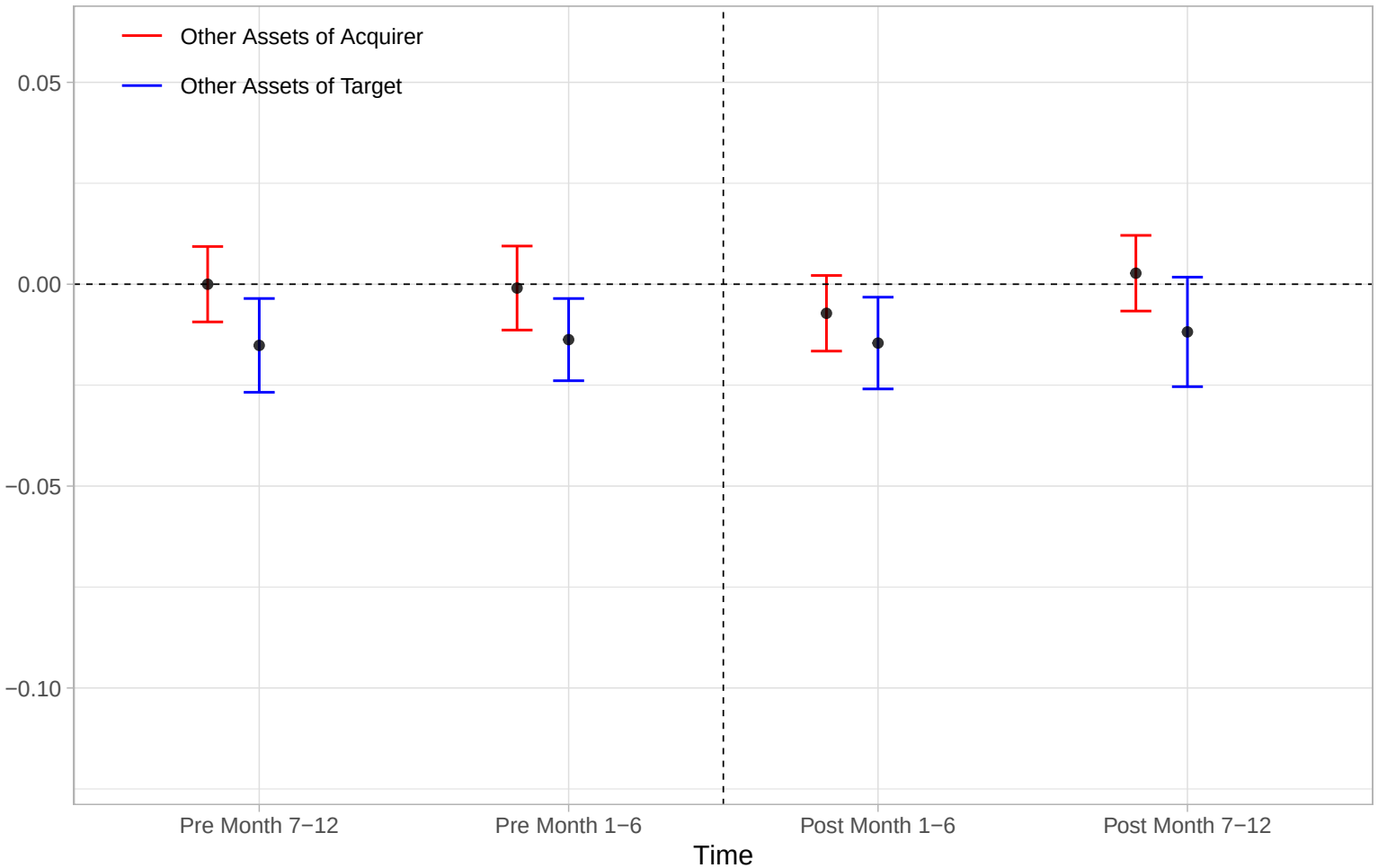
- Important feature of acquisitions: Asset reallocation between incumbent firms
  - 64 percent of transactions target firms sell part of their portfolio and acquiring firm has existing assets

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

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

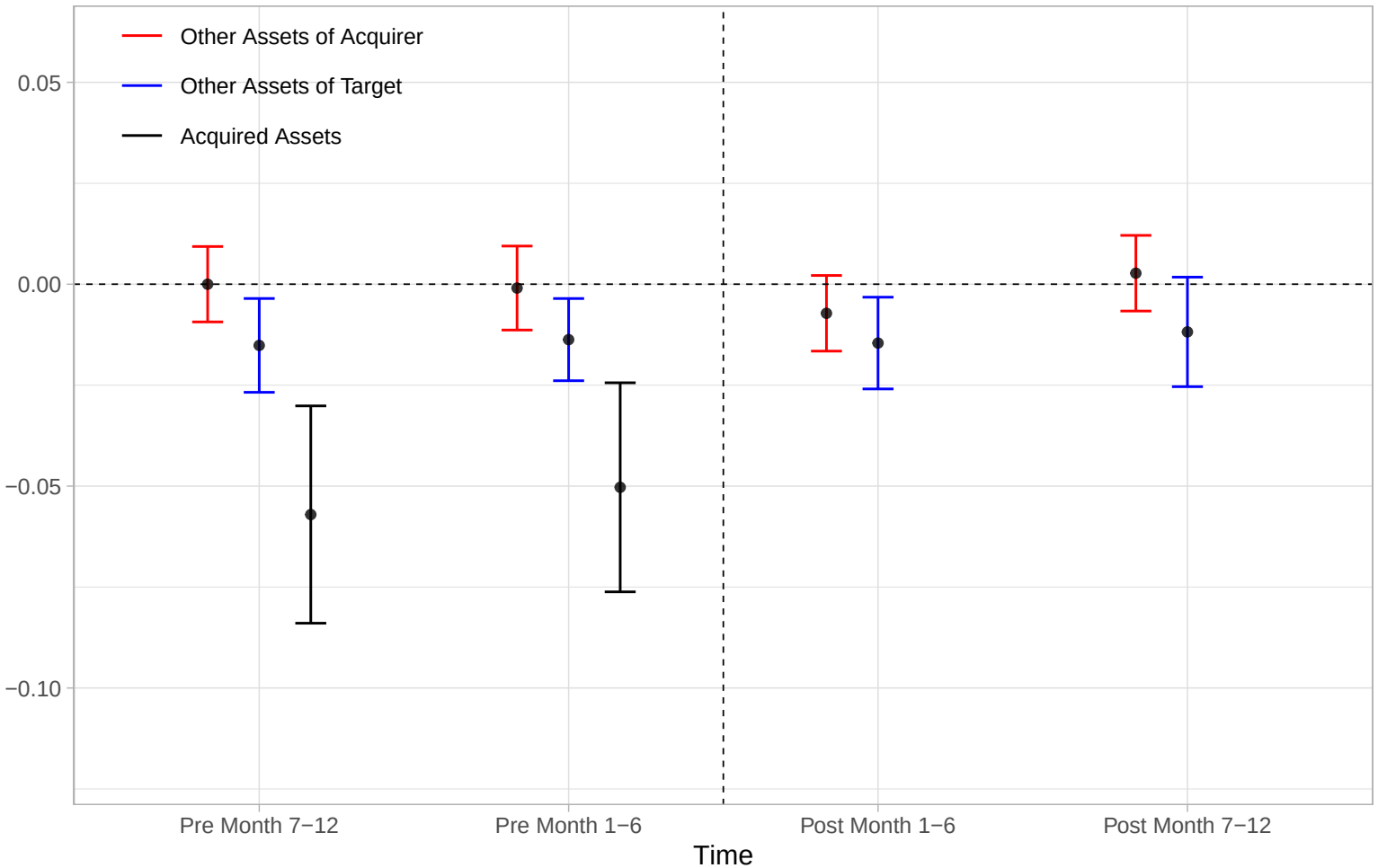
- Estimate DiD with three sets of treatment dummies

Efficiency of Acquirer and Target



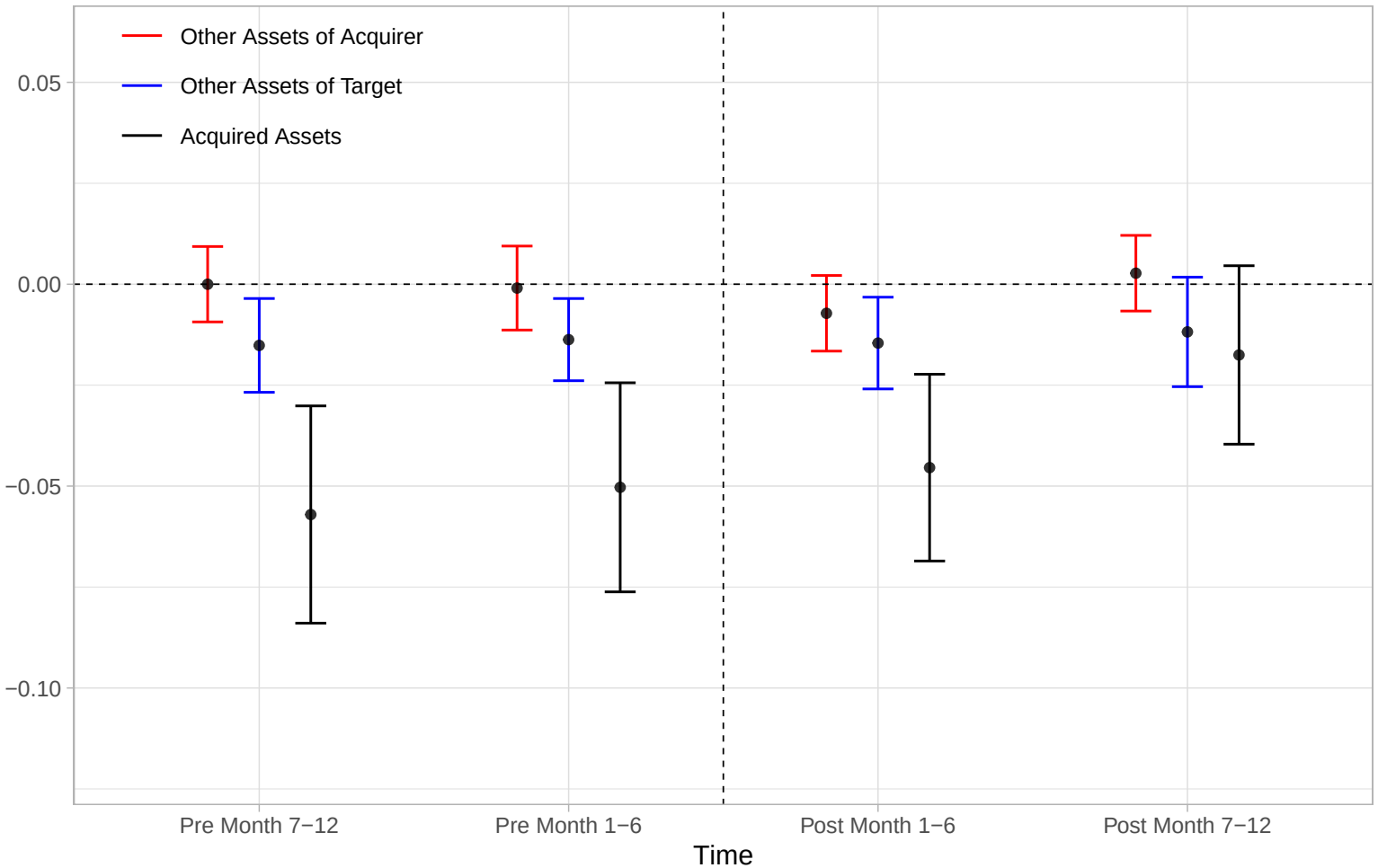
- More efficient firms buy from less efficient firms

Efficiency of Acquirer, Target and Acquired Assets



- Target firm is selling under-performing assets

Efficiency of Acquirer, Target and Acquired Assets



- Efficiency of Acquired Assets Increase

Outline

1. **Industry**
2. **Data**
3. **M&A**
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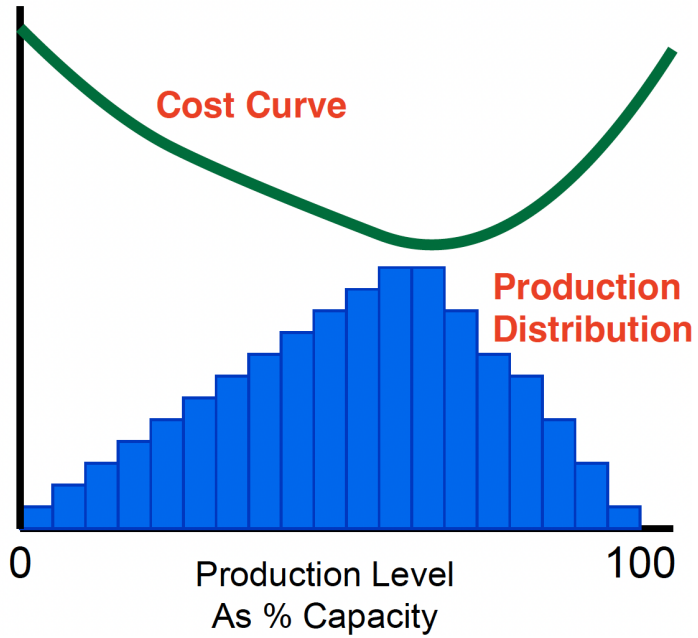
5. **Mechanisms**
   - Sources of Efficiency Gains
   - What Do Acquirer Firms Do?
6. **Conclusion**

Efficiency in Power Plants



Three Sources of Efficiency Gains

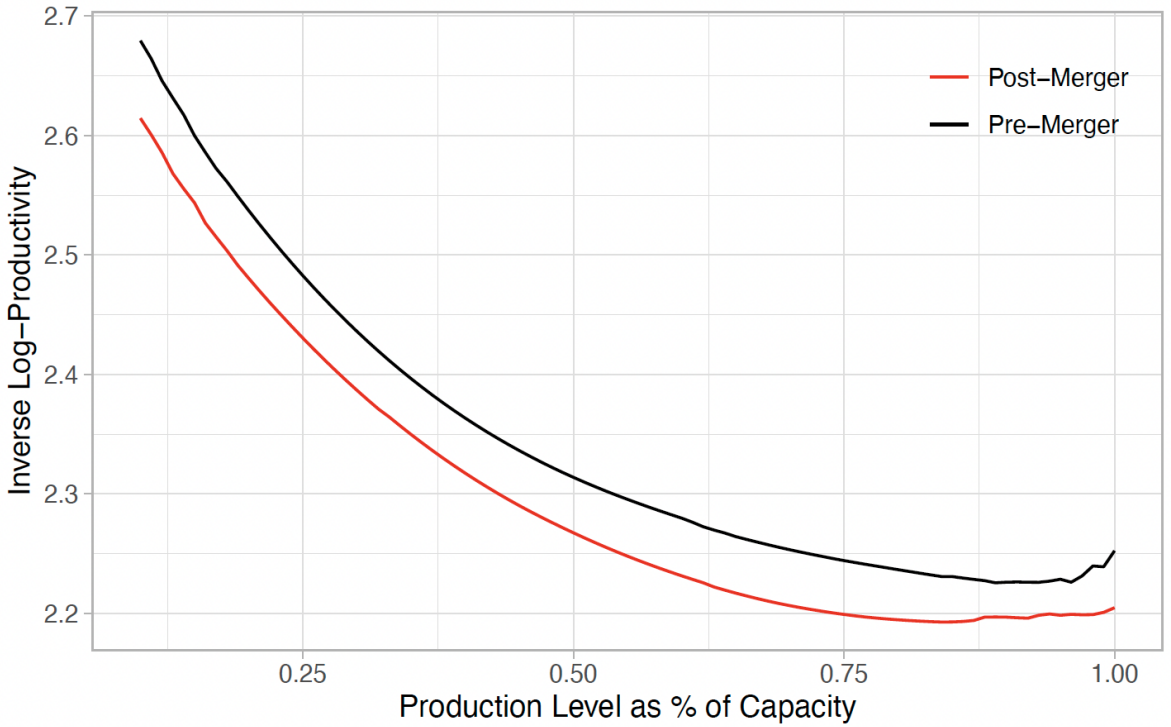
1. Productive Efficiency
2. Improved Capacity Utilization
3. Portfolio Effects (Synergies)

- Develop predictions and test these sources of efficiency gains
  - **Prediction 1:** Cost curve shifts down at every production level
  - **Prediction 2:** Standard deviation of heat rate goes down
  - **Prediction 3:** Efficiency of the existing plants of the acquirer firm 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)



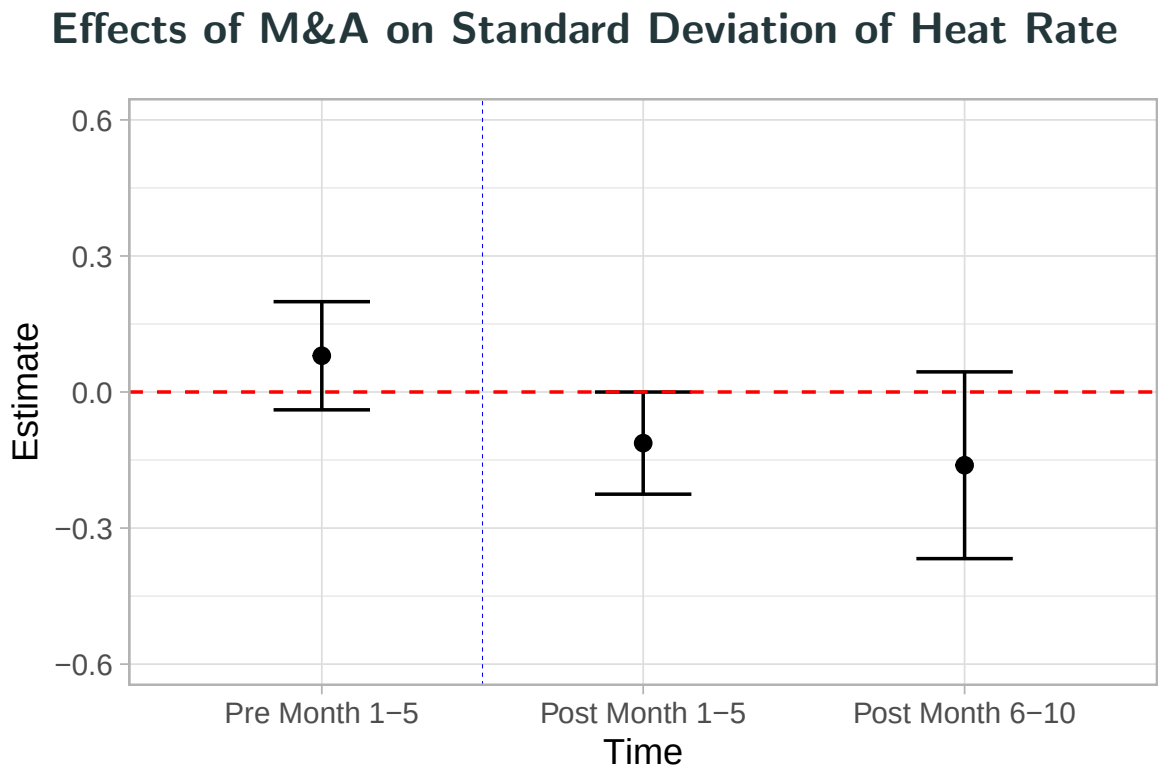
- Average 2.9 percent gain through productive efficiency (75% of total)

▸ 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



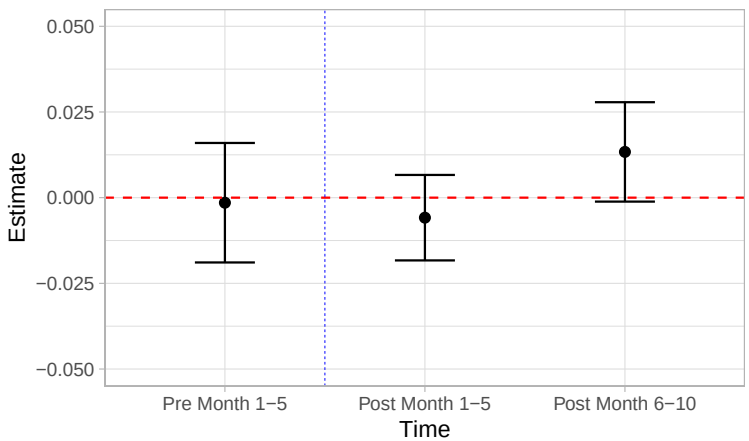
Synergies: Portfolio Effects

Portfolio effects implies for the existing generators of the acquirer

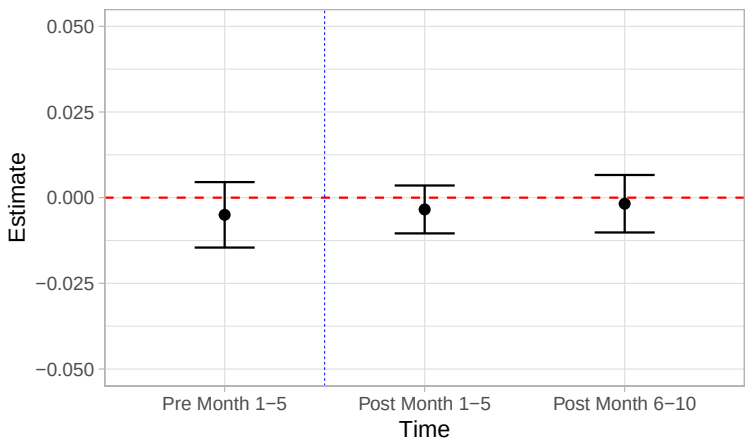
- Efficiency improvements of the portfolio in the **same market**
- No change in **different markets**

Diff-in-diff: Existing portfolio of the acquirer firms is treated

(a) Same Market



(b) Different Market



What do firms do?

What increases productive efficiency? Two potential hypotheses

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

Additional data on operation and production

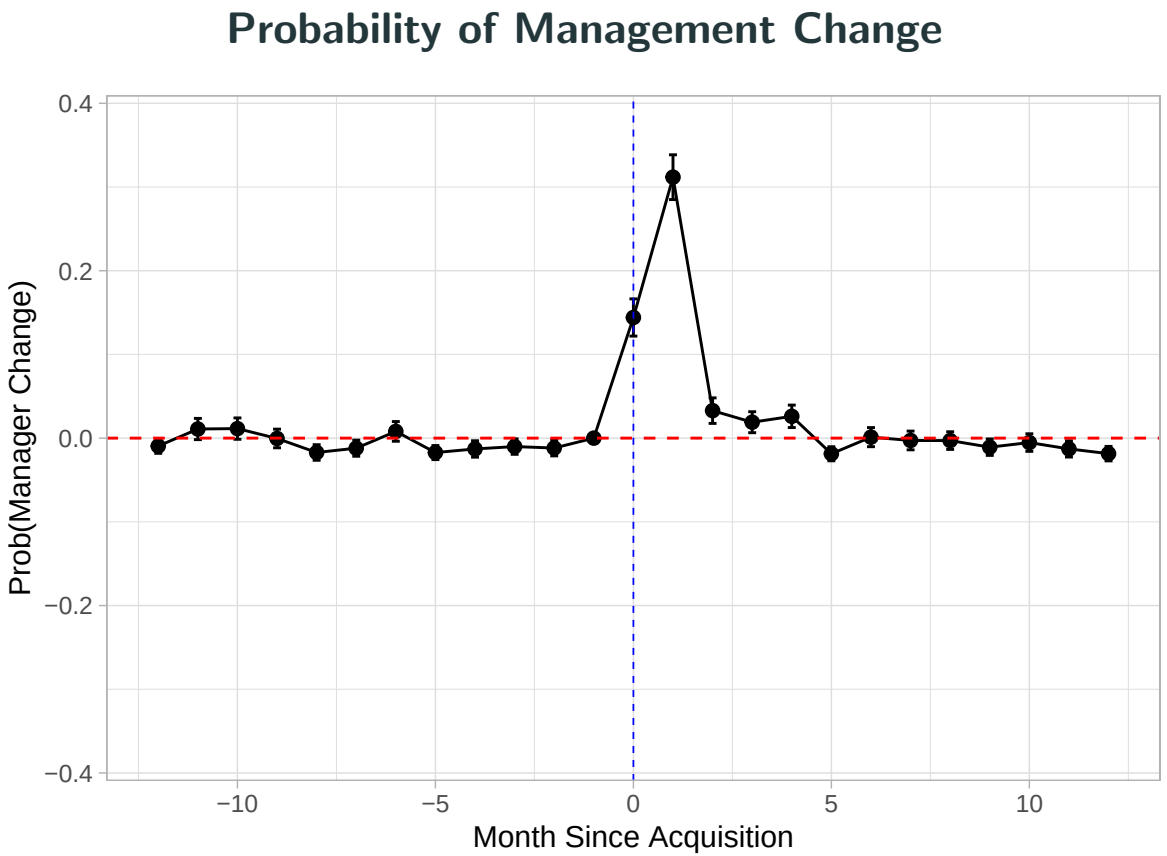
- Manager changes (name and date)
- Annual non-fuel costs, labor and capital expenditure

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

Difference-in-differences 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

Diff-in-diff 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 efficiency gains 5-7 months after acquisition

Who Acquires What Assets from Whom?

- Efficient firms buy assets from less efficient firms.
- Sellers sell under-performing assets

What mechanisms generate efficiency gains?

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