

Do Mergers and Acquisitions Improve Efficiency: Evidence from Power Plants

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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?

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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

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[This paper:](#) Evidence from Power Plants

① Do mergers increase efficiency?

What predicts efficiency gains?

What are the mechanisms?

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What are the mechanisms?

② What do firms do?

Process improvements or capital upgrades

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

- Retrospective study (2000-2020) using all US power plant acquisitions
- A cumulative 95% of 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

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Why Power Plants?: The data does not have the **revenue-is-output problem**

- Precise definition of efficiency measure: Fuel efficiency
- Physical output and input quantities observed, not revenues
- Homogeneous product: No quality changes
- Actual input/output, not survey-based

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

- ① Industry Overview
- ② Data and Summary Statistics
- ③ Empirical Model and Results
- ④ Mechanisms
- ⑤ Conclusion

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

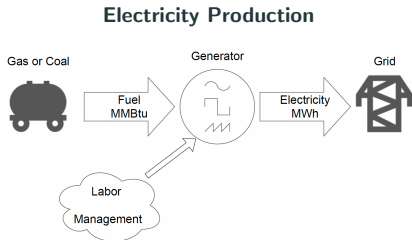
Electricity generation

- A power plant includes multiple generators
- ▶ Our unit of observation is generator

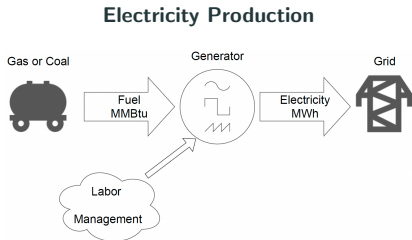
Electricity released to the grid

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

Generator is the unit of production



Generator is the unit of production



Efficiency is measured by **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

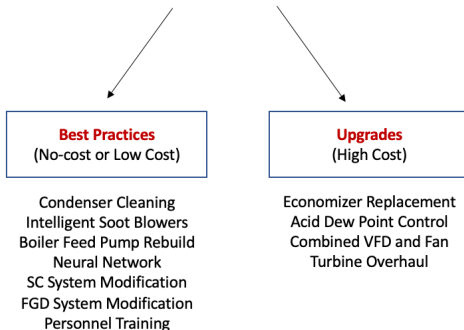
What Firms do to Improve Heat Rate

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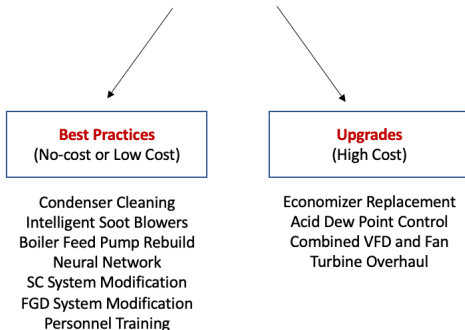
Two Main Ways to Improve Productivity



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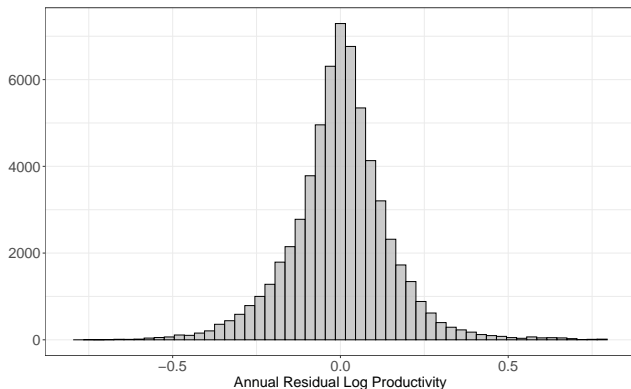
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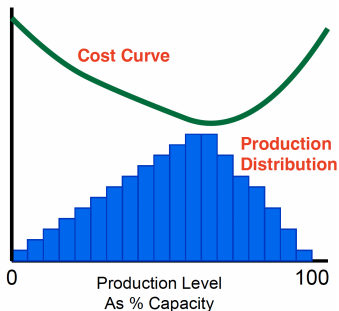


Heat Rate Improvement Conference: Every year, power plant managers gather to discuss these practices

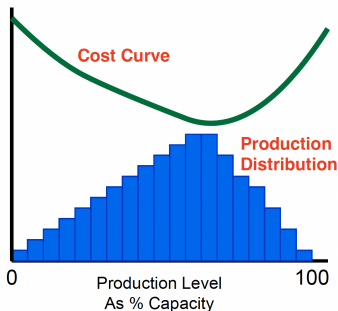
Distribution of Residual Log Productivity



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



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



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- ▶ 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)

- ① Industry
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Production Data and Acquisition Data (2000-2020)

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

Input-Output Data: Hourly Input, Output, Efficiency

Generator Data: Age, Model, Manufacturer, Fuel Type, Capacity, Location

Manager Changes: Plant Managers, Education, Experience

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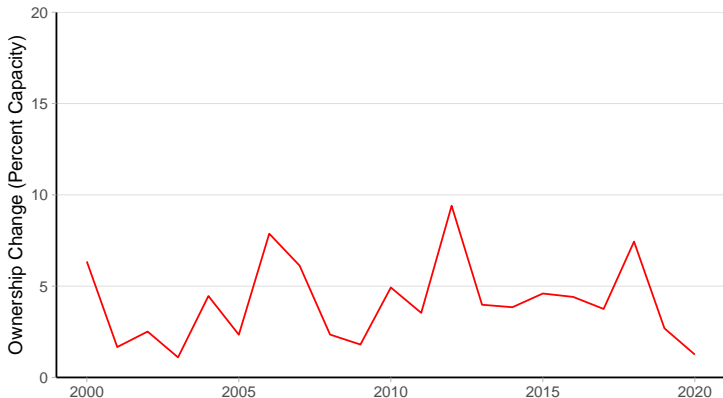
Manager Changes: Plant Managers, Education, Experience

Acquisition Data: S&P Global and Capital IQ 2000-2020

Ownership Data: Time series data on all shareholders of all US power plants

Transaction Data: Deal Size, Buyer, Seller, Announcement and Close Date, Conference Call Transcripts, Deal Description

Ownership Change



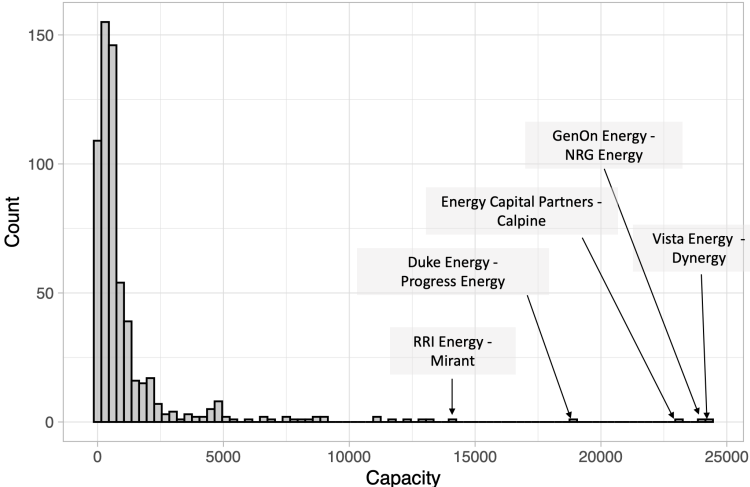
- ▶ Cumulatively, 95% of industry capacity changed ownership (50% distinct plants)

Summary Statistics: Mergers and Acquisitions

	All	Change in Majority Owner
<i>Unit Characteristics</i>		
# of Units	4834	4030
# of Plants	1567	1264
# of Distinct Units	2365	2198
# of Distinct Plants	735	674
<i>Firm Characteristics</i>		
# of Acquirer Firms	267	234
# of Target Firms	266	229
Acquirer Capacity (MW)	5459	5055
Target Capacity (MW)	7025	6912
<i>Transaction Characteristics</i>		
# of Deals	689	532
Deal Size in # of Units	7.0	7.6

Large Heterogeneity in Transactions

Distribution of Capacity that Changes Ownership in Transactions



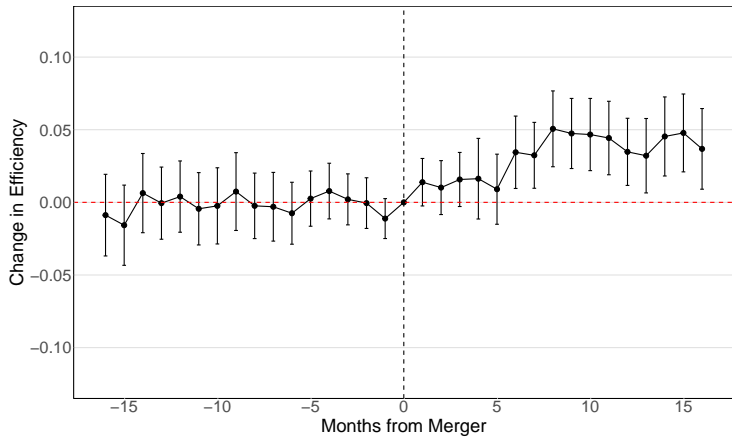
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Differences-in-differences: Estimate how productivity changes over time after the acquisition

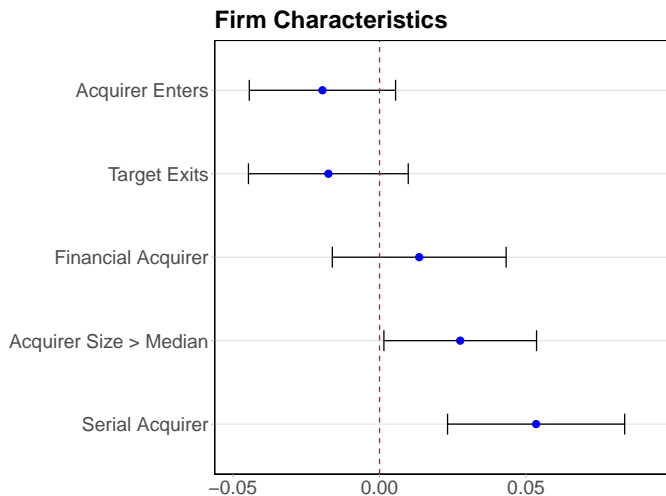
$$\log(y_{it}) = \sum_{s \in (-16, 16)} \delta_s D_{i(t-s)} + X_{it} + \mu_t + \alpha_i + \epsilon_{it},$$

- y_{it} productivity (inverse heat rate)
- Weekly data, at the unit level (i:unit, t:week)
- $D_{i(t-s)}$ is a dummy variable for month $t + s$ for a generator that is acquired at month t
- Controls: time varying generator characteristics, unit fixed effects, state-month fixed effects, week fixed effects

Change in Log Productivity

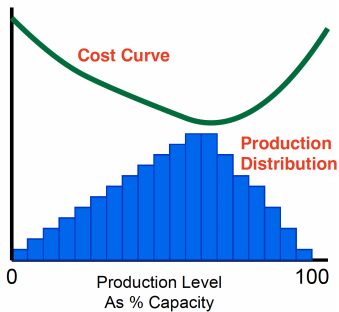


What Firm Attributes Predict Efficiency Gains?



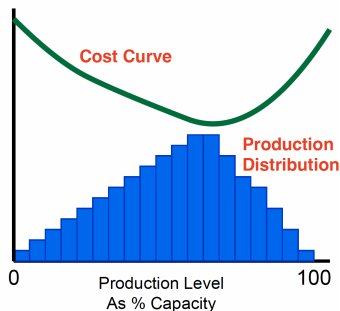
- Larger effect when buyer has more experience in operation and acquisitions

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Three Sources of Efficiency Gains

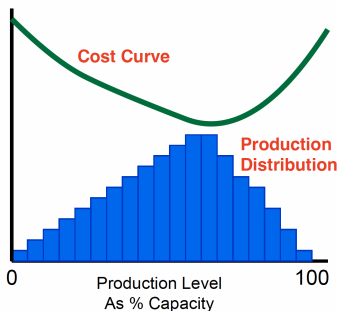
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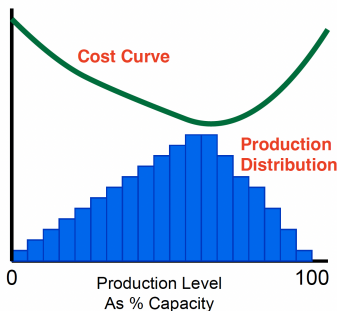
- ▶ Develop predictions and test these sources of efficiency gains
 - **Prediction 1:** Cost curve shifts down at every production level



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- ▶ 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

Productive Efficiency: Cost Curve Estimation

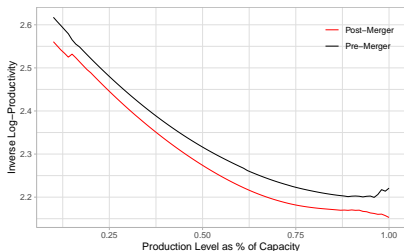
Estimate cost curve pre- and post-merger (one year) nonparametrically

Controlling for ramp-up and ramp-down (change in production)

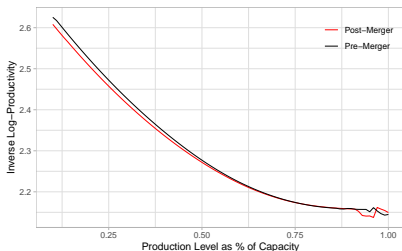
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Estimated Average Cost Curves



(a) Treated Group



(b) Control Group

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

Improvements in Production Allocation: Volatility of Production

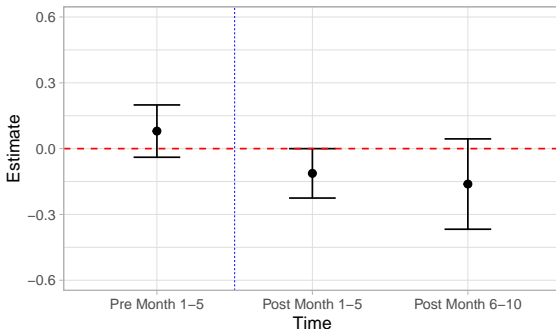
Improved in capacity management implies a decline in volatility of heat rate

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

Improvements in Production Allocation: Volatility of Production

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Effects of M&A on Standard Deviation of Heat Rate



Synergies: Improvements in Existing Assets in the Same Market

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

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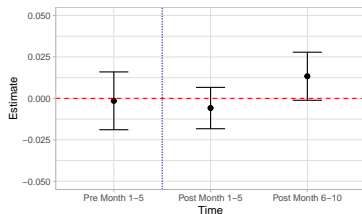
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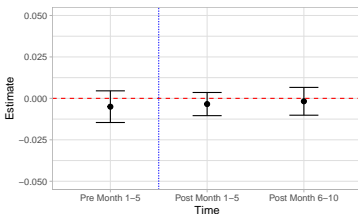
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(a) Same Market



(b) Different Market



What do acquirer firms do?

What increases productive efficiency? Two potential hypotheses

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

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

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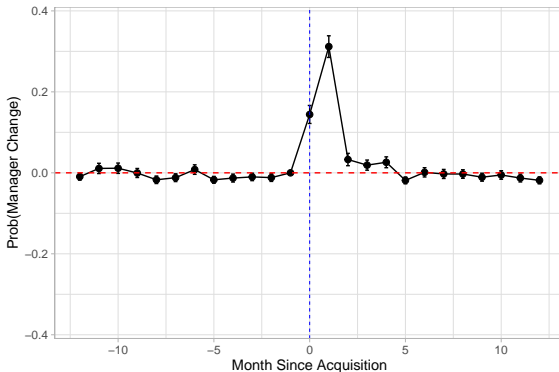
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Question: How do management, capital investment and other inputs change after the acquisition?

Difference-in-differences estimation with outcomes:

- (i) Manager changes, (ii) Capital expenditures, non-fuel cost, labor and expenditures

Probability of Management Change



- ▶ 55% of acquirers replace plant manager within three months
- ▶ 5 percentage points more likely to have a master's degree and 4 percentage points more likely to have a bachelor's degree compared manager changes without mergers

Diff-in-diff estimation. Outcome variables are the logarithm of

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

Annual data for a sample of plants reporting to FERC

Labor and Capital Change After the Merger

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

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

Evidence of efficiency gains from power plant M&A

4 percent efficiency gains 5-7 months after acquisition

The effect is heterogenous

Experience in plant operations and acquisitions leads to higher productivity

What mechanisms generate efficiency gains?

Productive Efficiency: 75 percent

Evidence for adopting best practices rather than costly investment