Electricity restructuring and plant production costs: evidence from the United States, 1995-2011

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Electricity restructuring

- In the mid 1990s, most electricity customers in the U.S. were served by investor-owned, vertically integrated utilities under cost-of-service regulation.
- Between 1995 and 2002 most states considered major regulatory reforms aimed at introducing competition in various utility functions.
- Restructuring was intended to improve efficiency, enhance coordination of grid operations and lower consumer costs.
Many studies have examined the impact of restructuring on plant performance and operations (Bushnell and Wolfram (2005); Chan et al. (2017); Cicala (2015); Craig and Savage (2013); Davis and Wolfram (2012); Fabrizio et al. (2007); Goto and Tsutsui (2008); Kleit and Terrell (2001); Knittel (2002); Zhang (2007)).

Bushnell et al. (2008), Hortaçsu and Puller (2008), Joskow (2006) and Mansur and White (2012) consider efficiency improvements from better coordination of operations and lowering of transaction costs within ISOs/RTOs.

A more recent strand of the literature focuses on the effects of restructuring on retail prices (Borenstein and Bushnell (2015); Hortaçsu et al. (2015); Joskow (2006); Kwoka (2008)).
Contribution

1. Using a differences-in-differences approach, we examine the impact of restructuring on production costs reported by investor-owned fossil fuel power plants.

2. We construct a 17 year (1995-2011) panel data set including many years of post restructuring observations.
Data

- Our primary data source is FERC Form 1
  - Plant characteristics (technology type, construction year, installed capacity, average number of employees)
  - Plant operations (net generation, net peak demand on plant)
  - Capital costs (“Total cost”)
  - Production costs (“Total production expenses”, including fuel costs)
  - Costs are presented in 2010 dollars

- Dates of restructuring are from the EIA and earlier studies (Fabrizio et al., 2007; Craig and Savage, 2013; Chan et al., 2017)
Identification strategy

- We use a differences-in-differences approach
- Restructuring is our binary treatment
- Production costs at the plant level represent our outcome variable
- Treated plants are located in states that have pursued restructuring
- Control plants are located in states that have not pursued restructuring
Definition of restructuring

1. RST1: Access to wholesale electricity markets
   ▶ Treatment is equal to 1 from the year in which utilities in the state were allowed to trade in a wholesale electricity market

2. RST2: Passage and repeal of restructuring legislation
   ▶ Treatment is equal to 1 from the year in which the state enacted restructuring legislation (and set back to zero if legislation was repealed or suspended)
Definition of restructuring

1. **RST1**: Access to wholesale electricity markets
   - Treatment is equal to 1 from the year in which utilities in the state were allowed to trade in a wholesale electricity market

2. **RST2**: Passage and repeal of restructuring legislation
   - Treatment is equal to 1 from the year in which the state enacted restructuring legislation (and set back to zero if legislation was repealed or suspended)

3. **RST3**: Access to wholesale electricity markets for individual power plants
   - Treatment will be equal to 1 if the plant is within a ISO/RTO footprint (ISO/RTO designation is not available before 2010)
Empirical specification

\[
\log(\text{Production costs}_{it}) = \beta_0 + \beta_1 \text{Restructuring}_{st} + X\gamma + \mu_i + \delta_t + \varepsilon_{it}
\]

- where \(i, s\) and \(t\) refer to plant, state and year
- \(\text{Restructuring}_{st} = \{RST1, RST2\}\)
- \(\beta_1\) is our coefficient of interest
- \(X\) includes covariates affecting production costs of electricity generation
- \(\mu_i\) captures within-plant unobserved heterogeneity
- \(\delta_t\) captures annual shocks common to all plants that may affect production costs
- \(\varepsilon_{it}\) is an i.i.d. error term
Identification assumptions

1. **Parallel trends assumption**
   - Violation means that we cannot attribute the effect on production costs solely to restructuring

2. **Exogeneity of treatment**
   - May be violated if plants select into treatment based on unobservable characteristics or if restructuring activity is affected by production costs
\[ \log(\text{Production costs}_{it}) = \beta_0 + \beta_1 \text{Restructuring}_{st} + X\gamma + \mu_i + \delta_t + \varepsilon_{it} \]

<table>
<thead>
<tr>
<th></th>
<th>(1) RST1</th>
<th>(2) RST1</th>
<th>(3) RST2</th>
<th>(4) RST2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restructuring</td>
<td>-0.068*</td>
<td>-0.035</td>
<td>0.010</td>
<td>0.011</td>
</tr>
<tr>
<td>(Log) net generation</td>
<td></td>
<td>0.345***</td>
<td></td>
<td>0.345***</td>
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<tr>
<td>Capacity factor</td>
<td>-0.197**</td>
<td></td>
<td>-0.198**</td>
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</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td>-0.001</td>
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</tr>
<tr>
<td>Avg. no. employees</td>
<td>5.37e-12***</td>
<td></td>
<td>5.51e-12***</td>
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<tr>
<td>Plant fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Observations</td>
<td>11,182</td>
<td>11,135</td>
<td>11,182</td>
<td>11,135</td>
</tr>
<tr>
<td>Adjusted (R^2)</td>
<td>0.920</td>
<td>0.943</td>
<td>0.920</td>
<td>0.943</td>
</tr>
</tbody>
</table>

Standard errors are clustered by plant. * , **, *** indicate significance at 10%, 5%, and 1% levels, respectively.
Robustness checks I: Endogeneity

- Exogeneity of treatment may be violated if states initiated restructuring in response to unobserved time-varying factors affecting the dependent variable (plant generation costs).
- We believe this violation is unlikely to happen.
- We used instrumental variables as an alternate method to identify variation in restructuring policy.
- Instruments are state-level political variables that likely affect the restructuring decision but are not directly related to plant generation costs.
- Statistical tests suggest that endogeneity bias is not a concern.
Conclusions and future work

- We examine the impact of electricity restructuring on plant operating efficiency by considering production costs reported by investor-owned utilities.
- We apply a differences-in-differences estimator to a panel data set from 1995 to 2011.
- Preliminary results suggest that restructuring did not lead to reductions in production costs of existing fossil fuel plants.
- Future work will refine model specification (through inclusion of additional covariates, e.g. input prices) and consider differences-in-differences estimation with matched plants.
Questions?

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Bibliography


Robustness checks II: Parallel trends assumption

- We conduct placebo tests by assigning a value of 1 to treatment in 1996 for states that allowed utilities to trade in wholesale markets since 1997

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
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<tbody>
<tr>
<td>Pseudo restructured</td>
<td>-0.011</td>
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<tr>
<td>(Log) net generation</td>
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<tr>
<td>Capacity factor</td>
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<td>Observations</td>
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<tr>
<td>Adjusted $R^2$</td>
<td>0.853</td>
</tr>
</tbody>
</table>

Standard errors are clustered by plant.
* * * indicate significance at 10%, 5%, and 1% levels, respectively.