***IMPACTS OF ELECTRICITY RESTRUCTURING***

***ON PLANT GENERATION COSTS IN THE u.s.***

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## Overview

The electricity sector has long been regarded as a natural monopoly. Under the regulatory model that is still in use in many U.S. states, vertically integrated utilities perform all activities required to supply electricity to customers within a defined geographic area, and charge rates set by cost-of-service regulation that allow recovery of their operating expenses. This creates little incentive for efficient plant operations, because utilities are compensated regardless of their level of performance. In light of the limitations of cost-of-service regulation, several states in the U.S. restructured their electricity markets in the late 1990s. Restructuring was intended to produce cost efficiencies and price benefits to the consumers, and led to separation of the generation sector from the transmission and distribution sector, and establishment of wholesale electricity markets.

Several empirical papers have evaluated the effects of electricity restructuring in the United States (Kwoka, 2008). Bushnell et al. (2008) and Mansur and White (2012) consider its impact on the efficiency of wholesale power markets. Another part of the literature has examined the effects of electricity restructuring on plant operations. In particular, Fabrizio et al. (2007), Craig and Savage (2013) and Chan et al. (2017) consider the effects of restructuring on efficiency using a differences-in-differences approach. Using data from 1981 to 1999, Fabrizio et al. (2007) find evidence that investor-owned plants in states that allowed competition experienced higher efficiency gains than publicly owned plants. Restructuring effects are modeled through state-specific dummies equal to 1 from the year in which each state held formal hearings to begin the restructuring process, the year in which each state passed restructuring legislation, and the year in which each state implemented retail competition. Craig and Savage (2013) also examine the effects of restructuring on thermal efficiency of electricity generation using plant-level annual data from 1996 to 2006, and find that access to wholesale markets and retail competition increased efficiency by about 9% regardless of ownership type. Restructuring effects are modeled through state-specific dummies equal to 1 from the year in which utilities were allowed to participate in wholesale electricity markets, and year in which each state implemented retail choice. Finally, Chan et al. (2017) assess the impacts of restructuring on heat rates, fuel costs and capacity utilization of coal-fired power plants from 1991 to 2005. Similarly to Fabrizio et al. (2007), they model restructuring effects through state-specific dummies equal to 1 from the year in which each state held formal hearings or authorized legislation to begin the restructuring process.

Using annual data for investor-owned large thermal generating plants in the U.S. from 1995 to 2011, we estimate the impact of electricity restructuring on plant generation costs. Our study differs from previous work in several ways. First, our dataset includes many years of post restructuring observations: this allows us to examine the effects of restructuring in greater detail, compared to studies having little data after restructuring was in effect (e.g., Fabrizio et al. (2007)). Second, earlier papers have defined restructuring either based on participation in wholesale markets and retail access (Craig and Savage, 2013), or on dates of hearing/legislation authorizing restructuring (Fabrizio et al., 2007; Chan et al., 2017). Our proposed approach will account for both aspects. Our third contribution lies in analyzing the impact of restructuring on the total cost of generating electricity at each power plant. Zhang (2007) examines per unit average production costs, but only focuses on nuclear plants. Other papers in the literature examine the impact of restructuring on heat rates, fuel input, capacity factors, employment, coal procurement costs, and nonfuel expenses.

## Methodology and Data

Our identification strategy to estimate the effectiveness of restructuring consists in using the variation in restructuring activity within utilities over time and across utilities. In effect, we use the method of differences-in-differences. Differences-in-differences (DD) is used to determine causal relationships, and its basic idea is to identify a policy intervention or treatment by comparing the difference in the outcomes before and after the intervention for the treated groups with the difference for the untreated groups. It is, therefore, crucial to have observations from the treated and untreated units both before and after the policy intervention. In our analysis, we consider treated units to be those plants located in states that have undergone restructuring activity.

The validity of the DD approach rests on two key identification assumptions. The first is that the trends in the outcome variable are similar for both treatment and control groups in the absence of treatment, referred to as the parallel (or common) trends assumption. The violation of this assumption means that we cannot attribute the effect of the outcome solely to the policy intervention. The second assumption is that the assignment of a unit to the treatment group is exogenous. This may be violated if there is selection based on unobservable characteristics of units, or if the policy intervention is affected by the outcome. We will perform robustness checks to analyze if these issues are a concern. The empirical specification can be written as:



where *i* and *t* are indexes for plant and year, respectively,is our coefficient of interest, the matrixconsists of other covariates (besides the decision to restructure the market) affecting the total cost of electricity generation, captures within-plant unobserved heterogeneity, captures the annual nation-wide macroeconomic shocks common to all individual plants that may affect the total cost of production, andis an i.i.d. error term. The variableis binary and indicates if plant *i* is located in a state that has undergone electricity restructuring in year *t*. We will modify equation (1) by using state-time or region-time fixed effects to account for differences between the eastern and western parts of the U.S. Other covariates of interest are the price of labour, price of fuel, and price of capital. Since these prices will be at the state level, state-time fixed effects will capture these differences and, hence, region-time fixed effects may be more appropriate.

Our dataset includes publicly available data on plant owner, characteristics (i.e., technology type, vintage and installed capacity), operations (i.e., net generation), average number of employees, and costs (i.e., fuel expenses and production expenses) from FERC Form 1. Information on restructuring activity comes from the Energy Information Administration and earlier studies (Craig and Savage, 2013; Fabrizio et al., 2007.; Chan et al., 2017).

## Preliminary results

|  |  |  |
| --- | --- | --- |
|  | (1) | (2) |
| Restructuring | -0.058c (0.031) | -0.075b (0.029) |
| Log (net generation) |  | 0.058a (0.011) |
| Load factor |  | 0.022(0.021) |
| Plant fixed effects | Yes | Yes |
| Year fixed effects | Yes | Yes |
| Observations | 11,373 | 10,000 |
| Adjusted R2 | 0.950 | 0.962 |

Preliminary results for our fixed effects regressions are presented in Table 1. The estimated coefficient for the Restructuring variable in column (2) indicates tat total cost of generation is lowered by 7.5% for plants located in states that have undergone restructuring.

a: significant at the 1% level;

b: significant at the 5% level;

c: significant at the 10% level.

Standard errors (clustered by plant) are reported in parenthesis.

## Conclusions

Using annual data for investor-owned, large thermal generating plants in the U.S. from 1995 to 2011, we estimate the impact of electricity restructuring on power plant generation costs. Our identification strategy consists in using the variation in restructuring activity within utilities over time and across utilities (differences-in-differences approach). Our data includes many years of post restructuring observations and adopts a novel approach to define restructuring, based on utility participation in electricity markets and dates of state restructuring hearings/legislation. In line with earlier studies, our preliminary results suggest that restructuring appears to have reduced the total cost of producing electricity in the United States.

## References

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