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Do Subsidies Extend Lifeline to Coal?

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Abstract

Emphasis on cleaner power sector and the need for maintaining system reliability often have contrasting influence on fossil fueled electricity generation. This paper contributes to the literature by evaluating the impact of capacity subsidies, which were introduced by the northeastern Regional Transmission Organizations to ensure resource adequacy, on the retirements of electricity generation in the US. Using state level data, I present evidence that states with capacity mechanisms have experienced decelerated retirements compared to states with no capacity markets overall, but not for coal-fired generation in particular. Findings also suggest that renewable energy policies like the Renewable Portfolio Standard are more effective in achieving sustainable energy goals.

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1 Introduction

There has recently been an overwhelming emphasis on the need for greater integration of cleaner energy sources in the US electricity sector. At the same time, concerns about system reliability have led some regions in the US to adopt 'capacity markets' to subsidize electricity generation to ensure adequate supply for meeting future demand. This paper aims to evaluate the effect of these capacity markets on potentially extending the life of generators at risk of retirement, particularly coal-fired plants.

Most of US coal, 93%, is used for electricity generation, and between 2008 and 2015, coal production in the US declined by 23% (Culver et al. 2016). Share of coal-fired electricity fell from 50% of total generation in 2008 to 37% in 2012, and state policies like Renewable Portfolio Standards (RPS) tend to empower clean energy sources over vulnerable coal in most of the 29 states which have RPS mandates (Fleischman et al. 2013). In other literature, argument has been made that the falling prices of natural gas starting early 2000s is the main driver of coal plant retirements. McMahon et al. (2016) highlight how even the most efficient coal plants, that are well-controlled for emissions, are facing difficulties in competing in markets with low gas prices.

The market development of interest in this paper, i.e. capacity payments[1], were introduced by the northeastern Regional Transmission Organizations (RTOs) in the US to maintain system reliability by subsidizing the fixed costs of investment in electricity generation. Capacity markets were meant to compensate for the 'missing money' problem: marginal generators typically run for only a few peak hours in a year, and many regions have imposed price caps that prevent prices to reflect the true cost of scarcity (Joskow 2008; Newbery 2016). Since existing power plants have lower revenue requirement to continue operating than newer plants, older power plants are more likely to qualify for capacity payments under the current design of these markets. That capacity markets provide comparable compensation to existing generation and new generation, I hypothesize that they could be prolonging the life of otherwise at-risk fleet. A 2011 report by Synapse Energy highlights how Pennsylvania-New Jersey-Maryland Interconnection's (PJM) capacity market, called Reliability Pricing Model (RPM), has made most payments to incumbent generators supporting coal plants that would have otherwise retired.

Empirical research on the impact of capacity markets is very limited. In this paper, I assess the impact of capacity markets on the retirements of power plants in the US. The potential deceleration of retirements and the lack of sufficient revenue certainty for the financing of new projects under these markets 'may actually prevent the construction of newer, more efficient, and cleaner generating stock to replace aging and higher-emissions resources' (Hausman and Whittenstein 2011).

The next sections comprise of a discussion of relevance of capacity markets to electricity generation retirements and the research question of the paper, followed by explanation of data, methodology, and results of the analysis. Finally, conclusions are presented at the end.

[1]Capacity payments is the term used for remuneration under capacity markets

2 Data, Identification, and Results

2.1 Data and Model Specification

I use annual state level data for 15 years between 2000 and 2014. The sources for data include US Energy Information Agency (EIA), Federal Energy Regulatory Commission (FERC), Bureau of Economic Analysis (BEA), States' Public Utilities Commissions, and US Census Bureau.
The equation for estimation takes the following form:

$$\mathrm{Y}_{i,t} = \beta \mathrm{X}_{i,t} + \upsilon_{i,t}$$

where subscripts i and t, refer to state and year, respectively.
The dependent variable is *Log of retirements (measured in megawatts)* in a state in a given year. The explanatory variable of main interest is *State capacity market shares*, which is the percentage of state's electricity customers that are served by utilities covered under capacity market auctions. Other independent variable include *Renewable portfolio standards - compliance*, which are state mandated goals for the percentage of electricity to be produced by renewable sources (yearly compliance benchmarks are used here), *Share of natural gas fueled generation in state's total generation*, to control for the expanding role of natural gas fueled generation[2], *Log of state's installed generation (measured in megawatts)*, to account for differences in states' sizes, three year moving averages of *state population* and *state income per capita*, to capture state's demand for electricity, and three year moving averages of *coal price* and *natural gas price* delivered to electric generators in each state. State fixed effects are also used in the estimations.
Over the time period 2000-2014, natural gas plants constituted around 48% of all retirements, followed by coal at 31% and petroleum at 15%. Table 2 in the Appendix reports the summary statistics for the data. For estimation, both total retirements and coal retirements are used as dependent variables, respectively. In order to address the potential self selection bias of states into capacity markets I use the following instrument variables in the two-stage least squares model:
1. Percentage of Republican representatives in the house - since Republican majority states have traditionally been associated with market-oriented policies, like disapproval of price caps[3], there would be lesser need for capacity markets to compensate for missing money.
2. Percentage of residential customers - legislatures and commissions in states with a higher proportion of residential customers are likely to be leaning towards more pro-consumer policies to avoid blackouts[4].
First stage estimations are reported in the Appendix Table 3.

[2]Since natural gas is fueling younger/newer power plants during this period (EIA 2011), the share of natural gas power plants as a control variable is indirectly capturing the age of power plants in the states

[3]See Hlasny 2017, Widmaeir 2005, Navarro 2004, and Rosston et al. 2008 for reference

[4]Residential customers are more dependent on centralized sources/grid for electricity need as opposed to industrial and commercial customers (which are more likely to have back-up options)

2.2 Results

The main results in Table 1 show that, in the 2SLS model, as state's capacity market share increases by one percentage point, total retirements decrease by 2.7%, which implies that capacity markets slow down retirements overall by enabling aging electric generators to operate for more years.

As expected, the positive coefficients on values for renewable portfolio compliance suggest association with increased retirements. In the 2SLS model, it can be seen that a one percentage point increase in RPS compliance drives a 9.14% increase in retirements, which is a very strong influence. Same is true for the directional effects of state's size (though statistically insignificant) and share of natural gas in generation. The negative coefficients on coal price imply that as coal becomes cheaper, it leads to increased retirements of natural gas and petroleum fuel plants. Income growth has the strongest effect among demand-side variables, as can be seen in the 2SLS model that as the 3-year average growth rate increases by 1%, retirements decrease by 7.4%. Looking at coal retirements results, the 2SLS model suggests a negative but statistically insignificant effect of capacity markets on coal retirements, which is interesting, because it suggests that capacities subsidies aren't particularly saving coal plants from retirements. One percentage point increase in renewable portfolio standard compliance increases coal retirements by 5.7%, which is very significant. What is interesting here is the statistically insignificant and negative coefficient on coal price growth, which highlights the inconsequential role of fuel price in supporting or slowing down the closure of coal fired power plants.

3 Conclusion and Implications for Public Policy

This paper empirically evaluates the impact of capacity payments on states' fossil fuel powered fleet in the US.

Findings suggest that as capacity markets subsidize existing generation, they slow down retirements overall by extending the financial assistance needed by plants to survive longer, but do not have significant impact on coal retirements. This is an interesting finding in that it suggests that even strong financial incentives, like capacity subsidies, are not helpful in prolonging the life of coal fired plants in the face of lasting inefficiencies and enormous regulatory/environmental pressures.

It is found that increases in renewable portfolio standard compliance are associated with large and statistically significant increases in both total and coal retirements. This reaffirms the value of renewable energy policy in achieving clean energy goals, and also highlights the need for more refined reliability mechanisms in electricity markets that avoid conflict with environmental aspirations.

Table 1: Main Regression Results

Dep Var: Log Retirements	Total OLS	Total 2SLS	Coal OLS	Coal 2SLS
Capacity market share	-0.000578	-0.0267*	0.00224**	-0.0129
	(0.00119)	(0.0145)	(0.00108)	(0.0115)
Renewable portfolio standard	0.0389***	0.0914***	0.0271***	0.0575**
	(0.00940)	(0.0314)	(0.00852)	(0.0248)
Log total installed generation	0.539*	0.223	0.681***	0.497
	(0.284)	(0.407)	(0.257)	(0.322)
Share of natural gas in generation	0.0170***	0.0332***	0.0119***	0.0213***
	(0.00385)	(0.0102)	(0.00349)	(0.00810)
Natural gas price growth	0.934**	0.243	0.430	0.0279
	(0.367)	(0.609)	(0.333)	(0.482)
Coal price growth	-1.905*	-1.096	-2.387**	-1.917
	(1.125)	(1.523)	(1.019)	(1.205)
Income growth	-4.477***	-7.432***	-1.333*	-3.050**
	(0.828)	(1.950)	(0.750)	(1.543)
Population growth	-5.775	-10.42	-5.756	-8.457
	(4.746)	(6.658)	(4.301)	(5.268)
Constant	-1.393	0.0211	-2.629**	-1.808
	(1.226)	(1.768)	(1.111)	(1.399)
N	765	765	765	765
Fixed Effects	Yes	Yes	Yes	Yes
Instruments		Rep,Res		Rep,Res

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Appendix

Table 2: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent Variables					
Log total retirements (MW)	765	1.096	1.039	0	3.717
Log coal retirements (MW)	765	.384	.817	0	3.46
Explanatory Variables					
State capacity market share	765	15.568	35.098	0	100
Renewable portfolio standard - compliance	765	2.601	5.749	0	29
Log state's total installed generation (MW)	765	4.116	.495	1.033	5.089
State's share of natural gas generation	765	20.265	22.536	0	100
Natural gas price growth (MA3)	765	.096	.082	0	.713
Coal price growth (MA3)	765	.034	.029	0	.173
Income growth (MA3)	765	.03	.039	0	.17
Population growth (MA3)	765	.01	.008	0	.05
Instrument Variables					
State's residential customers share	765	86.587	2.315	78.772	90.594
State's Republicans' share in the house	765	52.402	31.964	0	100

Table 3: First Stage Results for Capacity Market Share

	(1)
Dep Var: State capacity market share	
State's residential customers share	2.778***
	(0.526)
State's Republicans' share in house	-0.140***
	(0.0457)
Renewable portfolio standard - compliance	0.953***
	(0.273)
Log state's total installed generation (MW)	-12.42***
	(2.581)
State's share of natural gas generation	0.169***
	(0.0574)
Natural gas price growth (MA3)	-11.11
	(11.51)
Coal price growth (MA3)	76.18
	(49.13)
Income growth (MA3)	-146.8***
	(20.54)
Population growth (MA3)	-787.3***
	(137.8)
_cons	-161.8***
	(43.26)
N	765
R^2	0.264
Adjusted R^2	0.255

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$