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Imperfect Markets versus Imperfect Regulation in U.S. Electricity Generation

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When regulation brings its own host of distortions and inefficiencies, the mere existence of a market failure is insufficient to ensure that government intervention will improve welfare. Instead, by comparing the distortions under potential regulatory regimes, one can identify superior policies as those with relatively fewer imperfections. My research undertakes such an evaluation in the context of U.S. wholesale electricity markets, which have replaced command-and-control-type operations in some areas.

To do so, I construct a virtually complete hourly characterization of supply and demand of the U.S. electrical grid from 1999–2012. Data on fuel costs, capacities, heat efficiency, and operations of nearly all generating units at the hourly level allow me to construct power supply curves (known as the "merit order") for each of 98 "Power Control Areas" (PCAs), as well as observe the units that were chosen to operate to meet demand at any moment in time. These curves allow me to calculate two key welfare measures for each PCA-date-hour: "out of merit" losses from dispatching higher marginal cost units relative to installed capacity, and the gains from trading electricity across areas. Market power losses manifest themselves as out-of-merit production, as do normal grid operations such as maintenance, refueling, start-up costs, and transmission congestion. In either case, the increased operational costs are observationally equivalent as the distance between the realized cost of operations and cost from utilizing only the lowest-cost installed capacity.

I develop a framework and compile the necessary data to examine both gains from trade and out-of-merit losses over the history of market transitions since 1999. I use the staggered creation and expansions of wholesale electricity markets over this period to estimate the causal impact of using markets to allocate production on these welfare measures. I estimate changes in gains from trade and out-of-merit losses following the transition to market dispatch against PCAs that have not undergone any regulatory changes. This approach finds that gains from trade increase by upwards of 30 percent after adopting market dispatch due to a 10 percent increase in electricity traded. There is also a 10 percent decrease in out-of-merit operations, reducing these costs by nearly 20 percent.

This simple approach is susceptible to the confounding effects of fuel price fluctuations (over time and across areas) when estimating counterfactual outcomes: fuel prices shift supply curves, making historical outcomes poor counterfactuals for what would have happened

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today under a different set of prevailing fuel prices. This means one might estimate changes in the gains from trade without any actual changes in production patterns because the value of offset production scales with fuel prices. This issue motivates a "policy function" approach in which I estimate each system operators' rules for dispatching units in a given year, and compare outcomes the following year against those predicted by the policy function. I show how the treatment effect can be estimated by comparing changes in the quality of fit of this rule across areas that switch to market dispatch against areas with no change in regulation.

Estimating dispatch probabilities with out-of-sample validity is a pure prediction problem for which recent developments in the machine learning literature have proven to be particularly effective. I use such methods to estimate the policy functions, then embed the results in a framework to estimate causal treatment effects.

This approach yields estimates smaller in magnitude than the simpler estimates for gains from trade, suggesting fuel price confounding. I find that production costs are reduced by about three billion dollars per year due to market-based improvements in allocating output to lower cost units, with these savings split between reduced output from uneconomical units and gains from trade by a factor of 2 to 1.

I note that my estimates measure changes in how output is allocated, given the installed capacity, costs, and patterns of demand. It would not be unreasonable to suspect that market dispatch has affected investment incentives, which are likely an important source of welfare changes. In addition, my estimates measure the average effect of market dispatch, which itself has been heterogeneous both with respect to preexisting institutions (i.e., power pools, bilateral markets, or smoke-filled rooms), and with respect to the rules of the markets implemented (uniform or locational marginal prices, virtual bidding, market monitors, etc.).

However, given the even greater differences between market and traditional dispatch methods, these estimates should be informative regarding the performance of the relatively new mechanisms that currently determine how more than 60 percent of generating capacity in the United States is utilized.

NOTE:

This research brief is based on Steve Cicala, "Imperfect Markets versus Imperfect Regulation in U.S. Electricity Generation," January 22, 2017, https://epic.uchicago.edu/research/publications/imperfect-markets-versus-imperfect-regulation-us-electricity-generation.