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# Does Generation Investment Follow Locational Price Signals? Long-term Evidence from the PJM Electricity Market

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This paper examines whether locational marginal pricing (LMP) of electricity and other locational price elements (such as zonal capacity prices and state-level solar subsidies) affect where generators invest in new capacity. A claimed benefit of LMP is that providing locational prices will encourage spatially more efficient generation investment. However, there is a very limited economic literature testing this empirically. One of the few published studies yielded some evidence that investment occurred in areas of the ERCOT market in Texas with higher prices, but overall, the evidence was somewhat inconclusive. In this study, we rely on much larger and longer data set on the PJM electricity market to test the LMP investment hypothesis.

The paper begins with a review of the existing literature on LMP and investment. The paper also explains the complex and multi-part PJM market structure overall. In addition to LMP energy prices, PJM also has locational capacity prices which are calculated on a zonal basis. Some of the PJM states also have state-based solar renewable energy credit (SREC) prices which can differ substantially be state and over time. Each of these three elements is tested as a driver of long-term generation siting decisions.

The paper describes the patterns of new generation investment over the last 25 years in PJM Most new generation plants over the period have been gas-fired (primarily in the form of combined cycle gas turbine (CCGT) plants) and renewables. In recent years PJM has seen many solar PV plants enter the market. These make up most of the new plant dataset analysed, which includes over 1000 new plants with greater than 1 megawatt capacity.

A simple two-part investment model for a new generator is presented where future revenues are decomposed into spot market revenues (such as day-ahead LMPs as tested here and capacity prices) and hedged revenues (from hedging contracts that new generators sign to reduce risks. We note that while LMPs are highly volatile and difficult to predict, the PJM data shows that zonal LMPs are highly correlated in general to a few hub prices.

We use first use descriptive statistics to characterise where investment has occurred in 3 types of generation (gas-fired CCGTs and combustion turbines), wind and solar PV. Out of locations where new generation has occurred, the descriptive statistics show that solar generation was concentrated in top tier LMP locations initially, but as solar costs fell solar investment has spread

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to other regions. Wind generation has been very concentrated in PJM to a few regions with a high wind resource and does not seem to have been affected by historical LMPs or capacity prices. Gas-fired generation has been concentrated in locations with higher LMPs, LMP margins (adjusting for gas input costs) and capacity prices.

We also test entry decisions against historical LMPs (direct LMPs and LMP margins), capacity prices and solar subsidy prices using logistic regression. The results are broadly consistent with the descriptive statistics analysis. The logistic analysis shows that historical LMPs. Capacity and SREC prices are significant in solar PV locational investment decisions with appropriate lags (which are generally consistent between the approximate period from a final investment decision on a project to start of commercial operations).

The same analysis holds true for gas-fired generation (CCGTs and CTs). Here, the highest significance was found with lagged LMP margins, as well as capacity prices. The logistic analysis did not find significance for wind investment, which is heavily concentrated in a few areas of the PJM region.

We also investigate investment on an intrazonal basis, using data on new PV facilities in the Dominion zone (the largest set of new plants in a single zone in PJM). While the basis price differentials within a zone are smaller, the logistic regression analysis shows that lagged LMPs were significant with respect to siting decisions on an intrazonal basis as well.

As noted previously, most new generation is supported by hedging contracts. Many of these are settled at one of a small number of trading hubs. A natural question is whether price differentials between points and these hubs are stable enough to allow counterparties to form reasonable expectations. Using a simple OLS framework, we show that LMP basis differentials are reasonably stable even up to 8 years ahead, with a simple mean error (across PJM zones) of only a few percent.

This research has important implications not just for power market investment. We show that investment has significantly occurred where lagged LMPs have been higher on both a market-wide and an intrazonal basis, suggesting that investors in gas and solar generation do respond to market signals. We also show that while residual LMP basis risks exist, the magnitude of these appears practically manageable given over generator contracting horizons.


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