Overview

Electricity supply and demand have become an important topic related to economic development and environmental sustainability. As electricity cannot be readily stored in a large amount, plus the compensation of tax credit to the new power generation such as wind, there are more and more extreme price values appeared in the electricity market, such as price spike and negative pricing. These extreme price records imply larger and more frequent inequilibria of power supply and demand, compared with other asset markets, and bring larger uncertainty and mystery in the market.

Our study investigates new methods to study the pattern of such price anomalies in the electricity market, and sheds light on how these volatile prices affect the other market conditions for the policy makers. We focus on the phenomenon of volatile prices, especially negative prices, in the electricity market and investigate its pattern, impact, and origin. We derive a cluster analysis and find out the factor that dominates the volatility of electricity price.

The optimal resource allocation in the electricity market is tightly related to the investigation of calendar anomalies. Our study uses a new method to detect the calendar effects of electricity price and their significance in the electricity market.

Our study uses the real-time pricing (RTP) data from the wholesale Pennsylvania, New Jersey and Maryland (PJM) electricity market between 2013 and 2015. It includes over 12,000 transmission lines, and their RTP records update hourly and includes 26,280 hours (24 hours×365 days×3 years) for each transmission line.

Methods

Calendar Effects Analysis: We derive a powerful test for calendar specific anomalies, and assess the significance of the full universe of possible calendar effects. We implement our test to the PJM electricity market and assess the calendar effects in different time frequencies (Day-of-the-week, Hour-of-the-day, Month-of-the-year, Day-of-the-month and season). Our results show that calendar effects exist in every time frequency, and also specify those calendar effects with statistical significance. The assessment of calendar effects will help improve the market efficiency and environmental sustainability of the electricity market.

Cluster Analysis: to compare the effects on price volatility from negative prices and peak load spike prices, we construct a Principal Component Analysis (PCA) model instead of the traditional multivariate regression. We find that PCA provides more useful outcomes by separating the peak load pricing and negative pricing effects into individual components.

Results

Our results are two-folds.

First, through a cluster analysis, we find that price spikes have larger explanatory power compared with negative prices, indicating that over-supply is more prevalent than power shortage in the current electricity market. But as a further investigation, we find that occurrences of negative price have concentrations from the prespective of time series. In the cross-sectional analysis, our results depict that negative price has become more and more prevalent in the electricity market. Second, we investigate the impact of negative price on the price volatility across individual electricity nodes. We find that the occurrence of negative price does not enlarge the fluctuation of price but lower it. Nodes with occurrence of negative price usually have a smaller volatility than those without negative price records.
Second, we derive a powerful test for calendar specific anomalies, and assess the significance of the full universe of possible calendar effects. We implement our test to the PJM electricity market and assess the calendar effects in different time frequencies (Day-of-the-week, Hour-of-the-day, Month-of-the-year, Day-of-the-month and season). Our results show that calendar effects exist in every time frequency, and also specify those calendar effects with statistical significance. The assessment of calendar effects will help improve the market efficiency and environmental sustainability of the electricity market.

**References**


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