Analysis of Market Conduct and Performance in Electricity Markets

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Overview

The purpose of our study is to investigate strategic behavior of power generating firms, in other words, the existence and degree of market power exercised in wholesale electricity markets. We apply an equilibrium spot price formula which is derived in Ishii and Tezuka(2013). Ishii and Tezuka(2013) extends the model of Ishii and Tezuka(2011), and develops a calibration procedure based on the price formula. With the formula and the procedure, we analyze the market of Pennsylvania New Jersey and Maryland (PJM). Even though we use only two time series data: spot prices and trading volumes, we can estimate the mark-up and decompose it into two factors. These factors are interpreted as averaged risk attitude of power producers and market concentration. Based on the decomposition, we unveil a structure behind the market power or mark-up in wholesale electricity market.

Methods

The basis of our study is the following price formula:

$$\varphi(Z, s^*) = \frac{aZ}{n} + b + \frac{az_\alpha}{n(n-1)} \qquad (1)$$

where $n \in \mathbf{N}$ is the number of power generators in the market, a function φ denotes future spot price, $s^* \in [0,\infty)^n$ is the Nash equilibrium strategy vector, a random variable Z describes uncertain future electricity demand, z_α is the α-quantile of Z, and positive constants a and b are respectively the slope and intercept of the marginal cost function of each power generating firm. See Ishii and Tezuka(2011) or Ishii and Tezuka(2013) for the details.

Equation (1) is the equilibrium spot price formula in the model developed by Ishii and Tezuka(2011), which is extended by Ishii and Tezuka(2013). For the investigation, we put assumptions on the electricity demand. Since we suppose that the electricity demand is inelastic, the trading volume is equal to the demand. Furthermore, the electricity demand process is assumed to be the sum of a deterministic function and a first-order auto-regressive process, hereafter denoted by AR(1). The deterministic function is first estimated.

After that, we estimate the parameters of the AR(1) with the difference of the electricity demand process and the estimated deterministic function. In order to determine the value which is a control point for allover power producers, we apply a calibration method developed in Ishii and Tezuka(2013). Based on these results, we can compute the α-quantile of one-day ahead electricity demands for each sample day.
Then we consider a multiple regression model, where the dependent variable is the electricity spot price and the independent variables are the electricity demand and the calibrated α-quantile of one-day ahead electricity demands.

Results and Conclusions

We focus on analyze PJM market during the period 2006-2010. We apply the equation (1) to investigate the existence of mark up in the PJM wholesale electricity market. We use hourly spot price and trading volume data from the PJM interconnection (http://www.pjm.com/). We calculate average daily spot prices and trading volumes, and estimate the related parameters. We then apply multiple least square based on equation (1), and find that there are some differences for each year, and the structure is examined. Especially, negative mark-ups are found during the sample period.

We will show the detail results in our presentation.

References

Ishii, M., and Tezuka, K., ``Assessing the Impact of Strategic Behavior on Spot Prices in an Electricity Market,'' *Proceedings of 30th USAEE/IAEE North American Conference*, 2011.
Ishii, M., and Tezuka, K., ``Measuring strategic behavior in electricity markets,'' mimeo, 2013.