AN EMPIRICAL STUDY OF MARKET PERFORMANCE IN WHOLESALE ELECTRICITY MARKETS

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Overview

Various factors affect market participants in electricity markets, and generate volatilities of spot electricity prices. Interdependently, the uncertain price fluctuations itself influence the risk attitude and strategies of the market participants. Then, it is difficult for previous approaches to evaluate the market performance of electricity markets appropriately. To address this issue, a non-cooperative game model is developed in Ishii and Tezuka (2014). In the non-cooperative game, Nash equilibrium spot price formula is derived. With the spot price formula, we can decompose a mark-up into two factors: the effect of market concentration and of risk attitude. The former can be related to exercising market power, and the latter to risk premium. In addition, the formula has robust properties for empirical analysis. We then apply it to calibrate the above two factors for Pennsylvania New Jersey and Maryland (PJM) market, Nord Pool and Japan Electric Power Exchange (JEPX). Based on the calibration results, we evaluate market performances of the three markets and investigate the features of the market structures. In addition, also investigate the effect of the earthquake in 2011 on the market of JEPX from their results.

Methods

In Ishii and Tezuka(2014), the following equilibrium spot price formula is derived:

$$\varphi(Z) = \frac{n}{n+ac}\left(\frac{aZ}{n} + b + \frac{a(Z-bc)}{(n+ac)^2-n} + \frac{-a(Z-z_\alpha)}{(n+ac)^2-n}\right) \quad (1)$$

where n is a natural number which denotes the number of homogeneous suppliers, positive constants a and b are respectively the slope and the intercept of supplier's linear marginal cost function, a non-negative constant c is the slope of linear market demand, a positive valued random variable Z is the disturbance which makes the market demand stochastically fluctuate, and z_α is the alpha quantile of Z. See Ishii and Tezuka (2011) or Ishii and Tezuka (2014) for the details. Here, the equilibrium mark-up is proportional to the sum of the third and fourth terms in the parentheses. If the demand curve is predictable, that is, all market participants can perfectly forecast the value of Z beforehand, the third term is the equilibrium mark-up.In other words, it is the inevitable mark-up under even certainty in this market, which is generated to a great degree by the market power. While the market power parameter appears in both terms, the sign of fourth term is determined by the difference between Z and z_α. The sign is negative if and only if $Z > z_\alpha$. Then the equilibrium mark-up is expected to be less than in the certain case, when each supplier selects a small α such that $\mathrm{P}(Z > z_\alpha)$ is great enough. In other words, the suppliers throw away the chance of higher mark-ups to improve the minimum performance, or protect possible profits in the case that a left-tail event would occur with probability α. The opposite situation holds when α is close to 1. Therefore, the risk attitude of suppliers is reflected in the fourth term, which is interpreted as the risk premium for the suppliers.

For the empirical analysis, we put assumptions on the electricity demand. First the electricity demand is supposed to be inelastic, that is c=0. Then the trading volume is equal to the demand, and Equation (1) is reduced to

$$\varphi(Z) = \frac{aZ}{n} + b + \frac{az_\alpha}{n(n-1)}. \quad (2)$$

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. We then apply the calibration method developed in Ishii and Tezuka(2014) in order to estimate n, a,b and z_α in Equation (2).

Results and Conclusions

We apply the equation (2) to examine the features of PJM, Nord Pool and JEPX market structures. Then we find that there are some differences among the three markets, and the market structures change as years pass. We also have unexpected findings, e.g. negative mark-ups are observed during some periods in PJM, and seasonal effects in JEPX. In addition, we interpret the impact of the earthquake in 2011 on market performance of JEPX. 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., `` An Oligopoly Model for Market Performance Analysis with an Application to Electricity Market," mimeo, 2014.