

# Estimation of Time-dependent changes of Supply and Demand Curves in Japan Electric Power Exchange (JEPX) Spot Market

Kenta Ofuji and Nobuyuki Yamaguchi (Central Research Institute of Electric Power Industry(CRIEPI), Tokyo Japan)<sup>1</sup>

## 1. Overview

The purpose of this paper is to analyze the time-dependent changes inherent in the auction market in Japan Electric Power Exchange (JEPX). After its launch in April 2005, the exchange, the only wholesale electricity exchange in the country, has seen a constant growth in the number of participant companies and in the volume of electricity. The price trend does not have the well-known “spiky” feature, but the peak index once hit the all time high of 60[Yen/kWh] in late Spetember 2007 due to the tight demand/supply environment.

This study tries to build an estimation method that models the single-price auction market at JEPX to capture the time-dependent changes of the demand and supply curves, by estimatng the intercepts and the gradients of those curves as functions of dates, hence gaining insights to analyze the trends and the dynamics behind the deals. For our previous attempts with time-series, ecomometric models, see Goto and Yamaguchi (2007).

## 2. Methods

We applied Simulatenous Equations Models (SEM) to model JEPX’s spot market, since it is based on the simple structure where, aside from the market split that results from occasional transmission congestions, the sytem price  $p$  and the traded volume  $q$  are determined at the cross point of the demand and the supply curves. **Figure 1** illustrates the approximation of the demand and the supply curves as first-order straight lines:

$$p^S = a_0 + a_1 q^S - a_2 q_s^M + \varepsilon^S \quad (1)$$

$$p^D = b_0 + b_1 q^D - b_2 q_b^M + \varepsilon^D \quad (2)$$

where  $p$ [Yen/kWh]: System prices,  $q$ [MWh/h]: Traded volumes,  $q_s^M$ [MWh/h]: Selling offer volumes,  $q_b^M$ [MWh/h]: Buying bid volumes  $\varepsilon$ [Yen/kWh]: Error terms,  $a_0$  and  $b_0$ [Yen/kWh]: Intercepts of supply and demand curves respectively,  $a_1$  and  $b_1$ [(Yen/kWh)/(MWh/h)]: Gradients of supply and demand curves, respectively,  $a_2$  and  $b_2$  [(Yen/kWh)/(MWh/h)]: Coefficients for offer and bid volumes.

The time-dependent changes in  $a_i$  and  $b_j$  ( $i, j = 0,1,2$ ) are esimated by Kalman filter stepwise alorythm. The market data was sourced from the JEPX website, for business days from May 2005 to June 2007.

## 3. Results

**Figure 2** shows the price estimation result. Kalman Filter (KF) estimation yielded a better mean absolute fitting error of 1.89[Yen/kWh], compared from 2.02[Yen/kWh] by the OLS estimation. It was found that, while the supply curve mainly changes its slope by about as large as twice of its average, changes in the demand curve’s slope is comparatively moderate. On the other hand, the intercept of the supply curve, or the lowest offering price, remains rather stable (mean 11.02[Yen/kWh] and standard deviation 0.80[Yen/kWh]), while that of the demand curve, or the highest asking price, can change more significantly (mean 19.78 [Yen/kWh] and std.dev. 5.77[Yen/kWh]).

Among the important indices of the commodity’s property is price elasticity, computed once the gradients of the demand curve is estimated. It was found that the elesticity for the On-peak commodity has not well evolved into the elastic direction, but rather settling around -2 to -3 over the most recent six months period, sifnifying lack of competitiveness on the demand bids .

## 4. Conclusions

By applying SEM to estimate the supply and demand curves at the spot market of JEPX, combined with time-wise variations estimation by Kalman filter. The model was able to estimate not only the gradients and intercepts of the supply and demand curves, but also their

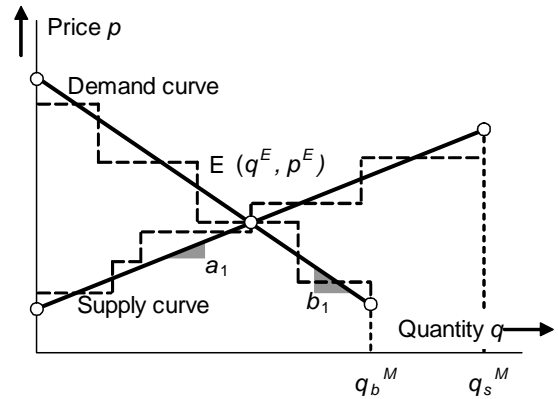


Figure 1. Approximation of demand and supply curves in JEPX spot market

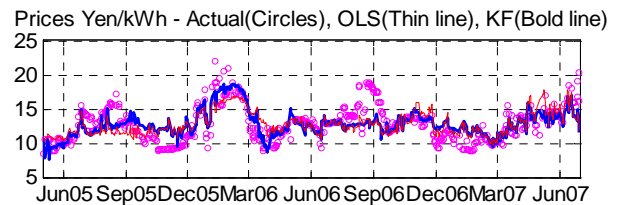


Figure 2. Price estimation result, On-peak commodity (OLS: Ordinary Least Squares, KF: Kalman Filter)

<sup>1</sup> ko-ofuji@crieipi.denken.or.jp, Socio-economic Research Center, CRIEPI 2-11-1 Iwado Kita, Komae city, Tokyo Japan, 201-8511

time-dependent changes, capturing the short- to long-term variation in the trade environment in JEPX. From the estimated results, it was inferred that while the supply curve, especially its intercept or the lowest offering prices, remained stable over time, the demand curve was moving significantly, mainly by its intercept or highest bidding prices. The large variations in the demand intercepts contributed much to the variation in system prices and traded volumes.

#### **References**

- Goto, M., and N. Yamaguchi: "An Econometric Analysis of Wholesale Electricity Prices in Japan,,"; 29th IAEE International Conference, 7–10 June 2006 in Potsdam, Germany, (2007)
- JEPX website: <http://jepx.org>
- Ofuji, K. and N. Yamaguchi: "Trade Dynamics Estimation using Time-varying Simultaneous-Equations Models," IEEJ Transactions on Power and Energy, forthcoming (in Japanese)