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AN ECONOMETRIC ANALYSIS OF WHOLESALE ELECTRICITY PRICES IN JAPAN

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Overview

Liberalization of the electricity industry in Japan began in 1995 when market mechanisms were first introduced for the wholesale market as a competitive bidding for additions to the generation capacity. This change was implemented with the enforcement of the first amendments to the Electric Utility Industry Law in 35 years. Since its initiation, market liberalization has made steady progress toward further introduction of competition in the industry. The electricity liberalization entered a new stage in April 2005 when contestability was expanded to include all high voltage customers. New market reform initiatives also include the establishment of two new organizations, the Electric Power System Council of Japan (ESCJ) and the Japan Electric Power Exchange (JEPX).

So far trading volume at the JEPX has been marginal, approximately 0.1% of the total demand. The primary reason for the low liquidity is that the wholesale electricity market began operations only in April 2005 and is still in the initial stages of its market operations. Thus, most trading members are cautiously studying the behavior of the other members and the market developments with regard to prices and volumes. However, such a low liquidity at a formative stage is not an intrinsic feature of only the Japanese market; in other nations as well, markets usually have a low level of liquidity in the initial stages of their operations, and the volume gradually increases over the course of time.

An efficient and robust wholesale power market is a key factor for the success of electricity liberalization. Therefore, further developments in the spot market should be closely monitored. To foster active wholesale markets, it is necessary to increase number of members and a variety of products. In addition, it is important to examine whether prices are rationally determined depending on several factors such as electricity demand and weather conditions. If we can rationally explain the prices, it consequently leads to the predictability of the price changes. The predictability of prices is important for market players to effectively manage price risks.

The purpose of this study is to examine levels and changes of the wholesale electricity prices in Japan using several econometric models, particularly those to deal with time series data. Based on the results, this study reveals several properties of the wholesale electricity prices in Japan and indicates important implications for the progress of market liberalization. In addition, future issues of the Japanese wholesale power market are discussed in this paper from a perspective of the industry policy.

Methods

This study applies several econometric models to the analysis of the Japanese wholesale electricity market. Specifically, we start our study with basic statistical tests and simple time series analyses such as AR and ARMA models. These preliminary analyses are followed by applications of ARCH-type models so that we examine time-varying volatility of the prices. For example, the basic GARCH(1,1) model we estimate in this study is described as follows:

$$P_t = d(t) + e_t, \qquad (1.)$$

$$d(t) = b_0 + b_1 \cdot P_{t-1} + c_1 \cdot Volume\,, \qquad (2.)$$

where P_t is a daily wholesale electricity price level at period t, *Volume* is a total demand of electricity, and

$$e_t = \sigma_t \varepsilon_t\,, \qquad (3.)$$

$$\sigma_t^2 = h_t = \omega + \alpha \cdot e_{t-1}^2 + \beta \cdot h_{t-1}\,, \qquad (4.)$$

$$\varepsilon_t \sim \text{i.i.d.}\, N(0,1)\,. \quad (5.)$$

Results

One of the principal results of this study is that so far the Japanese electricity prices are reasonably explained by basic GARCH models as described in Table 1. The results indicate that the volatility process converges as expected and it is well explained by the GARCH process. Some studies, including Deng (2000), emphasizes the importance of modeling jump processes in electricity prices, because electricity prices are well known that they sometimes indicate jumps due to several factors particularly in summer and winter. However, our study reveals that models without jump parameters can be applied to our Japanese data. This result may be due to relatively stable development of electricity prices, i.e., there are no remarkable price spikes so far in the Japanese electricity markets as depicted in Figure 1.

Table 1: Results of Estimation of GARCH (1,1) Model

	Coefficient	S.D.
b0	−4.743	0.523
b1	0.079	0.046
c1	5.62E−06	2.10E−07
α	0.313	0.093
β	0.648	0.084
ω	0.080	0.041

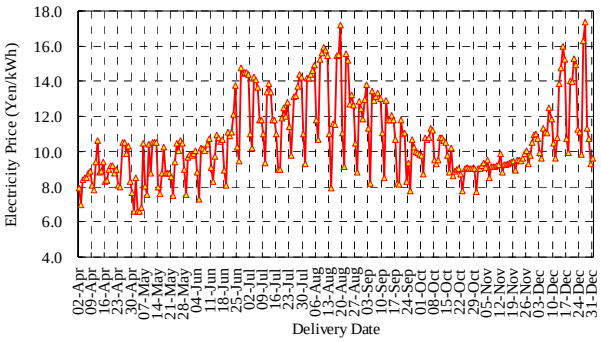

Fig. 1: Development of Wholesale Electricity Prices

Conclusions

Our study applies several econometric models to the Japanese wholesale electricity market to examine behaviors of dynamic price changes. The results indicate that wholesale electricity prices in Japan can be reasonably explained by these models with statistical significance. Although the wholesale power market in Japan is still in the initial stages of market operations and the data obtained are not necessarily sufficient for the robust estimation of much demanding models with many variables and complex structures, our analysis proves that at least several well-known econometric models are applicable to examine price changes for the Japanese market. We propose important implications for the price risk management based on results of our study. In addition, this study discusses future issues of the electricity market and further progress of liberalization in Japan.

References

Deng, S., “Stochastic models of energy commodity prices and their applications: Mean-reversion with jumps and spikes,” University of California Energy Institute working paper (2000).
Gourieroux, C. and J. Jasiak (2001), Financial Econometrics, Princeton University Press.