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AN ERROR-CORRECTION, SIMULTANEOUS EQUATION MODEL TO ESTIMATE THE DEMAND AND THE SUPPLY CURVES IN ELECTRICITY MARKETS

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Overview

In this paper we develop a dynamic, structural model to analyse the relations between price and quantity in restructured, liberalised electricity markets. Under deregulation the uncertainty of electricity price has increased dramatically and thus, providing reliable models to interpret and forecast electricity prices has assumed a critical importance. This task proved to be quite challenging because of the peculiar characteristics of electricity, which are considerably different from those of other commodities. The simple extension of the methodologies typically implemented in modelling asset prices, for instance, offers a poor representation of the electricity price process (Knittel and Roberts, 2005). Better results can be obtained if price dynamics are modelled taking into account the fundamental drivers of the market, such as the quantity traded and the excess capacity available in the electric system (margin). In previous works (see, for example Karataksani and Bunn 2005, Weron and Misiorek 2005, Rodriguez and Anders 2004, Popova 2003) this issue has been analysed through single equation models. Doing so, the quantity traded on the market has been explicitly considered as fixed (i.e. exogenous), assuming a perfectly inelastic demand curve. This feature is still an open, relevant question, since, from an economic perspective, the cases in which the demand curves can be fundamentally considered inelastic are quite rare.

The model developed in this paper identifies the supply and the demand curves, and allows to test, inter alia, hypotheses on the elasticity of demand to price and the hypothesis of demand exogeneity. Furthermore, the model is robust to the presence of non-stationarity in the series analysed. On this point it is important to emphasise that the assumption of mean-reversion of electricity price and demand raises subtle issues of specification. Even though elsewhere (see Escribano et al. 2002, Karakatsani and Bunn 2005, Knittel and Roberts 2005 for some illustration) the null hypothesis of a unit root in electricity prices is tested and rejected with standard techniques, this result cannot be assumed in general. After analysing this issue on daily PJM data, we model the series as non-stationary in order to avoid potential problems of spurious regression, developing an error-correction term embedded in a simultaneous equation model.

Methods

The choice of modelling the series as non-stationary leads naturally to the implementation of the cointegration methodology. Therefore, we use the technique developed in Johansen (1988, 1991) to test for the number of cointegrating vectors. As showed in Boswijk (1995) and Davidson (1998) the cointegrating vectors can be interpret as long-run behavioural relationships, with direct economic meaning. Hence, we identify them with the long run supply and demand function, following the methodology introduced in Johansen and Juselius (1994) and Johansen (1995). In the last step we use these estimates to specify an error-correction simulta-

neous system of equations between price and quantity. The system is estimated through Full Information Maximum Likelihood.

Results

We empirically estimate the model on PJM daily wholesale electricity market outcomes. In the long run, the results show a supply curve with a high, positive elasticity to quantity and a small, negative elasticity to margin (excess capacity). The demand curve, on the contrary, seems to be fairly inelastic to price (price parameter not significant). The estimated coefficients in the short term simultaneous equation model reveal a peculiar structure. The elasticity of demand to price, in fact, is not significantly different from zero. For this reason the demand curve can be though as perfectly inelastic (i.e. vertical). This does not imply that the quantity traded on the market is not influenced by the price, since the past disequilibrium in the long run supply function significantly influences the short run dynamics of quantity through the error-correction term. Hence the demand function, even though vertical, adjusts to past higher prices shifting to the left and to past low prices shifting to the right according to the adjustment coefficient relative to the supply function. Price variation on the contrary does not adjust to previous disequilibrium in the demand function (the error-correction parameter is not significative) but strongly responds to instantaneous changes in the quantity. The short run elasticity is in fact almost twice the long run one.

Conclusions

The electricity market model proposed in this paper is novel and, instead of focusing only on the dynamics of price in a single equation framework, it analyses price and quantity interaction in a simultaneous system of equations. It shows that, even when demand is completely inelastic to price in the short and in the long run, the quantity traded on the market responds to price variation trough an error-correction mechanism. For this reason quantity can be considered weakly exogenous only if the interest is focused on the short term parameters.

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