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Estimating the volatility of electricity prices: The case of the England and Wales wholesale electricity market

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AUTHOR-HIGHLIGHTS

- The impact of regulation on the dynamics of electricity prices is examined.
- Price-cap regulation has decreased the level at the cost of higher volatility.
- The first series of divestments has reversed the trade-off.
- The reversed trade-off is explained as an indication of tacit collusion.
- The second series of divestments is found generally successful.

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ABSTRACT

Price fluctuations that partially comove with demand are a specific feature inherent to liberalized electricity markets. The regulatory authority in Great Britain, however, believed that sometimes electricity prices were significantly higher than what was expected and, therefore, introduced price-cap regulation and divestment series. In this study, I analyze how the introduced institutional changes and regulatory reforms affected the dynamics of daily electricity prices in the England and Wales wholesale electricity market during 1990–2001.

This research finds that the introduction of price-cap regulation did achieve the goal of lowering the price level at the cost of higher price volatility. Later, the first series of divestments is found to be successful at lowering price volatility, which however happens at the cost of a higher price level. Finally, this study also documents that the second series of divestments was more successful at lowering both the price level and volatility.

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1. Introduction

Fluctuations in electricity prices are usually explained by electricity being nonstorable and the critical need to continuously meet market demand. Prior to liberalization, price fluctuations were generally minimal and controlled. However, after liberalization, during the history of the England and Wales wholesale electricity market, price fluctuations, caused by frequent spikes, were sometimes excessively large. Large fluctuations in electricity prices generally introduce uncertainties about revenues for producers and costs for retail suppliers, which could result in higher prices paid by consumers.

The regulatory authority, the Office of Electricity Regulation (OFFER), believed that excessively high prices and fluctuations were possibly the result of the exercise of market power by incumbent electricity producers (National Power and PowerGen). Hence, in order to decrease the influence of the incumbent producers, the regulatory authority introduced price-cap regulation and divestments.

This empirical study quantitatively evaluates the impact of institutional changes and regulatory reforms on price and volatility dynamics. For this purpose I consider an *AR–ARCH* model, which is extended to include periodic sine and cosine functions to

Abbreviations: ACF, Autorcorrelation Function; ADF, Augmented Dickey–Fuller; AIC, Akaike Information Criterion; APX, Amsterdam Power Exchange; AR, Autoregressive; ARCH, Autoregressive Conditional Heteroscedasticity; ARIMA, Autoregressive Integrated Moving Average; ARMA, Autoregressive Moving Average; BDS, Brock Dechert Scheinkman; EEX, European Energy Exchange (Germany); ESI, Electricity Supply Industry; FFT, Fast Fourier Transform; GARCH, Generalized Autoregressive Conditional Heteroscedasticity; NEM, New Zealand Electricity Market; NGC, National Grid Company; OFFER, Office of Electricity Regulation; OFGEM, Office of Gas and Electricity Markets (formerly, the OFFER); PACF, Partial Autorcorrelation Function; PJM, Pennsylvania–New Jersey–Maryland; PPX, Paris Power Exchange; SFE, Supply Function Equilibrium; SMP, System Marginal Price; SUR, Seemingly Unrelated Regressions.

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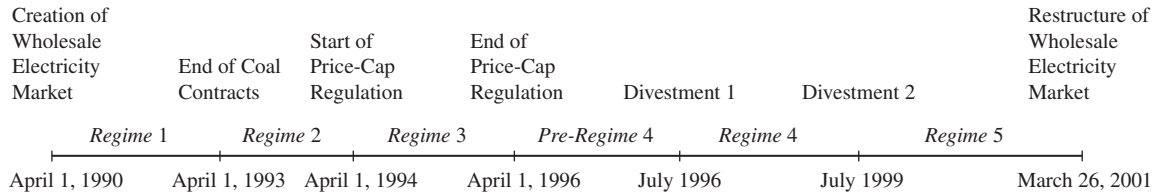

Fig. 1. Institutional changes and regulatory reforms in the ESI in Great Britain during 1990–2001. *Sources:* Department of Trade and Industry (1997–2002), National Grid Company (1994–2001), Newbery (1999), Robinson and Baniak (2002), Wolfram (1999); author's illustration.

accommodate weekly seasonality. The application of periodic sine and cosine functions, rather than daily dummy variables, is found to lead to a more parsimonious model. Finally, in order to analyze the impact of institutional changes and regulatory reforms on price and volatility dynamics, I also include regime dummy variables, which are created based on the timeline described in Fig. 1.

The adopted methodology allows evaluating the impact of regulation on price and volatility dynamics during the liberalization process. This research documents new evidence of the impact of price-cap regulation and divestment series on price level and volatility. In particular, I find that the price-cap regulation was successful at lowering the price level, which however happened at the cost of higher price volatility. Later, after the first series of divestments was introduced, the trade-off reversed. I explain this as the evidence of possible tacit collusion, which is also discussed in Sweeting (2007).

The research finally documents that the second series of divestments was more successful at ensuring lower price level and volatility. The first result that a lower price level is related to decreased market concentration is consistent with findings in Evans and Green (2003), where the authors using monthly data on capacity ownership and electricity prices show that increases in market competition are chiefly responsible for a decrease in the price level during the late 1990s.

Joskow (2009) characterized the privatization, restructuring, market design, and regulatory reforms pursued in the liberalization process of the electricity industry in England and Wales as the international gold standard for energy market liberalization. In this respect, the findings and conclusions of this research could be of interest to countries that formed or are about to form the operation of their modern electricity markets based on the original model of the England and Wales wholesale electricity market.

2. Related literature

After the liberalization of energy industries started in different countries, it became important to model and forecast price development. This is of special interest to producers and retail suppliers because price fluctuations now introduce uncertainties about revenues and costs. A government is also usually interested in understanding price developments resulting, for example, from auctions, because they eventually define the costs that consumers will have to face. High costs for energy, besides decreasing the economic welfare of consumers, may also at times undermine the political stability of a country.

Green and Newbery (1992) and von der Fehr and Harbord (1993) are the seminal studies in modeling electricity auctions. Both of these studies apply their models for the case of the England and Wales wholesale electricity market. Green and Newbery (1992) use the framework of supply function equilibrium (SFE), where it is assumed that each electricity producer submits a continuously differentiable supply function. This is usually applicable when producers' production units are small enough or when each producer has a sufficiently large number of production units as was the case, for example, with National Power and PowerGen in the early years of the wholesale electricity market. The authors show that a producer with a larger production capacity has more incentive to exercise market power by bidding in excess of marginal costs.

In contrast, von der Fehr and Harbord (1993) consider the framework where each electricity producer submits a step supply function on the uniform price auction. In particular, the authors model the electricity market as a sealed-bid multiple-unit auction. The authors demonstrate that no pure-strategy bidding equilibrium exists when electricity demand falls within a certain range. Their result is explained by an electricity producer's conflicting incentives to bid high in order to set a high price and to bid low in order to ensure that its production unit is scheduled to produce electricity.

Similar to von der Fehr and Harbord (1993), Wolfram (1998) and Crawford et al. (2007) model the market as a sealed-bid multiple-unit auction and empirically examine the bidding behavior of electricity producers. Wolfram (1998) finds that electricity producers submit price bids reflecting higher markups for production units that are likely to be scheduled to produce electricity if that producer has a large infra-marginal production capacity. The author indicates that the incentive to submit a price bid reflecting a higher markup for a certain production unit is moderated by the presence of threat that the production unit might not be scheduled to produce electricity. Wolfram (1998) also finds that larger producers tend to submit higher price bids than smaller producers for comparable production units (i.e., production units using the same input to produce electricity and having almost the same marginal costs).

Crawford et al. (2007) empirically establish the presence of asymmetries in the bidding behavior of marginal and infra-marginal electricity producers: during the highest-demand trading periods marginal electricity producers behave strategically by submitting price bids higher than their marginal costs, whereas infra-marginal electricity producers behave competitively by submitting price bids reflecting their marginal costs.

Sweeting (2007) analyzes the development of market power in the same electricity market. The author measures market power as the margin between observed wholesale market prices and estimates of competitive benchmark prices, where the latter is defined as the expected marginal cost of the highest-cost production unit required to meet electricity demand. Sweeting (2007) finds that electricity producers were exercising increased market power. This result, as the author indicates, is however in contradiction with oligopoly models, which, when market concentration was falling, would have predicted a reduction in market power. Sweeting (2007) also finds that from the beginning of 1997 the incumbent electricity producers could have increased their profits by submitting lower price bids and increasing output. These findings are explained as tacit collusion.

In the following paragraphs I describe the development of modeling techniques applied for price time series from deregulated electricity supply industries in different countries. This research has been important for my development of the modeling

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