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Reassessing the integration of European electricity markets: A fractional cointegration analysis☆

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ABSTRACT

This study extends existing literature on the assessment of electricity market integration in Europe, by developing and testing hypotheses on the convergence of electricity wholesale prices, and adopting a time-varying fractional cointegration analysis. In addition, the potential impacts of some special events that may affect system capacity (new interconnection, market coupling, increase in share of intermittent generation) on spot and forward markets are considered and evaluated. Daily spot prices from February 2000 to March 2013 of nine European electricity spot markets (APX-UK, APX-NL, Belpex, EPEX-FR, EPEX-DE, IPEX, Nordpool, Omel and OTE) and month-ahead prices in four markets (French, British, German and Dutch) from November 2007 to December 2012 are investigated. Results show that unit root tests, which are generally used in the literature to test market integration, are inadequate for assessing electricity spot market convergence, because spot prices are found to be fractionally integrated and mean-reverting time series. Furthermore, spot price behaviour and their association with different markets change over time, reflecting changes in the EU electrical system. One-month-ahead prices, by contrast, were found to have become more resilient to shocks and to follow more stable trends.

1. Introduction

The present study aims to assess whether liberalised European electricity wholesale markets are increasingly associated and converging to a single price. Empirical evidence is important since the integration of European electricity markets has been in process for many years and was planned to be completed by 2014 (European Commission, 2012a). The first step towards a pan-European liberalised wholesale market was taken in 1996 with *EU Directive 96/92/EC*, which defined common rules for the generation, transmission and distribution of electricity and aimed at creating an efficient supranational European market (Gebhartd and Höffler, 2007). Subsequent electricity market directives (e.g. *2003/54/EC* and *2009/72/EC*) have also addressed emission targets for the electricity sector and specified paths to integrate renewable energy. In the last decade, cross-border transmission has been fostered through energy transactions at power exchanges and electricity markets have been joined via interconnectors, such as the NorNed linking Norway and The Netherlands. Market coupling initiatives attempt to optimise the usage of interconnector capacity and to ensure that electricity flows from low to high price areas. Yet, in the last quarter of 2012, the European Commission claimed that a pan-European market for electricity had been delayed, because member states had been slow in adjusting their legislation and most energy policies remained centred on national interests (European Commission, 2012a). Since decisions on electricity mixes and system capacity are made by individual states, they may conflict with the aims of competitive prices and security of supply in connected markets. In this context, an assessment of the speed of mean reversion of wholesale prices towards a common price is informative for regulators and policy-makers, both locally and regionally, because it indicates how quickly and flexibly the supply side reacts to unexpected events (Bosco et al., 2006). This study investigates the speed of mean reversion and convergence of electricity prices in nine European spot markets and four one-month-ahead markets. In contrast to previous literature, it allows for associations between markets to be time-varying, in the sense that the model specification can vary over time. It also analyses how specific events that may have an impact on electricity generation and cross-border transmission capacity in one market may intervene in the process of electricity market integration.

This article is divided into six parts. In the next section, the literature on electricity market integration is reviewed. Section 3 sets the hypotheses to be tested and identifies special events that are likely to affect European electricity wholesale prices and, consequently, may have an impact on their co-movement. The fourth section describes the method that is adopted to model the long run dynamics of electricity prices in the study, which is reported in Section 5. Finally, Section 6 summarises the findings and concludes the paper.

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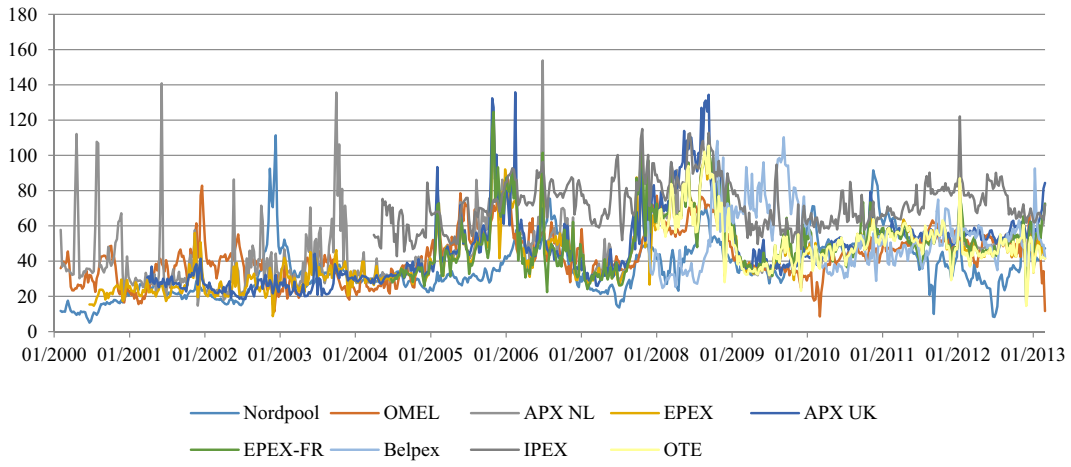

Fig. 1. Week-daily electricity spot price series in €/MWh from 28.02.2000 to 29.03.2013.

2. Assessments of electricity market integration

Most literature on electricity market integration used the Law of One Price (Fetter, 1924) as the theoretical foundation for determining whether two geographic regions, in which a well-defined product is traded, comprise a single market. Accordingly, cointegration analysis (Johansen, 1988, 1991) became the most used econometric method for assessing market integration (used for example by: Böckers and Heimeshoff, 2012; Bosco et al., 2010; Bunn and Gianfreda, 2010; Balaguer, 2011; Kalantzis and Milonas, 2010; Nitsch et al., 2010). Among cointegration studies of electricity prices, Robinson (2007, 2008) focused on retail data from 1978 to 2003 for ten European countries (Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain and the UK), and concluded that electricity prices in these countries had converged. However, this method requires the time series to follow a trend, and as such, may be too restrictive when investigating the time series behaviour of electricity spot prices which have often been described as stationary or mean-reverting processes (Karakatsani and Bunn, 2008). In fact, the suitability of this method for the analysis of electricity prices was already questioned in one of the early studies of market integration, when Boissellau (2004) analysed six European spot electricity markets in 2002, and observed that most price series were stationary, thus concluding that the nature of the data did not allow for testing long run integration. Subsequently, Armstrong and Galli (2005) examined the four main electricity day-ahead wholesale markets in the Eurozone with common borders and similar price-setting processes (France, Germany, The Netherlands and Spain), and found that the average price difference decreased between January 2002 and December 2004 in almost all pairs of markets, but more so during peak periods of demand. Consequently, they inferred that prices in the main continental European markets were converging. Nevertheless, Zachmann (2008) showed that by mid-2006, market integration of eleven European markets (Austria, the Czech Republic, East Denmark West Denmark, France, Germany, Netherlands, Poland, Spain, Sweden and the UK) had not been attained.

Overall, there are indications of price convergence in subsets of markets. For example, the studies of De Jonghe et al. (2008) and Nitsch et al. (2010) concerning the effect of market coupling on day-ahead prices in Belgium, France and The Netherlands, found a sharp decrease in price differences after the event, which took place in November 2006. Bosco et al. (2010) also concluded that week-daily average prices in the German and French markets were integrated. Moreover, Bunn and Gianfreda (2010), who analysed price levels and volatilities via cointegration analysis, causality tests and impulse-response models, found evidence of increasing market integration between Germany, France, Spain, The Netherlands and the UK. Yet, they rejected their hypothesis of higher integration in the forward market than in the spot market. In addition, Huisman and Kilic (2013), when using regime switching models to capture changes between 2003 and 2010, observed a decrease in the impact of price spikes and volatility, and also noted the similarity in the parameter estimates of the Belgian, Dutch, French, German and Nordic models of day-ahead prices. Yet, a study of six

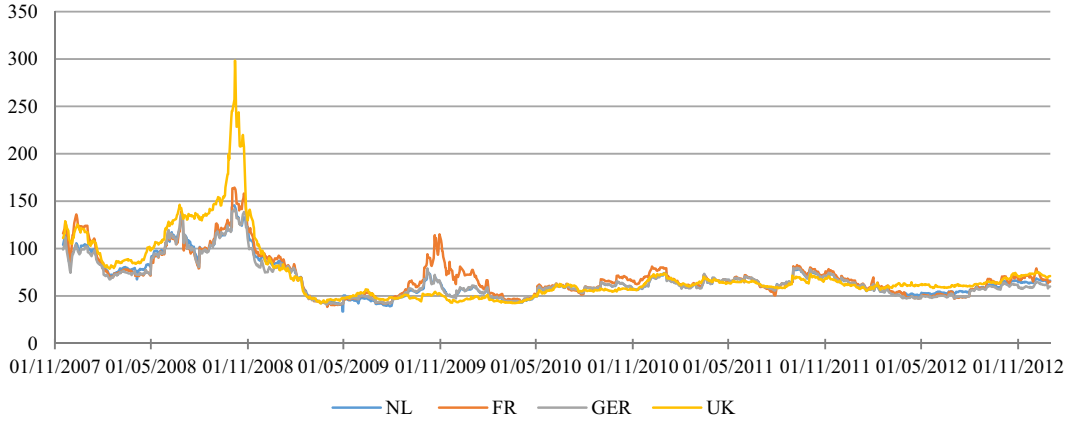

Fig. 2. Week-daily electricity forward prices in €/MWh from November 2007 to December 2012.