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Structural models for coupled electricity markets

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ABSTRACT

One of the major changes in European electricity markets is – besides the increasing share of renewable infeed – the fact that previously independent market areas have been connected. Day-ahead auctions are no longer done separately and available interconnector capacity is not always auctioned independently from electricity. Instead, interconnector capacity is implicitly auctioned in the day-ahead auction of electricity such that price differences between market areas are minimized, respectively overall welfare is maximized. The latest cornerstone in this evolution of the European electricity market is the so called North-Western European Market Coupling (NWE) which is online since February 4, 2014.

For market participants, such a change in the structure of the market naturally leads to the question of how to model prices in the affected market areas. Particularly, if positions in more than one market area exist, it becomes crucial for risk and portfolio management to model electricity prices in all areas consistently in one integrated framework.

In order to construct a model suitable for these tasks, we extend the class of structural or hybrid models, which were introduced by Carmona et al. (2013) and Aid et al. (2013), to a multi-market framework. We derive analytical formulae for the distribution of spot prices, for futures prices, and for plain vanilla options. We also calibrate the model to the French–German market area and study the effect of market coupling on electricity prices and the value of power plants.

1. Introduction

Since the deregulation of the European electricity markets, modeling price dynamics of electricity became an important topic for market participants. Changes in the structure of the markets lead to changes in price behavior and thus induced the requirement to regularly update and revise existing pricing models.

A very recent development is the (implicit) market coupling of electricity markets for the day-ahead markets. Neighboring electricity markets are typically coupled via transmission capacities owned by the Transmission System Operators (TSOs). This process can be organized using one of the two following approaches. With an explicit auction the transmission capacity on an interconnector is auctioned to the market separately and independently from the marketplaces where electrical energy is auctioned. However, as transmission capacity and electrical energy are traded at two separate auctions price information may not be available instantaneously and an inefficient use of interconnectors may result. Alternatively, transmission capacities can be integrated in the price finding algorithm of cooperating exchanges via implicit auctioning. With implicit auctions market participants do not bid for cross-border capacity themselves but the day-ahead transmission capacity is integrated in the auction of the spot markets in the connected market areas. The exchanges then use the available cross-border transmission capacity to minimize the price difference between two or more areas. The prices obtained then reflect the cost of

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energy and the cost of energy flows. As a result of implicit auctions electrical energy should flow from low price areas towards high price areas with prices converging.

In Europe the Central Western Europe (CWE) initiative couples Belgium, France, the Netherlands, Germany and Luxemburg. The North-Western-European (NWE) Region was implemented in February 2014. It consists of the power exchanges APX, Belpex, EPEX SPOT and Nord Pool Spot and 13 TSOs from the involved countries. In May 2014, Spain and Portugal joined; in February 2015, Italy coupled with France, Austria and Slovenia. As a result, the coupled area is called Multi-Regional Coupling and covers now 19 countries, standing for about 85% of European power consumption. A similar deployment is also planned for the intraday timeframe.

The aim of our study is to analyze the effects of implicit market coupling on typical products traded on energy exchanges such as futures, options on futures, hourly power forward curves, and virtual power plants. In our empirical study we analyze the price dynamics of day-ahead prices in Germany and France before and after the Central Western European Market Coupling (CWE) which was implemented on November 9, 2010. Fig. 1 shows in the upper plot French hourly day-ahead electricity prices from January 1, 2010 to December 31, 2011. The lower plot shows the corresponding prices in Germany. November 9, 2010 is marked in red. Visually, there is no indication for a strong structural break in the markets. Neither the overall price level nor the variability of prices seem to have changed due to the introduction of CWE Market coupling. However, looking at the scatter plot of hourly German prices versus hourly French prices as it is done in Fig. 2 reveals the new market dynamics. The upper plot shows a scatter plot of German (y-axis) versus French (x-axis) prices in hour 24 before the introduction of CWE, the lower plot shows the same scatter plot after the implementation of CWE. In the upper plot, prices seem to be loosely correlated, higher prices in France indicate higher prices in Germany and vice versa, but correlation is not very high with values between 0.33 in hour 03 and 0.56 in hour 19. On the other hand, after market coupling, German and French prices coincide exactly in about 70% of the hours. Only in 30% of the hours, price differentials could be observed.

The literature on market coupling so far focuses on comparing explicit and implicit schemes and on the empirical analysis on the effects of market coupling. Examples for theoretical studies are among others, Gebhardt and Höffler (2013), who discuss price differences in interconnected markets with explicit coupling and find that limited participation of traders explains much of the price differences. Weber et al. (2010) investigate details of explicit and implicit market coupling and give a preview on markets after the introduction of CWE market coupling. Also, Oggioni and Smeers (2013) contain an in-depth analysis of implicit coupling in nodal and zonal price systems in terms of optimizing algorithms to obtain prices. Richter and Viehmann (2013) discuss explicit auctions from an informational point of view and explain another source for inefficiencies of explicit auctions.

Huisman and Kilic (2013) present an empirical analysis on the development of day-ahead prices in five European markets after they became connected. There the focus is on market conditions that cause extreme spikes in one market. They show that increasing connectivity reduces the impact of price spikes, decreases volatility and that the

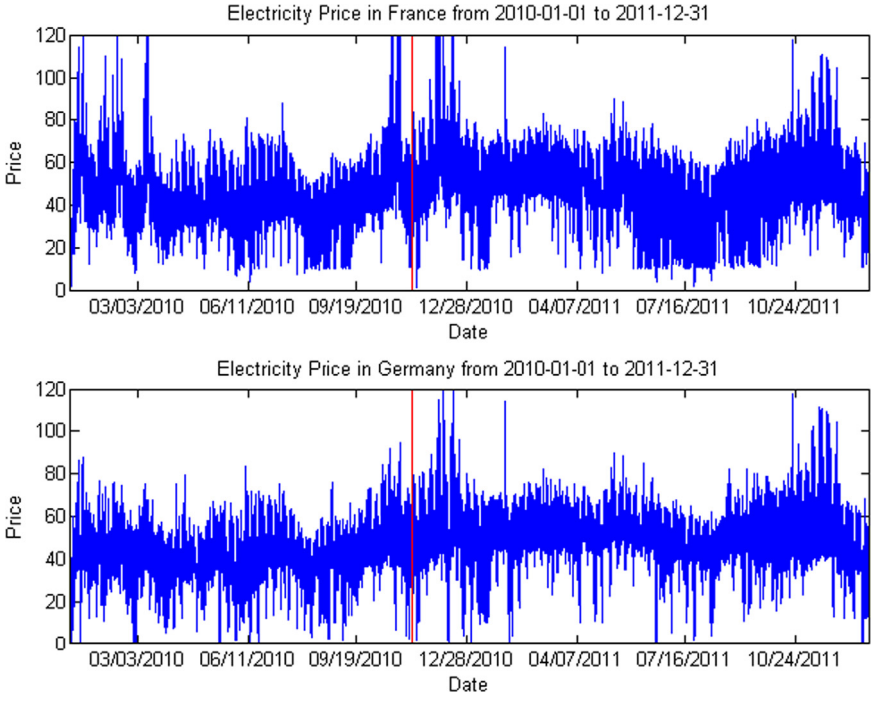

Fig. 1. Day-ahead prices in Germany and France. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this paper.)

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