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Econometric analysis of 15-minute intraday electricity prices☆

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ABSTRACT

The trading activity in the German intraday electricity market has increased significantly over the last years. This is partially due to an increasing share of renewable energy, wind and photovoltaic, which requires power generators to balance out the forecasting errors in their production. We investigate the bidding behaviour in the intraday market by looking at both last prices and continuous bidding, in the context of a reduced-form econometric analysis. A unique data set of 15-minute intraday prices and intraday-updated forecasts of wind and photovoltaic has been employed. Price bids are explained by prior information on renewables forecasts and demand/supply market-specific exogenous variables. We show that intraday prices adjust asymmetrically to both forecasting errors in renewables and to the volume of trades dependent on the threshold variable demand quote, which reflects the expected demand covered by the planned traditional capacity in the day-ahead market. The location of the threshold can be used by market participants to adjust their bids accordingly, given the latest updates in the wind and photovoltaic forecasting errors and the forecasts of the control area balances.

1. Introduction

Trading in the intraday electricity markets increased rapidly since the opening of the market. This may be driven by the need of photovoltaic and wind power operators to balance their production forecast errors, i.e. deviations between forecasted and actual production. Evidence for this is a jump in the volume of intraday trading as the direct marketing of renewable energy was introduced. Furthermore, there may be a generally increased interest in intraday trading activities due to proprietary trading. Our main goal is to identify explanatory variables, specific to the electricity intraday market, that influence the bidding behavior in the 15-minute intraday market at the European Power Exchange (EPEX).

Along the basic timeline of electricity trading activities, see Fig. 1, the intraday activities relate mostly to further adjustments of positions after the closure of the day-ahead market.

While day-ahead trading offers the possibility to correct the long-term production schedule (build on the forward markets) in terms of hourly production schedule of power plants (Delta Hedging) and to adjust for the residual load profiles on an hourly basis, the increasing share of renewable energy sources (wind, solar) in electricity markets requires a finer adjustment.

According to the Equalization Mechanism Ordinance (ger.: Verordnung zur Weiterentwicklung des bundesweiten Ausgleichsmechanismus, abbr.: AuglMechV) all electricity generated by renewable sources has to be traded day-ahead. This is usually done by the transmission system operator (TSO) with the plant operator receiving a legally guaranteed feed-in-tariff. From 2012 on, the inclusion of a market premium led direct marketers within the feed-in premium support scheme to enter the market as well. Trading of electricity from a renewable energy source is based on forecasts which may have a horizon of up to 36 h (taking some data-handling into account). To correct errors in forecasts the AusglMechV requires the marketers of renewable energy to use the intraday market to

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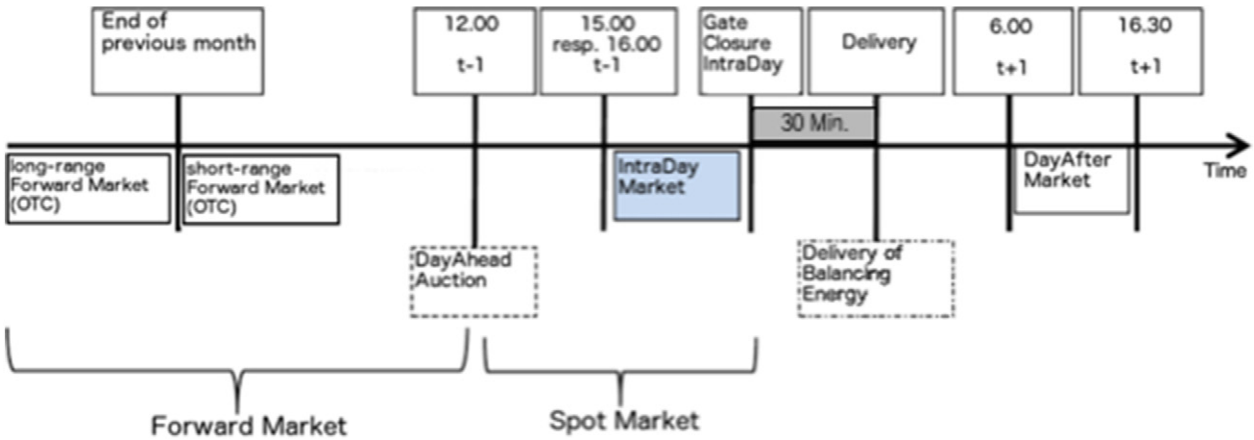

Fig. 1. Timing electricity trading.

balance differences in actual and updated forecasts. Intraday trading starts at 3 pm and takes place continuously until up to 30 min before the start of the traded quarter-hour. As forecasts change regularly, marketers may sell and buy the same contract at different times during the trading period.

After the closure of the intraday market balancing energy has to be used to close differences between available and forecasted electricity. As a smaller number of power plants are used for balancing energy the merit-order curve is steeper than that in the intraday market. Thus, on average larger prices are paid and marketers aim at minimizing this difference, see Graeber (2014). In addition, TSOs may impose sanctions on marketers who frequently require balancing energy.

Balancing energy is supplied by generators with the necessary flexibility to balance the market. In case generation is below demand, positive balancing energy is used, otherwise negative balancing energy is used. Graeber and Kleine (2013) and Just (2012) contain a detailed description of the integration of renewable energy in electricity markets and the regulatory requirements and we refer the reader to these sources for further information.

The day-ahead market (spot market) and the balancing markets have been investigated extensively. For example, Paraschiv et al. (2014) show that the day-ahead price formation process at EPEX depends on the interaction/substitution effect between the traditional production capacity (coal, gas, oil) with the fluctuant renewable energies (wind and photovoltaic (PV)). Further empirical studies on intraday/balancing markets include Karakatsani and Bunn (2008) and Klaeboe et al. (2013). Also, Mller et al. (2011) linking day-ahead and balancing markets.

An investigation in the merit-order effect is given by Cludius et al. (2014), who find that electricity generation by wind and PV has reduced spot market prices considerably by 6 €/MWh in 2010 rising to 10 €/MWh in 2012. They also show that merit order effects are projected to reach14–16 €/MWh in 2016.

Recent studies of the intraday high-frequency electricity prices at EPEX are Hagemann (2013) and Hagemann and Weber (2013) who look at liquidity effects and forecast determinants on a hourly basis. Also, Garnier and Madlener (2014) considers trading strategies to minimize costs from imbalances for both PV and wind, but generates price changes in terms of a reduced-form model (using a stochastic process). The focus lies in developing a trading strategy for a given setting, and not on explaining the relevant price process. Several studies have discussed the effects of prognosis errors for wind generation (see Ketterer, 2014; Nicolosi, 2010) . As Fig. 2 suggests, a PV production introduces quarter-hour ramps quite naturally. In addition, changes in forecasts of renewable energy production require a timely correction of day-ahead positions. However, photovoltaic has not been investigated so far.

Hagemann (2013) and Hagemann and Weber (2013) used the ex-post published wind infeed data to explain ex-ante their impact on the day-ahead market. These are publicly available data from the Transparency Platform EPEX. However, the actual infeed is only known ex-post and therefore it cannot be used directly to explain the price formation on the intraday market. In fact, the intraday market participants have access to updated forecasts of wind. In our study, we will extend the existing literature by taking into account the intraday updated forecasts for wind and PV, which have been supplied by EWE Trading GmbH.

Each day, hourly day-ahead electricity prices are revealed around 2 pm at EPEX (see Paraschiv et al., 2015). At the same time, market participants have access to forecasts for wind and PV published by each Transmission System Operator (TSO) in 15-minute intervals for the next day. However, wind and PV forecasts are updated frequently during the trading period. Thus, at the time when market participants place their bids for a particular intraday delivery period (hour, quarter of hour), updated information about the forecasting errors of renewables becomes available. In consequence, also deviations between the intraday prices and the day-ahead price for a specific hour are expected to occur. Our main research question is, thus, to which extent do market participants change their bidding behavior when new information on wind and PV forecasts becomes available. We will employ a unique data set of the latest forecasts of wind and PV available at the time of the bid.

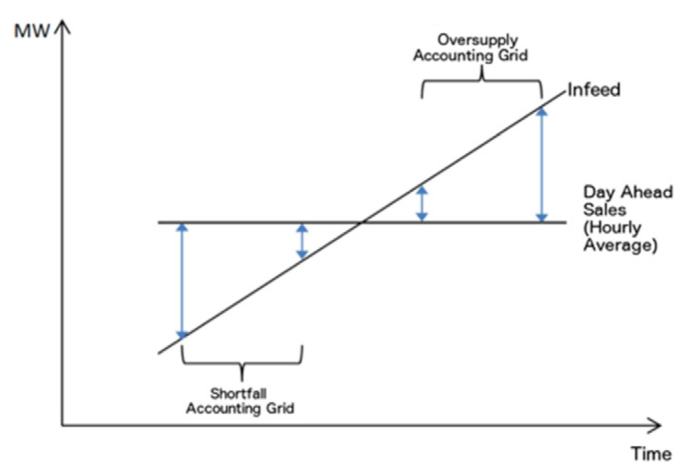

Fig. 2. Quarter hour ramps.