The Impact of Renewable Energy Forecasts on Intraday Electricity Prices

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Motivations underlying the research

Over the coming years, the shift to renewable power is set to be one of significant structural changes in the German energy system. Being actively facilitated and supported by the German government, the shift will lead, among others, to an expansion of the share of wind and solar power in the German energy mix. Due to the fact that energy harnessed by wind turbines or photovoltaic panels is intermittent, having precise wind and solar power forecasts is important. Therefore, the focus of the present study will be placed on analyzing forecast errors in wind and solar power forecasts.

We study these forecast errors in the context of the German electricity market. Besides a day-ahead market, electricity can be traded in a continuous intraday market in Germany. The day-ahead and intraday market have two features relevant for the present study. First, both of them take place before the moment of physical delivery of electricity. Second, intraday market takes place closer (in temporary terms) to the moment of delivery.

These two features have two important implications. First, prices in both day-ahead and intraday markets are based on wind and solar power supply forecasts. Second, these forecasts are usually closer to actual values at the moment of physical delivery (i.e. are more precise) in the intraday market. As a consequence, the influence of forecast errors on intraday prices drops (meaning that prices become closer to the actual fundamental equilibrium) the closer trading occurs to the point of actual electricity delivery. Our study proves that this influence is non-linear.

Moreover, there is a second, more technical, contribution that our study makes. This contribution is a wholesale auction-curves- and optimization-based non-linear econometric model which we develop. This model extends the family of relatively unelaborated empirical-wholeasle-curves-based models. In its core, the model shifts day-ahead supply curves to approximate the corresponding intraday supply curves and calculate intraday prices.

A short account of the research performed

To carry out our results, we focus on the German-Austrian EPEX SPOT market and study the period between 01.01.2016 and 31.12.2017. We use prices from the day-ahead market as well as hourly weighted average intraday prices usually referred to as VWAP by the EPEX SPOT. From the EPEX SPOT we also have the data as to the wholesale empirical supply and demand curves. We obtain the data regarding the forecasted and actual wind and solar power supply from ENTSO-E Transparency.

As opposed to our linear and non-linear benchmarks, our main econometric models are not built on the analysis of the day-ahead and intraday price time series. Instead, the main models are based on manipulations with empirical wholesale supply and demand curves. The models first transform demand curves into their inelastic analogues to simplify the study and then shifts the wholesale day-ahead supply curves to approximate the corresponding intraday supply curves. The magnitudes and the directions of the shifts are determined by (a) errors in wind and solar power forecasts and (b) absolute amounts of wind and solar power generated at the moment of delivery. To optimally select the shift size, a non-linear optimization technique is applied. In other words, we add or subtract the adjusted forecast errors from the day-ahead supply. As a result, the day-ahead wholesale supply curves are shifted horizontally. The shifted day-ahead supply curves are thus our approximations of the intraday supply curves. Naturally,

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the intersections of the shifted day-ahead supply curves with the demand curves coincide with the intraday prices.

Main conclusions and policy implications of the work

First, the results showed that our main models, although being unconventional, can be used successfully to model intraday prices. The benefit of our models would be their straightforward interpretability because we can easily see the impact of each considered parameter on the shift size of a supply curve. Second, we demonstrated non-linear impact of forecast errors in wind and solar forecasts on intraday electricity prices. As our study indicated, the non-linear shape of the merit order curve and the sector of this curve in which the equilibrium price is realized are possible reasons for the non-linear impact. Third, we conduct an auxiliary study to show that forecast errors also impact volatility of intraday prices in a non-linear manner. The auxiliary study also allows us to conclude that the rising amount of wind or solar power capacities in fact increases the volatility of intraday prices.

Furthermore, our results allow us to derive 6 main policy implications. First, we show that locations of new wind and solar power plants must be selected to minimize correlations between the outputs of the already existing and new capacities. Second, we argue for more diversity of renewable power supply sources. Third, we show that it is efficient to expand cross-border transmission infrastructure to avoid country-specific bottlenecks. Fourth, greater investments into quality of renewable energy forecasts are beneficial. Fifth, that flexible generation and better demand side management will ease the non-linear impact of forecast errors. Finally, efficient and transparent renewable energy curtailment management can further improve the stability of energy systems.