Electricity Price Forecasting Using Sale and Purchase Curves: The X-Model

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Introduction

Our paper aims to model and forecast the electricity price by taking a completely new perspective on the data. It will be the first approach which is able to combine the insights of market structure models with extensive and modern econometric analysis. It aims to fill the gap in electricity price forecating between research done in time-series analysis where the structure of the market is usually left out and the research done in structural analysis, where empirical data is utilized very rarely and even less thoroughly. Instead of directly modeling the electricity price as it is usually done in time series or data mining approaches, we model and utilize its true source: the sale and purchase curves of the electricity exchange.

We will refer to this new model as X-Model, as almost every deregulated electricity price is simply the result of the intersection of the electricity supply and demand curve at a certain auction. Therefore we show an approach to deal with a tremendous amount of auction data, using a subtle data processing technique as well as dimension reduction and lasso based estimation methods. We incorporate not only several known features, such as seasonal behavior or the impact of other processes like renewable energy, but also completely new elaborated stylized facts of the bidding structure - e.g. price clustering. We describe and show the proposed methods for the day-ahead EPEX spot price of Germany and Austria.

Sale and purchase curves

The electricity price of exchanges is the result of competitive bidding and offering. Focusing merely on the time series of prices therefore neglects their true source, see Weron (2014). The prices can be solely determined by the intersection of sale and purchase curves resulting from the electricity auctions. The left-hand side of Figure 1 shows the day-ahead price of the 12.04.2015 with the sale and purchase curves for 12:00 and 13:00 are provided. There we see that a small change in the supply and demand curve led to a (negative) price spike. The X-Model aims for modeling the curves in (1) directly using highdimensioal statistics, esp. lasso. We utilize past sale and purchse curves and fundamental inputs, like planned conventional power generation or planned wind and solar power net feed-in.

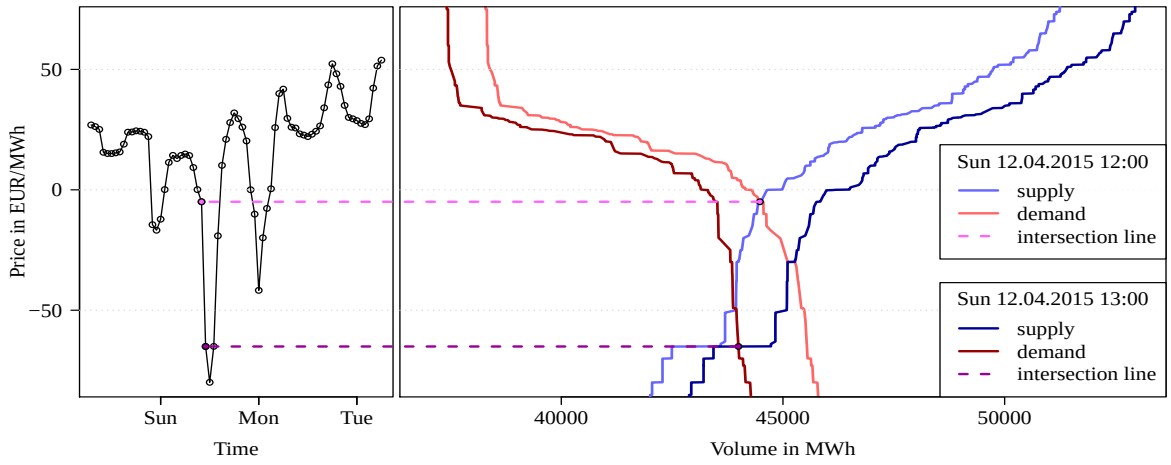

Figure 1: Market clearing price time series with supply and demand curves for 12:00 and 13:00 on 12.04.2015.

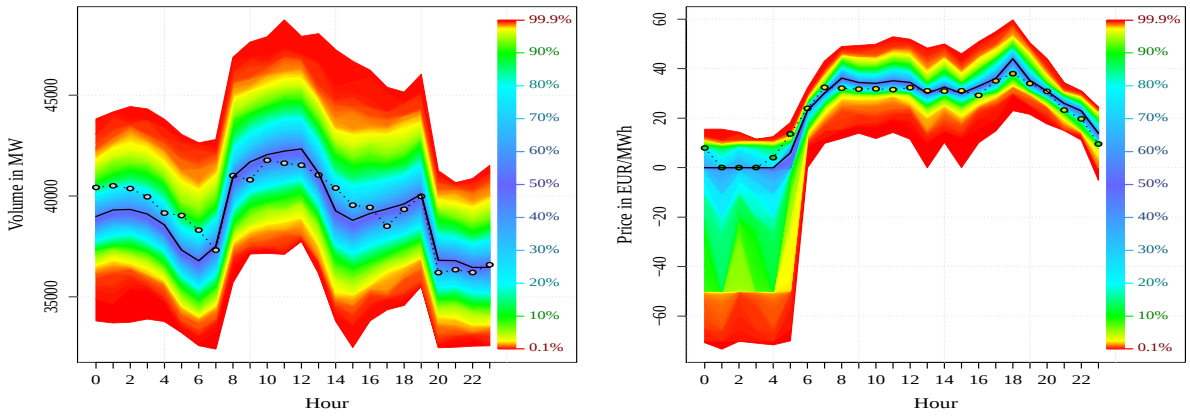

Figure 2: Probabilistic volume and price forecast of the X-Model with point estimate (black line) and observed values (colored dots) with legend for the 19.12.2014.

The X-Model

We refer our model for the sale and purchase curves of the electricity price as X-Model. We choose the letter X, as it symbolizes visually the intersection of the supply and demand curve. For the setting up the X-model we proceed in three steps:

1. To overcome the massive amount of data we will organize the bid volumes in price classes.
2. We provide a stochastic model to forecast the bid volume of each price class.
3. Given the forecasted bids within each price class we reassemble the precise bidding structure by reconstructing the classes. Then we calculate the supply and demand curves to compute the market clearing price by the intersection of both curves.

The X-model is able to capture the non-linear behavior of the electricity price, which is especially useful for predicting huge price spikes. Using simulation methods we show how to derive prediction intervals for probabilistic forecasting that capture complicated non-linear behavior well. Figure 2 shows probabilistic volume and price day-ahead forecasts of the X-model.

Conclusion

Our empirical results show that it is possible to model the electricity prices using such an approach in a very promising way. We can capture known stylized effects of the electricity price, like daily and weekly seasonalities, very well and are also able to model the newly elaborated stylized facts of price bids. The complex bidding structure for day-ahead prices allows us to model and predict extreme and rare price events by estimating realistic prediction densities for the market clearing price. The conducted out-of-sample study shows that the introduced model clearly outperforms standard methods and even very well performing methods of the recent literature in terms of densities as well as error measures like MAE and RMSE. Especially the latter was stunning and remarkable to us, as the model approach is relatively simple in its core and mainly developed for the purpose of modeling extreme price events.

The provided X-Model approach opens the door to many other different applications, especially those related to policy making. One very important issue is for example the impact of market regularizations.

References

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