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Master Thesis

Predicting Price Regimes in German Short-term Electricity Markets

The increasing share of renewable energies has caused an exacerbated need of short-term trading opportunities for electricity. Forecast uncertainty and highly volatile feed-in profiles of renewable energies favor the trade of shorter contracts closer to the time of physical delivery [1,2,3]. Against this backdrop, the German electricity market design comprises successive markets which differ in terms of their respective market design. The day-ahead auction which is probably the most important wholesale electricity market is held at noon one day ahead physical delivery and allows for trading hourly contracts. Its uniform market clearing price acts as an important reference price. As information with respect to the electricity generation by renewable energies is updated several times until delivery, there is a need to balance the corresponding short-term forecast errors. As a consequence, the continuous intraday market which allows to balance forecast errors continuously until 30 minutes[1] before delivery was established in Germany. The continuous intraday trading period begins at 3pm one day ahead delivery. Within continuous intraday trade, bids and asks are continuously matched whenever possible and a pay-as-bid principle is applied.

When analyzing the development of prices along the continuous intraday trading period, it is striking that electricity prices for the same product vary significantly dependent on the time difference between the trading and delivery period. Especially close to market closure, a very high volatility of prices can be observed. These relations may be traced back to irrational behavior and imbalance aversion to avoid penalties in the sense of imbalance prices. These findings suggest, that intraday price patterns and their respective development can be described by the identification of similar price regimes. In [4], these states are also named economic regimes. Such regimes may, for example, refer to periods with decreasing, stagnating, or increasing prices.

From a business point of view, the prediction of future price regimes is crucial to support real-time trading decisions. The expectation of increasing prices may, for example, trigger the recommendation to unwind or offset a position. However, predicting future price developments by the use of economic regimes requires sophisticated methods selected from the field of data science. In this thesis, prior findings and methodological improvements presented in [4] shall be transferred and tailored to the continuous intraday electricity market in Germany.

[1] Inside one specific balancing zone, it is possible to trade continuous intraday contracts until 5 minutes before delivey.

From a methodological point of view, this thesis is sub-divided into two parts. The first part is to identify and fit models which are able to map the distribution of prices in the different economic states. These may, for example, be Gaussian Mixture Models. Second, a model (e.g. a Hidden-Markov-Model) shall be developed to predict the transition probability of the respective price regimes. The model choice has to fit the underlying data format and business application and shall especially be motivated through predictive accuracy and the final business value.

To support the decision making process of relevant stakeholders, such as energy trading companies, the results of the data science approach shall be contextualized against the backdrop of the underlying business goals. One major purpose is to develop and test different trading strategies based on the prediction algorithm and historical market data. Furthermore, this thesis shall address how to implement the models which have been developed within the thesis in a real-world business application.

This thesis will be supervised in collaboration with ProCom GmbH. We will provide extensive historical order book data from German intraday electricity markets covering a sufficient period of time to guarantee meaningful results. The data science and machine learning tools shall be developed by the use of the *Python* programming language.

Literature References:

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