The Impact of Renewable Energy Generation on the Spot Market Price in Germany: Ex-Post Analysis using Boosting Method

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The merit order effect of renewable energy has been deemed to be a major factor in the price slump in wholesale electricity prices, particularly in the German market. To advance understanding of the merit order effect, this study uses both regression analysis and machine learning analysis with particular focus on Germany using hourly data of wind and solar generation, load, and spot market price.

The existing studies of the merit order effect of renewable energy have largely focused on estimation of the average change in the wholesale price using regression method; however, studies that have investigated how the merit order effect differs across the hours of the day are scarce. Therefore, to fill this gap, this study investigates both the average change in the wholesale price and also the changes in the merit order effect across the hours of the day. Another important feature of this paper lies in its use of the machine learning approach to investigate the merit order effect. Machine learning approach is used in this study to analyze the features that are difficult to capture using the linear regression method that we also employ, and it is also used to perform a scenario-based analysis to investigate how different proportions of wind and solar generation would affect market prices.

The results show that electricity from wind and solar sources reduced the spot market price by 9.64 €/MWh on average during the period from 2010 to 2017. Wind had a relatively stable impact across the day, ranging from 5.88 €/MWh to 8.04 €/MWh, while the solar energy impact varied greatly across different hours, ranging from 0.24 €/MWh to 11.78 €/MWh and having a stronger impact than wind during peak hours. The results from the machine learning approach have shown further important characteristics of the interactions between renewable energy and the spot market price as can be observed from Figure A, including: 1) the somewhat linear interactions of the load and the renewable energy with the price, which imply that the linear regression method can estimate the merit order effect accurately to a certain degree; and 2) the slightly diminishing merit order effect of the renewable energy sources at high generation volumes, particularly for wind generation. Finally, using a scenario-based variable breakdown analysis, we showed how the different proportions of renewable energy generation change the merit order effect.

This study contributes to the existing studies by not only quantifying the average merit order effect of renewable energy covering the longest time period to date for investigation of the merit order effect of renewable energy using hourly data, but also showing how the merit order ef-

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fect differs across the hours of the day, capturing and visualizing the interactions between renewable energy and the spot market price, and forecasting how the expected increase in the renewable energy capacity in Germany would affect the spot market price.

Figure A: Three-dimensional partial dependence plots