

Electricity Market Flexibility and Renewables Intermittency: New evidence from Quantile Causality

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Overview

This paper considers the causal relationships between electricity prices and fundamental components of the electricity market, such as the increasing share of intermittent renewables, from the perspective of conditional quantiles. As opposed to a large part of the literature that tests non-causality in a certain moment, we test the null hypothesis of non-causality in various quantile intervals. By doing so, we provide more insights about the true causal relationship, since the latter is better described by a portfolio of local measures of causality computed in different locations of the conditional distribution than a one-number measure of causality. Moreover, we capture any asymmetric responses of electricity prices to intermittent renewables that are associated with different types of power system flexibility and functioning of the intraday market.

Methods

Rather than testing non-causality in a moment (mean or variance) or in a fixed quantile level, we test for non-causality in quantiles over some quantile intervals. By doing so, we can capture from which quantile range the causal relationships arise. To select the optimal lag for any quantile range, we follow Chuang et al. (2009) and use the sequential lag selection to determine the optimal lag truncation order. We also test whether the pairwise causal effects are symmetric about the median. The symmetry of quantile causal effects explains why conventional methods yield an insignificant estimate of the causal effects, since positive and negative effects at upper and lower quantiles cancel out each other in "averaging". Finally, we avoid the need for sample splitting under various market situations, and therefore we do not reduce the sample size or lose the time dependence structure in the original data.

Results

We find asymmetric and heterogeneous across quantiles effects propagating from different underlying factors, for instance intermittent renewables, to electricity prices. We also show that some factors may possess opposite signs at lower and upper quantiles and be stronger at more extreme quantiles. For instance, the quantile causal effects of wind power generation on electricity prices exhibits a spectrum of asymmetric V-shape relations. That is the distribution dispersion of electricity prices increases with higher penetration of wind power.

Conclusions

Large-scale integration of renewable energy nowadays has been a fact for several countries. However, this has increased the need for electricity market flexibility and thereby the important role of intraday electricity market. Hence, we model the nonlinear and asymmetric causal relationships between different fundamental components of the electricity industry in terms of predictability, thus providing a better understanding of the unprecedented market dynamics and testing the adequacy and flexibility of the intraday electricity market.

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