RENEWABLE ENERGY AND THE PRICING OF ELECTRICITY FUTURES

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Overview

We explore theoretically and empirically the impact of renewable energy on forward markets for electricity. Existing modelling and econometric approaches explain forward prices mainly by movements in stochastic demand and according stochastic spot prices against which market players seek insurance. Amid increasing market entry of renewable intermittent energy sources, the volatility of spot prices however is not anymore a function of underlying demand volatility only, but also a function of the variance of the renewable output that shifts the supply curve and thereby changes spot prices.

To understand the effect of stochastic renewable energy output on the hedging needs of market participants and the resulting forward prices for electricity, we first establish a theoretical model that derives optimal heding positions and the equilibrium forward price as a function of renewable output risk. Then, we test the hypotheses on the theoretically derived determinants of the forward price using data from the European Electricity Exchange.

In particular, we find that forward prices increase with higher variance of renewable energy output (respectively higher variance in the residual demand to be served by conventional plants). Thus generating firms receive a premium for committing to deliver in times of high variability of renewables and according high variability in ramping conventionals up- or downward.

We thereby show how forward markets offer risk mitigation in the presence of supply intermittency. Next to contributing with a novel model and empirical results to the literature on risk mitigation, we view our results also as an argument in favour of energy-only spot and forward markets for hedging and supporting investment decisions in power markets.

Methods

We assume constant absolute risk aversion among both generation and retailers, where the latter act on behalf of consumers. We specify retail and generation firm profits and solve for the spot and the forward market equilibrium prices. We thereby are able to analyse the theoretical effect of renewable energy on the risk premium, defined as the forward price minus the spot price. The model guides our empirical application and our hypotheses. We hypothesize that the risk premium decreases with spot price variance (as in earlier findings) and increases with the uncertainty on renewable generation.

We test this model in a simple but direct way, using the theoretical derived forward market equilibiurm identity and data from the European Electricity Exchange spot and forward markets for Germany and Austria. We also test for an interaction between the uncertainty in renewable output and the marginal costs of conventional plants. We expect a positive interaction, because for high marginal cost of conventional units, also the uncertainty in renewable output should be valued higher. For instance, compensating a negative shock to renewable output is costlier for higher marginal cost of fossil fuel generation.

We use a pooled cross section of forward contracts and underlying spot prices between January 2011 and December 2014 and employ ordinary least squares estimation with time fixed effects.

Results

Our main finding is that the risk premium in electricity forward markets increases for forward contracts with maturity dates in which high volatility in renewable generation exists - mainly for the summertime when photovoltaic sources introduce shocks to the supply side. Forward markets thus include a premium for generators when signing forwards and committing to deliver during this time. We derive this effect theoretically and empirically. Next to this novel finding, we are able to confirm existing findings: the risk premium decreases with the variance in spot prices and increases with the skewness of spot prices, as first found by Bessembinder and Lemmon (2002) and Longstaff and Wang (2004). As our results hold when controlling for the price variance and skewness, they can be viewed as a contribution to earlier models and results, rather than an opposite finding.

Conclusions

We conclude that forward markets for electricity react to market risk introduced by renewable energy sources and that forward contracting plays an important role for hedging market risk that arises in low-carbon electricity markets. Recently, a range of new hedging products relating to risks imposed by renewable generation have been or are being introduced, such as the Phelix Sun Peak Future and the Cap Futures on the EEX, constituting a scope for interesting further research on forward contracting in electricity markets with high shares of renewable generation.

References

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