Estimating the value of flexibility from real options – on the adequacy of hybrid electricity price models

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Overview

In contemporary energy markets dealing with the stochasticity of electricity and input commodity prices is a key issue. Generally, electricity price models are distinguished according to the forecast horizon. Longer term electricity price models estimate the price development for a time horizon of one or several years, e. g. to schedule power plant revisions. Shorter term electricity price models forecast with a time horizon from less than a week, e. g. to optimize the day-ahead unit commitment. Notably due to the increasing renewable infeed the consideration of short term fluctuations in longer term price forecasting models is crucial for proper valuation of flexibilities, the assessment of optionalities or other risk management purposes. For financial markets this long term relations tend to be unstable and for energy commodities the situation is even much more extreme (among others see Alexander, 1999 Eydeland and Wolyniec, 2003 Bencivenga et al., 2010) but for spread option evaluation being able to model the dependencies between input commodities and electricity is of great importance (Aïd et al., 2013).

The article deals with the question how to assess and hedge the real option value given the incompleteness of the future markets. We introduce two hybrid modelling approaches for electricity prices based on fundamental expectations accounting for both short and long term uncertainties consistently. In the application the price estimation results are used to value and hedge a state-of-the-art 800 MW gas power plant for the delivery year 2012. For the hedging transaction costs and low granularity of hedge products is considered.

Methods

The price modelling approaches differ in the way to model the long term relations of electricity and input commodity prices. Model 1 is a one-factor mean reversion approach to model the longer term spread directly. Model 2 is a multi-factor approach for the longer term variations of electricity and input commodity prices. The valuation approach basis on a real options theory and use stochastic dynamic programming to consider technical constrains and the uncertainty of electricity prices.

Results

We show that modelling the mean-reversion behaviour of spreads provides better estimates of the real options flexibility value than conventional multi-commodity price models. In contrast to the presented multi-factor approach, the spread simulation does more accurately forecast the bandwidth of possible price paths.By comparing the two approaches to cover the longer term uncertainty of the electricity prices we found that modelling the mean-reversion behaviour of spreads provides better estimates of the flexibility value of real options than conventional multi-commodity price models. The multi-factor approach tends to overestimate the variability of the spread between electricity and input factor prices and thus leads to an overestimates the total option value. Accordingly this value cannot be recovered through hedging in the futures market. The results for the one-factor approach are more conservative regarding the achievable spread option value. Despite the incompleteness of the futures markets remarkable 95 present of the initial option value are hedged with a dynamic delta hedging strategy for 2011 till 2012.

Conclusions

It is shown that the consistent modelling of shorter and longer term uncertainty in electricity spot prices is from crucial importance for the valuation and hedging of flexibility value from real options. Therefore we suggest a hybrid electricity price modelling approach that harness the benefit from different methodologies and deliver a consistent consideration of short to long term uncertainties. (1) An equilibrium model based on fundamental expectations to forecast the fundamentally expected electricity price. (2) A stochastic approach to model the short term fluctuation around the fundamental price to representation of the short term uncertainty. (3) A one-factor (mean-reversion) approach to model the longer term development of the generation spread. In contrast to the presented multi-factor approach, the spread simulation does more accurately forecast the bandwidth of possible price paths.

*References*References

Aïd, R., Campi, L., Langrené, N., 2013. A Structural Risk-Neutral Model for Pricing and Hedging Power Derivatives. Mathematical Finance 23 (3), 387–438. 10.1111/j.1467-9965.2011.00507.x.

Alexander, C., 1999. Correlation and Cointegration in Energy Markets. Managing Energy Risk 1999 ((2nd Edition)), 291–304.

Bencivenga, C., Sargenti, G., D'Ecclesia, R.L., 2010. Energy markets: crucial relationship between prices, in: Corazza, M., Pizzi, C. (Eds.), Mathematical and statistical methods for actuarial sciences and finance. Springer Verlag, Dordrecht, New York, pp. 23–32.

Carmona, R., Durrleman, V., 2003. Pricing and Hedging Spread Options. SIAM Rev. 45 (4), 627–685. 10.1137/S0036144503424798.

Eydeland, A., Wolyniec, K., 2003. Energy and power risk management: New developments in modeling, pricing, and hedging. Wiley, Hoboken, N.J, 1 online resource (xiv, 490.

Guo, X., Beskos, A., Siddiqui, A., 2014. The natural hedge of a gas-fired power plant. Comput Manag Sci. 10.1007/s10287-014-0222-x.