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Modelling Correlation in Carbon and Energy Markets.

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Philipp Koenig

In January 2005, the European Union Emission Trading Scheme (EU-ETS) was launched, establishing a price for CO2 (carbon dioxide) emissions. Due to its large share in total EU CO2 emissions, the power generation industry is significantly impacted by carbon pricing. The cost of producing one unit of electricity, based on fossil fuel generation, is now a function not only of the fuel price and the power plant's thermal efficiency, but also of the carbon price and the fuel's carbon density.
The focus of this study lies on baseload electricity in the United Kingdom, which is to a large extent generated using Combined Cycle Gas Turbines (CCGT), Wright (2006). The energy needs of baseload generators are mainly covered in forward markets, due to the high associated storage costs of natural gas and hard coal. Furthermore, electricity cannot be stored without significant losses and only over a short period of time and so baseload generators also sell a proportion of their output in forward power markets. The purchase of forward energy as well as the sale of forward power contracts allows the generator to lock in a given amount of profit per unit of electricity produced, that is the generator hedges the risk of unfavourable price movements in both energy and power markets. Following Roques et al. (2008), the cash-ows of a CCGT plant are self-hedged to the extent that power, natural gas and carbon prices naturally co-move. In particular, if higher gas and carbon prices are associated with higher power prices, that is there is strong positive co-movement, then fuel price changes may be profit neutral. It becomes immediately obvious that the extent to which the cash-flow of a CCGT plant is self-hedged critically depends on the nature of the co-movement of natural gas, carbon and power prices.

Co-movement between prices for input fuels and the price of CO2 emission allowances is the result of the ability to switch between input fuels in power generation, especially between hard coal and natural

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gas. It is commonly measured as correlation and is not only used in hedging decisions of power generators. Correlations between power, carbon and fuel prices are also used in optimization of power generation plant portfolios. Roques et al. (2008) use cross-correlations and standard deviations of UK quarter-ahead fuel, power and carbon prices in a Monte-Carlo simulation of power plant net present values. They point out that, under certain circumstances regarding access to capital and the failure to secure long-term power purchase agreements, the correlation between electricity, gas and carbon markets makes 'pure' portfolios of gas power plants more attractive than diversified plant portfolios. Correlations are therefore not only important for hedging decisions on the individual plant level, but are also taken into considerations when evaluating initial capital investment decisions.
However, the relationship between the prices of natural gas, carbon emission allowances and electricity is not constant. This study will show that there are periods when the carbon, natural gas and power prices decouple. This reduces their co-movement and therefore the degree to which a CCGT plant is self-hedged. The ambition of this study is not to explicitly model the process driving baseload electricity prices, nor the prices for carbon emission allowances or natural gas. Rather, it will contribute to the literature in three ways. First, it will show that the pairwise correlations of energy, carbon and power prices are not constant over time. Second, it will analyze the effects of extreme weather conditions, commodity market volatility and seasonal effects on the pairwise correlations. Thirdly, it will identify periods in which the absence of an economic incentive to switch input fuels leads to a decoupling of prices and a reduction in correlation. All three aspects affect the degree of self-hedging of a CCGT power plant.

Data characteristics, such as fat tails in the empirical distribution as well as clustering of volatility, suggest the use of a GARCH-type estimation framework. In order to model correlation and its drivers, this paper shall follow the literature in empirical financial econometrics by estimating an extended Dynamic Conditional Correlation (DCC) model, based on daily observations of month-ahead energy, power and carbon futures returns. A generalized DCC model, which both accounts for heterogeneity in the correlation parameters across series as well for asymmetries of correlation sensitivities to standardized innovations, is extended by a set of relevant control variables. These control variables include indicator variables for the April 2006 oversupply event in the EUA market, seasonal effects, high commodity market volatility, extreme weather conditions (air temperature, wind speed and precipitation), and finally static merit order regimes.

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Based on daily return data from April 2005 to August 2010, the estimation results are summarized as follows. First, conditional correlation of all series in the sample is clearly time-varying. That is, the relationship between them changes over time, which significantly affects the self-hedging property of CCGT investments. Second, the DCC methodology yields much smoother conditional correlations when compared to unconditional correlation measures. In particular, the DCC correlation estimate of month-ahead electricity and natural gas futures returns describes a much more stable relationship between the variables when compared to a rolling window correlation measure. Third, model extensions suggest that there exists significant heterogeneity in the correlation parameters across series and that only some control variables matter. In particular, asymmetries in the sensitivity of correlations to shocks can only be detected for hard coal and crude oil returns. Importantly, extreme weather, seasonal and high commodity market volatility controls show no statistically significant effect on correlation. As expected, the April 2006 oversupply event significantly reduces conditional correlation between the series in the model. Finally, the static merit order control variable is significantly positive, which is the key result of this study. The main working hypothesis of identical correlation between carbon emission allowances and natural gas returns across merit order regimes is rejected in favour of the alternative hypothesis, namely a reduced correlation during static merit order regimes. This means that there is a statistically significant decoupling of electricity, fuel and carbon month-ahead returns during periods in which fuel-choices in the power sector are set in either hard coal or natural gas. During those periods there is no incentive to switch input-fuels as a response to price changes and the link between fuel and carbon prices is broken. This effect remains robust to the inclusion of other relevant controls.

Contact pk304@cam.ac.uk
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