Electricity, Fuel & Carbon Allowance Spot Prices: The Case of Germany

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Overview

Few studies have focused on the dynamic interactions between electricity prices and EU ETS from an econometric point of view (Keppler and Mansanet-Bataller 2010, Nazifi and Milunovich, 2010, Creti et al. 2012,). Keppler and Mansanet-Bataller (2010) found Granger causalities running from the carbon future price to the gas and the coal future prices during the three years of Phase I and in the year 2008 of Phase II. Nazifi and Milunovich (2010) investigated the relationships among carbon, fuel, and electricity prices in a VAR model for Phase I and detected a significant influence of the electricity price on the carbon price. Notably, they found that the electricity price Granger causes the carbon price. Even fewer studies have investigated the relationship between the volatilities of electricity spot prices and carbon allowance prices. Tian et al. (2012) found a positive effect of EUA market volatility on electricity price volatility during Phase II, also showing that the relationship is positive and symmetric. However, Germany was not included. In the present study I empirically analyse the relationships between carbon allowance emission spot prices and both fuel and electricity spot prices, within the German market. Data relative to the period 04/01/2008 to 25/12/2012 are employed. I apply a semiparametric cointegration model and the Granger cointegration model, finally studying the relevant volatility interactions through a Generalised Autoregressive Conditional Heteroscedasticity (GARCH) analysis. With this work the previous literature is effectively extended through the provision of new insights into the question of interdependency between carbon prices and the prices of energy fuels and electricity. I aim at filling the gaps between models that focus on idiosyncratic effects of the electricity market and models that focus broadly on interdependencies between energy markets.

Methods

I used daily data for fuels, carbon, and electricity spot prices. The series run from July 15, 2009 to May 27, 2011, ie, EU ETS (or EUA) Phase II. Data relative to the carbon allowance and the natural gas spot prices are directly from the European Energy Exchange (EEX), whereas the electricity and oil spot prices are from Bloomberg. All prices have been transformed in natural logarithm with the return being then computed. Short- and long-run parameters in a Vector Error Correction Model (VECM) have been computed. I further investigate the above relationships by using impulse-response functions, which go over dynamic interactions between a set of variables by tracing out the effect of a shock to one of the endogenous variables through the entire system. This is different from the above Granger causality tests since the effect is free of propagating via any of the endogenous variable channels, rather than only accounting for a direct (i.e. partial derivative) impact under the *ceteris paribus* assumption. The impulse response functions can be used to produce the time path of the dependent variables in the VAR to shocks from the explanatory variables. If the system of equations is stable, any shock should decline to zero, whereas an unstable system would produce an explosive time path. Granger causality test was used in order to determine the influence of fuels and electricity prices on the price of carbon emission allowances. A Threshold GARCH (TGARCH) model was used to analyze the conditional variance, or volatility, of EUA spot prices.

Results

The oil and electricity spot prices are all variables significant in the cointegration equation for the EUA spot price. Therefore, they can impact on carbon price possibly by changing the fuel demand through the fuel switching. In fact, the sign of the gas price is consistent with the fuel-switching theory, with a positive relation between carbon and gas prices in equilibrium. This is in line with the results of Creti et al. (2012) for Phase II, which indicate a significant influence of the switching price on the carbon price in equilibrium, with the expected positive sign. Moreover, since estimations have been made with natural log prices, the estimated coefficients can be interpreted as elasticities. Consequently, we can deduce that, in long-run equilibrium, a gas price increase of 1% would be associated with a carbon price rise of about 0.18%, whereas an oil price rise of 1% would be associated with a carbon price increase of 1.58%. Similarly, an electricity price increase of about 1%. It is reasonable that it is the oil price that impacts much more than the gas price on carbon, as oil is more polluting than natural gas. As for the short-run interactions, the main results show that the carbon price is influenced by the natural gas and electricity price lagged values and by its own lags. It is interesting to note that the electricity price affects the carbon price while it would be expected the electricity price to be driven by the fuel cost, including carbon, of the price-setting plants, but not to feed back to the carbon price. For some industries, especially in power generation, the price of gas relative to the price of coal affects operating choices. A relatively high gas price encourages an increased use of coal, which should drive up the demand for carbon allowances given that coal effectively emits twice the CO_2 content of natural gas. Since the electricity price is mainly driven by the gas price it is likely that the rise of the natural gas price reflects on the electricity price, and consequently, on the carbon price. The Granger causality test shows that both the natural gas price and the oil price influence the carbon price. However, the contrary does not hold. Furthermore, the gas price influences the electricity price. The influence of the gas price on the carbon price was detected during Phase I through single-equation estimations (Alberola et al., 2008; Hintermann, 2010) and impulse-responses (Bunn and Fezzi, 2009; Fell, 2008). The influence of the fuel prices on the carbon price reflects the fuel-switching theory. In contrast, the absence of Granger causality running from carbon to electricity does not support the *pass-through theory* (Bunn and Fezzi, 2009; Fell, 2010; Zachmann and von Hirschhausen, 2008; Keppler and Mansanet-Bataller, 2010) at least within the time frame considered and for the case of Germany. In agreement with this paper's results, Nazifi and Milunovich (2010) did not find a significant influence of the carbon price on the NordPool electricity price for Phase I but rather they demonstrated the inverse. Similarly, Chemarin, Heinen and Strobl (2008) did not observe Granger causality running from carbon to electricity prices for the EU ETS Phase I when examining the relationship between the French electricity and carbon prices. Finally, according to Nazifi and Milunovich (2010), I did not impose any restriction when constructing the Granger causality. The impulse response functions show that, according to the fuel-switching theory, the carbon price increases when the natural gas or the electricity prices increase (a positive response of carbon to gas). In addition, the magnitudes of the responses of the carbon price to each of the energy prices are very small and that this effect is absorbed within 4 days after the shock. The volatility of carbon price, assessed with TGARCH analysis, is driven by the gas, oil and electricity prices. The ARCH and GARCH parameters are positive and significant, indicating the presence of ARCH and GARCH effects in the carbon price returns. The ATARCH term allows the effect of unanticipated innovations to be asymmetric, accounting for differential impacts of "good" (positive innovations) and "bad" (negative) news on the market. Since $\alpha_1 + \beta_1 = 0.832832 < 1$ it can be argued that there is volatility persistence and regime switching. However, the observed value of $\alpha_1 + \alpha_2 + \beta_1 = 0.993237 < 1$ is an indication of stability in volatility. This could be due to news asymmetry since $\beta_1$is large.

Conclusions

In the present investigation I studied the interactions between carbon allowance prices and the prices of electricity, natural gas and oil, during the time frame 2009-2011 of Phase II of the EU ETS. I used a VECM approach, Granger causality and impulse response functions to study the short- and long-run dynamics of the relationship between carbon, fuels and electricity prices. Since the EU ETS has operated for only a few years, trading in the futures market is very thin with a large number of zero-trading days. In contrast, the spot market provides a continuous series of changing price values necessary for robust econometric testing. This latter is a reason why I have chosen to consider the spot prices of EU carbon allowances in my analysis. My study shows the presence of short and long term interactions between the studied variables. In particular, I observed a Granger causality relation running from natural gas, oil spot prices and electricity to the carbon spot price, and from gas to both oil and electricity prices. The VECM analysis showed that both fuels and electricity are significant drivers of the carbon price in equilibrium. Therefore, the present results not only are in line with the fuel-switching theory, but they show also that electricity spot price itself drives the carbon price. The fuel switching theory states that fuel prices determine the demand for carbon allowances by setting the composition of power generation. In fact, without a carbon price, coal plants are usually brought on line first, because of their lower fuel cost. Gas plants are used next, during shorter periods, when demand for power is higher. However, with a price for carbon emissions, gas plants may be preferable to coal plants, due to their lower carbon intensity (Kanen, 2006). In addition, natural gas, oil and electricity spot prices are the main drivers of the conditional variance or volatility of the carbon spot price. My results suggest that, at least in the case of Germany, carbon allowance prices do not influence electricity prices but rather it is the price of fuels and electricity that drive the carbon spot price as well as its volatility. These results, thus, differ from those in Keppler and Mansanet-Bataller (2010) who observed Granger causalities running from the carbon future price to the gas and the coal future prices during the three years of Phase I and in year 2008 of Phase II. These differences may rely on the fact that the authors used future prices instead of spot prices, as well as it might be explained from the different time frames analyzed. In contrast, the results presented in this paper are in agreement with those of Nazifi and Milunovich (2010) who found that the Nordpool electricity price Granger causes the carbon price. Germany plans to reduce greenhouse gas emission by at least 30% from 1990 to 2020 and to drop out the nuclear power generation plan to 2032. To achieve this, the German government has settled a series of measures including the increase of renewable sources, the utilization of bio-fuels and a project for carbon capture and storage. However, as far as the nuclear power plants are dismissing, the electricity produced from natural gas is increasing and this might explain the strong influence of gas prices on the carbon price. In addition, I present data on carbon price volatility, showing influences of electricity, natural gas and oil prices on the conditional variance of carbon allowance prices. Finally, my results and conclusions only refer to the German case and cannot extend to other markets. A possible future extension of the present study is a complete analysis of other European countries with different proportions of nuclear and renewable energy.