CO_2 EUAs: MODELLING SPOT AND FUTURES PRICES

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Overview

As the price of CO_2 EUAs has a major impact on many types of projects: power stations, cement factories, steel works etc, it is important to be able to model their spot and futures prices. Previous work on this topic (Benz et al (2007), Daskalakis (2009), Taschini (2009)) does not incorporate economic factors driving prices such as external macroeconomic variables or energy commodities. Furthermore it was mainly based on Phase I data. Since then, important changes have occurred to the CO_2 EUA market. The over-allocation of credits in Phase I led to a sharp drop in the spot values in May 2006 and because allowances were not bankable their price declined to zero just before the end of the first period. This means that prices in Phase I, are unlikely to be representative of later periods. This is why we will restrict our analysis of the market to the second phase.

We believe CO_2 allowances should be analyzed in a wider context, for example by including GDP data. In an in-depth study, Lee & Lee (2009) demonstrated the relationship between GDP and CO_2 emissions. There are two difficulties with incorporating these data in a model; firstly they are not available at the same frequency as market data and secondly as GDP is not a traded commodity. Commodities are often considered as advanced indicators for the economy. Moreover, as oil, gas & coal play an important role in generating CO_2 emissions we have investigated their relation to EUAs and have determined how they can be used for modeling CO_2 prices. Most of the work on the factors determining CO_2 allowances was done during or before the first phase of the EU ETS market, mainly using economic arguments or econometric methods such as cointegration. For example, Reinaud (2007) and Fell (2008) found a statistically significant relationship between electricity prices and CO_2 prices. Working on the phase I market, Convery & Redmond (2007) pointed out the importance of oil, gas & coal for EUAs due to the possibility of switching fuels. Similarly Laguna (2009) found that the gas prices and electricity futures prices are linked to CO_2 prices in the long run. Using data from the first year of phase II, Bonacina (2009) found that "*Brent is the key determinant in the long run*".

Methods & Results

In view of these results we considered the relationship between the CO_2 price and the gas & coal spot prices from EEX and the oil price (here we use the 1 month futures price for Brent as a proxy for the spot). Figure 1 shows that the oil price tracks the CO_2 price more closely than coal & gas do.

The next step is to test whether the CO_2 and these three prices are cointegrated. A Johansen test (Johansen (1988), Pesaran et al (2000), Zeugner (2006)) with the 4 variables gave a negative result, which was not surprising. Next we carried out an ADF test for oil which was also rejected (see Table 1). Looking more closely at the oil price, we realized that this was probably due to the shortness of the time series. When testing the cointegration between oil & EUAs with a non null expectation (which was also rejected) we found that the normalised cointegration coefficients give rise to small residuals.

Figure 1: Spot prices for oil (red), coal (green), gas (black) & EUAs (blue). Note coal & oil prices have been rescaled to facilitate the comparison.

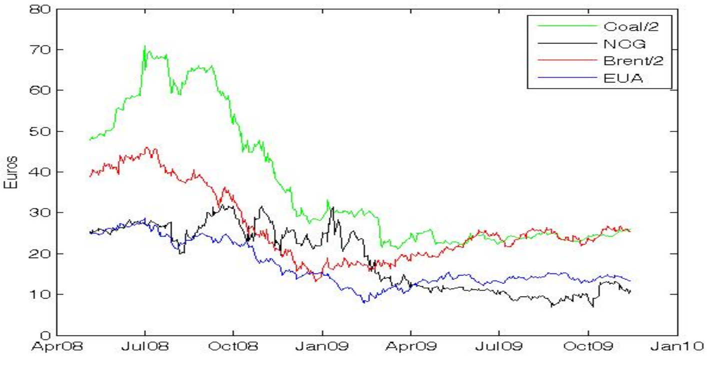

Table 1. Augmented DF test for oil prices.

CADF t-statistic	# of lags	AR(1) estimate
-2.11521242	1	0.027152
1% Crit Value	5% Crit Value	10% Crit Value
-3.362	-2.775	-2.461

So we postulated two alternative models for spot EUAs:

$$S_{CO2}(t) = \beta_0 + \beta_1 S_{OIL}(t) + S_R(t) \qquad \text{Model I}$$

$$\log\left(S_{CO2}(t)\right) = \tilde{\beta}_0 + \tilde{\beta}_1 \log\left(S_{OIL}(t)\right) + \log\left(S_R(t)\right) \qquad \text{Model II}$$

Here $S_{OIL}(t)$ is the oil price, $S_R(t)$ is the residual of the regression. With model I it is easier to compute the futures $F(t,T) = E^Q(S_C(T) \mid \mathcal{F}_t)$ under the risk neutral measure, Q. For model II it would easier to assume that the two terms are independent if we want to have analytical formulas. However model II has the advantage of involving two positive variables. As many models for oil prices are available (eg Schwartz's two factor model or more complex models involving stochastic volatility) we concentrated on the model for S_R assuming we get the exact value of the oil futures. This is not unrealistic because the future market for oil extends out to maturities of 10 years. The models will be compared for various possible choices for the processes defining the residual.

Conclusions

This paper presents two models for the spot and futures prices of CO_2 EUAs, an additive model and a log-additive model which are linked to the overall economy through one of the most active marketed commodity, namely oil. We show how to compute future prices from them, and compare their performances. With some of our models a closed form formula is available for options of EUAs.

Because of the shortness of the time series, cointegration tests using the four variables (oil, gas, coal and CO_2 EUA) and two variables (oil & CO_2 EUA) gave negative results. Although it is not needed for the models developed here it would have been more satisfying to have a better economic interpretation of the stochastic model for prices. So in the future it would be interesting to repeat these tests. Another perspective would be to develop integrated models for electricity including EUA prices.

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