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The relationship between European electricity markets and emission allowance futures prices in phase II of the EU (European Union) emission trading scheme

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ABSTRACT

We investigate how electricity markets relate to emission allowance prices. We analyze the price determinants of the European Allowance Units' returns and account for exchange specific effects. We employ a Threshold GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model and, apart from the exchange specific analysis, introduce several energy specific variables in the analysis. As such we extend the work of other scholars. We find that natural gas, oil prices and the switching possibilities between gas and coal for electricity generation are significant drivers of the carbon futures price. This is because the price of electricity is partly determined by the cost of the fuel inputs, and these costs are affected by the CO_2 allowance price. Furthermore, it appears that Nordpool and APX-UK spot prices have a profound impact on these prices. Therefore, another contribution is that we establish that local market specifics play a distinctive role in carbon price formation.

1. Introduction

With EUAs (European Allowance Units), the European Union wants to provide an incentive to invest in low carbon technology and to reduce carbon emissions. In this respect, it is of interest to investigate how and why different electricity exchanges impact on carbon emission allowance prices. To this extent, we investigate the drivers of the EU's emission allowance futures prices in Phase II of the Emission Trading Scheme in various electricity exchanges in Europe.

The carbon emission allowances system started on January 1st, 2005. Under this system, the European Union implemented a scheme of tradable permits, as part of its commitment to the Kyoto Protocol. The EUAs give the right to emit one metric ton of CO_2. To enforce carbon reduction, the EU has chosen a “cap-and-trade” mechanism. Member states receive a cap on their CO_2 emissions and allocate the permits across companies in CO_2-intensive industries. The cap coincides with the Kyoto reduction target. It resulted in the creation of a market for carbon emission allowances: the EU ETS (European Union Emission Trading Scheme). The EU ETS' design consists of three phases: Phase I covers a three year pilot period from 2005 to 2007 and Phase II the period from 2008 to 2012. In Phase II the actual objectives of the Kyoto Protocol are implemented by more stringent caps than in the first phase. For Phase III (2013–20), the European Commission proposes the setting of an overall EU cap, with allowances then allocated to EU members, tighter limits on the use of offsets, unlimited banking of allowances between Phases II and III and a move from allowances to auctioning [1].

The policy objective with the EUA carbon futures is to provide an incentive to reduce carbon emissions and to invest in low carbon technologies. However, the price of the permits exchanged through the EU ETS may have little relationship with the social costs of greenhouse gas emissions. EUA carbon futures were introduced April 22, 2005 by the ECX (European Climate Exchange) in London. Futures trading on the ECX has expanded rapidly and the ECX has become the most liquid platform for EUA futures trading [2]. Nine industries are subjected to the EU ETS, but over 70% of the permits

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goes to combustion installations. Within this industry, more than two thirds of the permits are allocated to electric electricity generation. Thus, about half of all EU emission allowances are allocated to power generators. At the industry level, the combustion industry has a shortage in EUAs [3]. The coexistence of short and long positions and their dynamics is an important driver of the allowance market. The short position of the combustion industry explains why the relative switch price between natural gas and coal has been regarded as an important driver of the permit prices [2,4]: The switch relationship reflects the opportunity to switch from coal to a less carbon intensive fuel like natural gas. However, energy-intensive industries are generally locked into long-term fuel contracts and may be unable to switch, or unwilling to do so until the price signal becomes more stable [5]. In the short run, the fuel switching opportunity does not necessarily relate to substitution within the same plant, but rather to substitution across plants [6]. Price differentials between European electricity exchanges have fallen over the last few years, but electricity markets are far from being integrated [1,6]. In particular, the country-specific EUA allocation, cross-border grid capacity and the structure of the electricity markets affect the demand for EUA allowances [7].

The aim of this paper first is to provide an analysis of the EUA futures of Phase II by focusing on the empirical relationship between the EUA futures return and its price determinants. Secondly, this paper aims to analyze the exchange-specific effects of European spot and futures electricity markets regarding carbon futures prices. We hypothesize that the various electricity exchanges may have a different impact on EUA futures, because the energy generation mix and the political choice of EUA allowance allocation differs among the countries [3,5]. We use daily EUA futures prices from the ECX for the period 2005–2010 and will employ a Threshold-GARCH(1,1) model. We consider the main combustion fuel prices, several European electricity prices and weather as potential carbon market determinants. For the fuel prices, oil, natural gas, coal and the relative prices for switching from coal to natural gas are used. We investigate six spot markets (the German EEX, the English APX-UK, the Dutch APX, the Spanish Omel, the French Powernext and the Nordic Nordpool), and two futures markets (EEX and Powernext).

The remainder of this paper is organized as follows. Section 2 contains a brief overview of the literature and introduces the hypotheses. Section 3 describes the data. Section 4 details the model and the methodology. Section 5 presents the results. Section 6 holds the conclusions.

2. Literature and hypotheses

Several studies analyze carbon emission allowances and identify price determinants. CO_2 emissions depend on energy prices, weather and economic growth. These factors impact on CO_2 allowance demand and prices too. In the short run, CO_2 abatement decisions are driven by relative fuel prices, fluctuations in electricity demand and weather conditions. Furthermore, the marginal fuel switching relationship – from carbon intensive sources to low carbon sources – also is crucial for carbon abatement. The significant effect of the switch-relationship is the common denominator in most EUA price studies. Among others, Seifert et al. [8] and Uhrig-Homburg and Wagner [9] study the price dynamics of carbon spot and futures prices respectively in Phase I. We extend the analysis for Phase II and look into several European exchanges to account for market specifics.

Mansanet-Bataller et al. [2] and Rickels et al. [10] identify Brent oil, electricity prices, and the switching relationship between natural gas and coal as carbon price determinants. They also find that extreme temperatures influence carbon prices. Regarding weather, especially cold days have a positive impact on carbon prices. Convery and Redmund [1] analyze coal, oil, and natural gas. They find that an increase in oil prices appears to have the largest impact on EUA prices. Their analysis suggests that weather is not a major factor for EUA price development, which appears to contrast with Rickels et al. [11] who also find evidence for an increasing influence of renewable energy on the EUA price. Benz and Trück [12] categorize the principal drivers of environmental allowance markets into policy and regulatory issues and market fundamentals that concern the production of CO_2 and the demand for allowances. The supply of CO_2 allowances depends on policymakers and their decisions concerning the NAPs (National Allocation Plans). As a result, industries operate with a long-term price signal that depends on (international) political events.

Alberola et al. [13] find that EUA price fundamentals vary between sub-periods, before and after the "compliance break" of April 2006. They include clean dark and clean spark spreads to their analysis. The former being the difference between the price of a unit of electricity and the price of coal used to generate that unit of electricity, minus the corresponding CO_2 emission costs (i.e. the price of the permits, not the costs of emissions to society). The clean spark refers to the spread calculated with natural gas and electricity. Alberola et al. [13] find that Brent, electricity, low temperatures and the switch variable are significant before the break, in contrast to natural gas, coal, clean spark and clean dark. After the compliance break spot prices react similarly but with more significance regarding the energy variables and the clean dark spread shows a significant negative sign. They conclude for the first sub period that institutional factors play a dominant role in EUA price formation. Hintermann [6] develops a market model where the allowance price change is a function of fuel prices, the availability of hydro power, stock indices and various weather indicators. He finds a nonlinear relationship between fuel prices, temperature and precipitation with the allowance price. In addition, Hintermann [6] suggests that there is evidence of learning effects regarding the incorporation of new information on allowance prices.

Using an ARMA-GARCH model, Sanin and Violante [14] do not find evidence for the assumption that EUA returns can be explained by energy fundamentals, except for a weak significance of Brent oil. Instead, they find that changes in EUA trading volume and changes in the regulatory environment drive the regime shifts. Sanin and Violante [14] argue that the significant spikes in the return series can be due to trades placed by large investors in relatively illiquid markets, even in the absence of important news about market fundamentals. Chevallier [4] examines the empirical relationship between Phase II EUA futures and changes in macroeconomic conditions, using a T-GARCH(1,1) model, with a sample from April 22, 2005 to October 1, 2008. In his model, common stock portfolio returns, junk bond yields, T-bill rates, and market portfolio excess returns capture macroeconomic influences. Furthermore, he includes electricity, Brent oil, natural gas and a dummy for the series break of April 2006. The results suggest that the carbon market is only remotely connected to macroeconomic risk factors.

Alberola et al. [15] study the country-specific effects of the production of the combustion and the iron sector on the EUA price during 2005–2007. Using a T-GARCH(1,1) model they analyze monthly production indices for Germany, Spain, France, Italy, Poland and the UK. They find that the industrial production impacts EUA price changes in Germany, Spain, Poland and the UK and they underline the central role of German electricity producers. Bunn and Fezzi [16] use a co-integrated VAR (variance) model to analyze the relationship between allowances, power and natural gas in the UK daily spot markets. They show that the carbon and gas prices help determine the electricity price. Hintermann [6] discusses whether electricity prices are exogenous and should be included as