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Market efficiency in the European carbon markets

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HIGHLIGHTS

- We study the cost-of-carry hypothesis in the European carbon markets during Phase 2.
- We apply cointegration tests with and without structural breaks on several maturities.
- We find that futures contracts are cointegrated with spot prices and interest rates.
- The cost-of-carry model is rejected for all maturities and carbon markets.

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ABSTRACT

In this paper, we study the relationship between futures and spot prices in the European carbon markets from the cost-of-carry hypothesis. The aim is to investigate the extent of efficiency market. The three main European markets (BlueNext, EEX and ECX) are analyzed during Phase II, covering the period from March 13, 2009 to January, 17, 2012. Futures contracts are found to be cointegrated with spot prices and interest rates for several maturities in the three CO_2 markets. Results are similar when structural breaks are taken into account. According to individual and joint tests, the cost-of-carry model is rejected for all maturities and CO_2 markets, implying that neither contract is priced according to the cost-of-carry model. The absence of the cost-of-carry relationship can be interpreted as an indicator of market inefficiency and may bring arbitrage opportunities in the CO_2 market.

1. Introduction

The European Union Emission Trading Scheme (EU ETS) went into effect on January 2005, considering the EU Directive 2003/87/EC. The EU ETS is one of the most important initiatives taken to reduce the greenhouse gas (GHG) emissions (primarily CO_2) that cause climate change (Kyoto protocol). The inclusion of the aviation sector from 1st January 2012 onwards represents a new step in the implementation of the EU ETS.[1] Following the steady expansion of the EU ETS' scope to new Member States since 2005, the European Commission is now adding around 5000 European airline companies and foreign companies that do business in Europe to the 11 500 industrial and manufacturing participating installations. In 2010, it is estimated that the sources to which the trading scheme applies account for 45% of CO_2 emissions and a little less than 40% of total GHG emissions in that year.

The EU ETS introduces a cap-and-trade system, which operates through the creation and distribution of tradable rights to emit, usually called EU allowances (EUAs)[2] to installations. Since a constraining cap creates a scarcity rent, these EUAs have value. The distribution of these rights for free is called free allocation and is the unique feature of this cap-and-trade system. The cap-and-trade scheme operates over discrete periods, with the first or pilot period (Phase I, 2005–2007) and with the second period corresponding to the first commitment period of the Kyoto Protocol. This period extends from 2008 to 2012 (Phase II) and will be followed by a third period from 2013 to 2020 (Phase III). Phase II

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[1] To improve the fluidity of the EU ETS, organized allowance trading has been segmented across trading platforms: Nordic Power Exchange (Nord Pool) in Norway began in February 2005, European Energy Exchange (EEX) in Germany began in March 2005, European Climate Exchange (ECX) based in London and Amsterdam started in April 2005, BlueNext in France and Energy Exchange Austria (EEA) in Austria began in June 2005, and SendeCO2 in Spain started at the end of 2005.

[2] In fact, the EUAs are the conversion of Assigned Amount Units (AAUs), which are the permits allocated to Annex B of the Kyoto Protocol. See Convery (2009) and Chevallier (2012) for a discussion of the EU ETS.

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represents the fundamental regulatory tool allowing Member States to reach their Kyoto target. The EU target is a reduction of 8% below 1990 emissions in the 2008–2012 period.[3] To help countries in achieving their reduction objectives, the Protocol includes three flexibility mechanisms: The creation of an International Emission Trading, Joint Implementation and the Clean Development Mechanism.[4]

The EU ETS includes spot, futures, and option markets with a total market value of €72 billion in 2010. Futures contracts account for a wide part of this value (about 87% in 2010). Understanding the relationship between spot and futures prices is thus of crucial importance for all participants in the carbon market. Carbon trading works only if markets for carbon provide enough liquidity and pricing accuracy, i.e. markets provide prices that are useful for hedgers and other users of carbon markets. The efficiency of the CO_2 market is particularly important for emission intensive firms, policy makers, risk managers and for investors in the emerging class of energy and carbon hedge funds (see Krishnamurti and Hoque, 2011).

Although relevant papers have been published on the behavior of emission allowance spot and futures prices (see, e.g., Alberola et al., 2008; Daskalakis and Markellos, 2008; Paolella and Taschini, 2008, Seifert et al., 2008; Benz and Trück, 2009), studies on CO_2 market efficiency between futures and spot prices are rather sparse (Daskalakis et al., 2009; Uhrig-Homburg and Wagner, 2009; Joyeux and Milunovich, 2010). These studies examine the extent of market efficiency in the CO_2 futures market by conducting empirical tests of the cost-of-carry model, which allow us to ascertain the degree to which carbon futures prices reflect their theoretical (no arbitrage) values. This approach is especially useful in the context of examining whether futures contracts are efficiently priced with respect to the underlying emission rights allowances. If these contracts are efficiently priced then participating countries and covered installations in them can achieve environmental compliance in a cost-effective and optimal manner (Krishnamurti and Hoque, 2011).

The aim of this paper is to investigate the efficiency hypothesis between spot and futures prices negotiated on European markets from a cost-of-carry model, by extending the previous studies in three ways: (i) we study the three main European markets, BlueNext, European Energy Exchange (EEX), and European Climate Exchange (ECX); (ii) we consider the second trading period (Phase II) from March 13, 2009 to January 17, 2012; and (iii) we test the cost-of-carry model using four futures contracts (December 2009, December 2010, December 2011 and December 2012 maturities). This study should give a more complete picture of the relationships between spot and futures prices in the EU ETS. We apply the cointegration methodology developed by Johansen (1988, 1991) to test for multivariate cointegration between the series (futures prices, spot prices and interest rate) before estimating the cost-of-carry relationship. Indeed, the theoretical connection between spot and futures prices is a long-run, rather than short-run, concept. In the short-run, there might be deviations between spot prices and futures prices that can be induced by, for example, thin trading or lags in information transmission (Maslyuk and Smyth, 2009). The visual inspection of the data in Figs. 1–3 reveals a sharp price break for spot and futures price series of all maturities in the three markets in June 2011.[5] This fall of 20% followed the announcement of the EU's upcoming "energy efficiency directive," presented on 22nd of June 2011, proposing a new contract with member states for cutting energy consumption in buildings, vehicles and more controversially, industry. Therefore, we also use the approach suggested by Johansen et al. (2000) to take into account the presence of structural breaks.[6]

The remainder of this paper is organized as follows: Section 2 presents the cost-of-carry model. A brief literature review is given in Section 3. Section 4 displays the cointegration tests with and without structural breaks. The empirical framework is discussed in Section 5. The conclusion is drawn in Section 6.

2. The cost-of-carry model

Theoretically, if spot and futures markets operate efficiently and are frictionless, futures contracts should be traded at a price known as the fair value (the Law of One Price). The starting point of most studies is the arbitrage free or cost-of-carry model in which the futures price is represented as

$$F_t = S_t e^{(r+u-y)(T-t)} \tag{1}$$

where F_t is the futures price at time t, S_t is the spot price at time t, r is the risk-free interest rate, u is the storage cost, y is either a dividend yield in the case of a dividend paying stock or a convenience yield in the case of commodity, and T is the expiration date of the futures contract, and $(T{-}t)$ is the time to expiry of the futures contract.

The storage costs for CO_2 allowances are equal to zero because they only exist on a companies' balance sheet. Taking logarithms on both sides of Eq. (1) gives

$$\mathrm{Ln}(F_t) = \mathrm{Ln}(S_t) + (r-y)(T-t) \tag{2}$$

Various approaches are possible to determine the term structure by using alternative model specifications for the convenience yield term. Nevertheless, there is no consensus about the state of futures prices (backwardation, normal backwardation, contango and normal contango).[7] The different possible states of the CO_2 emissions market for each maturity are given in Table 1. As in Borak et al. (2006), the futures of the three markets appear to be in contango, whatever the maturity. Considering Kaldor (1939), the convenience yield appears as a way to explain backwardation, a situation where the futures price is lower than the spot price. Consequently, in this paper we will consider a cost and carry model with zero convenience yield

$$\mathrm{Ln}(F_t) = \mathrm{Ln}(S_t) + r(T-t) \tag{3}$$

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[3] Phase III is set to help meet the European target of 20% GHG emission reduction in 2020 compared to 1990, in line with the objective of the Climate Energy Package approved in December 2008.

[4] The Joint Implementation (JI) mechanism consists of the realization of an emission reduction project by a developed country (Annex I country) in another developed country (Annex I). JI projects provide for Emission Reduction Units (ERUs) that may be utilized by an Annex I country promoting the project to meet its emission targets under the Kyoto Protocol. The Clean Development Mechanism (CDM) provides for a similar mechanism for an Annex I country to achieve its emissions target when the project is implemented in a developing country. The units arising from such projects are termed Certified Emission Reduction units (CERs). In 2011, the volume of transactions amounted to 6053 million EUAs, 1418 million CERs and 62.8 million ERUs (up 20%, 53% and 1406%, respectively, compared with 2010).

[5] We use in Section 5 the approach of Bai and Perron (2003) to identify the (possible) presence of structural breaks in the spot and futures EUA prices.

[6] Gregory et al. (1996) show that the rejection frequency of cointegration tests of the null hypothesis of no cointegration is considerably reduced in the presence of structural breaks. As a consequence, the null hypothesis may be (incorrectly) not rejected due to the existence of a break.

[7] The futures market is said to exhibit backwardation when the futures price $F_{t,T}$ is less or equal to the current spot price S_t, it exhibits normal backwardation when the futures price is less or equal to the expected spot price $E_t(S_T)$ in T. On the other hand, the term (normal) contango is used to describe the opposite situation, when the futures price $F_{t,T}$ exceeds the (expected) spot price in T (Borak et al., 2006). In other words, backwardation and contango are used to describe the relationship between current spot prices and futures prices, whereas normal backwardation and normal contango are used for the relationship between expected spot prices and futures price. The idea of normal backwardation and normal contango was initially suggested by Keynes (1930) and Hicks (1946).