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# Modeling the relationship between European carbon permits and certified emission reductions ☆

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ABSTRACT

Recent years have seen an expansion of carbon markets around the world as various policymakers attempt to reduce CO2 emissions. This paper considers two of the major types of carbon permits: European Union Allowances (EUAs, arising from the European Union Emissions Trading Scheme, EU ETS) and certified emissions reductions (CERs, arising from agreements made under the Kyoto Protocol). The rules of the EU ETS allow for some use of CERs in place of EUAs by EU firms, but this substitutability is only partial. Allowing for carbon permits from different sources to substitute for one another should help achieve CO2 emissions reductions at least cost. Understanding the degree and nature of linkages (if any) between the markets for EUAs and CER is, thus, an important policy issue. In this paper, we jointly model the spot and future prices of an EUA along with the price of a CER using flexible multivariate time series methods which allow for time-variation in parameters. We find evidence of contemporaneous causality between these three variables with the EUA futures price playing the dominant role in driving this relationship. We also document time-variation in this relationship which is associated with macroeconomic events such as the financial crisis of late 2008 and early 2009. We find very little evidence of volatility spillovers or of Granger causality among any of the variables. We discuss how these empirical findings are consistent with markets which are loosely linked, but are not tightly linked as would be found for perfectly substitutable assets in efficient financial markets.



## 1. Introduction

The European Union Emissions Trading Scheme (EU ETS) is a cap and trade scheme in which firms in the EU are allocated carbon permits to cover their CO2 emissions. These carbon permits are known as EUAs (European Union Allowances).[2] EUAs can be traded so that firms which exceed their CO2 allocations can purchase more of them to cover their excess emissions. Firms with more permits than CO2 emissions are free to sell their excess permits. A number of financial exchanges have been established in recent years to trade carbon permits and associated financial derivatives. Carbon offsets are also traded in financial markets. Offset markets have arisen as an alternative way of obtaining carbon permits. A firm may offset some of its carbon emissions[3] by investing in emission reductions elsewhere in the world. The main form of carbon offset is called a CER (certified emission reduction).

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[2] One EUA gives the holder the right to emit one metric tonne of CO2.

[3] EU member states have set individual limits on the number of CERs that installations can use for compliance purposes. These range from 0% (Estonia) to 22% (Germany) of total emissions.

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The goal of the EU ETS and carbon offset markets is to achieve CO2 reductions in an economically efficient manner. The existence of efficient financial markets for trading carbon permits is necessary to achieve this goal. The purpose of the present paper is to investigate the spot and futures markets for EUAs and their relationship with the market for CERs. These carbon markets are relatively new and have specific institutional features that set them apart from conventional financial markets. For instance, unlike conventional assets, the markets for EUAs exist due to the need for firms to comply with EU regulations, which have been changing over time. Problems have arisen in the EU ETS due to the overallocation of permits to individual firms and fraud of various sorts. Furthermore, there is uncertainty over the future form of the EU ETS. Similar concerns hold with the CER market.[4]

It is an important public policy question whether the EU ETS is operating efficiently. One need only looks at the titles and conclusions of some recent papers, to see that the dynamics of these markets may not be consistent with financial theory. For instance, the title of the paper by Daskalakis and Markellos (2008) "Are the European carbon markets efficient?" answers this question in the negative. Bredin and Muckley (2011) title their paper "An emerging equilibrium in the EU emissions trading scheme" and point to gradually maturing markets. However, Koop and Tole (2013) find considerable instability in forecasting models even very recently.

Investigating the linkages between the EU ETS and the CER markets is also of great importance. Allowing for CERs to count towards CO2 emissions quotas is crucial if CO2 emissions are to be reduced in a cost efficient fashion. For instance, if it is cheaper to reduce CO2 emissions via projects in China rather than fuel switching by EU electricity generators then it is economically efficient to do so. Incorporating CERs into the EU ETS is currently the best mechanism for achieving such gains. If CERs were perfectly substitutable with EUAs, then the prices of these two assets would move together. However, as discussed below, there are several reasons why such perfect substitutability may not exist and arbitrage between the two markets may be limited. But, even if there is no perfect substitution between CERs and EUAs, there is likely to be some relationship and measuring its strength and nature is of interest to those in the finance industry investing in the carbon markets and to economists investigating whether CO2 emissions reductions are being achieved in an efficient manner.

Such considerations motivate the present paper. Using daily data since 2008,[5] we examine the nature of the relationship between the spot and futures markets in the EU ETS and investigate whether there are linkages with the CER carbon offset market. We also consider the question of whether these relationships are changing over time. To this end, we do not seek to impose financial theories specifying the relationship between futures and spot price on our data. Rather, we document the patterns in these carbon markets using reduced form multivariate time series models. In particular, we use time-varying parameter vector autoregressive (TVP-VAR) models that allow for multivariate stochastic volatility. This approach allows us to address questions such as: i) What are the causal relationships between these carbon markets?; ii) How does news affecting one price spill over onto the prices in other markets?; iii) Are there relationships between the EU ETS and the CER carbon markets?; and iv) Are there spillovers in volatility from one market to another?. Importantly, it allows us to answer all these questions in a time-varying manner in the context of a flexible model which lets the data speak.

Our main findings are that there is only weak evidence of Granger causality between any of the markets. What evidence there is indicates some time-variation where causality increased during the financial crisis. However, there is strong evidence of contemporaneous relationships between EU ETS spot and future prices and between EU ETS futures prices and CER futures. We present evidence that the EU ETS futures market is driving these relationships. We document time variation in these relationships and offer an explanation for why this might occur. We find little evidence for volatility spillovers except perhaps for the EU ETS spot and future markets.

The remainder of the paper is organized as follows: Section 2 reviews the related literature, emphasizing how the carbon markets differ from similar financial markets. Section 3 outlines our econometric methods and defines several important features of interest which are reported in our empirical results. Section 4 presents and discusses our empirical results. Section 5 concludes.

## 2. Related literature

The carbon markets are relatively new and exhibit some unique characteristics. Nevertheless, they are related to commodity markets in general and energy markets in particular. Accordingly, we divide this section into two parts. In the first part, we offer a very brief overview of some relevant literature relating to the commodity markets. In the second part, we focus on the carbon markets.

### *2.1. Commodity & financial markets*

Modeling of the spot and future price relationship has often been framed in terms of the financial theory of commodities (see, e.g., Pindyck, 2001). The cost-of-carry relationship often plays an important role in these analyses. This theory argues that the future spot price will depend on the contemporaneous spot price and the cost of holding the commodity and a convenience yield.

[4] Linacre, Kossoy, and Ambrosi (2011), TheCityUK (2011) and Mizrach (2012) provide useful summaries of institutional details, problems, concerns and basic facts about the EU ETS and the CER markets.

[5] The EU ETS is divided into phases with the second phase beginning in 2008. This second phase will end in December 2012 which is the settlement date for the futures used in this paper.