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Downside risks in EU carbon and fossil fuel markets

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Abstract

The European Union carbon market is undergoing rapid development and its interdependence with fossil fuel markets is increasingly important for energy investors. In this study, exponential general autoregressive conditional heteroskedastic models, extreme value theory and copulas are used to evaluate downside risk through the traditional value-at-risk and expected shortfall measurements. Empirical evidence for daily data from January 2008 to October 2012 indicates that the carbon market has more downside risks than the oil market but fewer than the gas market. Copula analysis provides evidence of positive average dependence and extreme symmetric market independence between the carbon and oil markets, and average and extreme independence between the carbon and gas markets. The implications of these results for portfolios consisting of European Union Allowances and fossil fuels point to the existence of downside risk gains. The carbon market is therefore an attractive market for investors in terms of risk management.

Keywords: Emission allowances; Fossil fuel prices; EGARCH, EVT; Downside risk

1. Introduction

In January 2005, the European Union (EU) launched the first international emissions trading system aimed at reducing carbon emissions in a cost-effective way by means of a market-based instrument. The EU emissions trading system (EU ETS) sets caps for CO_2 emissions by manufacturing plants across EU countries; these caps can only be surpassed subject to the acquisition of emission allowances. Greenhouse gas emission credits thus became a scarce resource and the EU allowances (EUA) became a tradeable asset that could be negotiated in organized spot, futures and options markets. The EUA market has experienced rapid growth and is steadily increasing in size, complexity, liquidity and trading volume. Research into allowance allocations and pricing mechanisms in the EU carbon market has been greatly spurred, since studies are of interest to policy makers, traders and risk managers who operate in the EUA and related markets.[1]

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[1] Research has been conducted as follows—price dynamics of different EU ETS instruments: Benz and Trück [4], Chevallier [8], Conrad et al. [14], Daskalakis et al. [17] and Paolella and Taschini [43]; price efficiency and information transmission between EU carbon spot and futures markets: Benz and Hengelbrock [3], Chevallier [9], Chevallier [10], Milunovich and Joyeux [37], Rittler [54] and Uhrig-Homburg and Wagner [59]; EU ETS impact on financial markets: Daskalakis and Markellos [16], Oberndorfer [41] and Veith et al. [60]; potential drivers of carbon price changes: Alberola et al. [1], Bredin and Muckley [6], Christiansen et al. [12], Convery and Redmond [15], Kanen [31], Mansanet-Bataller et al. [34] and Redmond and Convery [53]; finally, for a comprehensive overview of current research into the EU ETS, see Zhang and Wei [61].

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The development of the carbon market has had noticeable effects on energy markets, given that the price of emissions influences energy prices and the development of renewable energies. In fact, carbon prices have been found to be closely related to energy prices, in particular for oil (see Kanen [31], Redmond and Convery [53], Chevallier [11], Reboredo [50]); furthermore, there is clear evidence of interdependence between emissions and fossil fuel markets (Chevalier [11]). EUAs and energy commodities are negotiated just like any financial asset in well-developed spot and futures markets, and so carbon and energy commodities are financially linked through market co-movements. In this context, measuring market risk is of practical interest for investors who operate in those markets.

The main objective of our study, therefore, was to assess the risk exposure for investors operating in carbon and fossil fuel energy markets. Our risk assessment was performed from 2008 and the onset of Phase II of the EU ETS, given that a more stable relationship was configured between the EUA system and its determinants for this phase (Bredin and Muckley [6]); also, there was a significant rise in EUA futures market liquidity (Benz and Hengelbrock [3], Bredin et al. [7]).

We attempt to add to the existing empirical evidence regarding the risk assessment in carbon and fossil fuel markets along two axes. First, our research line is novel in that, as far as we are aware, it is the first that examines value at risk (VaR) and expected shortfall (ES) risk measurements for EUA, natural gas and crude oil markets using EGARCH models, extreme value theory (EVT) and copulas. Our evidence extends the risk analysis implemented by Feng et al. [23] for the carbon market and by Marimoutou et al. [35] for the oil market in that it considers not only the distinctive features of risk in each market, but also assesses market risk of portfolios composed of carbon and energy commodities. To that end, we modelled interdependence between carbon and fossil fuel markets through copulas, given that copula methodology provides information on both average dependence and upper and lower tail dependence (joint extreme movements) — information that is crucial for portfolio risk assessment. Also, using copulas we were able to provide information on the dependence structure between the carbon and fossil fuel markets in terms of answers to questions such as: Is there any extreme value dependence? Is there any asymmetric response by energy prices to carbon prices? And has the dependence relationship changed in recent years? This information enhances understanding of the relationship between carbon and fossil fuel markets and also improves risk assessment for portfolios composed of carbon and energy commodities. We provide empirical evidence of positive average dependence and extreme symmetric market independence between EUA and crude oil stocks, and of average and tail independence between carbon and natural gas prices, with the Gaussian copula as the best performing dependence model. This evidence is consistent with no contagion effects between the EUA and fossil fuel markets. A second way in which we add to the existing empirical evidence regarding risk assessment in carbon and fossil fuel markets is that we address the consequences of EUA and fossil fuel risk and market links for portfolio risk management, providing evidence that EUA stocks are useful in a crude oil and natural gas portfolio since they reduce portfolio risk and show significant VaR and ES reductions.

The rest of the paper is laid out as follows: Section 2 provides a short synopsis of the EU ETS. Section 3 outlines the theoretical reasoning behind the methodology for studying interdependence and downside risk in EUA and fossil fuel markets. Sections 4 and 5 present data and discuss the estimation results, respectively, and Section 6 provides our conclusions.

2. The European Union emissions trading system

As part of its commitment to the Kyoto Protocol, in January 2005 the EU started a cap-and-trade scheme for CO_2 emission permits – the EU ETS – as the largest emission trading scheme in the world and the first international one for CO_2 emissions. It currently includes 29 states (27 EU member states plus Norway and Liechtenstein) and covers over 10,000 industrial installations performing emission-intensive activities responsible for about half of Europe's CO_2 emissions. Under the EU ETS, a restricted number of allowances are allocated to participating states for what is called a 'phase' (in other words, a trading period). The first phase of the ETS, running from 2005 to 2007, was considered a "trial phase". Phase II, lasting from 2008 to 2012, coincided with the first Kyoto protocol commitment to reduce EU greenhouse gas emissions by 8% below the 1990 level. Phase III runs from 2013 to 2020. Participating states draw up national allocation plans (NAPs) which determine the number of emission allowances to be allocated to each industrial installation in a trading period.

Large CO_2 emitters, which must monitor and annually report their emissions, annually return an amount of emission allowances equivalent to their CO_2 emissions for that year. Companies that keep their emissions below the level of their allowances can sell their excess allowances, while those facing difficulty in keeping their emissions in line