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Variance risk premia in CO_2 markets: A political perspective

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HIGHLIGHTS

- Enriched dataset covering all three political phases of the CO_2 markets.
- Clear policy implications for regulators to most effectively cap the overall CO_2 emissions pool.
- Applying a cross-asset benchmark index for variance beta estimation.
- CER contracts have been analyzed with respect to variance risk premia for the first time.
- Increased forecasting accuracy for CO_2 asset returns by using variance risk premia.

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ABSTRACT

The European Commission discusses the change of free allocation plans to guarantee a stable market equilibrium. Selling over-allocated contracts effectively depreciates prices and negates the effect intended by the regulator to establish a stable price mechanism for CO_2 assets. Our paper investigates mispricing and allocation issues by quantitatively analyzing variance risk premia of CO_2 markets over the course of changing regimes (Phase I-III) for three different assets (European Union Allowances, Certified Emissions Reductions and European Reduction Units). The research paper gives recommendations to regulatory bodies in order to most effectively cap the overall carbon dioxide emissions.

The analysis of an enriched dataset, comprising not only of additional CO_2 assets, but also containing data from the European Energy Exchange, shows that variance risk premia are equal to a sample average of 0.69 for European Union Allowances (EUA), 0.17 for Certified Emissions Reductions (CER) and 0.81 for European Reduction Units (ERU). We identify the existence of a common risk factor across different assets that justifies the presence of risk premia.

Various policy implications with regards to gaining investors' confidence in the market are being reviewed. Consequently, we recommend the implementation of a price collar approach to support stable prices for emission allowances.

1. Introduction

Recent political discussions and regulatory topics discuss in depth the environmental impact of carbon dioxide emissions. Main players are the major league of dominant energy companies, lobbying wherever possible to influence regulatory instruments covering the emission trading scheme, or representatives of unions looking after the interests of leading industrial sectors. The European Emission Trading System (EU ETS) serves as a major instrument in the realization of Europe's plan to reduce carbon dioxide emissions. Moreover, it is the largest implementation of carbon dioxide regulation in form of an emissions trading scheme currently in operation and encompasses more than 11,000 installations spread over 31 countries. The EU ETS covers more than 40% of Europe's total carbon dioxide emissions. Its environmental impact can best be explained by traditional supply and demand theory, and in particular against the two primary objectives: (1) to efficiently reduce CO_2 emissions at a well-balanced equilibrium of cost and environmental gains for both agents and principals, and (2) promoting corporate investments in lowering carbon emissions such as new filter- and recycling-technologies.

The fundamental goal of the EU ETS remains the environmental focus, ultimately lowering carbon dioxide and greenhouse gas emissions. However, having a good grasp of its wider impact is not only important for investors trading underlying carbon contracts, but also for regulators finally being able to establish a stable

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supply and demand equilibrium on CO_2 markets. Although perceived as a cornerstone instrument for regulators (Ellerman and Buchner, 2007), with drastic improvements of its functionality during the first two Phases of existence, multiple severe malfunctions have been discovered in the past. These include not only an over allocation of CO_2 allowances during the beginning of Phase II and subsequent sharp decline in asset prices, but also windfall profits stemming from free-allocation contingents and heredity of prior-owned emission allowances that corporations were allowed to carry forward. In addition, the EU ETS has also had issues with financial fraud and cyber-crime, alluding to a broader set of sensitivities (Phillips, 2009). Nevertheless, since the start nine years ago, the system has gathered ample data and provided the motivation for multiple EU ETS ex-post research studies in the field of environmental economics (see for example Laing et al. (2013) and Chevallier (2012)). Topics for scientific research papers have been the mechanism's design, its price formation processes, various pricing models, and the system's performance in general. In our opinion, there are indeed research papers discussing political trade-offs from an economic point of view, but very few papers that give recommendations to regulators based on quantitative research results. These works are crucially important as they provide policy makers worldwide with ideas and suggestions in the development of a new generation in carbon pricing policies, using Europe as a real world example.

The international emission trading market features several characteristics that make it unique and barely comparable with regular commodity markets. Introducing the active trading of European Unit Allowances (EUAs) in 2005 with the so-called Phase I (trial period), lasting from 2005 until 2007 and serving as a quasi-testing period for companies, allowing habituation to new market environments, with reduced fines, free allocation of EUAs and no reduction in the overall pool of CO_2 emissions. Phase II began 2008 and lasted until 2012, realizing the Kyoto Protocol CO_2 reduction commitments and the introduction of Certified Emission Reductions (CERs), strictly allocating CO_2 contingents, including fines of 100 Euros per extra-produced ton of CO_2. In December 2012, the United Nations Framework Convention on Climate Change (UNFCCC) decided to originate a Kyoto Protocol-2, which will be signed in 2015, thus giving CERs a temporary, but certain lifetime. CERs are the emission trading reduction certificates based on Kyoto Protocol commitments, which in contrast to EUAs, are traded globally, reflecting the “world carbon” price for 1 ton of CO_2 emissions. This interdependence is of utmost importance, since arbitrageurs could trade the spread between those two assets, representing the same commodity (carbon dioxide), and gain access to 'free lunch opportunities' if mispricing occurs.

In the context of increased awareness, the trading of new CO_2-related assets European Reduction Units (ERUs) and EU Aviation Allowances (EAAs), as well as upcoming game-changing political regulations such as the decision 'Kyoto Protocol-2', the paper intends to address historic mispricing and allocation issues by quantitatively analyzing variance risk premia (*VRP*) of CO_2 markets over the course of changing regimes (Phase I-III) for three different assets (EUA, CER and ERU). Furthermore, robustness and verification of the results shall be strengthened by using a second dataset for EUAs obtained from the European Energy Exchange (EEX).

The paper is organized as follows: Section 1.1 provides an overview of relevant literature; Section 2 describes the underlying theory and computational steps, whereas Section 3 provides detailed empirical results; Section 4 concludes.

1.1. Literature review

Variance risk premia have become a well-known research area during the past decade. The term was coined to large extents by Carr and Wu (2009), Bollerslev et al. (2009) and Jiang and Tian (2005), applying a model-free measure of implied volatility to equity markets. Bollerslev et al. (2009) provide evidence for positive risk premia in equity markets in the dimension of 0.18 on average, arguing that investors are willing to pay a premium to hedge against volatility. Guberovic et al. (2012) find that the average risk premium in equity markets does have a similar magnitude to the one found for emission markets.

Bollerslev et al. (2009) propose to measure variance risk premia as the difference between implied and realized volatilities (*RV*). He further applies a model free measure of implied volatility (*IV*), which has been proposed by Britten-Jones and Neuberger (2000). Extending Bollerslev et al.'s (2009) approach by realized volatilities obtained from high-frequency intraday trading data (in comparison with end-of-day data), provides a fairly accurate and model-unbound measurement of variance risk premia. In contrast with (model bound) Black-Scholes implied volatilities, Bollerslev et al.'s (2009) model does not focus on any specific asset-pricing framework and utilizes the entire cross-section of available contract data, as opposed to just close to the money-option prices. However, this convenience trades at the cost of having to fit model-free implied volatilities over the entire space of strike prices with infinite range to fulfill underlying theory. In practice, we will use truncated (bounded above and below) discretized option prices, thus introducing a bias, which is at least partly dealt with by a method proposed by Jiang and Tian (2005).

The unique issues in CO_2 markets (i.e. its short period of existence and a constantly changing regulatory environment), using the outlined techniques below, are twofold: Firstly, the calculation of realized volatility requires the specification of a predefined time frame to accurately capture price movements without being affected by microstructure noise. Remedy is obtained by using volatility surface plots (Chevallier, 2012). As CO_2 markets have been established in 2005 with the trading of EUAs and subsequent introduction of new assets, the market foundations are not as robust as in fixed-income or equity markets, leading inevitably to data variations and short-term flawed price discovery processes as a result of constant regulatory changes. Secondly, option prices are not quoted in such detail as are usually found for equities. Moreover, the intervals between quoted prices are larger, resulting in greater imprecision when using the interpolation- and extrapolation-technique proposed by Jiang and Tian (2005). Chevallier (2012) points out that literature provides methods to obtain *RV* from high frequency data. As outlined above, this approach has the advantage of increased accuracy, but also becomes more sensitive to outliers and introduces the problem of market immaturity and data scarcity. Moreover, the approach of the calculation of *RV* has to be treated with caution as the determination of the optimal sampling frequency that minimizes market microstructure noise might be tricky. Literature often deals with this issue by using volatility signature plots for different sampling frequencies. Volatility signature plots are being used in combination with research results found by Chevallier and Sèvi (2010, 2011), who define the best sample window for CO_2 assets as a 15-min interval. Additionally, they show that this choice is not only most accurate, but also fairly conservative compared to the 5-min sampling frequency usually used in FX Markets. Thus, volatility signature plots seem to be promising for finding a robust and appropriate sampling frequency.

Consequently, all information is provided to proceed with the actual research, which is the calculation of variance risk premia, being calculated by the difference of *IV* and *RV* (Andersen et al., 2009). Moreover, a valuable addition in the framework of our research context originates from Chevallier (2012), who applies exactly this approach to EUA and CER future prices over a period from 2008 to 2011, using data obtained from the InterContinental