



Measuring the risk-adjusted performance of CO₂ emission markets: Evidence from SENDECO₂

José Manuel Feria-Domínguez^{a,*}, David Rodríguez-Carrillero^b, José Carlos Guerra-Martínez^c

^a Department of Financial Economics and Accounting, Pablo de Olavide University of Seville, Ctra. de Utrera, Km 1, 41013, Seville, Spain

^b Quintas Energy UK Limited, Suite C, Third Floor, 3 Harbour Exchange Square, Canary Wharf, E14 9GE, London, United Kingdom

^c Centre for Postgraduate Studies, Universidad Pablo de Olavide of Seville, Ctra. de Utrera, Km 1, 41013, Seville, Spain

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ABSTRACT

This paper analyzes the historical risk-adjusted performance of CO₂ emission allowances traded on SENDECO₂ (the reference market for Southern Europe) by using the daily spot prices of the European Union Allowances (EUAs) and Certified Emission Reductions (CERs) from 2008 to 2012. We revisit the Sharpe-ratio, taking into account the modified version proposed by Ferruz and Sarto (1997), to propose a new performance indicator, the Sharpe-VaR_{FS}, estimated by Monte Carlo simulation. Due to the existing imbalances between demand and supply for allowances, both the EUA and CER markets underperform when compared with financial stock markets, being unattractive to potential investors.

1. Introduction

Climate change is one of the greatest challenges currently facing society. Its more serious consequences have become much more evident in recent years, including the alarming rate at which the polar ice caps are melting, frequent natural disasters, the extinction of species, and so on. Global warming is caused by the emission of greenhouse gases (GHGs), such as Carbon Dioxide (CO₂), Methane (CH₄), Nitrous Oxide (N₂O), Sulphur Hexafluoride (SF₆), Perfluorocarbons (PFCs) and Hydrofluorocarbons (HFCs). Of these, CO₂ has the greatest impact on global warming, which is why the terms Carbon, CO₂ and GHGs are often used interchangeably.

To contain, stabilize and, in the long term, reduce greenhouse gas emissions, the so-called Kyoto Protocol (Nations, 1997) was signed in 1997. However, it was not until 2005 that the EU directive reflecting these changes came into force. This directive was given the title of the European Union Emission Trading Scheme (EU-ETS). The EU-ETS is a cornerstone of the European Union's policy to combat climate change and is its key mechanism for reducing industrial greenhouse gas emissions cost-effectively (see Pereira Freitas and Pereira da Silva, 2015). This is an ambitious and prescriptive policy initiative affecting many countries and economic sectors; therefore, its implementation and deployment were planned in different phases (Maria Mansanet-Bataller, 2007):

- *In the first or pilot phase (2005–2007)*, there was no obligation for Member States to reduce emissions; this phase merely dealt with establishing a price for the CO₂ through the creation of a market for trading emission allowances and the testing of all the bureaucracy created by the monitoring and registering of emissions.
- *In the second phase (2008–2012)*, participating countries committed to reduce their emissions by an average of 5% below 1990 levels. In particular, the EU-15 members, were committed to an 8% cut for the Eurozone. Denmark (–21%), Luxembourg and Austria (–13%) had to significantly reduce their emissions, while Ireland (+13%), Spain (+15%) and Portugal (+27%) committed to not exceeding the maximum allowable increase.¹ Each individual country is responsible for setting the allowance allocations for companies and sectors through the National Allocation Plans (hereafter referred to as the NAPs). The granting of allowances was free at first for 95% of sectors, who had to acquire the rights they needed on the market if emissions exceeded the limit that had been established. According to the Spanish regulatory framework, the only sector that did not receive free allowances was the electricity sector, which by then had already passed the cost on to customers.
- *The goal of the third phase (2013–2020)* is to improve the deficiencies of the system at the regulatory level and in the field of trading. This is to be done by setting a single emission limit for all of Europe and to progressively reduce the percentage of allowances allocated for

* Corresponding author.

E-mail addresses: jmferidom@upo.es (J.M. Feria-Domínguez), david.rodriguez@quintasenergy.com (D. Rodríguez-Carrillero), vrestrategia@upo.es (J.C. Guerra-Martínez).

¹ https://ec.europa.eu/clima/policies/strategies/progress/kyoto_1_en.

free.

- During the fourth and successive phases, each lasting eight years, it is expected that most allowances will be allocated through an auction system and that there will be a gradual reduction of emission allowances that are set aside for trading until the treaty objectives are achieved.

The development of a global market for trading CO₂ allowances is a fashionable topic for scientists, politicians, policymakers and, more recently, for the finance industry (Stern, 2007). Accordingly, Lowrey (2006) points out that the main aim of the EU-ETS is not only to reduce CO₂ emissions, but also to establish a market price for allowances. Since they all are transferable and negotiable, they serve as vehicles for investment, speculation or hedging (see Borak, 2006). Benz and Trück (2009) describe the differences between emission allowances and classical stocks and they argue that in the case of CO₂ allowances, the price is determined directly by the expected scarcity in the market induced by the current demand and supply of allowances in the carbon market.

Each emission allowance or carbon credit is equivalent to emitting one metric tonne of CO₂. There are three main types of allowances:

- The EUAs (European Union Allowances). Each country is allocated a certain number of emission allowances called EUAs, which are distributed among its companies. Any unused surpluses can be sold on the market.
- The CERs (Certified Emission Reductions). Companies in developed countries receive CERs by implementing emission reduction projects in developing countries. These can be exchanged for emission allowances in their country of origin or any other country.
- The ERUs (Emission Reduction Units). These are emission allowances received in order to develop clean energy projects in another developed country.

There are several markets in Europe where carbon credits can be traded, such as SENDECO₂² (which is the reference market for Southern European countries), the BlueNext in Paris and the ECX (European Climate Exchange) in London. The latter and penultimate are reference markets for the electricity and financial sectors: spot trading on BlueNext and futures trading on ECX. While the EEX (European Energy Exchange) in Germany specializes in the energy market and also trades commodities and related derivatives, including emission allowances.

Since allowance trading was first applied in the USA, most of the existing literature is focused on the price behavior of US SO₂ market under the Acid Rain Program of the US Environmental Protection Agency (EPA). However, the financial literature examining the CO₂ allowance prices from an econometric or risk management point of view is not rather extensive. Uhrig-Homburg (2006) assumes that the spot and futures price dynamics for CO₂ emission allowances can be described sufficiently with the cost-of-carry approach. Paoletta (2006) develops an econometric analysis to address the heteroskedastic dynamics in the returns of both CO₂ and SO₂ allowances and Daskalakis (2007) assesses the weak form efficiency by analyzing spot and futures market data, demonstrating that allowances returns are serially predictable. Seifert (2006) tests the hypothesis of no autocorrelation in CO₂ returns, concluding that the CO₂ allowance market seems to be relatively efficient compared to the USA's SO₂ market and the DAX index. Daskalakis (2009) states the pricing mechanism and relationship between spot and futures allowance prices may vary considerably, depending on if the futures contract is written and expires in the same phase or between different phases of the EU-ETS. Fan et al. (2014) analyze the hedging effectiveness in the European Union Emissions Trading Scheme (EU-ETS) by estimating the hedge ratios for CO₂

market in comparison with alternative ones, finding consistency among them. Benz and Trück (2009) provide a short-term spot price behavior of CO₂ emission allowances, focusing on the price dynamics and changes in the volatility of the underlying stochastic process. They also suggest the use of the Value at Risk as a helpful tool for risk managers and traders in carbon markets.

The main goal of this paper is to evaluate the historical performance of CO₂ emission allowances in terms of risk-adjusted return. We assess whether these tradable CO₂ assets have been sufficiently attractive as investment instruments, comparing them to alternative investments in the capital markets during the second phase of implementation of the EU-ETS. Specifically, we focus our analysis on the EUAs and the CERs, which are traded daily on the SENDECO₂ spot market, because they are the most representative and most traded. To evaluate the risk-adjusted performance of emission allowances, we used a classic performance indicator: the Sharpe ratio. Using this ratio as a basis, we propose a new key performance indicator based on the concept of Value at Risk (VaR), giving rise to the Sharpe-VaR ratio. This metric enables us to gauge whether these allowances have provided a return that matches the risk attached to them during a period of international financial crisis.

The paper is organized as follows. We describe the main indicators of classic performance in section 2. In section 3, we introduce the concept of VaR, discuss the new proposed indicator SVaR, and outline the methodological framework. In section 4, we comment on the results and in section 5, we present the main conclusions.

2. Performance indicators

In the sixties, the economists Sharpe (1966), Treynor (1965) and Jensen (1969) developed performance indicators that measured the risk-adjusted return of financial assets and portfolios, thereby allowing their classification and ranking.

The Sharpe index is a risk premium ratio. The numerator indicates the excess of return defined by the difference between the return of the portfolio and the return of the risk-free asset in the same period. The risk of the portfolio is measured by its standard deviation (volatility). The Sharpe ratio reads as the return premium offered per unit of total risk.

$$S_i = \frac{R_i - r_f}{\sigma_i} \quad (1)$$

Where:

- R_i is the average of the return obtained by the stock or portfolio i .
- r_f is the risk-free rate.
- σ_i is the total risk (measured using the standard deviation of return) of the stock or portfolio i .

Consequently, a financial asset or portfolio is better the higher its values are, which are recorded on each of the indices described. Thus, we can rank investments in terms of risk-return, as they are perfectly comparable due to the matching of returns to the risk taken on.

In the mid-nineties, J.P. Morgan made public its valuation of market risk methodology (RiskMetrics™), which was based on the concept of Value at Risk (VaR). In recent decades, VaR has become a commonly accepted measure of risk within the banking industry, encouraged by the Basel II regulatory framework.³ Different VaR methodologies have been used for assessing investments in terms of risk so board members could rank asset portfolios based on a risk-adjusted performance. Garman (1998) define the VaR of a portfolio as the maximum loss expected for a specified time horizon and level of confidence, measured in a specific reference currency. Following Alexander (1997), the Value at Risk measure is a nominal quantity “C”, such that:

² www.sendeco2.com.

³ <http://www.bis.org/publ/bcb128.htm>.

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