ARTICLE IN PRESS

Economic Modelling (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/econmod

Can energy commodity futures add to the value of carbon assets?

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A R T I C L E I N F O

JEL classification:
C51
G11
Q43

Keywords:
Carbon asset
Energy commodity futures
Portfolio management
Copulas

A B S T R A C T

This paper examines whether energy commodity futures are an attractive asset class for helping investors manage carbon risk. We use futures prices for EU allowances (EUAs) and four energy-related commodities (crude oil, coal, natural gas, and electricity) in Phase II and about half of Phase III of the European Union Emissions Trading Scheme. Both static and generalized autoregressive score dynamic copulas are used to model the dependence between the EUAs and the four energy commodity futures prices, with an emphasis on the performance of two different portfolio strategies (diversified portfolios and hedged portfolios) and the resulting effect on risk mitigation in the carbon market. Our empirical results show that despite the superiority of the hedged portfolios in increasing the risk-adjusted returns of carbon assets, the dynamic diversified portfolios are much preferred for reducing variance and the downside risks of carbon assets. Of the four energy commodity futures examined, coal (electricity) is found to be the most (least) attractive in terms of mitigating the carbon risk. These results are confirmed in both sub-sample and out-of-sample analyses.

1. Introduction

The European Union Emissions Trading Scheme (EU ETS) is the largest greenhouse gas (GHG) emissions trading system in operation and is the world's foremost tool for managing the reduction of carbon dioxide (CO_2), the main GHG (Bing et al., 2015). Launched on January 1, 2005, the EU ETS is a cap-and-trade system in which mandated companies are allocated permits to emit CO_2. These carbon permits, called EU allowances (EUAs), are traded on financial markets. EUAs, which have emerged as a factor of production, give their holders the right to emit one ton of CO_2 (or its equivalent). Small energy users (i.e., cleaner companies) whose emissions are below their allowable limits (caps) can sell their unused EUAs to large energy users (i.e., polluting companies) whose CO_2 emissions exceed their caps. As of December 2015, the EU ETS covers more than 12,000 heavy energy-using installations in power and industry plants across the 28 EU countries and Iceland, Liechtenstein, Norway, and Croatia. To date, the EU ETS has had three trading periods, known as operational phases: Phase I (January 1, 2005 to December 31, 2007), Phase II (January 1, 2008 to December 31, 2012), and Phase III (January 1, 2013 to 31 December 2020). Each phase has its own specific compliance requirements.[1] Phase I was used to test price formation in the carbon market; this pilot period experienced over-allocation, leading to a fall in the price of allowances. Phase II overlapped with the first commitment period of the Kyoto Protocol, in which the involved countries had committed to meet their emissions reduction targets. Despite the inclusion of the aviation industry into the scheme on January 1, 2012, Phase II featured a surplus of unused allowances that weighed on the carbon price. Furthermore, the economic slowdown coupled with the global financial crisis led to a cut in both emissions and demand. Phase III featured a major reform with the introduction of an EU-wide cap on emissions (reduced by 1.74% each year) and the progressive replacement of the free allocation of allowances by auctioning.

Now in operation for over 10 years, the EU ETS has gained great popularity among traditional and alternative asset managers and has become an important investment vehicle for managing asset risks (Subramaniam et al., 2015). With more worldwide climate regulations in force to encourage sustainable development, carbon has become a valuable asset for heavy energy-using plants and industries. Managing the carbon asset price is essential for a large number of those plants and industries. In addition to hedging the upside risk of the carbon price, which potentially shifts more costs to companies demanding carbon allowances, hedging the downside risk of the carbon price is becoming more urgent. As noted in a recent news article by Thomson

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[1] Detailed explanations of the EU ETS phases are available at http://ec.europa.eu/clima/policies/ets/index_en.htm.

http://dx.doi.org/10.1016/j.econmod.2016.12.022
Received 6 August 2016; Received in revised form 12 November 2016; Accepted 21 December 2016
0264-9993/

Please cite this article as: Wen, X., Economic Modelling (2016), http://dx.doi.org/10.1016/j.econmod.2016.12.022

Reuters,[2] carbon prices have fallen dramatically in recent years, partly because of a worsening global economic outlook and declining levels of GHG emissions, which has led to a slowdown in the demand for carbon credits. Furthermore, the oversupply of carbon allowances by the UN climate panel has led to a surplus of emission permits, resulting in a large imbalance between the demand for and supply of carbon credits (Balcilar et al., 2016).

The fact that EUAs are a factor of production suggests that changes in EUA prices are closely related to the dynamics of other energy commodity markets. For example, Reboredo (2014) points out that the state of macroeconomic indicators and financial markets affects carbon and energy prices, leading to an interaction between them; Zhang and Sun (2016) show that sharp changes in carbon prices in recent years have been closely correlated with energy prices. However, given that decreases (increases) in energy prices can increase (reduce) companies' energy use, which may increase (mitigate) demands for carbon allowances, a low positive or negative relationship between the energy price and the carbon asset price is also expected. Accordingly, the diversification potential of energy futures for carbon assets is worthy of attention. Therefore, we study the dependence between energy commodity futures and carbon prices with emphasis on portfolio diversification and hedging potential for the carbon asset.

Most of the studies that have addressed the market linkages between carbon and energy markets have focused on the time-varying correlations on average and on the dynamic volatility spillovers. Although the work of Marimoutou and Soury (2015) is an important step in modeling the dependence between CO_2 emission spot prices and a set of commodity prices (Brent crude oil, natural gas, coal and S & P energy index) for extreme cases using copulas, it overlooks the effects on portfolio diversification and hedging strategies and lacks in-depth sub-sample and out-of-sample analyses. Reboredo (2013a) is another interesting work examining EUA and crude oil market dependence using copulas; however, this work is restricted to the dependence between the price of carbon and the price of one type of fossil energy, crude oil. As for the risk management of the carbon asset, prior studies mostly focus on the effectiveness of carbon derivative markets (see, among others, Daskalakis et al., 2009; Narayan et al., 2015; Balcilar et al., 2016; Philip and Shi, 2016; Xu et al., 2016).

This paper contributes to the literature in the following three dimensions. First, unlike previous studies, which generally focused on the effectiveness of carbon derivative markets in managing the carbon risk, this paper seeks more diverse hedging tools for the carbon asset. Specifically, it emphasizes hedging the risks of (extreme) decreases in the carbon price. This timely and urgent issue has been rarely explored thus far, and this paper provides a detailed analysis of the extent to which various energy commodity futures can offer protection for the carbon asset. Second, copula functions, which are capable of capturing both the average and tail dependence between markets and of establishing a more effective multivariate distribution of asset returns, are used to model the relationship between carbon and other energy commodity futures markets. Specifically, in addition to the static copulas, the generalized autoregressive score (GAS) specification of Creal et al. (2013) is applied to characterize the dynamics of copula parameters; such modeling, which is still relatively novel in the field of energy economics, is more sensitive to correlation shocks, which enables us to better capture the dependency structure. On the basis of the copula information, various portfolios are constructed; then, our portfolio management has the advantage of flexibly and fully characterizing the market dependence structure. Third, all of the analyses are conducted in different market phases/environments (sub-samples) and out-of-sample as well, thus making the empirical evaluations more comprehensive and robust.

We provide evidence of symmetric tail dependence between the returns of carbon assets and energy commodity futures and find that despite the superiority of the hedged portfolios in increasing the risk-adjusted returns of carbon assets, the dynamic diversified portfolios are much preferred for reducing both variance and the downside risks of carbon assets. Of the four energy commodity futures examined in this paper, coal futures (electricity futures) are found to be the most (least) attractive in terms of mitigating the carbon (extreme) risk; these results are confirmed in both sub-sample and out-of-sample analyses.

The remainder of the paper is structured as follows. Section 2 reviews the related work. Sections 3 and 4 present the empirical model and the data, respectively. Section 5 presents the results. Section 6 concludes the paper.

2. Literature review

Since the launch of the EU ETS in 2005, the body of research literature on carbon markets has grown rapidly. The first strand of research focuses on the efficiency of the European carbon market (Daskalakis and Markellos, 2008; Krishnamurti and Hoque, 2011; Philip and Shi, 2016), its price discovery (Rittler, 2012; Benz and Hengelbrock, 2009; Schultz and Swieringa, 2014; Narayan et al., 2015), and its price dynamics (Benz and Trück, 2009; Daskalakis et al., 2009; Conrad et al., 2012; Zhu et al., 2014).

A second strand of research has emphasized the factors affecting European carbon prices. Several studies have provided evidence that carbon allowance prices are affected by weather conditions (Mansanet-Bataller et al., 2007; Alberola et al., 2008; Bredin and Muckley, 2011; Liu and Chen, 2013). Various economic activity indicators and financial factors have also been found to be empirically linked with carbon prices. Chevallier (2009a) examines the macroeconomic determinants of EUA prices and reports a weak association between carbon prices and stock and bond variables. Bredin and Muckley (2011) find significant relationships between carbon and stock prices and the level of industrial production. Furthermore, Chevallier (2011) argues that exogenous recessionary shocks on the economy have an adverse effect on carbon prices. Reboredo (2014) finds that oil prices, which are closely linked to economic activity indicators and financial variables, may transmit financial uncertainties to carbon prices. Other studies have provided evidence on the linkages between European carbon prices and electricity stock returns (Oberndorfer, 2009; Veith et al., 2009; Tian et al., 2016), arguing that emission prices introduce additional costs to power generators, bringing about more volatility in their cash flows.

A third strand of research has concentrated on the linkages between European carbon prices and electricity prices (Sijm et al., 2006; Lu et al., 2012; Aatola et al., 2013; de Menezes et al., 2016) based on the rationale that the electricity sector is affected by carbon prices because of its large contribution to total EU CO_2 emissions. In addition, substitutions between fuel oil, coal, and natural gas affect the price of carbon credits because of the difference in CO_2 emissions across these fossil energies. Motivated by this strand of research, a fourth strand argues that energy prices are important drivers of carbon prices (Convery et al., 2007; Mansanet-Bataller et al., 2007; Hammoudeh et al., 2014; Hammoudeh et al., 2015). Power plants can reduce their CO_2 emissions and thereby the cost of producing one unit of electricity by switching from high-carbon-density fuels such as oil and coal to lower-carbon-density fuels such as natural gas. This leads the carbon and energy markets to interconnect. Accordingly, Bunn and Fezzi (2007) indicate that carbon prices are highly responsive to gas prices. Fezzi and Bunn (2009) show that electricity prices are driven by carbon and natural gas prices. Chevallier (2009b) focuses on fuel-switching behavior and shows that the relative prices of coal and gas are drivers of carbon prices.

Numerous studies have examined the linkages between carbon and

[2] "Carbon offsets near record low, worst performing commodity," Reuters (August 5, 2011).http://www.reuters.com/article/2011/08/05/us-carbon-low-idUSTRE77442920110805.