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Modelling volatility spillovers for bio-ethanol, sugarcane and corn spot and futures prices☆

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ABSTRACT

The recent and rapidly growing interest in biofuel as a green energy source has raised concerns about its impact on the prices, returns and volatility of related agricultural commodities. Analyzing the spillover effects on agricultural commodities and biofuel helps commodity suppliers hedge their portfolios, and manage the risk and co-risk of their biofuel and agricultural commodities. There have been many papers concerned with analyzing crude oil and agricultural commodities separately. The purpose of this paper is to examine the volatility spillovers for spot and futures returns on bio-ethanol and related agricultural commodities, specifically corn and sugarcane. The diagonal BEKK model is used as it is the only multivariate conditional volatility model with well-established regularity conditions and known asymptotic properties. The daily data used are from 31 October 2005 to 14 January 2015. The empirical results show that, in 2 of 6 cases for the spot market, there were significant negative co-volatility spillover effects: specifically, corn on subsequent sugarcane co-volatility with corn, and sugarcane on subsequent corn co-volatility with sugarcane. In the other 4 cases, there are no significant co-volatility spillover effects. There are significant positive co-volatility spillover effects in all 6 cases, namely between corn and sugarcane, corn and ethanol, and sugarcane and ethanol, and vice-versa, for each of the three pairs of commodities. It is clear that the futures prices of bio-ethanol and the two agricultural commodities, corn and sugarcane, have stronger co-volatility spillovers than their spot price counterparts. These empirical results suggest that the bio-ethanol and agricultural commodities should be considered as viable futures products in financial portfolios for risk management.

1. Introduction

1.1. Discussion

Following the Industrial Revolution, as industries rapidly developed all over the world, energy resources began to be used in increasingly large amounts, and oil stocks gradually declined. As the usage and exploitation of the world's oil accelerated, the U.S. Energy Information Administration (EIA) (2014) ("Biofuels Production Drives Growth in Overall Biomass Energy Use over Past Decade," Washington, DC) stated that the supply of oil was insufficient to meet demand, and because of speculation and the need to tap into oil reserves, the price of oil became increasingly unstable.

During the First World War, due to the shortage of oil, motor vehicles began to use a mixture of ethanol and gasoline as fuel. As the world subsequently experienced a succession of oil crises, there were

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dramatic fluctuations in oil prices. For example, in 1973 due to the war in the Middle East, the Organization of the Petroleum Exporting Countries (OPEC) imposed an embargo on exports of oil which led to the First Oil Crisis, during which time the price of crude oil rose from less than US$3 per barrel to nearly US$12. In addition, following the outbreak of the Iran-Iraq war in 1979, there was a significant decline in the amount of oil produced, which resulted in the Second Oil Crisis, during which oil prices rose from US$15 a barrel to nearly US$39.

Furthermore, excessive use of fossil energy also contributed to global warming and greenhouse gas emissions, with the result that a meeting of the United Nations Framework Convention on Climate Change was convened in Kyoto, Japan in December 1997, at which member countries unanimously agreed to draw up the "Kyoto Protocol" (United Nations Framework Convention on Climate Change, 2015) (http://unfccc.int/kyoto_protocol/items/2830.php). Each country was invited to sign the Protocol between 16 March 1998 and 15 March 1999 in order that, through the implementation of this Agreement, each country's emissions of greenhouse gases would be reduced. Many countries began to implement policies in response, with the use of biomass energy being an important development.

During the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. The second period, as the report from United Nations Framework Convention on Climate Change (UNFCCC) in 2015, the Paris Agreement committed to reduce GHG emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020.

According to EIA data, between 2002 and 2013, biomass energy production grew by more than 60% in the USA, with the main source of this growth being the production of ethanol. Some 60% of the biomass energy crops grown were able to be converted from the original raw materials into biomass fuels. Total energy production in the USA shows that, from 2000 to 2015, there were increases in natural gas, crude oil, renewables, and natural gas plant liquids, decreases in coal, and little change in nuclear (upper figure in Fig. 1). Currently most of this biomass energy is blended with gasoline or diesel and used as fuel in motor vehicles, with substantial increases in inputs to ethanol from 2002 to 2013 (lower figure in Fig. 1).

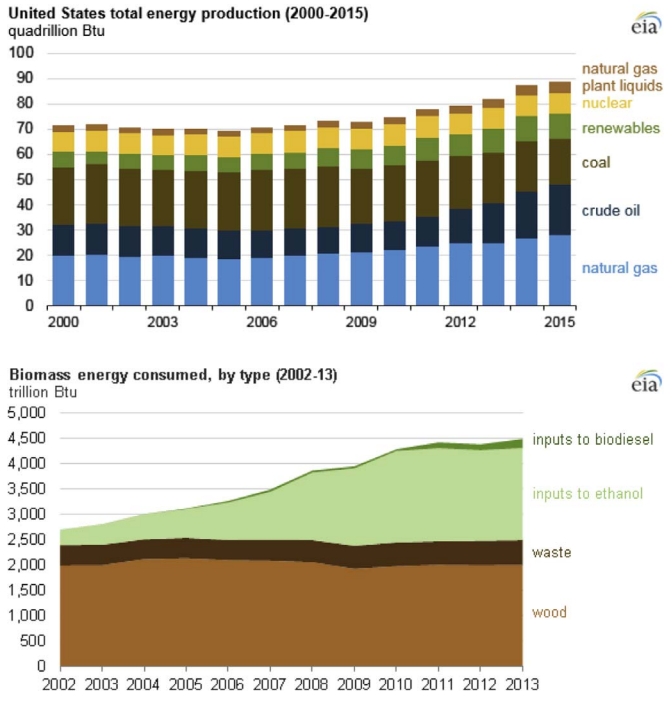

Fig. 1. Use of Biomass Energy in USA.
Source: U.S. Energy Information Administration (EIA).

This paper broadly divides biomass energy according to how it is used after production into two categories, namely bio-ethanol and bio-diesel. Bio-ethanol can be blended with gasoline to be used as fuel, and its main sources are corn, cane sugar and sugar beet. Switchgrass is an expanding source of green fuel as an alternative to gasoline, but its financial characteristics have yet to be analyzed empirically, primarily through lack of financial data.

Co-products are supposed to be credited with the area of cropland required to produce the amount of feed they substitute. If co-products are taken into account, the net use of feed stocks declines. By adding co-products substituted for grains and oilseeds, the land required for cultivation of feed stocks declines from about 2–1.5% net land requirement of the global crop area. Moreover, it is important to include the co-products in GHG assessment, because of their potential impact on overall emissions (for further details, see Popp et al. [1,2]).

Bio-diesel can be blended with diesel fuel, and its main sources are soybeans, palm oil and rapeseed. The USA mainly produces corn and soybeans, while Brazil mainly produces sugar cane, corn and soybeans. The rapeseed used in the manufacture of bio-diesel is mostly grown in Europe, while South-East Asia mainly produces palm oil. From the countries in which these crops are produced, we can see the countries in which the major bio-fuels are manufactured. The USA and Brazil mainly manufacture bio-ethanol, while Europe and South-East Asia concentrate on bio-diesel.

In addition to the agricultural products used in the past to manufacture bio-fuels, in recent years many scholars have begun to study the use of algae as a biomass energy raw material. Different kinds of algae can be used for different purposes. The polysaccharides found in large seaweeds, such as asparagus, ulva and sargassum, can be used to refine ethanol, and micro-algae, such as green algae and diatoms, which are higher in fats than other energy crops, can also be used as raw materials for bio-diesel (see Fig. 2).

Corn production plays a major role in the economy of the USA, which is one of the world's corn leaders with 96,000,000 acres (39,000,000 ha) of land reserved for corn production. Corn growth is dominated by west-north central Iowa and east-central Illinois. The USA is ranked first in the world in corn production, and approximately 13% of its annual yield is exported (http://www.grains.org/buyingselling/corn). The total production of corn in the USA for 2013-14 is reported to be 13.016 billion bushels, of which the major use is for manufacture of ethanol and its co-product (Distillers' Dried Grains with Solubles), accounting for 37% (27% + 10%), or 4845 million bushels (3552 + 1293) ("Production and Use", Iowa Corn organization, retrieved 6 March 2014).

On the basis of the sourced evidence above, although the USA is the major producer of corn worldwide, about 50% of the corn produced is used as feed, with less than 10% being used as food for human consumption. For this reason, rising corn prices have caused the cost of feeding livestock to increase, with the result that budgets for the costs of technology have been impacted (the Renewable Fuels Association (RFA) (2014) ("Ethanol Facts: Agriculture," Washington, DC), the ethanol industry's lobby group, claims that ethanol production increases the price of corn by increasing demand).

Renewable Fuels Association (2014), "Ethanol Facts: Agriculture," Washington, DC: Renewable Fuels Association.

In addition, impacted by the increased production of corn alcohol, many regions have begun to plant bean crops used as biofuels, hence the yield and price volatility of corn have caused the prices of other crops to become increasingly unstable (Wisner [3]; Texas Comptroller of Public Accounts [4]).

Almost all US production of ethanol uses corn as a feedstock. Even with the decline in US ethanol production, demand for corn to produce ethanol continues to have a strong presence in the sector, and is expected to account for over one-third of total US corn use throughout 2015–2025. By 2025, 22% of global sugarcane and 10–11% of global coarse grains production is expected to be used to produce ethanol (see