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Contemporaneous interactions among fuel, biofuel and agricultural commodities

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ABSTRACT

This study examines the contemporaneous interactions among energy (oil and ethanol) and agricultural commodities (corn, soybean, and wheat) in the United States during the period 1 June 2006 to 22 January 2016. Since traditional VAR analysis is not able to capture the contemporaneous interactions among these commodities, we employ a structural VAR analysis in combination with the identification through heteroskedasticity approach. The empirical results indicate that i) the contemporaneous interactions are important, asymmetric, and have implications for impulse response functions; ii) crude oil has a unidirectional contemporaneous impact on the agricultural commodities, and the agricultural commodities (corn and soybean) – mostly used in the biofuel production – have a unidirectional contemporaneous impact on ethanol; and finally, iii) these contemporaneous relations depend on the price level of crude oil in that there are stronger effects from crude oil (agricultural commodities) to agricultural commodities (ethanol) in high crude oil price states.

1. Introduction

In recent years, strong linkages among energy and agricultural markets have attracted widespread attention from practitioners, academics and policy makers. Various theories related to the food crises, legislative policies on biofuels, global demand for and supply of agricultural products and the financialization of commodities have been put forward and examined empirically to explain these linkages. Most of the empirical studies rely on lead–lag dynamics to explain these linkages. However, given that many of these commodities are also actively traded in their respective futures markets, we expect the interactions among them to occur almost immediately. Commodity futures markets incorporate information quickly (see e.g. Lehecka et al., 2014; Chatrath et al., 2012) and information about one commodity affects other commodities swiftly, especially nowadays where markets are highly integrated (see, e.g., Hong and Yogo, 2012; Hou and Szymanowska, 2015; Boons et al., 2014, among others). As such, correctly identifying the interrelations among energy and agricultural markets is vital for properly understanding the dynamics of these commodities (and determining the relation between oil and food prices), and developing trading and risk management strategies.

As previous literature has predominantly relied on reduced-form models, such as vector autoregressive (VAR) or vector error correction (VEC) models,[2] these models are not able to capture the contemporaneous relations among energy and agricultural commodities. In these models, the contemporaneous relations, which can be interpreted as causal relations, are generally left in the residuals of the model, and are therefore unidentified. Saghaian (2010), for instance, investigates the interrelationship between crude oil, ethanol, corn, soybean and wheat and concludes that while there is strong evidence of contemporaneous correlations among these commodities, the evidence on causality is mixed.

In this study, we aim to resolve the problem of contemporaneous correlations, by implementing a novel technique known as identification through heteroskedasticity which was originally developed by Rigobon (2003). This technique uses a structural VAR (SVAR) approach to break up the contemporaneous relationships into causal relations. These contemporaneous relations differ from Granger causality, which captures the causal effect of one lagged variable on the current value of another variable. Through implementation of this model, we attempt to assess the price transmission between energy commodities (crude oil and ethanol), and agricultural commodities (soybean, corn and wheat). Furthermore, given that data aggregation over time would only increase

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[2] For an overview of the price transmission literature that focuses predominantly on VAR and VEC models, see Serra and Zilberman (2013).

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the issue of contemporaneous correlations, we estimate our model using daily data on the futures contracts of these commodities for the period from 1 June 2006 to 22 January 2016. We employ futures contracts traded in the US markets. These markets are all in the same time zone and have extensive overlapping trading hours. This makes the modeling of contemporaneous interactions among these commodity futures even more important.

Investigating the contemporaneous interactions among fuel, biofuel and agricultural commodity futures is important for, at least two reasons. First, information is transmitted rapidly among markets these days and may no longer be captured by investigating the impact of lagged variables on current variables as in standard VAR models. Second, the contemporaneous interactions are not only important for describing short-term commodity price behavior, but also long-run behavior, as captured by impulse-response functions. We thus expect the contemporaneous relations among the commodity futures contracts in our sample to be strong, as nowadays energy and agricultural markets are interconnected, and information is transmitted swiftly across markets.

We document several important findings. We show that traditional VAR analysis based on lead–lag relations does not capture much of the co-movement among the commodities in our sample. Through the application of SVAR analysis, we are, however, able to identify the directional contemporaneous effects, which in many cases are significant and asymmetric, i.e. the contemporaneous effect of one commodity on the other can be of a different magnitude than the other way around. For instance, we document that crude oil has a direct impact on the agricultural commodities, while there is no direct impact in the opposite direction. We also note that corn and soybean have a unidirectional impact on ethanol and there are bi-directional effects between the pairs soybean–corn and corn–wheat. These dynamics are not observed in the traditional reduced-form VAR. Through impulse-response analysis, we demonstrate that appropriately accounting for the short-run relations has important consequences for the long-run as well. We observe that shocks applied to a traditional reduced-form VAR lead to very different outcomes than shocks applied to the SVAR. Finally, we show that the contemporaneous relations are dependent on the price level of crude oil, with stronger contemporaneous effects from crude oil on agricultural commodities, and likewise, stronger contemporaneous effects from agricultural commodities on ethanol in high price states.

The remainder of this paper is organized as follows. Section 2 provides an overview of the relevant literature. Section 3 outlines the identification through heteroskedasticity approach. Section 4 describes the data and in Section 5, we present and discuss the empirical results. Section 6 concludes the paper.

2. Literature review

The literature on the relations between fuel–biofuel/feed crop commodities has expanded rapidly in the last decade.[3] Part of this literature addresses the question of whether the usage of biofuel has caused a stronger linkage between fuel prices and food prices. The idea of production of large amounts of crop-based biofuels to reduce dependence on fossil fuels has proven to be controversial, particularly because of the sharp upsurge in food prices, known as the "food crisis" (see, e.g., Du et al., 2011; Harri et al., 2009; Ji and Fan, 2012) which is attributed to price spill-over from crude oil to other markets, especially the agricultural ones. As the price of crude oil increases, demand for biofuel increases, and since biofuels are mainly extracted from agricultural commodities that are normally used in food production, a higher crude oil price encourages farmers to substitute food production by energy-related commodity production (known as the substitution effect) which results in higher food prices (see, e.g., Tyner, 2010; Chen et al., 2010; Vacha et al., 2013).

However, these arguments have been contested. Wetzstein and Wetzstein (2011), for instance, go as far as calling the hypothesis of a strong connection between crude oil and agricultural commodity prices a myth. They argue that investment in biofuel is subject to adjustment costs, irreversibility, and uncertainty. Hence, biofuel production and consequently the demand for agricultural commodities may be less responsive to energy prices than has been assumed. Meyers et al. (2014) find that, while over short and intermediate time horizons the co-movement between energy and agricultural prices are strong, in the long-run agricultural prices tend to be determined predominantly by agricultural supply conditions and the non-biofuel demand for agricultural feed-stocks. Furthermore, energy prices play an inconsequential role in setting long-run agricultural prices.

In addition, the huge increase in demand for raw materials and agricultural commodities by the growing Asian economies, in particular China and India, has led to persistently high crude oil and agricultural commodity prices in the past decade (Hamilton, 2009; Kilian, 2009; Wolf, 2008). Therefore, the observed co-movement in crude oil and agricultural commodity prices could be due to higher global demand for agricultural commodities driven by economic activities, rather than price spill-over from crude oil to these markets. Meyers et al. (2014) attempt to distinguish oil-specific shocks from aggregate demand shocks. They observe that oil shocks can explain a small fraction of agricultural commodity price variations before the food crisis in 2006–2008, whereas in the post-crisis period their explanatory abilities become much more significant. After the first food crisis of 2006–2008, the contributions of oil-specific factors to variations in agricultural commodity prices are far greater than those of aggregate demand shocks. Meyers et al.'s (2014) findings are generally in line with those in related studies that clearly show much stronger oil–agriculture linkages after 2006 (see, e.g., Kristoufek et al., 2012; Nazlioglu, 2011; Nazlioglu et al., 2013).

Besides global market conditions, biofuel prices are also affected by government policies and regulations. In the U.S., for example, the main policy instruments are subsidies such as the Renewable Fuel Standard and the Clean Air Act as of May 2006, and the import tariff introduced on ethanol (see, e.g., Taheripour and Tyner, 2008). Generally, the proposed standards require motor fuels to contain a minimum amount of fuel generated from renewable sources, such as ethanol, solar or wind energy. In reality, so far only ethanol has become a viable substitute to comply with the new standard, further accelerating the linkage between energy and commodity markets. According to Avalos (2014), the higher the crude oil prices, the greater the incentives for gasoline producers to bring to market blends with higher levels of ethanol.

From an empirical point of view, the linkages between energy and commodity markets have been investigated by various studies. Ciaian and Kancs (2011a), for instance, show that the prices of nine agricultural commodities are cointegrated with crude oil prices over the period of 2005–2010. Ciaian and Kancs (2011b) and Kristoufek et al. (2012) examine the relations among the prices of energy and agricultural commodities before and after the first food crisis of 2006–2008 and report that the connections have become much stronger in the post-crisis period. More recently, Kristoufek et al. (2016), utilizing a continuous wavelet framework, find that the prices of ethanol feedstock both in Brazil and the US lead the prices of ethanol and not the other way around.

Finally, a number of studies argue that agricultural commodity prices are not affected by the price of crude oil and hence support the neutrality of agricultural commodity markets. Zhang et al. (2010), using the Johansen trace test, find that there are no direct long-term price relations between crude oil and agricultural commodity prices, and that there are only limited direct short-term relationships. Reboredo (2012), employing copula models, investigates the conditional dependence between world oil prices and agricultural commodity prices, and finds a weak dependency between food and oil. Finally,

[3] Three overview articles on various aspects of biofuel-related price transmission literature have appeared recently. Janda et al. (2012) consider the technological, social, environmental and policy aspects. Serra and Zilberman (2013) focus on biofuel related time-series literature and Zilberman et al. (2013) provide a general overview of biofuel (and fuel) and commodity food prices.