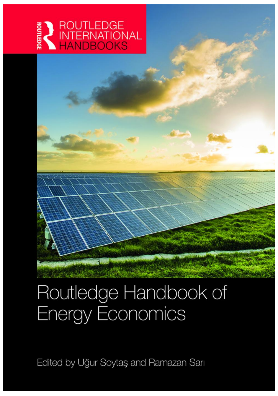

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Oil and agricultural commodity prices

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1 Introduction

Recent dynamics (fluctuations and volatility) of global commodity prices have attracted an interest in examining what are the drivers and consequences of price booms and drops. The literature has focused on energy market linkages, financialization of commodities, macro variables context, and demand-supply equilibrium. This chapter is related to the literature on energy (oil) and agricultural commodity markets linkages and reviews the papers which have new perspectives and documented fresh information to better understand the interrelations between energy and agricultural commodity prices.

The rest of the chapter is organized as follows. The next section is devoted to discuss the drivers of agricultural prices followed by describing a framework for oil and agricultural price linkage in Section 3. Section 4 tries to summarize the empirical literature by focusing on referring to the papers which have employed different econometric methods and documented a fresh information. Finally, in Section 5, the concluding remarks are presented within the context of policy discussion and future directions.

2 Drivers of agricultural prices

In order to better understand what drives agricultural prices, several factors are discussed. Based on the micro economic theory, a price of a commodity is driven by demand- and supply-side conditions. Figure 26.1 describes the demand- and supply-side factors which play a role in the fluctuations of agricultural commodity prices.

2.1 Demand-side factors

The population growth is the primer determinant of demand for agricultural products. No doubt that increase in *population* stimulates demand for agricultural commodities, in particular, for food products. In addition to population growth, economic growth is one of crucial drivers of agricultural prices. The linkage between *economic growth/income increase* and agricultural commodity/food prices is twofold. First, rapid economic growth (especially after 2000 in China and

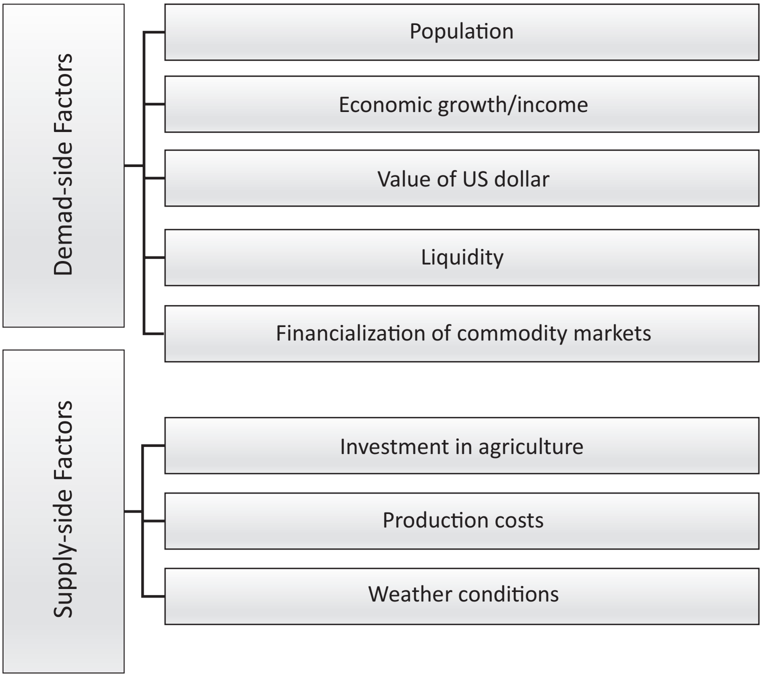

Figure 26.1 The factors driving agricultural commodity prices

India that are emerging market economies) seems to be one of key factors effecting agricultural prices because income increases leads to increase in demand for commodities. Second, as income increases food consumption increases more slowly than other goods and services (Engel's law) and hence the terms of trade between food and manufactured goods prices has declining trends (Prebisch-Singer hypothesis).

The interconnection between *value of the US dollar* and (agricultural) commodity prices is expected to be in a reverse direction. More specifically, global weakness (strength) of the dollar leads to higher (lower) agricultural prices. One reason for this relation is that the dollar is the benchmark currency for pricing agricultural commodities in global markets and thereby agricultural commodity contracts are issued in terms of the dollar. Drops in the value of the dollar requires to pay more dollar for buying commodities, which means higher commodity prices. Weaker dollar also keeps financial investors and speculators in countenance to hold more commodities because of increasing purchasing power by paying less domestic currency, and this tendency increases demand for agricultural commodities in derivatives markets. A fall in the value of the dollar directly drops price of agricultural products in terms of domestic currencies which in turn changes domestic demand for and supply of agricultural commodities.

The relationship between *liquidity* and commodity prices can be clarified within the context of overshooting model of agricultural prices. Frankel (1986) considers how agricultural prices respond to money supply changes and proposes the overshooting model under the closed-economy assumption. A decline in the money supply level in the short run leads to an increase in real interest rates. High interest rates reduce demand for storable commodities and lead speculators to shift out of commodity contracts (Frankel, 2006) and depresses commodity prices which proportionally will fall more than to the change in money supply and thereby overshoot a new long-run equilibrium for generating an expectation of sufficient future appreciation to offset higher interest rates. All these real effects will consequently vanish because the decrease in real interest rate and commodity prices as a result of the reduction in money supply disappears from short run to long run as the general price levels adjust to the money supply changes. Saghaian et al. (2002) relax the closed-economy assumption and develop the overshooting model of agricultural prices by allowing for international trade of agricultural commodities, under the assumption that agriculture and services are the flexible-prices sectors and manufacturing sector is the sticky-prices sector. The model implies that agricultural prices – as a response to money supply changes in the economy – overshoot in the short run and then turn back to their long run levels. The overshooting theory clearly implies that agricultural commodity prices are not only driven by traditional sector-specific microeconomic variables but also are closely related to macroeconomic policy which may have an important role behind agricultural price fluctuations.

After the mid-2000s, it has been observed that there has been substantial increase in capital investment to commodity futures markets, and this process is referred to as the *financialization of commodities*. It leads commodity futures to be popular as much as other classes of assets like stocks and bonds. The energy and agricultural markets which have appreciated large investment inflows of capital move in tandem as a result of the financialization. No doubt that the financialization of commodities is not a phenomenon anymore, there is a growing concentration on whether the financialization creates any distortion on commodity prices. Cheng and Xiong (2014) determine two different views in that respect which are "bubble view" and "business-as-usual view". The proponents of the bubble view argue that speculative behavior of portfolio investors causes price booms in commodity markets by adducing evidence to the 2007–2008 and 2011 bubbles in oil and grain commodities. The business-as-usual view on the other hand propounds that there is a weak evidence in favor of price booms in commodity markets as a result of speculation and commodity markets' speculations do not lead to price distortions. Even though the debate between two different views appears to be still going on, the financialization seems to substantially change behavior of commodity markets through its effects on risk sharing and information discovery (Cheng and Xiong, 2014).

2.2 Supply-side factors

Agricultural growth rate and productivity growth in agriculture have steadily slowed from 1970s which constraint global supply of agricultural commodities. Agricultural production growth on the average was 2.2% per year between 1970 and 1990 and it has declined to about 1.3% since 1990. Agricultural productivity growth contributes much more to global stock levels of agricultural commodities than agricultural production growth. Global average aggregate yield was 2.0% per year between 1970 and 1990, but declined to 1.1% between 1990 and 2007 and it is projected to decline less than 1.0% per year up to 2020 (Trostle, 2008).[2]

The key factor which determines growth in agricultural production and productivity is investment in agriculture. Not only governments but also international institutions have reduced agricultural research and development (R&D), although investment in agriculture from private sector has increased. Nonetheless, private sector investments generally focus on reducing production costs rather than technological development which is the key driver of yield improvements. On the farmers side, farmers solely are unable to invest in agricultural R&D and to pay for yield-enhancing technology to a large extent (Trostle, 2008).

The total cost of production consists of variable costs and fixed costs. The variable costs have two dimensions: cash costs (seeds, fertilizers, pesticides, energy, paid-labor, custom services, etc.) and non-cash costs (unpaid-labor, own-produced inputs, owned-machinery, etc.). The fixed costs on the other hand can be classified into capital costs (depreciation of machinery, equipment), farm overhead costs, and land costs (FAO, 2015). The cost structure is not same for all agricultural commodity prices and it clearly differs for different commodity groups such as beverages, food, and raw materials. Even though there are differences in the structure of production costs for different groups of agricultural commodities, fluctuations in the components of variable costs, in particular cash costs, play a crucial role for commodity price fluctuations.

Last but not least, weather conditions are one of main drivers of agricultural production. Adverse weather conditions result in poor harvest which in turn tightens stock-to-use levels of agricultural products.

3 Oil and agricultural price linkage: a framework

The link between oil and agricultural commodity prices in fact has an historical consideration. Oil prices effect agricultural prices through direct (supply and demand) and indirect (finance) channels (see Figure 26.2). It is a well-known fact that agriculture is an energy-intensive sector and therefore there is a direct *supply-channel* from oil prices to agricultural commodity prices. An increase in oil prices leads to an increase in input and transport costs which in turn causes agricultural prices to rise (Hanson et al., 1993). Some chemicals and fertilizers are also by-products of oil, which increase energy-intensity of agricultural prices to energy markets.

Energy market shocks which lead to oil price booms encourage incentives for production of biofuels (biodiesel and bioethanol) and hence trigger demand for biofuels. Different crops (wheat, corn, soybeans, barley, sugar cane, and sugar beet, as well as other substitute and complementary crops) are used as raw materials in biofuel production. An increase in production of biofuels increases demand for agricultural commodities and in turn leads to rise of agricultural commodity prices. This demand channel hence creates a closer link between energy and agricultural prices. It also affects other agricultural commodity prices because crops used in biofuel production – especially wheat, corn and soybeans – are the key commodities for food in the world. They not only compete with each other but also with other crops for arable land allocation. During the last decade, biofuels are the largest source of demand growth for crops and oilseeds due to the fact that 3% of global area allocated to agricultural raw materials is devoted to biofuels as of 2016 (Baffes, 2016).

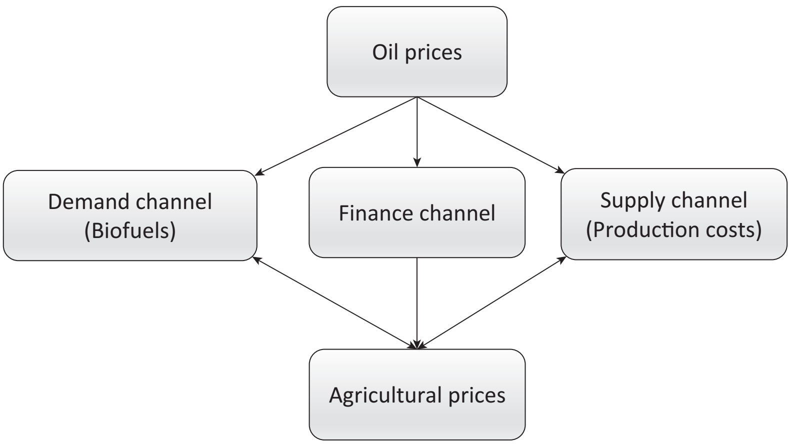

Figure 26.2 Oil and agricultural commodity prices connection

Even though historically neglected, the third link from oil prices to agricultural commodity prices is through the finance channel. The literature on the relationship between oil prices and financial sector documents that changes in oil prices affect stock market returns. This affect influences the financialization of agricultural commodities and agricultural trade. Although the co-movement between stock prices and agricultural commodity prices is found to be weak up to the mid-2000s, it has been getting stronger after the 2007–2008 food price crisis in association with the 2008 financial crisis, due to the fact that the 2008 financial crisis has led financial investors and speculators to flee from mortgage funds to agricultural commodity futures, causing a positive demand shock for agricultural commodities. Oil prices also influence the value of the dollar because oil is mainly traded in terms of the dollar in global markets similar to many commodities. High oil prices increase the dollar revenue of oil exporting countries, resulting in weak dollar in global markets. High oil prices, on the other hand, increase requirements for dollar of oil importing countries, resulting in strong dollar in global markets. Changes in oil prices hence have indirect impact on agricultural commodity prices through its direct impact on the value of dollar. The appreciation/depreciation of local currency, in return, influences local prices of agricultural commodities which would change demand and supply conditions in international markets.

4 Research questions and modeling strategies

Increasing interconnection between oil and agricultural markets has led to a huge and still growing empirical literature. Researches have focused on various kinds of research questions (co-integration, causality, volatility spillover, etc.). Even though it is unfortunately not possible to review all the papers, it is fortunately possible to draw a picture which mirrors the differences in research questions and modeling strategies.[3]

An early attempt goes back to Hanson et al. (1993), who apply an economy-wide environment computable general equilibrium (CGE) model to analyze the effects of a world oil price shocks on US agriculture and indicate that the impacts of oil price shocks vary among agricultural commodities. The study finds out that oil prices affect agriculture not only through direct and indirect input costs but also through exchange rate and foreign borrowing. CGE models suffer from arbitrary determined or calibrated price elasticities for simulating long-run sensitivity of agricultural commodity prices to oil price shocks. Since CGE framework is based on a long-run perspective, it is not able to examine interdependence between oil and agricultural prices within the context of short- to long-run perspective. If the question is to focus on modeling short-run dynamics and long-run structural behavior, one can utilize from the co-integration framework. Campiche et al. (2007) by employing co-integration analysis examine the co-movements between world crude oil and corn, sorghum, sugar, soybeans, soybean oil, and palm oil prices. The results show that while there is no co-integrating relation between oil and agricultural prices for the period 2003–2005, corn and soybean prices are co-integrated with crude oil prices during the 2006–2007 period.

Another aspect of empirical research question is to examine causal linkages between energy (specifically oil) and agricultural commodity prices. The widely used common approach is standard Granger causality analysis (Granger, 1969), which is based on estimation of VAR (vector auto regressions) or VEC (vector error correction) models. Zhang et al. (2010) estimate VEC models to distinguish short and long-run causal linkages between energy (oil, ethanol, gasoline) and agricultural commodity (corn, rice, soybeans, sugar, and wheat) prices. Authors not only find out that the agricultural commodity prices are neutral to the energy prices in the long run but also there is a weak evidence for the short-run interconnections.

The standard Granger causality analysis is sensitive to unit root and co-integration properties of VAR system and requires a careful pretesting procedure because the distribution of Wald statistic for testing causality hypothesis depends on integration order (degree of unit root) and nuisance parameters. The causality approach proposed by Toda and Yamamoto (1995) overcomes these problems and is widely used for causality analysis during last two decades. Kwon and Koo (2009) explore causal relationships among energy prices, exchange rate, and food prices for the US economy by means of the Toda and Yamamoto approach and find out that the exchange rate and energy prices affect food prices thorough various channels. Nazlioglu and Soytaş (2011), for an emerging market economy (Turkey), examine short- and long-run interdependence between world oil prices, lira-dollar exchange rate, and individual agricultural commodity prices (wheat, corn, cotton, soybeans, and sunflower). The long-run causality analysis reveals that the changes in oil prices and appreciation/depreciation of the Turkish lira are not transmitted to agricultural commodity prices in Turkey.

The causality analysis is based on Granger (1969) and Toda and Yamamoto (1995) is not able to capture regime/structural changes in causal linkages. In the presence of regime shifts, nonlinear models work better than linear models to obtain information for forecast (Baek and Brock, 1992; Chiou-Wei et al., 2008). The recent studies (Bekiros and Diks, 2008; Cheng-Lang et al., 2010; Kim et al., 2010) in the energy literature call an attention to investigate nonlinear causal linkages between oil and agricultural commodity prices due to the fact that commodity prices seem to be higher than their historical levels, signaling new price regimes.[4] Nazlioglu (2011) extends the literature on the oil-agricultural commodity prices nexus by particularly concentrating on nonlinear causal relationships between the world oil and agricultural commodity prices (corn, soybeans, and wheat) by employing the nonparametric causality method of Diks and Panchenko (2006). He finds out that while the linear causality analysis supports evidence on the neutrality, the nonlinear causality analysis shows an evidence on nonlinear feedbacks between the oil and the agricultural prices.

Either ignoring structural breaks in VAR models or incorrect specifications of them could falsely result in rejecting the null hypothesis of non-causality (Enders and Jones, 2016; Nazlioglu et al., 2016). It is therefore important to not only account for any structural shifts but also measure structural changes with a careful treatment. In a VAR specification, controlling for structural breaks and determining their sources are challenging because a break in one variable potentially causes shifts in other variables (Enders and Jones, 2016). One simple way to accommodate structural changes is to estimate rolling regressions and conduct causality analysis in each step. Cooke (2009) carries out rolling Granger causality tests to examine whether causal linkages between oil and agricultural (wheat, corn, soybean, and rice) prices are subject to any structural changes. The results present that there is an information flow from oil to corn prices in the second half of 2004.

Rolling window regressions approach to Granger causality may not be practical and also have an inference problem when sample size increases and data frequency becomes small because it requires estimating so many regressions and calculating the test statistics. Enders and Jones (2016) propose a simple and flexible method to accommodate structural changes in a causality analysis which simplifies the determination of form, number, and dates of breaks. They first extend VAR models with a Fourier approximation[5] and then examine causal linkages between oil and corn prices. Similar to Nazlioglu (2011), authors indicate that while Granger causality test based on conventional VAR estimations does not support any causal linkage between oil and corn prices, the causality analysis based on the VAR estimates with structural changes supports evidence on the direction of causation form oil to corn prices.

The methods based on estimating VAR models with either rolling window regressions or a Fourier approximation are able to test for Granger causality in the conditional mean. The conditional mean is a disputable tool if variables have non-elliptic or fat-tailed distributions such as return series and includes an overall information for the conditional distribution. Jeong et al.

(2012) develops a nonparametric test for Granger causality in quantile by imposing restrictions on conditional quantiles. This approach is also able accounts for structural breaks and nonlinear dependence of variables. Balcilar et al. (2016) focus on the interrelationships between world oil and South African agricultural commodity prices (wheat, corn, soybeans, and sunflower) within the context of Granger causality in quantiles. Although the standard Granger causality test does not indicate any causal linkage from oil to agricultural prices, the causality in quantiles in contrast shows that causation from oil prices to agricultural commodity prices vary across different quantiles of the conditional distribution.

Structural breaks and nonlinearity in prices may result in asymmetric relations between oil and agricultural prices. Effects of negative and positive oil price shocks on agricultural price dynamics appear to be a fruitful area to explore. Rafiq and Bloch (2016) focus on exploring the dynamics of commodity prices through asymmetric oil shocks for a large set of commodity prices by employing Shin et al. (2014) non-linear ARDL approach and Hatemi-J (2012) asymmetric causality test. An elaborated analysis in summary supports a long-run positive impact of oil price for 20 commodities and short-run negative impact for 13 commodity prices.

In addition to information for causal linkages, VAR models also give information for dynamic interrelationships among variables through impulse response functions and forecast error variance decompositions. VAR models however are not suitable to distinguish (demand- and supply-side) shocks and are failure to impose restrictions according to an economic theory. Structural vector auto regression (SVAR) models mitigate these shortcoming of VAR models and are suitable to identify innovations. SVAR models can decompose unpredictable changes in prices and demand and supply into mutually orthogonal components with restrictions based on economic theory. Qiu et al. (2012) by estimating a SVAR model decompose supply and demand shocks to corn prices by concentrating on the role of energy (oil, ethanol, and gasoline) markets. The results reveal that energy market shocks do not transmit to corn market; corn prices are driven by the demand shocks in the short run, and there is a steady-state equilibrium in the long run.

Another dimension of empirical research questions is of whether there is a risk transfer/volatility spillover between energy and agricultural markets because these markets have more volatile dynamics after the mid-2000s. The causality in variance tests are getting popular in order to conduct a volatility spillover analysis. To investigate volatility spillover between two series, Cheung and Ng (1996) and Hong (2001) propose the causality-in-variance tests based on cross-correlation functions (CCF) of standardized residuals from univariate GARCH (general autoregressive conditional heteroscedasticity) models. Harri and Hudson (2009) by employing the CCF approach find a causal linkage from variance of oil prices to variance of corn prices after the 2007–2008 food price crisis, implying a volatility spillover from oil to corn markets.

The CCF approach is sensitive to order of leads and lags of the standardized residuals and shows an oversize problem in small and medium samples when the volatility process is leptokurtic. Monte Carlo simulations designed by Hafner and Herwartz (2006) show that an inappropriate lead and lag order choice distorts small sample properties of the CCF-based test and thereby leads to a risk of selecting a wrong order of the CCF-based statistic. A simple Lagrange multiplier (LM) causality-in-variance test proposed by Hafner and Herwartz (2006) overcomes these shortfalls and is more robust against leptokurtic innovations in small samples. Nazlioglu et al. (2013) by employing the LM test examine volatility spillover between oil and agricultural commodity (wheat, corn, soybeans, and sugar) prices. The causality-in-variance test shows that while there is no risk transmission before the 2006 food price crisis, oil price volatility spills on agricultural prices after the crisis.

Time series studies widely focuses on small subsets of agricultural commodities such as grains (wheat, corn, soybeans, etc.) or oils (palm oil, soybean oil, sunflower oil, etc.) that are used in ethanol and/or biodiesel production. Agricultural markets are highly integrated and thereby a shock in one market is transmitted to other market(s). Since time series analysis is able to examine the impact of oil prices on agricultural commodity prices one by one, panel data framework seems to be an appropriate tool to account for the impact of such common factors on agricultural commodities. Besides, panel data methods have higher statistical power than time series analysis because they combine information from cross-sectional dimension in addition to time period. Nazlioglu and Soytaş (2012) extends the empirical literature on oil and agricultural commodity price nexus from time series analysis to the panel data context. The study covers data for not only grain and oils prices but also beverage, meat, and fresh fruit prices and employs panel co-integration and causality frameworks. The panel co-integration analysis provides a strong evidence on the positive effects of oil prices changes and the negative effect of the weak value of the US dollar on agricultural commodity prices. The panel causality analysis indicates both short- and long-run causality from oil prices and the US dollar to agricultural commodity prices.

5 Concluding remarks: policy implications and future directions

The empirical literature shows that (1) agricultural commodity prices are either neutral or non-neutral to oil price movements, (2) structural shifts in commodity prices effect the nature of relationship between commodity markets, and (3) the nature of the relationship provides us with essential information for policy analysis within the context of different perspectives.

The existence of neutrality indicates that oil prices do not have a significant impact on agricultural commodity prices. The agricultural price stabilization polices therefore may not need to account for world oil market and policy makers to manage agricultural price booms and drops may focus on supply and demand conditions of agricultural markets. Even though the neutrality implies that agricultural markets seem to be protected from oil price shocks, it does not mean that they are disintegrated from energy markets. Provided that agricultural production preferences are in tandem with energy (biofuel) policies, a tendency for increasing biofuel production (due to higher oil prices and environmental concerns) leads to increasing sensitivity of agricultural prices to oil shocks. A closer link from higher biofuels production to higher corn and soybeans (that are the main crops used in the production of ethanol and biofuels) prices have led farmers to increase production of these commodities at the expense of other crops such as wheat which in turn likely to boost the crop prices. It is well known that agricultural markets are highly integrated with each other and hence a shock in one market transmits to other markets. As the linkage between energy and agricultural markets becomes stronger, agricultural commodity prices would be more related to energy prices. Since price stabilization policies are not able to fully break off the dependence between local and global agricultural markets, policy makers should take into account energy markets in designing sound agricultural price support/stabilization policies whose costs and effectiveness increasingly depends on the dynamics of international energy and agricultural markets.

As a result of the expansion in biofuels, agricultural producers are challenged whether to produce for people or for fuel. Increasing importance of biofuels has motivated them to produce for fuels. For both the least developed and developing countries, the agricultural sector still keeps its importance in the structure of economy and a large portion of the population thereby are affected by agricultural price fluctuations. Agricultural price surges harm poor people more than others because they need to allocate the large share of their incomes on food. The food versus fuel trade-off, moving in favor of fuel after the 2000s, calls attention to invest more in agriculture in a long-run perspective to alleviate world hunger and poverty.

The neutrality and non-neutrality have also different policy implications for global investors. If agricultural prices are neutral to oil prices, then agricultural commodity markets can be viewed as an alternative to oil markets for portfolio diversification and risk sharing. The neutrality also implies that investors cannot have predictive power for spot and future prices of agricultural commodities by following past prices of oil. On the other hand, the non-neutrality shows that the dynamics of oil prices can help investors to forecast agricultural commodity prices which provides information for investment strategies. If investors expect an increase or a decrease in oil prices, they can gain revenues by investing or speculating in agricultural markets.

The recent dynamics of agricultural commodity prices are complicated and different factors may affect agricultural markets. In addition to the energy-agriculture linkage, the macro economic factors and the financialization of the commodities may play a role on the recent dynamics of agricultural prices. Analyzing agricultural price dynamics by jointly identifying the impacts of various factors may have merits to extend the literature. Researches can benefit from the developments in multivariate modeling frameworks in both time series and panel data analyses to discover price and volatility transmission between energy and agricultural markets. Domestic agricultural prices may show different degrees of dependence to world energy prices at different stages of development and this fact opens a door to focus on different samples including developed, emerging, developing, and underdeveloped countries as well as employing threshold models by controlling the level of development. The empirical literature shows a clear evidence on the importance of structural breaks in prices to examine price transmission and volatility spillover. Researchers can handle the research question within the context of developments in structural change and nonlinear models. It is worthy to emphasize as a final sentence that the motivation of re-examination of the research question might be constructed on fresh evidence to better understand the dynamics between energy and agricultural markets rather than only employing new tests which reproduce the previous findings.

Notes

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2 See Trostle (2008) for much more descriptive analysis of agricultural supply statistics.
3 See Serra and Zilberman (2013) for a detailed survey (data, methods, main findings) on biofuel related price transmission literature.
4 See Nazlioglu (2011) for a discussion on the sources of non-linear behavior of agricultural commodity prices.
5 A Fourier approximation captures the dynamics of series with structural break(s) by using a small number of low-frequency components and does not require prior knowledge of the number and/or dates of the breaks.

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