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Torsten Schmidt

Long-run Trends or Short-run Fluctuations – What Establishes the Correlation between Oil and Food Prices?

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Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, email: W.Leininger@wiso.uni-dortmund.de

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University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Christoph M. Schmidt
RWI, Phone: +49 (0) 201/81 49-227, e-mail: christoph.schmidt@rwi-essen.de

Editorial Office

Joachim Schmidt
RWI, Phone: +49 (0) 201/81 49-292, e-mail: joachim.schmidt@rwi-essen.de

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Karoline Krätschell and Torsten Schmidt[1]

Long-run Trends or Short-run Fluctuations – What Establishes the Correlation between Oil and Food Prices?

Abstract

In this paper we use the frequency domain Granger causality test of Breitung/Candelon (2006) to analyse short and long-run causality between energy prices and prices of food commodities. We find that the oil price Granger causes all the considered food prices. However, when controlling for business cycle fluctuations this link exists especially at low frequencies. Thus, short-run phenomena like herd behaviour and speculation do not seem to have a considerable effect on the studied food prices. The relation between oil and food prices is rather established by long-term developments. A possible explanation for this could be the production of biofuel.

JEL Classification: C32, E43

Keywords: Granger causality; spectral analysis; commodity prices

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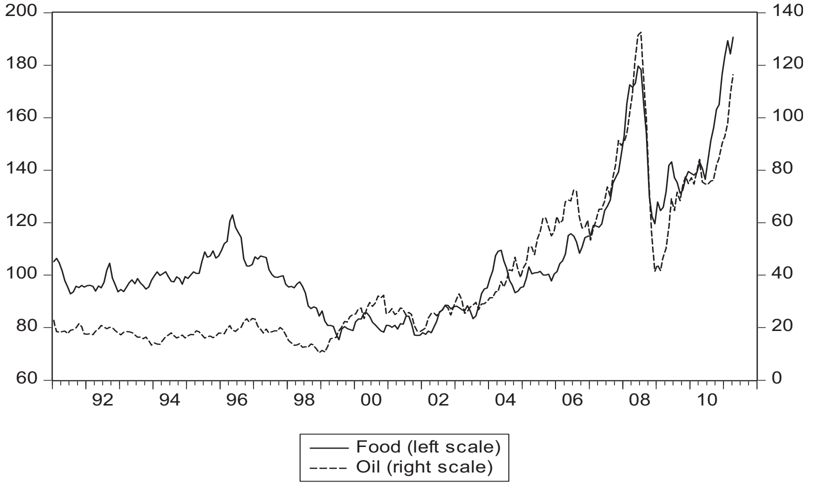
1 Karoline Krätschell, RWI and Ruhr-Universität Bochum; Torsten Schmidt, RWI. *– We thank Christoph M. Schmidt for valuable comments and suggestions.* *– All correspondence to Karoline Krätschell, RWI, Hohenzollernstr. 1-3, 45128 Essen, Germany, E-Mail: karoline.kraetschell@rwi-essen.de.*

1. Introduction

Rising food prices have gained much attention in the public debate. Increasing demand for food commodities from emerging economies and the increasing importance of food commodities for biofuel production are often seen as the main factors behind the recent surge in food prices (Headey/Fan 2008). It is well documented in the literature that a strong correlation between food prices and energy prices exists (e.g. United Nations Conference on Trade and Development 2009). Clearly, if biofuel became a noticeable substitute for petroleum both prices should move together (Figure 1). Another reason for this correlation might be the importance of chemical and petroleum derived inputs in agricultural production (Harri et al. 2009). In both cases oil and food prices should move together over longer periods. But if this correlation reflected one of these fundamental reasons, it should dissipate, when the development of macroeconomic growth is taken into account. In contrast, Pindyck/Rotemberg (1990) find that the link holds even after controlling for changes in economic activity. They argue that this co-movement exceeds the degree that can be explained by common macroeconomic factors. Although they did not distinguish between short- and long-term causality in their analytical approach, they concluded that this excess co-movement was driven by herd behaviour. This view was challenged by recent empirical studies (Lescaroux 2009, Vansteenkiste 2009), though, that do not find strong evidence for the excess co-movement hypothesis stated by Pindyck and Rotemberg.

Figure 1: Oil and food prices from 1991 to 2011



Source: IMF primary commodity prices database.

None of the numerous other papers related to the link between energy prices and the prices of other commodities has yet attempted to disentangle short-, medium- and long-run effects in a joint approach. In this paper we analyze the link between crude oil and food commodity prices more closely by using the frequency domain Granger causality approach (Breitung/Candelon 2006; Lemmens et al. 2008). This testing procedure allows new insights because tests are performed for particular frequencies. Hence, it is possible to see directly whether the link results from long-run trends, business cycles or short-run dynamics.[1] To provide our conclusions with a more solid empirical basis, we use a wide range of food commodities and their prices as our data series. Abstracting from the issue of frequency, our results are in line with findings of other studies. We find for all food prices considered that they are Granger caused by oil prices. Thus, the oil price seems to be a good indicator to predict the prices of other commodities.

[1] A growing number of studies (e.g. Assenmacher-Wesche, Gerlach 2008; Gronwald 2009; Croux, Reusens 2011) show the usefulness of these tests.

However, our results reveal some important differences with respect to the frequencies involved. In the bivariate VAR the oil price Granger causes the overall food index with a lag of about 6 month. In addition, if we control for global industrial production it becomes visible that the link is much stronger at longer cycles. The results are similar for soybean oil and maize. In the case of barley and sugar we find that controlling for industrial production also removes a link at higher frequency but the tests remain significant for longer cycles. For rice, sunflower oil and palm oil the tests became insignificant if we control for economic activity. Thus, by and large, we do not need to discuss speculation as a source of excess co-movement, because at the relevant frequencies there does not seem to be such excess for most of the considered food commodities.

The paper is organized as follows. Section two gives an overview on the relevant literature. Section three sets out the testing procedure. Section four presents the empirical results and section five concludes.

2. Literature Review

The empirical literature pays much attention to the link between energy prices and the prices of other, especially food commodities. Generally one can distinguish diverse reasons for the co-movement of commodities that correspond to different time periods. In the short run, herd behaviour and short-term speculation can explain why the prices of commodities oscillate together. Herd behaviour refers to the phenomenon when investors are either optimistic or pessimistic on all commodities (Pindyck/Rotemberg 1990). Thus, an increase in e.g. the price of crude oil would lead to an increase in the prices of other commodities just because traders would expect them to rise as well and therefore would have a higher demand for these commodities. Short-term speculation may lead to an excess co-movement between energy and food commodities because investors allocate funds to commodity indexes rather than to specific commodities (UN 2009; Silvennoinen/Thorp 2010). Thus, an (expected) increase in the oil price could lead to higher investments in commodity indexes and therefore result in an increase in the prices of other commodities, too, although their fundamentals may have stayed the same.

In the medium run common macroeconomic shocks can explain why different commodity prices tend to move together. Increasing demand from emerging markets and higher oil and fertilizer prices are often seen as main factors driving this co-movement (Vansteenkiste 2009, Harri et al. 2009). Long-run factors like economic development may also intensify the co-movement of oil and food commodity prices. In what follows we do not distinguish medium- and long-run co-movement because in both cases it is driven by macroeconomic fundamentals.

Many empirical studies refer to the excess co-movement hypothesis stated by Pindyck and Rotemberg (1990) and analyse whether the co-movement arises from common macroeconomic shocks attributing or is due to herd behaviour or speculation. On a database that includes various non-energy commodities, Baffes (2007, 2010) shows that especially food commodities tend to move together with the oil price even after controlling for macroeconomic variables. He uses OLS regressions to estimate the pass-through of changes in the oil price to the prices of other commodities. This approach does not address any causality at low frequencies, though.

In particular, for the recent economic crisis there is some evidence that the co-movement between oil and food commodity prices increased due to financial investments (UN 2009; Silvennoinen/Thorp 2010). Lescaroux (2009) uses a market-oriented approach to identify common macroeconomic shocks by taking the role of inventories into account. He argues that macroeconomic shocks affect the inventory levels of commodities, the cost of storage and through this channel also the prices of commodities. After controlling for changes in inventory levels Lescaroux does not find strong evidence for excess co-movement. Vansteenkiste (2009) derives similar results using a dynamic factor model, finding that various common macroeconomic factors cause the prices of the commodities to oscillate together.

As a consequence of their analytical approaches, all these papers provide important insights into the co-movement between different commodity prices in the short and medium run. Yet they do not take the long run into account. In the long run the production of biofuel can be an explanation for the co-movement especially between the prices of energy and food commodities (Arshad/Hameed 2009), and the current state of the economic cycle might arguably be quite irrelevant. With the rising importance of biofuel production the agricultural and energy markets became more connected and prices should indeed move together over longer periods.

However, Cashin/McDermott (2002) find that many commodity prices exhibit small trends and big variability at business cycle frequencies suggesting that the link between oil and food prices should be strongest at this frequencies. This is evidence against the hypothesis that long-run economic developments are important for this co-movement. Some other empirical studies try to filter out the long-run component using the VAR framework to perform Granger causality tests. Cointegrated VAR models allow distinguishing short- and long-run co-movement. Arshad/Hameed (2009) and Harri et al. (2009) show that there is a link between the oil price and the prices of other commodities in the long-run. However, Harri et al. (2009) do not find evidence for such a link in the case of wheat. Saghainan's (2010) results are mixed, he can detect a long-run price relation between oil and agricultural commodities only for some of the considered commodities. In contrast, Zhang et al. (2010) do not find evidence for a co-movement between the prices of oil and agricultural commodities at all. While these co-integrated VAR models give some information about the sources of the co-movement, they provide no clear definition of "short-run" and "long-run". In particular what is meant by long-run in each specific model depends on the characteristics of the unobserved stochastic trend. In contrast, the frequency domain Granger causality test of Breitung/Candelon (2006) offers an intuitive interpretation of short- and long-run co-movement because it provides the length of the cycle for each test-statistic.

3. Testing procedure

Most empirical results on the link between oil and food commodity prices are generated using Granger Causality tests in the time domain. Therefore, we present results of this test as a starting point of our analysis. This allows us to compare our results directly with the findings of other studies.

A variable Y_t is said to Granger cause X_t, if Y_t contains information to predict X_t that is not available otherwise (e.g. Lütkepohl 2005: 41pp.). The idea of testing for Granger causality in the time domain can be easily illustrated in the following VAR model of order p.

$$X_t = \theta_{11,1} X_{t-1} + \ldots + \theta_{11,p} X_{t-p} + \theta_{12,1} Y_{t-1} + \ldots + \theta_{12,p} Y_{t-p} \quad (1)$$

$$Y_t = \theta_{21,1} X_{t-1} + \ldots + \theta_{21,p} X_{t-p} + \theta_{22,1} Y_{t-1} + \ldots + \theta_{22,p} Y_{t-p} \quad (2)$$

Using the lag operator (L) this model can be written in matrix notation as

$$\Theta(L)\begin{pmatrix} X_t \\ Y_t \end{pmatrix} = \begin{pmatrix} \theta_{11}(L) & \theta_{12}(L) \\ \theta_{21}(L) & \theta_{22}(L) \end{pmatrix}\begin{pmatrix} X_t \\ Y_t \end{pmatrix} = \varepsilon_t \quad (3)$$

where $\Theta(L) = I - \Theta_1 L - \ldots - \Theta_p L^p$ is the lag polynomial and Θ_k are 2×2 coefficient matricies. Under certain conditions Y_t does not Granger cause X_t if $\Theta_{12}(L) = 0$, which means that past values of Y_t are not related to X_t. This can be tested by using an F-Test for the coefficients $\Theta_{12,i}$ for i = 1, … , p. Due to the fact that Granger causality tests in most cases are based on one period ahead predictions it is not well suited to distinguish short and long run effects.[2]

To get a more precise picture of the short- and long-run effects we use a frequency domain Granger causality test (Ding et al. 2006). Geweke (1982) argue that in most empirical relevant cases it is possible to perform the causality test at different frequencies without loss of explanatory power, which means that his measure of causality $(F_{Y \to X})$ can be decomposed as follows

$$F_{Y \to X} = \frac{1}{\pi}\int_0^{\pi} f_{Y \to X}(\omega)\, d\omega . \quad (4)$$

Several proposals have been made to construct such tests in the frequency domain (Geweke 1982; Hosoya 1991; Breitung, Candelon 2006; Lemmens et al. 2008). In what follows we use the test proposed by Breitung/Candelon (2006). They construct an F-test for the coefficients

[2] Dufour et al. (2006) propose an approach to distinguish short and long-run causality based on several period ahead predictions.

$\Theta_{12}(L)$ at different frequencies by imposing an additional restriction. To get an idea where this restriction comes from we write system (3) in the following moving average representation

$$\Psi(L)\eta_t = \begin{pmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{pmatrix} \begin{pmatrix} \eta_{1t} \\ \eta_{2t} \end{pmatrix} \tag{5}$$

where $\Psi(L) = [\Theta(L)G]^{-1}$ and G is the lower triangular matrix of the Cholesky decomposition $G'G = \Sigma^{-1}$ such that $G\varepsilon_t = \eta_t$ and $E(\eta_t \eta_t') = I$. Fourier transforming this system we get the following spectral density of X_t which consists of two parts

$$f_X(\omega) = \frac{1}{2\pi}\left\{\left|\Psi_{11}\left(e^{-i\omega}\right)\right|^2 + \left|\Psi_{12}\left(e^{-i\omega}\right)\right|^2\right\}. \tag{6}$$

The first element in equation (6) which is related to the autoregressive coefficients of equation (1) is called the "intrinsic" term (Barnett, Seth 2011). The second element is related to the exogenous variable in equation (1) and is called the "causal" term of the spectrum. Breitung/Candelon (2006) use this causal element $\Psi_{12}\left(e^{-i\omega}\right)$ to construct their frequency domain Granger causality test. Due to the fact that

$$\Psi_{12}(L) = -\frac{g^{22}\Theta_{12}(L)}{|\Theta(L)|} \tag{7}$$

where g^{22} is the lower diagonal element of G^{-1} it is possible construct a test on the coefficients at each frequency by transforming $\Theta_{12}(L)$ into the frequency domain: $\Theta_{12}\left(e^{-i\omega}\right)$. It follows from De Moivre's theorem (Hamilton 1994) that

$$\Theta_{12}\left(e^{-i\omega}\right) = \sum_{k=1}^{p} \theta_{12,k} \cos(k\omega) - \sum_{k=1}^{p} \theta_{12,k} \sin(k\omega) i . \tag{8}$$

Therefore, $\left|\Theta_{12}\left(e^{-i\omega}\right)\right| = 0$ implies that

$$\sum_{k=1}^{p} \theta_{12,k} \cos(k\omega) = 0 \tag{9}$$

and

$$\sum_{k=1}^{p} \theta_{12,k} \sin(k\omega) = 0 \,. \tag{10}$$

The null hypothesis of no Granger Causality at frequency ω can be tested by using a standard F-test on a set of coefficients of equation (1).

$$H_0 : R(\omega)\Theta_{12}(L) = 0 \tag{11}$$

with

$$R(\omega) = \begin{bmatrix} \cos(\omega) & \cos(2\omega) & \ldots & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & \ldots & \sin(p\omega) \end{bmatrix} \tag{12}$$

This test has an F(2, T-2p) distribution. It can also easily be applied to VAR models with more than two variables. A crucial step in this testing procedure is to determine the lag order of the VAR because it determines the dynamic structure of the model (Lemmens et al. 2008). To get sufficient dynamic structure in the model to perform the frequency decomposition it is necessary to include at least three lags in the VAR.[3]

4. Empirical Results

To perform the Granger causality tests we first estimate bivariate and trivariate VAR models for oil prices, several food price indices, one at a time, and industrial production as a measure for global economic activity.[4] For oil and food prices we use monthly commodity price indices from the IMF primary commodity prices database. The studied commodities are crude oil (US-Dollar per barrel), the overall food index, soybean oil (US-Dollar per metric ton), maize (US-Dollar per metric ton), barley (US-Dollar per metric ton), EU sugar (US cents per pound), rice (US-Dollar per metric ton), sunflower oil (US-Dollar per metric ton) and palm oil (US-Dollar per metric ton). The sample depends on the data availability. In most cases it ranges from January 1980 to April 2011. For the overall food index and EU sugar we use data from January 1991 to April 2011. In addition, we use industrial production data from the International Financial Statistics database of the IMF. We seasonally adjust these data before using them in the testing procedure. To determine the lag length we use the LR criterion.

[3] We are grateful to Jörg Breitung for this hint.
[4] The GAUSS code can be downloaded from Jörg Breitung's homepage.

Before using the frequency domain Granger causality test of Breitung/Candelon (2006) we perform simple Granger causality tests to gain first insights into the effect of the oil price on the prices of the other commodities. The tests are performed for bivariate and trivariate VAR models in levels and first differences. The results are shown in Table 1.

Table 1: Granger Causality Tests (Oil → Food)

	Bivariate Level	Bivariate 1st differences	Trivariate Level	Trivariate 1st differences
Food Index	15.26	10.37	25.89**	14.94
Barley	12.57*	9.63	13.04	7.33
Maize	12.37***	4.98	19.78	15.58
Palm Oil	16.79**	16.48	21.65**	19.54
Rice	18.35	13.34	15.34	14.06
Soybean Oil	13.43*	12.76*	24.68	15.91
Sugar EU	12.80***	17.83***	19.16*	19.20**
Sunflower Oil	18.76*	9.29	27.48*	15.91

chi-square values, * significant at 10% level, **significant at 5% level, *** significant at 1% level.

As can be seen in Table 1, the oil price Granger causes more of the considered commodities in the models in levels compared to those in first difference. This implies that trends play a role in generating the co-movement between the oil price and the prices of the considered commodities. However, the Granger causality tests for these models do not provide clear evidence whether the co-movement is due to short-run fluctuations e.g. caused by herd behavior/short-term speculation or longer cycles not captured by industrial production. In some cases the tests become insignificant (barley, maize and soybean oil) or significant at a lower significance level (EU Sugar) when controlling for industrial production, indicating that at least part of the co-movement is due to common macroeconomic shocks. In other cases the tests are significant at the same significance level in the bivariate as well as in the trivariate model (palm oil and sunflower oil) or is only significant in the trivariate model in levels (food index). This implies that there seems to be other factors than trends and common macroeconomic shocks that drive the co-movement. To derive further insights into the possible causes of the co-movement we perform the frequency domain Granger causality test of Breitung/Candelon (2006) to disentangle short- and long-run effects. The test statistics for 314 frequencies as well as the 5 percent critical values (dashed line) are shown for each food price index in Figure 2.

Two graphs are shown for each commodity: the first depicts the results of the bivariate system, the second the results of the trivariate system that includes industrial production besides crude oil and the studied commodity. The frequencies on the horizontal axis range from 0 to 2. They can be translated into periodicities of T months by $T=2\pi/\omega$. This means that frequencies smaller than 0.05 corresponds to cycles longer than 10 years. Business cycles are typically assumed to last between 2 ½ and 7 years. The respective frequencies are roughly 0.2 and 0.07. Frequencies around 0.5 belong to cycles of 12 months which capture seasonal effects (Hamilton 1994: 167-170) and a frequency of two corresponds to cycles of three months.

Figure 2: Causality tests between oil and food prices

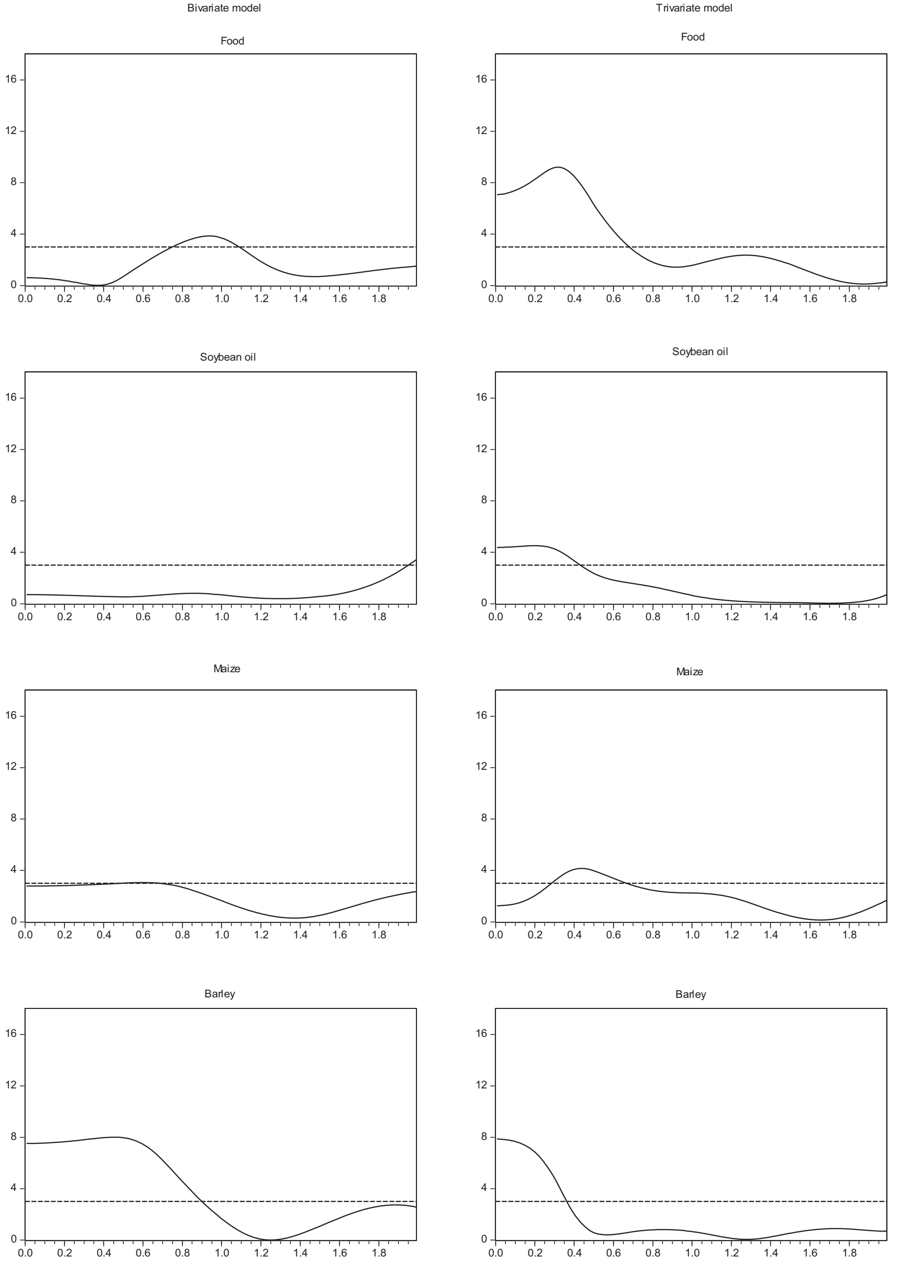
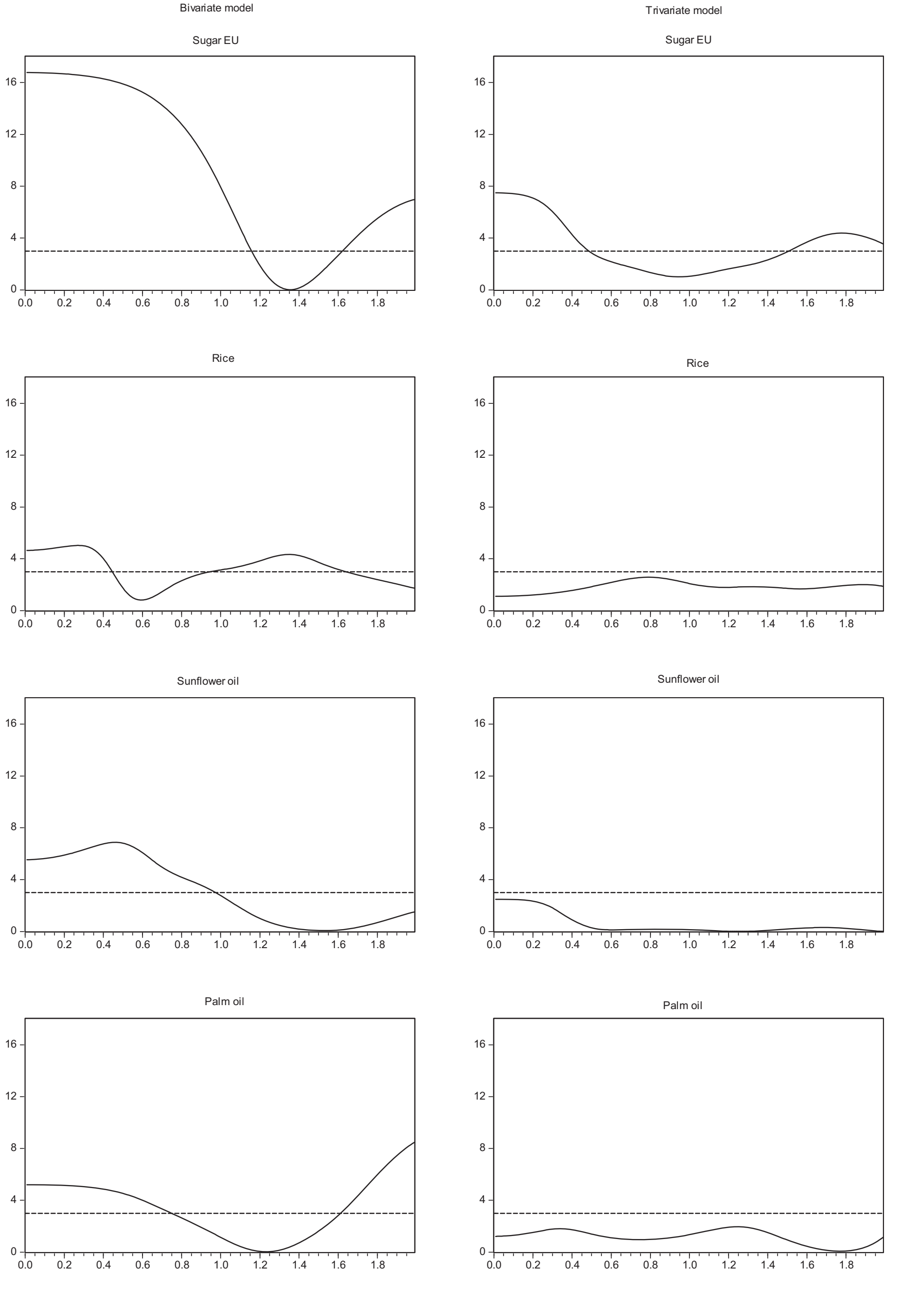


Figure 2 (continued)



First of all, the results show that at least at some frequencies the crude oil price index Granger causes the overall food price index as well as many of the subindices at least in the bivariate case. These results are roughly in line with other empirical studies. One exception is Baffes (2007) who finds no significant relation between oil and rice prices. However, if industrial production is included we also find no significant effects between both prices. Another exception is Zhang et al. (2010). They find no Granger causal relation effect from oil to sugar prices.

Next, we take a closer look at which frequencies the Granger causality is significant. The results reveal substantial differences between food commodities which remain undetected otherwise. We pool the results in three groups, corresponding to the frequencies at which we can detect a significant link between the oil price and the considered food prices.

To start with, the oil price is estimated to Granger cause the overall food price index in the range [0.8, 1.1] in the bivariate system, corresponding to a cycle length between 6 and 8 months. This result would suggest that the link between oil and food prices is driven by calendar effects or as Pindyck/Rotemberg (1990) propose by short-term speculation. However, if we control for global economic activity by including industrial production in the VAR we also detect such a link at frequencies with a wave length of more than 9 months. This means that in the bivariate approach the correlation of oil prices and industrial production hides the link between oil and food prices at lower frequencies in the bivariate system. It is therefore more likely that the correlation between oil and food prices is established at frequencies that are related to long-term economic developments. The results are similar for maize and soybean oil. The results for soybean oil are to some extent in contrast to the findings of Gilbert (2008) who concludes that soybean oil prices show an explosive behaviour between 2006 and 2008 driven by speculation.

Moreover, the tests reveal a different picture for barley and sugar. The oil price Granger causes the price of barley in the bivariate system at frequencies less than 0.9 which corresponds to cycle lengths of more than 7 months. If we control for industrial production the Granger causality tests become insignificant for cycle lengths between 7 and 15 months. Thus, only the low frequencies seem to be important. For EU sugar we receive a similar picture. The tests detect a link between the oil price and the price of EU sugar in the two-variable VAR at frequencies corresponding to cycles of more than 6 months. In the trivariate system the oil price Granger causes the price of EU sugar only at cycle lengths of more than 12 months.

In addition, the link in the bivariate system between 3 and 4 months does not vanish when controlling for industrial production. Hence, even if we control for global economic activity the oil price Granger causes barley and EU sugar prices at higher frequencies. This finding suggests that the oil price Granger cause the prices of at least some commodities at business cycle frequencies when controlling for economic activity.

Finally, we get similar results for rice, sunflower oil and palm oil. While the oil price Granger causes the price of all three commodities at lower frequencies in the bivariate case we cannot detect such a link when controlling for industrial production. This means that the link between oil and these commodity prices is driven by economic activity.

5. Conclusions

The high correlation between prices of oil and food is well established in the literature. However, it is an important question whether this relation arises from the long-run trend, business cycles or very short-run fluctuations. So far empirical studies use Granger causality tests in the time domain to distinguish short-run and long-run causality. A drawback of this approach is that it is difficult to see what short-run and long-run exactly means.

In this paper we use the relatively new frequency domain Granger causality test by Breitung/Candelon (2006). This allows us to test Granger causality at specific frequencies which can be translated into the associated cycle length. We apply this test to an overall food price index as well as to several indices of food commodity prices.

If only oil and food prices are considered the tests indicate that oil Granger causes food prices for all these indices. However, if we control for industrial production Granger causality vanishes in some cases suggesting that the link results solely from fluctuations in economic activity. In most of the other cases Granger causality is indicated at lower frequencies even when controlling for industrial production. This finding suggests that the relation between oil and food prices is established by long-term developments not directly related with economic activity.

Therefore herd behavior and speculation, considered to be short-run phenomena, do not seem to have a considerable effect on the studied food prices. What these developments are is still an open question. A possible explanation for this could be the production of biofuel. However, we find only weak evidence for some commodities that oil prices Granger cause food prices at very high frequencies.

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