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Are Food Prices Affected by Crude Oil Price: Causality Investigation[1]

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Abstract

In the last couple of years food prices have registered significant and more sustainable gains. Professional debate therefore has risen about this development and many of researchers seeing that food prices are majorly driven by crude oil prices as an input of production of the agriculture commodities. Others are seeing that food prices are driven by the rising demand of food commodities. The aim of this paper is to examine the long run relationship between crude oil and food prices and test whether there is an existing causality. Using the pairwise Granger causality and causality based on VECM, the results of investigation suggest that there is a long run relationship between crude oil price and prices of examined food commodities and the direction of long run causality is running from crude oil price to food prices.

Key words: Food prices, Crude oil prices, VECM, Granger causality

Introduction

In the last couple of years food prices have registered significant and more and less sustainable gains. Apart from the year of deep international economic crisis in 2009 the food prices have had an increasing trend since 2003. This development of food prices during the period 2003 – 2013 could be divided into two periods, the first period from 2003 to 2008, during which the food prices have registered significant increase and led to food crisis in 2008. The second period, from 2010 to 2013, has registered a minor price growth but did not reach the peak of the first period. In spite of the international financial and economic crisis the food prices had rising trend until the end of 2012. This development has evoked a debate about the factors that have led to rapid increase of the food prices since the global demand had downward trend during the crisis.

During the mentioned periods the development of food prices went against the results of many studies carried out in the second half of 20th century which suggest that the prices of primary commodities in real term have a decreasing trend. In addition this development is certainly in favour of food exporting countries especially those that are depending on export food commodities.

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The objective of this paper is to examine the Granger causality between food (some selected food commodities) and crude oil prices and the long run relationship between them.

The paper is organized as follows: section 2 describes the literature review related to the subject of paper. Section 3 briefly analyses the development of food prices and crude oil prices in the last decade. Section 3 denotes the methodology and empirically analyses the time series of crude oil and selected food commodities and section 4 concludes the results of the analysis.

1. Literature review

Development on commodity markets in recent years raised a question whether the fluctuations in oil market lead to similar behaviour in other commodity markets. As Cashin and Pattillo (2000) and McDermott (2002) point out, this is important issue concerning multiple stakeholders as about 25% of world merchandise trade is on commodities and for some countries commodity exports is an essential source of earnings. The recent commodity price boom emerged in mid 2000s after nearly three decades of low and declining trend in commodity prices. According to Baffes and Haniotis (2010) the long term decline in real prices had been especially marked in food and agriculture. Between 1975-76 and 200-01, world food prices declined by 53 % in real US dollar terms and issue of immiserizing growth arouse for commodity exporters[2].

McCalla (2009) summarizes that currently there are four storylines preferring different factors, seeking to explain recent price paths of commodities. Those are: macroeconomic factors (weak USD causing higher demand and lower supply, low interest rates that reduced the price of storage and encouraged buying and holding real commodities); speculators (increased inflow of capital in commodity market is driving prices up and increasing volatility); demand supply shocks (weather impacts, biofuel policies, trade barriers and others); combination of permanent structural changes in supply and demand conditions and exacerbated by shocks. The last storyline argues that supply and demand shocks together with permanent factors (such as more demanding diet patterns in emerging economies and urbanization on demand side and declining productivity growth as a result of lower R&D investments in agriculture, competition for water and land and higher oil prices on supply side) reinforce each other in their drive of prices. McCalla (2009) concludes that only fourth storyline may lead to permanently higher prices than historical ones, otherwise the bubble bursts and the same long run downward path in real prices as happened after earlier episodes of price spikes, will follow.

The view of some significant change happening in last decade is supported by several studies that revealed changing patterns of commodity prices development and interaction between food and crude oil prices around mid 2000s. Campiche et al (2007) applied VECM procedure to examine relationships between crude oil prices and feedstock prices. Their testing by using Johansen cointegration test revealed no cointegrating relationships during the 2003 – 2005 time frame. However, corn prices and soybean prices were cointegrated with crude oil prices during the 2006 – 2007 time period. Similarly, Avalos (2013) observes that price dynamics of corn and soybeans changed since this date and corn prices have become more related to oil prices. Nazlioglu et al. (2013) used causality in variance test and impulse response function to daily data from 1986 to 2011. While they conclude there was no risk of volatility transmission between oil and agricultural commodity markets in the pre-crisis period (before 2005), oil market volatility spills

[2] Although according to Cashin and McDermott (2001) the downward trend in real commodity prices was of little policy relevance because it is small when compared to the variability of prices.

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on the agricultural markets – with the exception of sugar – in the post-crisis period. Intuitively, this would imply strong influence of biofuels on agricultural commodity markets as new biofuel policies came to existence in this period. This view is shared by Mitchell (2009) who argues that biofuel production from grains and oilseeds in the US and the EU was the most important factor behind food price increase between 2002 and 2008, accounting perhaps, for as much as two thirds of the price increase. Another factor to this story was added by the World Bank (2009) that reported that only crude oil prices above $50/barrel effectively dictate maize prices. This conclusion was based on the strong correlation between the maize price and crude oil prices above $50/barrel and the absence of correlation below that level. The importance of recent development on oil markets were identified also by Trujillo-Barrera et al. (2011) whose study of volatility spillovers in the US from energy to agricultural markets in the period 2006 - 2011 revealed significant spillovers from oil to corn and ethanol markets, which seem to be particularly strong during high volatility periods in oil markets. The study also identified significant volatility spillovers from corn to ethanol markets. The impact of oil prices on biofuels – food prices channel was confirmed by Timilsina et al. (2011) who use a multi-country, multi-sector, recursive dynamic, global CGE model to examine the linkage between oil prices and the share of biofuels in the transportation fuel mix. According their paper, biofuels production (and consequently demand for related feedstock) is very much affected by changes in oil prices – a 65% increase in oil price in 2020 from the 2009 level would increase the global biofuel penetration to 5,4 % in 2020 from 2,4% in 2009. A doubling of oil price in 2020 from its baseline level, or a 230 % increase from the 2009 level, would increase global biofuel penetration in 2020 to 12,6 %.

This linkage, together with growing energy intensity of food production, was already in 2011 acknowledged by G20 Study Group on commodities (UN, 2011), however this report add that no clear evidence in the literature about the price impact of biofuel production was found. This stand is represented for instance by paper of Gilbert (2010) who found little direct evidence that demand for grains and oil seeds as biofuel feedstocks was a cause of the price spike.

Even if the evidence of the biofuel – commodity prices linkage is not unanimously considered clear, it needs to be kept in mind that this is only one of several channels through which high oil prices can affect commodity prices. The others are oil as a production cost[3] and co-movement of oil prices with prices of agricultural commodities due to diversification strategies of investment funds. Cost push effects of oil prices were found in study of Chantret and Gohin (2009) who by employing world CGE model found that cost push effects causing a positive relationship between food and energy products. Furthermore, their study also revealed that introduction of the real income effect may imply a negative relationship between world food and energy prices. Arshad and Hameed (2009) found evidence of a long run relationship between oil, corn, wheat and rice, with causality flowing from the fuel to the crops. They relate this effect to cost factors, namely, the growing reliance by modern agriculture on seed fertilizer technology that is highly dependent on chemical inputs derived from oil. Cooke and Robles (2009) on the other hand attribute the boom prices of corn, wheat, rice, and soybeans from 2006 till mid 2008 to financial activities of investors/speculators in futures markets with other factors looking of a less importance to them.

Zhang et al. (2010) acknowledge that research food versus fuel issue is generally examined by employing CGE models and incorporating mathematical simulations but remind that in many

[3] Most agricultural producers purchase energy indirectly in other inputs, such as commercial nitrogen fertilizers, fuel and electricity costs for field operations, irrigation and drying. Combined with fertilizer costs, these costs account for a significant proportion of the cost of production of many crops.

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cases such relationships are established exogenously based on economic theory and experts´ opinions with assumed elasticity and parameter specifications. This does not allow them to capture short-run price dynamics including the recent price spikes. Employing cointegration and VECM model Zhang et al. tested (2010) for relation among time-series prices on fuels and agricultural commodities. The study did not find any direct long-run price relations between fuel and agricultural commodity prices and only limited if any direct short-run relationship. However, in short run, sugar prices influence all the other agricultural commodity prices except rice. As sugar is the most important input for ethanol, it gained a position of mediator via which higher ethanol production affects other agricultural commodities. The existence of indirect linkage between oil and food prices was found also in paper by Esmaeili and Shokhoohi (2011) that investigates co-movement of food prices, the macroeconomic index and the oil price. According to them, the food production index has the greatest influence on the macroeconomic index and the oil price index influences the food production index, therefore crude oil prices has an indirect effect on food prices. Importance of incorporation of macroeconomic factors into equation was confirmed by Nazlioglu – Soytas (2012) who employed panel cointegration and Granger causality methods for a panel of twenty four agricultural products and world oil prices which was accounting for exchange rate. The paper concludes that both in short run and long run, oil prices and exchange rate Granger cause commodity prices, in long run commodity prices and exchange rate do not Granger cause oil prices but surprisingly, in short run, commodity prices and exchange rate affects oil prices. Nazlioglu – Soytas (2012) claim that this might be possibly explained by diversification of activities of global portfolio investors/speculators whose activities in recent years led to higher integration between energy-finance and agricultural markets. Contrary to this, Harri et al.'s (2009) examination of cointegration relationship between exchange rate, crude oil, soybeans, soybean oil, wheat, corn and cotton led to finding that crude oil Granger causes corn prices and exchange rate but the corn prices and exchange rate do not Granger cause oil prices, meaning, shocks to the oil prices are transferred to the corn prices and exchange rate but not vice versa. In general, their study found existence of cointegration between corn and crude oil since 2006 and concluded the oil prices are also linked to prices of soybeans and cotton, but not wheat. Even though the picture of mutual relationships between prices of oil and world agricultural commodities prices looks already mixed enough, the fact that world commodity prices are only proxies for local retail food prices (which is actually what matters for final consumers) must be noted and careful interpretation of any results of empirical studies based on global prices is necessary. Intuition suggests that relationships between commodity prices on global and local level might not be the same, as local markets are usually shielded by regulation, since food security is historically sensitive issues for policy makers. Evidence supporting this claim can be found in paper of Zhang and Reed (2008) arguing that oil price shocks did not trigger a response in corn, soy meal, and pork prices in China. In a similar vein, research by Nazlioglu and Soytas (2011) focused on Turkey suggests neutral effect of oil on the local agricultural commodity prices. To add into complexity of this issue, even primary commodity producers might not benefit from raising prices of primary commodity due to widening farm gate – to – retail price spreads documented by Chorarya (2008).

In any case, any policies offsetting the impact of increasing world food prices are costly and difficult to manage in environment of fluctuating prices and therefore even research aimed at global prices is of a crucial importance. As crude oil prices are unlikely to decline to its former low levels and their boom has strengthened link between energy and non energy prices and co-movement among prices of commodities considerably (Baffes – Haniotis, 2010). Strong relation

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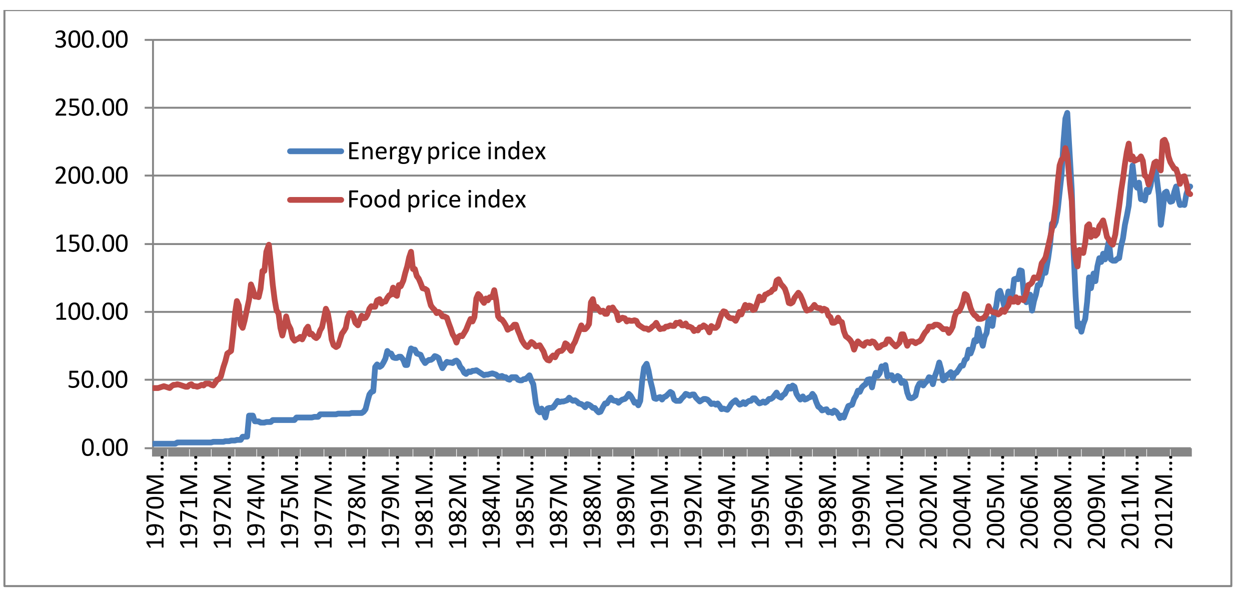
between oil and food prices is likely to persist and its deep understanding is crucial for stakeholders ranging from investors to policy makers. With this respect, our article's goal is to further examine this food oil link using methodology of Granger causality.

2. Analysis of development of food and crude oil prices

The issue of food prices was a subject of hot debate in the last decade especially since hike of food prices in 2007 and 2008, when many international and research institutes named this period as "food crisis". Indeed the hike of food prices in 2008 was accompanied by hike of energy and other commodities because of growing demand, particularly in emerging economies such as China and India. When we look at development of index of food prices since the end of the first quarter of the 70s of 20th century, the index of food commodities has fluctuated during the period 1973-2000 about the level of the base year (2005=100). Since the start of the third century the food price index has lunched to going up and reached its peak in Jun 2008 when it registered more than 120 points comparing to the base year. The number of factors has caused the food price spike in 2008, but in majority there are two main factors: increasing global demand and the oil price hike. Numerous authors as Trostle (2008) argued that there is a mix of short and long-term factors that contribute to higher food prices. Other authors argue that the main cause of high food prices is the increasing demand for biofuels (Mitchell, 2009).

Figure 1: Monthly food and energy price indices (2005=100)



Source: World Bank database, October 2013

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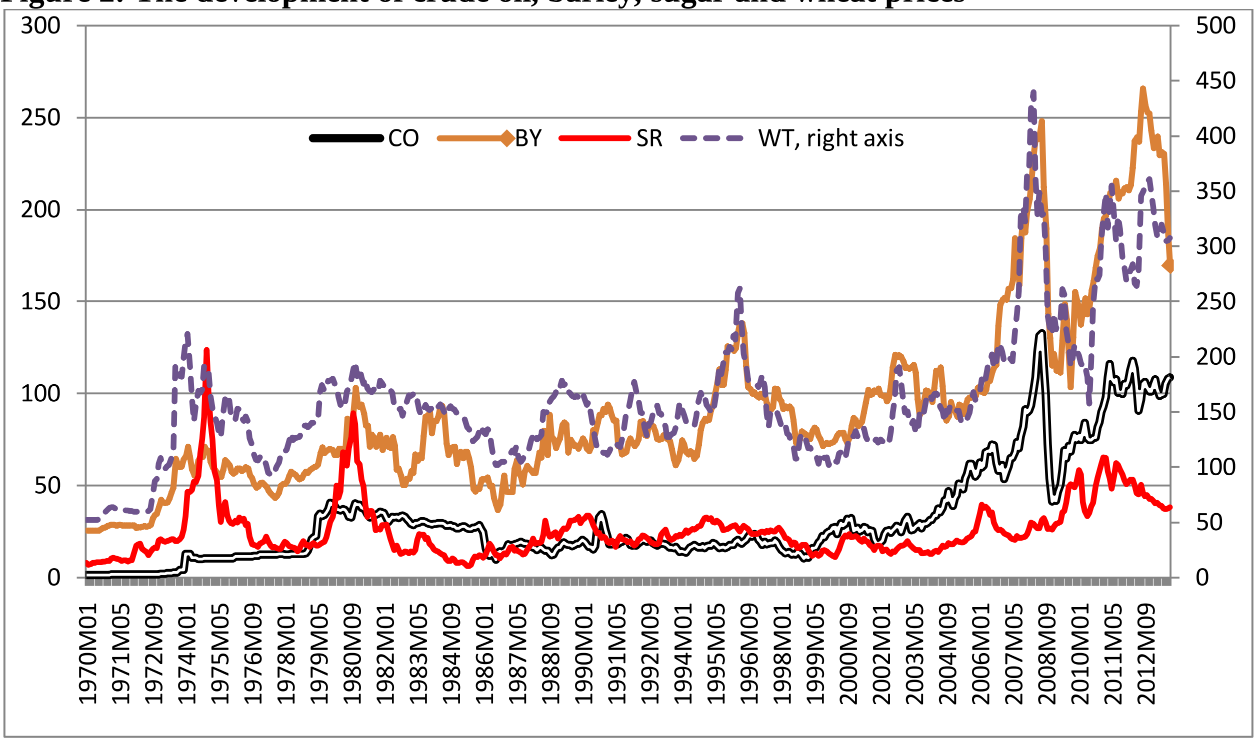
It can be said that in the last couple of years, food prices have registered significant and sustainable gains. Apart from the year of deep international economic crisis in 2009, the food prices have had an increasing trend since 2003. This development of food prices during the period 2003 -2013 could be divided into two periods. The first period from 2003 to 2008, during which the food prices have registered significant increase and peaked as a price boom and food crisis in 2008. The second period from 2010 to 2013, during which the food prices have registered also a minor price boom up to the end of 2012, but did not reach the peak of the previous price boom. In spite of the international financial and economic crisis, the slowdown of food prices, which has commenced in the third quarter of 2012, is not built on the basis of market fundaments. This development has evoked a debate about the factors leading to rapid increase of the food prices despite the global demand having downward trend during the crisis. Therefore, we believe that there are a more factors behind the rise of food prices. Of course, behind the rising prices of any commodity usually there is a complex set of factors as Trostle, (2008) and Abbott, (2009) argue, but in majority cases the main reason behind the increase is caused by one or two factors only.

Figure 2: The development of crude oil, barley, sugar and wheat prices



Source: Based on World Bank database, 2013

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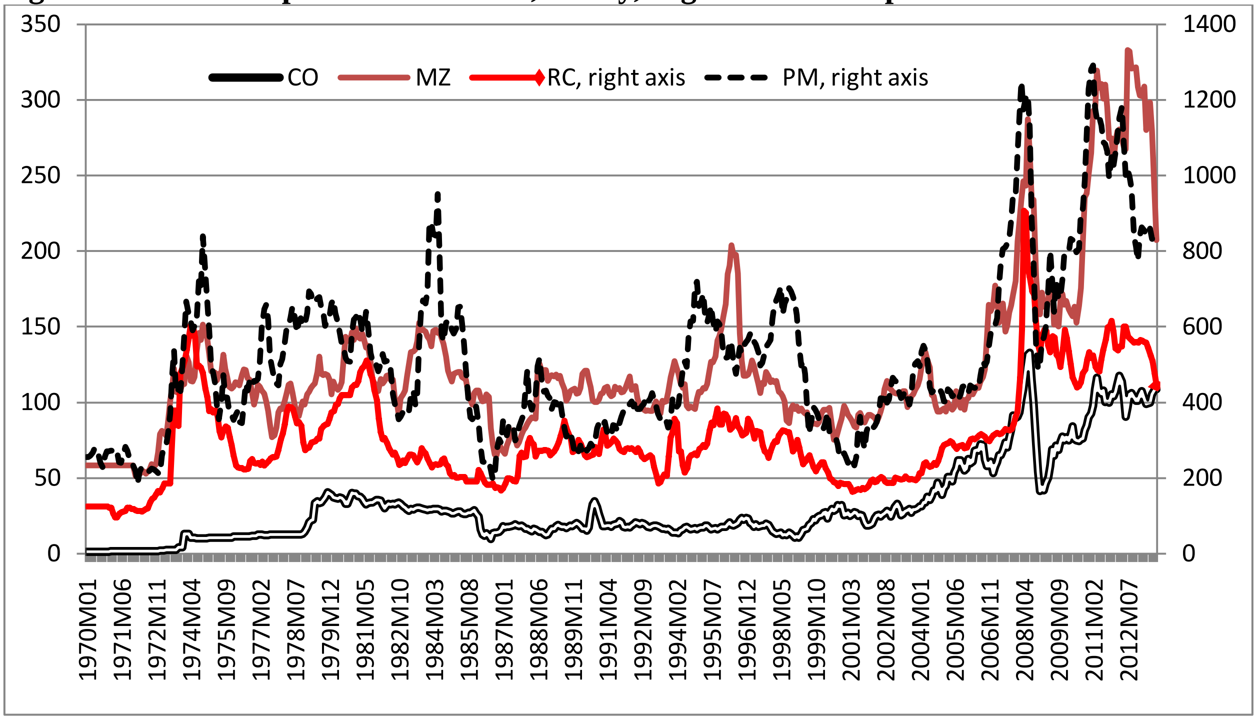
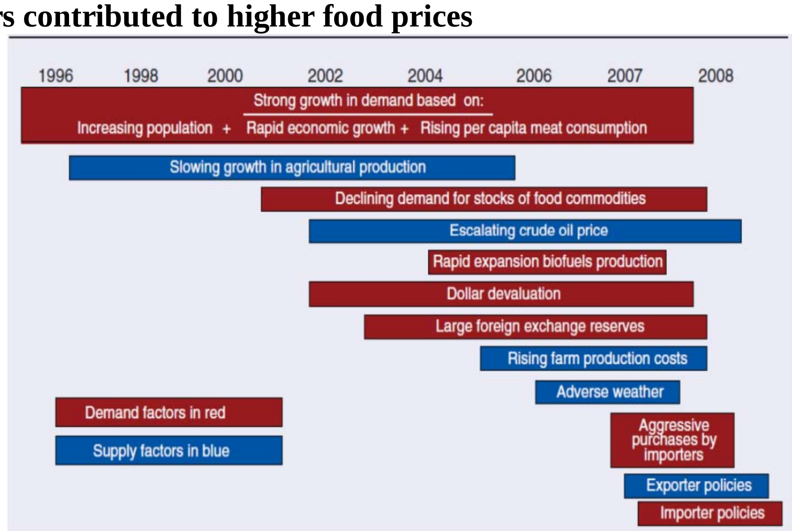
Figure 3: The development of crude oil, barley, sugar and wheat prices



Source: Based on World Bank database, 2013

Looking at the figure 1, the development of energy index has had a similar trend as the index of energy commodities. The share of crude oil prices index of sub-group (energy index) is 84.6 per cent, which mean that the crude oil prices are an acceptable measure of energy index development. The energy index has a fluctuating development since the end of 70th of 20th century especially from the second oil price shock in 1979. The energy price index has reached its peak in July 2008 when it registered more than 146 points comparing to the base year.

Figure 4: Factors contributed to higher food prices



Source: Trostle, (2008)

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Therefore, we could say that there is a high probability of long run relationship between the two mentioned indices. This issue (type and direction of relationship) will be a subject of our investigation in the next sections of this paper.

3. Data and Methodology

3.1 Data

To estimate the causality direction and relationship between crude oil and food prices, it is preferred to collect time series for the period long enough. Because of the big number of food commodities we have used prices of selected agriculture commodities which represent the major share of food prices. All examined commodities are denominated in US Dollar. Crude oil, average spot price of Brent, Dubai and WTI, equally weighed (USD/bbl), palm oil (Malaysia), 5% bulk, c.i.f. N. W. Europe (USD/mt), barley (US) feed (US cents/kg), maize (US) (USD/mt, wheat (US) (USD/mt), meat, chicken (US)(US cents/kg) and sugar (world) (US cents/kg).

All data used in this paper are monthly time series of commodities prices from World Bank Database (online accessed). The period included in the examined time series is from January 1975 to September 2013, which means that 465 observations are enough to run the Granger causality model.

3.2 Econometric methods

Theoretically, oil prices determinants are expected to be exogenous variables and therefore are expected to cause food price changes. However, in many cases, there could exist two-way relationships, meaning that food prices (some food commodity's price) may also affect these determinants.
The main objective of this paper is to estimate the direction of causality between food and crude oil prices, in other words we have to investigate the link between them. For this purpose we use the pairwise Granger causality (Granger, 1969). We will therefore investigate the link between crude oil price and each of wheat (WT), maize (MZ), palm oil (PM), rice (RC), sugar (SR), meat (MT) and barley (BY) prices.

This paper uses the following econometric model to denote the relationship between crude oil price and each of the food commodities under examination.

$$F_iP_t = \alpha_0 + \beta_1 CO_t + \varepsilon_t \qquad (1)$$

Where F_iP_t is food commodity (i) price at time t, CO_t represents crude oil price at time t, and ε_t is the error term.

Testing for Unit Roots

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Before we started the analysis, we have tested each variable for the presence of unit root. Integration of time series has been tested using the Augmented Dickey-Fuller test (ADF test). The null hypothesis of this test is that the series has a unit root. The null hypothesis of nonstationarity is rejected if the t-statistic is less than the critical value. Critical ADF statistic values are considerably larger (in absolute value) than critical values used in standard regression. Lag structure of the ADF test were determined using the Schwarz Information criterion.

The result of the ADF test, illustrates that all the time series (except Meat and Sugar with intercept and trend at 5% level) during the period from January 1975 to September 2013 are non-stationary at level. Meaning that, the variables have a stochastic trend.

If two or more variables are characterized by the same stochastic trend, they are called cointegrated(Lutkepohl, 2007). Some authors argue that if the time series is non- stationary, regression of one time series variable on one or more time variables can often give spurious results due the effect of the common trend (Chen and Patel, 1998). So, others argue against differencing of time series, because it disregards information concerning the co-movement of the data which will, in general, lead to poor forecast. Therefore, according to Engle and Granger (1987), if a set of variables is cointegrated, that is X_t, Y_t *~CI(1)*, then there must exist an error correction representation which describes the short-run dynamics of X_t, Y_t. Engle and Granger recommend a two-step procedure for cointegration analysis.

(i) Estimate the long-run (equilibrium) equation:

$$Y_t = \alpha_0 + \alpha_1 X_t + u_t \qquad (2)$$

The OLS residuals from (2) are a measure of disequilibrium:

$$\hat{u} = Y_t - \hat{\alpha}_0 - \hat{\alpha}_1 X$$

A test of cointegration is a test of whether û is stationary. This is determined by ADF tests on the residuals, with the MacKinnon (1991) critical values adjusted for the number of variables (which MacKinnon denotes as n).

(ii) Second step: estimate the Error Correction Model.

Granger causality

In this paper we have used standard Granger causality test (Granger, 1969) to examine whether crude oil prices cause prices of each of food commodities under examination. In other words, we have to test how much of the current *x* can be explained by a past value of *y* and then to test whether adding lagged value can improve the explanation. However, *y* is said to be Granger caused by *x* if *x* helps in the prediction of *y*, or equivalently if the coefficients on the lagged *x*'s are statistically significant. Note that two-way causation is frequently the case; *y* Granger causes *x* and *x* Granger causes *y*, Chen and Patel, (1998).

In this step the examining of the relationship by the traditional pairwise Granger causality test is simply to give an indicator of the relationship. Here it must be noted that the Granger causality test must be run on I(0) series, to test the hypothesis regarding whether CO_t (crude oil price) helps predict F_iP_t (Food commodity price).

The pairwise Granger causality as a bivariate autoregressive model looks as follow:

$$X_t = \alpha_1 + \sum_{j=1}^{m} \beta_j X_{t-j} + \sum_{j=1}^{m} \lambda_j Y_{t-j} + \varepsilon_{1t} \qquad (3)$$

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$$Y_t = \alpha_2 + \sum_{j=1}^{m} \gamma_j X_{t-j} + \sum_{j=1}^{m} \delta_j Y_{t-j} + \varepsilon_{2t} \tag{4}$$

where *m* is the maximum number of lagged observations included in the model (the model order), the matrix β, γ, δ, and λ contains the coefficients of the model (i.e., the contributions of each lagged observation to the predicted values of X_t and Y_t, α_1, α_2 are constants and ε_{1t}, ε_{2t} are residuals (prediction error terms) for each time series. If the variance of ε_{1t}, (or ε_{2t}) is reduced by the inclusion of the Y_t (or X_t) terms in the first (or second) equation, then it is said that Y_t (or X_t) Granger causes X_t (or Y_t). In other words, Y_t Granger-causes X_t if the coefficients in λ_j are jointly significantly different from zero. This can be tested by performing an F-test of the null hypothesis that $\lambda_j = 0$, given assumptions of covariance stationarity on X_t and Y_t. Similarly, X_t is causing Y_t if some δ_j is not zero in equation (4). If both of these events occur, there is a feedback relationship between X_t and Y_t.

Our hypothesis is: crude oil prices Granger cause food prices (prices of all selected commodities).

After selecting optimal lag length using vector autoregression model, we have applied the above first of Engle-Granger procedures to test whether the residuals of the linear combinations are stationary or not.

Table 1 Unit-root Test on residual of variable's combination

Price	Level	
	t-Statistic	Critical value 5% level
WT/ CO	-5.744608 (1)***	-3.3377
MZ/CO	-4.278791 (1)***	-3.3377
BY/CO	-4.209495 (1)***	-3.3377
MT/CO	-2.897758 (1)*	-3.3377
PL/CO	-4.044637 (3)***	-3.3377
RC/CO	-3.976156 (2)***	-3.3377
SR/CO	-4.668121 (3)***	-3.3377

Note: Number in parenthesis represents the optimal length of lag (Schwarz Info Criterion) on the dependent variable in the Augmented Dickey-Fuller test. *** 1%, ** 5% , * 10% denote statistical significance (p-value). Critical Values of ADF Integration & Cointegration Tests, MacKinnon (1991): -3.3377 for 5%.

From the results of ADF test, it is clear that all residuals of all equations combining the variables (except MT/CO) are stationary I(0) at level, meaning that linear combinations of the variables are cointegrated.

Cointegration test

After selecting the optimal lag length by re-estimating the vector autoregression (VAR) model, we have used cointegration analyses to describe long term relations between variables. Cointegration means economic variables share the same stochastic trend so that they are bound together in the long run. Even if they deviate from each other in the short run; they tend to come back to the trend in the long run. Engle and Granger (1987) pointed out that a linear combination of two or more

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non-stationary series may be stationary. If such stationary linear combination exists, the non-stationary time series should be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship among the variables. The output of Johansen test also provides estimates of the cointegrating relations between crude oil and each exogenous variable. The null hypothesis of the test denotes that there is no cointegration relationship between variables.

Vector Error Correction Model (VECM)

According to the theory, if cointegration has been detected between time series, a long-term equilibrium relationship between them should exist. Therefore, VECM was applied in order to evaluate the short run and long run properties of the cointegrated series. In case of absence of cointegration, VECM is no longer required and we directly proceed to Granger causality tests to establish causal links between variables.

The regression equation form for VECM is as follows:

$$\Delta X_t = \sum_{j=1}^{m-1} \alpha_j \, \Delta X_{t-j} + \sum_{j=1}^{m-1} \beta_j \, \Delta Y_{t-j} + \lambda_1 EC_{x\,t-1} + \varepsilon_{1t} \qquad (5)$$

$$\Delta Y_t = \sum_{j=1}^{m-1} \gamma_j \, \Delta X_{t-j} + \sum_{j=1}^{m-1} \delta_j \, \Delta Y_{t-j} + \lambda_2 EC_{y\,t-1} + \varepsilon_{2t} \qquad (6)$$

In the models above; X and Y coefficients indicate dependent or independent variables, α_j, β_j, γ_j and δ_j indicate the parameters to be estimated, λ_1 and λ_2 indicate error correction coefficients, EC_{xt-1} and EC_{yt-1} indicate lagged residuals from cointegration regression. The above two equations constitute a vector autoregressive model (VAR) in first difference, which is a VAR type of ECM, Chen and Patel, (1998). In equation (5) and (6), if λ_x and λ_y equal zero, it is a traditional VAR in first difference. If λ_x differ from zero, ΔX_t responds to the previous period's deviation from long-run equilibrium. Hence, estimating X_t as a VAR in first differences is inappropriate if X_t has an error correction representation. Therefore, if the variables are non–stationary and are cointegrated in the same order, the correct method is to estimate the VECM, which is a VAR in first-differences with the addition of a vector of cointegrating residuals.

The advantage of this formulation and estimation procedure is that it allows a straightforward test of the direction and the source of causality. Using the VECM, we can test the long-run and short-run causality between crude oil price and each of selected food prices. The existence of short-run causality meaning that the dependent variable responds only to short-term shocks can be determined by testing the null hypothesis of β_j in equation (5) and γ_j in equation (6). To determine whether energy consumption cause economic growth/or visa vice in the long-run, we look at the coefficients on the ECT's in equations (5) and (6).

While the size of the coefficients on ECT indicates how fast deviations from long-run equilibrium are eliminated, the significance of these coefficients implies the presence of long-run causality among energy consumption and economic growth. We can also determine whether these two sources of causality are jointly significant by testing the joint hypothesis of λ_1 =0 and

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β_j =0 in equation (5) and λ_2 =0 and γ_j =0 in equation (6).The rejections of the joint hypothesis imply that following a shock to the system, both these sources of causation are responsible for the re-establishment of long-run equilibrium.

3.3 Empirical results

Granger causality

Once the stationarity is validated by a unit root test and the optimal lag lengths are selected respectively, these selected factors can be used in a pairwise Granger causality test. The conventional pairwise Granger causality test is used in this research. Since we find that variables are non-stationary at level I(1) we have applied the Engle-Granger (1987) approach, "If two time series are integrated of the same order and some linear combination of them is stationary, then the two series are cointegrated".

The null hypothesis of the first part is ''Crude oil price does not Granger cause each of the price of selected commodities (Palm oil, Wheat, Maize, Rice, Barley, Meat, and Sugar) and the alternative hypothesis states each of the price of selected commodities does not Granger cause the crude oil price".

Table 2 The results of pairwise Granger Causality Test

Null Hypothesis:	Obs	Lags	F-Statistic	Prob.	Direction of causality
CO does not Granger Cause MZ	458	7	2.37860	0.0214	
MZ does not Granger Cause CO			3.04619	0.0039	*CO* ⇔ *MZ*
CO does not Granger Cause WT	457	8	3.52677	0.0003	*CO* ⇔ *WT*
WT does not Granger Cause CO			5.90596	8.E-08	
CO does not Granger Cause PM	458		5.13706	1.E-05	*CO* ⇔ *PM*
PM does not Granger Cause CO		7	3.71307	0.0006	
CO does not Granger Cause BY	463	2	3.31846	0.0371	*CO* =>*BY*
BY does not Granger Cause CO			2.83872	0.0595	
CO does not Granger Cause SR	458	7	1.46462	0.1779	*CO* <≠>*SR*
SR does not Granger Cause CO			1.04966	0.3955	
CO does not Granger Cause MT	457	8	0.94333	0.4803	*CO* <≠>*MT*
MT does not Granger Cause CO			1.02344	0.4173	
CO does not Granger Cause RC	457	8	2.74823	0.0057	*CO* ⇔ *RC*
RC does not Granger Cause CO			9.50855	4.E-12	

Source: Own calculations

The results of the traditional Granger causality test show that the crude oil prices Granger cause maize, wheat, and palm oil, barley and rice prices. Furthermore, there is bidirectional Granger causality between crude oil prices and each of maize, wheat and rice prices. The Granger causality was not occurring between crude oil prices and each of sugar and meat prices.

According Engle and Granger, (1991), a necessary condition for the cointegration test is that all the variables should be integrated of the same order or contain a deterministic trend. Once the

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variables are cointegrated, the short run changes can be explained through the vector error correction model (Engle and Granger, 1987). Because the residual of the linear combination MT and CO is non-stationary, we have excluded the mentioned combination of variables and performed the Johansen cointegration test for rest of the combinations.

Table 3: Results of Johanson (Trace) cointegration test

Variables	*Lag*	*Hypothesized No. of CE(s)*	*Eigenvalue*	*Trace Statistic*	*0.05 Critical Value*	*Prob.***
BY /CO	2	None *	0.030252	16.36713	15.49471	0.0369
MZ /CO	7	None *	0.039801	19.01514	15.49471	0.0141
WT /CO	9	None *	0.044999	21.10197	15.49471	0.0064
RC /CO	3	None *	0.044035	23.20969	15.49471	0.0028
SR /CO	7	None *	0.042058	19.79046	15.49471	0.0106
PM /CO	2	None *	0.028439	15.74843	15.49471	0.0458

None * = No cointegration equation

The result of the trace and maximum Eigenvalue test indicate 1 cointegrating equation for all combinations at the 5% significance level, *see Table 3*. Therefore, it demonstrates that all combinations of variables are cointegrated and share the common trends and have a long run relationship, during the period from January 1975 to September 2013.

If the variables are non-stationary and are cointegrated of the same order, the correct method is to estimate the Vector Error Correction Model, which is a VAR in first-differences with the addition of a vector of cointegrating residuals. Following the cointegration test based on the Johansen cointegration test, the VECM has been established to identify the long and short run relationship between crude oil and each of selected food commodities mentioned under examination. In VECM the cointegration rank shows the number of cointegrating vectors. For instance a rank of two indicates that two linearly independent combinations of the non-stationary variables will be stationary. A negative and significant coefficient of the ECM indicates that any short-term fluctuations between the independent variables and the dependant variable will give rise to a stable long run relationship between the variables.

Table 4: Results of Vector Error Correction Model

Independent variable		**Dependent Variable**					
		Δ BY	***Δ SR***	***Δ WT***	***Δ MZ***	***Δ RC***	***Δ PM***
ΔCO	Coefficient	-0.031104	-0.053924	-0.094615	-0.062085	-0.058970	-0.040196
	Std. Error	0.015003	0.012695	0.020952	0.015101	0.013563	0.013442
	t-Statistic	-2.073170	-4.247699	-4.515895	-4.111405	-4.347931	-2.990341
	Prob.	0.0387	0.0000	0.0000	0.0000	0.0000	0.0029
Independent variable	**Dependent Variable: ΔCO**						
	Coefficient	Std. Error	t-Statistic	Prob.			
Δ SR	-0.003177	0.004222	-0.752593	0.4521			
Δ WT	0.002663	0.011194	0.237886	0.8121			
Δ MZ	-0.009944	0.008807	-1.129115	0.2595			
Δ RC	0.004469	0.006832	0.654112	0.5134			
Δ PM	-0.005144	0.005783	-0.889570	0.3742			
Δ BY	-0.024790	0.011538	-2.148634	0.0322			

Source: Own calculation

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The results of VECM confirmed our hypotheses of existing long run relationship between crude oil and food prices under examination. The long run direction of causality based on VECM is running from crude oil price to each of examined food prices (except the combination crude oil and barley which have a bidirectional long run causality or relationship), *see the above Table*.

Using Wald coefficient test on the results of VECM, it has been confirmed also a short run association between crude oil and each of examined variables (except Sugar, where we could not reject the null hypotheses and accept the alternative hypotheses), but in this case the direction is running from food commodities to crude oil price (except the combination crude oil and palm oil, among which the VECM revealed the bidirectional short run association between them.

After finding that all performed VEC models were statistically significant we can say that apart from some weak results of residual tests, the results of used models are entirely desirable and suited to our hypothesis.

Conclusion

Apart from the year of deep international economic crisis in 2009, the food prices have had an increasing trend since 2003. This development has evoked a debate about the factors that have lead to rapid increase of food prices and still maintaining them in high price levels though the global demand was during the crisis in downward trend, or at least below the pre-crises level. Therefore, we believe that there are more factors behind the rise of food prices. One of the main factors is high crude oil price, which is an important intermediate input of agriculture production.

Using Johansen cointegration test, the vector error correction model and the pairwise Granger causality test, this research attempts to investigate the causality, long run and short run relationships between crude oil prices and each of palm oil, wheat, maize, sugar, rice and barley prices. The cointegration test results suggest that there is long run equilibrium between crude oil prices and each of the mentioned commodities prices, during the period January 1975 – September 2013.

The results of VECM confirmed our hypotheses of existence of a long run relationship between crude oil and food prices under examination. The long run direction of causality based on VECM is running from crude oil price to each of examined food prices (except for the combination of crude oil and barley which have a bidirectional long run causality or relationship). The findings from the VECM investigation confirmed also a short run association between crude oil and each of examined variables (except for sugar, where we could not reject the null hypothesis and accept the alternative hypothesis), but in this case the direction is running from food commodities to crude oil price (except the combination crude oil and palm oil, where the VECM revealed the bidirectional short run association).

The Granger causality is not always captured as expected in the selected period. These causal relationships are determined to be unstable in the conventional pairwise Granger causality test (especially between crude oil and each of sugar and meat prices, though the low indirect relationship between them is expected).

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