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Effect of Oil prices on Food prices: Time Series Analysis using Vector
Autoregressive (VAR) Model

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Abstract

This study examines the effect of oil prices on food prices using worldwide monthly data covering crude oil prices wheat, soybeans and rice prices from 08.2013 until 06.2017 from World-Bank-Database 2017. It specifically considers the identification of the short-term causal relationship between oil and the selected commodity prices using the Vector-Autoregressive-Model as main model and its post-estimation methods, Granger-Causality-Test and Impulse response function. The results show that there is no long run relationship between the variables but a significant causal short-term relationship between oil prices and wheat prices is confirmed. The impulse response results after a simulated shock on oil prices showed mainly negative response of soybeans prices and a persistent increase on wheat prices, for the rice prices response there was a slight increase on rice prices after the shock of oil prices. This research targets the detection of one influencing factor to food prices in order to support food security. To achieve this objective and recommend solutions research needed to further investigate the interaction of food prices with other variables.

Keywords: Food Prices, World Oil Prices, Co-Integration, VAR-Model, Granger Causality, Impulse Response Function

Introduction

Food is one parameter that should be taken into account from different scale levels, communal, national and international. As a necessity for human existence food could shape the relations between countries and between people and their governments. Prices of food have been through different periods of time where the changes were positive and negative. The green revolution in 1960 has shown the world an increase in agricultural production that was coupled with technological improvement. The second wave of green revolution was based on genetically modified crops and has also played a major role in reducing poverty and fighting famine around the world. Nevertheless there was also a period of time where food prices have increased due to a variety of factors. The need to identify these factors has become crucial in order to control and understand their relationship to food prices. The 2007 crisis has shown a surge in crude oil and agricultural prices during the period from 2007 to mid-2008. This fact led researchers to suspect that the so-called food crisis was due to increases in oil prices (Baffes, 2007; Mitchell, 2008). The increase in commodity prices since the start of the new century highlighted the importance of the investigation of its determinant among economists and politicians around the world. From September 2003 on, the oil price has witnessed a peak of \$145 per barrel in July 2008, but this surge was driven by the world financial crisis. By December 2008, the oil price had plummeted to \$40 per barrel. The specific character of volatility of oil prices over time has made it important to test its relation to food prices. Furthermore the investigation of the relationship between crude oil prices and food prices is essential in determining the socioeconomic trend for poor countries relying on food and oil imports in their economy, which make up a significant number in this category. Also stabilizing food prices is one of the objectives of all countries in the world.

Some researches mentioned in the literature consulted for this study have assigned the change in food prices and their volatility to biofuel production. Some claim that biofuel was developed under the ideology of supporting climate change improvement policy, energy security and rural development benefit. But then economists started to analyze the relationship between biofuel and food prices as food production has been changed and countries started the race to have a renewable energy plan to satisfy their energy needs out of the dependence from conventional fuel. Land use has also been investigated under the assumptions of food for energy or food for human. The studies mentioned in the literature have presented a nuisance argumentation about the biofuel-food-relationship. They as well have argued that food prices have been influenced by biofuel production, which has put famine and food prices around the world to a catastrophic stage. This argumentation claims a high competition between the consumption of food commodities by fuel and people that has negatively affected the food security objective. Jean Ziegler (UN Special Rapporteur) declared that biofuel is a 'crime against humanity' (UN News Centre, 2007). Other consulted studies have presented the biofuel production as not being the main reason for rising food prices by explaining, that the land can be used in many end production plans and the choice is not between food and fuel, but rather what proportion will go to which end product and that such flexing

decisions will be influenced by multiple factors, including policy incentives, regulation, global oil and commodity prices, market access, ownership, and technology development (Borras et al., 2015; McKay et al., 2015).

This paper seeks to investigate the effect of crude oil prices on food prices and how this relationship is characterized. In order to achieve this we used a data set from the World-Bank-Database 2017 covering oil, food and grain prices over a period spanning from 05.2013 to 03.2017 on a monthly basis, and applied the Vector-Autoregressive-Model as well as the Granger-Causality-Test. The main objective is to identify this relationship as one influencing factor to food prices in order to support food security around the world and make sustainable recommendations.

The upcoming parts of this paper will be organized as follows: A review of literature where we will present the existing and updating research work that has investigated the relationship of food and oil prices. After that we will present the data and methodological framework used in this study. This will be followed by a part on our empirical results and their discussion and finally a conclusion and some recommendations.

Review of Literature

In this part we have examined the recent literature related to our study topic in order to set up a clearer idea on the problem and the last scientific findings. (Debdatta and Mitra, 2017) have investigated the relationship between crude oil prices and food prices indices using monthly prices data from January 1990 to February 2016. The method used for this analysis was the wavelet-based analysis. Results have shown a short-term relationship between some food prices and crude oil prices. A significant correlation between crude oil and food prices was found, which means that world food prices react strongly to oil price fluctuations. The author has explained the relationship based on the fuel-food nexus. The main element of discussion was that an increase in demand and prices of energy crops would make farmers choose the food for oil production. This choice will influence the food prices worldwide.

(Yannick Lucotte, 2016) has examined the co-movement between crude oil prices and food prices using the VAR forecast errors model. The time range selected was divided into two major periods, a pre-commodity-boom (1990M1–2006M12) and a post-boom period (2007M1–2015M5). The results provided a significant relationship between the two variables in the post-boom period and no statically significant on the pre-boom period. His explanation on some changes in food prices was based on the theory of biofuel food consumption and its competition to the food supply.

(H. Ahumada, 2016) has forecasted food prices over the time period of 2008 until 2015. The study was based on three food commodities, being corn, soybeans and wheat. The author has investigated the interaction between their prices over the time. The author also explained the increasing demand for these selected food commodities was mainly due to the unprecedented growth of emerging economies such as China and India and the increasing demand on oilseeds due to their use as biofuels.

(Fernando Avalos, 2014) also has investigated the theoretical question of oil prices driving food prices. His study was based on the interaction between energy policy, in particular the promotion of biofuels and food market change. Results have shown that oil price shocks have a positive and significant effect on corn prices. (Shuddhasattwa and Bloch, 2016) also examined the linkage between oil and 25 commodity prices from 1900 to 2011. Results have shown that long-term positive impacts of oil price increases are found for 20 commodities whereas short-term negative impact are found for only 13 commodity prices. (Babajide Fowowe, 2016) has examined the relationship between oil and food prices in South Africa from 2004 until late 2008. His empirical findings have shown no relationship between the two goods over time. The main result was that agricultural commodities in South Africa are neutral to global oil prices. (M.C. Tirado et al, 2010) highlighted the effect of climate change and biofuel production on both food and nutritional security. In their review paper they explained that food security and prices are mainly affected by climate change and biofuel production. They have also provided some guideline policies and suggestions of cooperation between the developed and developing countries to manage the effect and insure higher socioeconomic stability.

(Nwoko et al. 2016) has examined the effect of oil prices on food prices in Nigeria from 2000 to 2010. The main result of the study was no long term relationship between the two variables. But still there was proof of a significant short-term relationship between the oil price and the prices of maize, soybeans, and sorghum. Another study related to food prices analysis but with its relation with biofuel (Tomei and Helliwell, 2016), in their review paper discussed the biofuel integration, which has helped supporting farmers' income, help reduce agricultural prices volatility and reducing subsidies via creating alternative markets. They also included the opposite side of the spectrum of literature that supports the idea of land use transformation from food production to fuel production.

Data and Methodology

The data selected for this study were crude oil prices, Rice, Soybeans and Wheat. The selected time range spanned from 08.2013 to 06.2017. The data was collected from the World Bank Data Base (2017).

The table below presents a summary of the dataset.

	Oil_price	Wheat_price	Soybeans_price	rice_price
Mean	69.6	186.45	438.39	406.03
Max	99.7	287.71	591	478.75
Min	29.78	191.98	367	357

Table1: Summary of the dataset used (Source: World Bank, 2017)

Table 1 shows that the study was covering almost 47 months from 2013 to 2017. The time variable used for the time series analysis is a monthly based data. The average oil price during the study period is 69.6 \$/bbl with a maximum of 99.7 and minimum of 29.7. The wheat prices had a mean of 186.45 \$/mt with a minimum of 191.98 \$/mt and maximum of 287.71 \$/mt. The Soybeans has an average of 438.39 \$/mt

with an interval price going from 367\$/mt to 591 \$/mt during the selected time range. The rice prices had a mean of 406.03 \$/mt.

The variables used in our empirical analysis are presented and explained below:

- Months: this variable is the time variable in our model. It covers the period from 08.2013 to 06.2017. The empirical analysis is based on monthly data.
- Oil_price: this variable represents the crude oil prices on a monthly basis in our model. It is Crude oil, with the average spot price of Brent, Dubai and West Texas Intermediate, equally weighed. It counts the Crude oil average spot (\$/bbl). The prices are current (nominal prices are used).
- Wheat: this variable reflects the wheat prices, US, Soft Red Winter (SRW), \$/mt, current also nominal on a monthly basis.
- Soybeans: is a variable representing Soybeans prices nominal on a monthly basis. I is the Grain index provided by the US Department of Agriculture in current US \$
- Rice: is a variable representing rice prices nominal on a monthly basis. It is provided by the US Department of Agriculture (World Bank) in current US \$.

To investigate the relationship between the selected variables over the time we chose to run a VAR model which is a time series analysis model which analyzes multiple time series, the natural extension to the autoregressive model is the vector autoregression, or VAR, in which a vector of variables is modeled as depending on their own lags and on the lags of every other variable in the vector. To do so we have four variables indicating prices with a monthly measurement of world data. The data used was a monthly observation from August 2013 until June 2017. First we assumed that all variables are not stationary and we convert them into first difference so they become stationary. This assumption is made without testing. We started by selecting order criteria, at this first step we have to decide the sensible log length.

Selection-order criteria
Sample: 1960m5 - 1963m12

Number of obs = 44

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-824.536				2.7e+11	37.6607	37.7209	37.8229
1	-673.328	302.42	16	0.000	5.7e+08	31.5149	31.8157*	32.3259*
2	-653.336	39.983*	16	0.001	4.9e+08*	31.3335*	31.8748	32.7933
3	-648.809	9.0539	16	0.911	8.6e+08	31.855	32.6369	33.9636

Endogenous: Oil_price rice Wheat Soybeans
Exogenous: _cons

Table 2: lag-order selection tests (Source: Stata software)

The table above displays the results of a battery of lag-order selection tests. Both the likelihood ratio test and Akaike's information criterion recommend tow lags, which we will use through the rest of the modelling process.

Second step is to run Johansen-Tests of co-integration in order to have an idea on stationarity and the order of co-integration of our variables. The null hypothesis is that there is no co-integration and the

alternative one is that there is co-integration. The outcomes of the Johansen test (figure 2) show that we cannot reject the null hypothesis, as the trace statistic of the zero rank is smaller than the critical value. So there is no co-integration among the variables meaning that our four variables have no long-term association and they are not moving together in the long run. According to this result we shall run the unrestricted VAR model.

Johansen tests for cointegration					
Trend: constant			Number of obs =		45
Sample: 1960m4 - 1963m12			Lags =		2
maximum				trace	5%
rank	parms	LL	eigenvalue	statistic	critical
0	20	-692.41354	.	45.9069*	47.21
1	27	-681.95802	0.37167	24.9959	29.68
2	32	-675.40143	0.25279	11.8827	15.41
3	35	-671.05517	0.17566	3.1902	3.76
4	36	-669.46009	0.06844		
maximum				max	5%
rank	parms	LL	eigenvalue	statistic	critical
0	20	-692.41354	.	20.9110	27.07
1	27	-681.95802	0.37167	13.1132	20.97
2	32	-675.40143	0.25279	8.6925	14.07
3	35	-671.05517	0.17566	3.1902	3.76
4	36	-669.46009	0.06844		

Figure 2: Output of the Johansen tests for Co-integration (Source: Stata software)

Results and discussion

After testing for co-integration we have estimated the VAR model with five lag periods. As the variables are not co-integrated we have eliminated the long-term causality from our analysis and we focus on short-term causality. According to Appendix 1 where the output of the model is presented and as we are analyzing the effect of oil prices on food prices the first model can be interpreted. As it is not immediately informative to look at the coefficients on individual covariates in isolation. Because of this we need to do some post-estimation statistics that could be more informative. The model is already tested to be stable.

Eigenvalue stability condition

Eigenvalue	Modulus
.9332507	.933251
.7775924 + .2294842i	.810748
.7775924 - .2294842i	.810748
.6304912 + .4977998i	.80332
.6304912 - .4977998i	.80332
.2818261	.281826
.04453337	.044533
-.04309317	.043093

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

Figure1: VAR stability Test (Source: Stata software)

To check the short-term causality of our independent variables on the dependent variable, we have estimated the well-known Granger-Causality-Test. In this test the null hypothesis is that oil prices do not

cause the dependent variables Rice, Soybeans and Wheat prices as presented in the figure below, all the lagged variables are equal to zero. In our result the short-term causality going from oil prices to Wheat prices has a z-probability equal to 0.02 which is smaller than 0.05. This means that there is a significant causal relationship of oil prices on Wheat prices in the short run. We could also see from this table that oil prices have a no significant causal relationship on commodity prices like soybean and rice.

Granger causality Wald tests

Equation	Excluded	F	df	df_r	Prob > F
Oil_price	rice	.18905	2	36	0.8286
Oil_price	Wheat	.18939	2	36	0.8283
Oil_price	Soybeans	4.6533	2	36	0.0159
Oil_price	ALL	2.0451	6	36	0.0847
rice	Oil_price	.3302	2	36	0.7209
rice	Wheat	.47917	2	36	0.6232
rice	Soybeans	.46296	2	36	0.6331
rice	ALL	.70836	6	36	0.6450
Wheat	Oil_price	4.3727	2	36	0.0200
Wheat	rice	2.5401	2	36	0.0929
Wheat	Soybeans	2.4114	2	36	0.1040
Wheat	ALL	2.9549	6	36	0.0189
Soybeans	Oil_price	.55557	2	36	0.5786
Soybeans	rice	.252	2	36	0.7786
Soybeans	Wheat	1.0936	2	36	0.3459
Soybeans	ALL	.51207	6	36	0.7952

Figure 4: output of the Ganger Causality Wald Tests (Source: Stata software)

The estimated model can be written as below:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \dots + \beta_q X_{t-q} + e_t$$

Where: Y_t is the dependent variable, α is the constant, β are the coefficients, e_t is the error term and q is the lag order.

As the Ganger –causality method could not tell us the complete picture about the interaction between our variables. We have applied the second post-estimation for our VAR model which is the impulse response function. We have tested the responses of our selected food prices on an impulse shock of oil prices with a horizon of ten periods of $T=10$. This kind of impulse response analysis is called multiplier analysis. to stimulate some shocks to the system and trace out the effect of those shocks on endogenous variables (Rice, Wheat ,Soybeans prices) without having errors correlation problem we have used the orthogonalized impulse–response function.

Figure 4: Graphs of the Impulse response function (Source: Stata software)

According to the figure above we could see the impulse response graph of oil prices shock and its effect on food prices. The horizontal axis for each graph is in the units of time that our VAR is estimated in, in this case months, hence, the impulse–response graph shows the effect of a shock over a 10-month period. The vertical axis is in units of the variables in the VAR; in this case as they are all prices, everything is measured in Dollar (\$). The first graph on the top left side present the effect of simulated shock of oil prices on soybeans prices, this graph present negative response during 8 month period and then start to convert into positive after $T_{\text{impulse}}=8$. The second graph on the top right side present the response of wheat prices which show a persistent an increase after two month shock on oil prices. The wheat prices reach its top 5 \$/mt on the fifth month simulated shocks of oils prices. The third graph down on the left presents the effect of rice prices after a shock on oil. This graph show that rice prices respond with slight change after the shock there is persistent light increase on rice prices.

To test the normality of our model we used the Jaque-Bera-Test. The results have shown that probabilities are greater than 0.05, which led us to the conclusion that the null hypothesis cannot be rejected and that normal distribution is verified. To test autocorrelation in the model we have used the Lagrange-Multiplier-Test. The result of the test has shown a higher probability than 0.05, so H_0 cannot be rejected and there is no autocorrelation at lag order.

Conclusion

As agriculture has a crucial role to play in alleviating hunger and poverty the need to investigate food price determinants and factors influencing it is becoming more important.

This study has analyzed oil prices as one factor that could influence food prices. Oil prices are known by their volatility and fluctuation over time. Our results have shown a short-term relationship between these Wheat prices and oil prices. But further investigation is needed to find out more about this relationship, for example whether it is biofuel production or related agricultural inputs factor such as fertilizer and transportation that are boosting the prices of these agricultural commodities.

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Appendix 1

Vector autoregression

Sample: 1960m4 - 1963m12	No. of obs	=	45
Log likelihood = -669.4601	AIC	=	31.35378
FPE = 4.97e+08	HQIC	=	31.89259
Det (Sigma_ml) = 9.82e+07	SBIC	=	32.79911

Equation	Parms	RMSE	R-sq	chi2	P>chi2
Oil_price	9	4.61949	0.9771	1923.445	0.0000
rice	9	14.9262	0.8012	181.3943	0.0000
Wheat	9	12.348	0.9099	454.6967	0.0000
Soybeans	9	21.0534	0.9043	425.4079	0.0000

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Oil_price						
Oil_price						
L1.	1.164839	.1423444	8.18	0.000	.8858494	1.443829
L2.	-.2797709	.1357046	-2.06	0.039	-.5457471	-.0137948
rice						
L1.	-.0205678	.0425042	-0.48	0.628	-.1038745	.0627389
L2.	.0001254	.0412389	0.00	0.998	-.0807013	.0809521
Wheat						
L1.	-.0332189	.0494287	-0.67	0.502	-.1300975	.0636596
L2.	.0177866	.0479296	0.37	0.711	-.0761537	.111727
Soybeans						
L1.	.0769931	.032237	2.39	0.017	.0138098	.1401764
L2.	-.0106299	.0353445	-0.30	0.764	-.0799038	.0586439
_cons	-10.39738	10.58799	-0.98	0.326	-31.14945	10.3547

rice						
Oil_price						
L1.	.266443	.4599344	0.58	0.562	-.6350119	1.167898
L2.	-.1320919	.4384805	-0.30	0.763	-.9914979	.727314
rice						
L1.	1.222357	.137337	8.90	0.000	.9531812	1.491532
L2.	-.5258875	.1332485	-3.95	0.000	-.7870498	-.2647251
Wheat						
L1.	-.1226955	.1597112	-0.77	0.442	-.4357236	.1903326
L2.	.1694967	.1548673	1.09	0.274	-.1340376	.473031
Soybeans						
L1.	.1083563	.1041622	1.04	0.298	-.0957978	.3125104
L2.	-.111698	.1142029	-0.98	0.328	-.3355315	.1121356
_cons	105.8112	34.21126	3.09	0.002	38.75834	172.864

Wheat						
Oil_price						
L1.	-.0367992	.3804888	-0.10	0.923	-.7825436	.7089452
L2.	.4478378	.3627407	1.23	0.217	-.2631209	1.158796
rice						
L1.	-.1966715	.1136144	-1.73	0.083	-.4193517	.0260087
L2.	.2775916	.1102322	2.52	0.012	.0615405	.4936428
Wheat						
L1.	.7836116	.1321239	5.93	0.000	.5246536	1.04257
L2.	-.1965012	.1281167	-1.53	0.125	-.4476053	.0546029
Soybeans						
L1.	.207643	.08617	2.41	0.016	.0387529	.376533
L2.	-.2041918	.0944763	-2.16	0.031	-.389362	-.0190216
_cons	22.94867	28.30187	0.81	0.417	-32.52198	78.41932

Soybeans						
Oil_price						
L1.	.1055037	.6487373	0.16	0.871	-1.165998	1.377005
L2.	-.3442283	.6184765	-0.56	0.578	-1.55642	.8679633
rice						
L1.	-.1232061	.1937137	-0.64	0.525	-.5028781	.2564658
L2.	.1478182	.187947	0.79	0.432	-.2205511	.5161875
Wheat						
L1.	.2860437	.2252725	1.27	0.204	-.1554823	.7275697
L2.	-.0327363	.2184402	-0.15	0.881	-.4608713	.3953987
Soybeans						
L1.	.8618765	.1469207	5.87	0.000	.5739172	1.149836
L2.	.0029893	.1610831	0.02	0.985	-.3127278	.3187064
_cons	8.619932	48.25497	0.18	0.858	-85.95808	103.1979