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Structural Breaks, Cointegration, and Causality by VECM Analysis of Crude Oil and Food Price

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ABSTRACT: This papers investigated form of the linkage beetwen crude oil price index and food price index, using Johansen Cointegration test, and Granger Causality by VECM. Empirical results for monthly data from 1990:01 to 2011:08 indicated that evidence for breaks after 2008:08 and 2008:11. We find a clear long-run relationship between these series for the full and sub sample. Cointegration regression coefficient is negative at the 1990:01-2008:08 time period, but adversely positive at the 2008:11-2011:08 time period. This results represent that relation between crude oil and food price chanced.

Keywords: Crude oil price; food price; structural break; VECM
JEL Classifications: C32; Q10; Q40

1. Introduction

Modern agriculture is dependent on petroleum products for fuel and fertilizer. Furthermore, petrolium price has a indirect effect on food price. Baffes (2007) argued crude oil prices effect on agricultural commodities prices. This paper showed that agricultural production function contain of various energy inputs. Rising petrolium price and environmental sensitivity supported transition from fosil-fuel to bioenergy. Crude oil and agricultural commodities prices moved historical highs at around 2008. Especially, after the Kyoto Protocol Implementation Act, SC 2007, rising bioenergy production began to boost the demand for agricultural commodities.

Yu et al. (2006) examined the cointegration and causality of higher crude oil prices on the vegetable oils prices. They deduced that the effect of shocks in crude oil prices on the vegetable oil prices is comperatively small for the period 1999-2005. As Askari and Krichene (2008) explain that increasing oil price will not have a significant effect on demand for food. Zhnag et al. (2010) studied to investigate the relationship between fuels and agricultural commodities for the 1989-2008 time period, using vector error correction model, Granger causality test, and variance decomposition. Results of this study showed no direct long-run price relation between oil and agricultural commodity prices. Mutuc et al. (2010), Lombardi et al. (2010) and Nazlıoglu and Soytas (2011) found no evidence to the effects of oil on agricultural price over the long-run.

Campiche et al. (2007) studied the relation between crude oil prices and variation of agricultural commodities using a vector error correction model. Cointegration results denote that corn and soybean prices cointegrated with crude oil price during the 2006-2007 time frame. Hameed and Arshad (2008) and Cooke and Robles (2009) examined the cointegration of oil on food prices. Harri et al. (2009) exhibit that commodity prices are relation to oil for corn, cotton, and soybeans. Chen et al.(2010) pointed that crude oil price effet on grain prices. Gilbert (2010) finds a negative Granger-causal link between crude oil prices and the IMF's agricultural food price index in the two decades up to 1989 and a positive impact in the two more recent decades. Tyner (2010) examined that correlation between energy and agricultural commodities has been strong with the a peak in mid-2008. Saghaian (2010) examined the link between corn prices, soybean prices, wheat prices, crude oil prices and ethanol prices utilized cointegration test, vector error correction model, and Granger causality test. This study indicate that oil affects food production through input prices. Gohin and Chantret (2010) examined the long-run relation between food and energy product using general equilibrium model. They point a positive relationship. Nazlıoğlu (2011) reported evidence based on non-linear causality of the influence of oil on agricultural prices. Reboredo (2012) explained that extreme crude oil price changes had no effect on food price, using copula.

As the existing empirical studies about the relation beetwen crude oil and agricultural commodity prices have no identically results. This study extends empirical evidence regarding the relationship food and crude oil price by utilized cointegration and VECM. We aim to answer this question: Has form of the relation beetwen crude oil and food changed over time? This study examined relation beetween crude oil and food price. The empirical results provided from the Clemente-Myers unit-root test for monthly data from January 1990 to Agust 2012 showed that breaks after August 2008 and 20008m11. The results derived from Granger causality by VECM indicated that evindence of long-run relationship between these series for the full sample and 1990:1-2008:08 and 2008:11-2011:08 time period. There is two way causality between crude oil and food. Cointegration regression coefficient is negative at the full sample. Cointegration regression coefficient is negative at the 1990:1-2008:08 time period, but adversely positive at the 2008:11-2011:08 time period. In generally, we find that crude oil price are linked to food price at the long term. But, form of the linkage exposed to structural change. Cointegration regression coefficient is negative at the pre-break sub-sample, but adversely positive at the post-break sample. After the Kyoto Prothocol at 2007, food products become input for fosil-fuil.

2. Methodolgy and Data Sources

2.1. Methodology

According to Engle and Granger (1987), two I(1) series are said to be co-integrated if there exists some linear combination of the two which produces a stationary trend [I(0)]. Any non-stationary series that are co-integrated may diverge in the short-run, but they must be linked together in the long-run. Moreover, it has been proven by Engle and Granger (1987) that if a set of series are co-integrated, there always exists a generating mechanism, called "error-correction model", which forces the variables to move closely together over time, while allowing a wide range of short-run dynamics.

The Johansen (1991) test, which has the advantage that both estimation and hypothesis testing are performed in a unified framework, was utilized. The Johansen approach has been extensively documented (Johansen, 1988; Johansen and Juselius, 1990) so we will only briefly describe the set-up and testing procedure. Co-integration between price series suggests that two prices may behave in a different way in the short-run, but will converge towards a common behaviour in the long-run (Barrett and Li, 2002). The characteristics of the dynamic relationship between the prices can be further described by an Error Correction Model (ECM) (Barrett and Li, 2002; Rapsomanikis et al., 2003). The short-run adjustment parameter for this type of model is used to measure the speed of price transmission, while the long-run multiplier is used to indicate the degree of price transmission from one price to the other (Prakash, 1999). The properties of a co-integrated series also imply the existence of a causality relation, as defined by Granger (Granger, 1969; 1980), that can be tested by assessing if the past observations of one of the two prices predict those of the other.

The Wald statistic explains the short run causality between economic growth and electricity consumption whiles the statistics provided by the lagged error correction terms explain the intensity of the long run causality effect. Short run Granger causalities are determined by Wald statistic for the significance of the coefficients of the series. Masih and Masih (1996) cited the ECT as another source of causality between the series. They indicated that the coefficients of the ECT's denote the speed that deviations from the long run equilibrium are removed due to variations in each variable. Wald test for the significance of coefficients of the are employed to test the long run causalities.

The Granger causality test were use when the variables are cointegrated. Engle and Granger (1987) warned that if the variables are stationary after first differencing in the existence of cointegration the application of VAR to the analysis will be spurious. The outcome of the stationarity test using ADF revealed that our variables are I (1). This is reported in Table 1. Since VECM is incapable of performing causality test at this point we adopted a procedure to causality known as the vector error correction model (VECM). This procedure does not only provide the short run dynamics but also the long run relationship between the variables through the use of the significant error correction term. Johansen (1992) model ise a p-dimensional, k^{th} order VAR-model, written in error correction form

$$\Delta X_t = \sum_{i=1}^{k-1} \tau_i \Delta X_{t-i} + \pi X_{t-k} + \varepsilon_t \quad (1)$$

Where X is a vector of crude oil and food price indexes, and τ_1 through τ_2 and π are parameters to be estimated for some r=1,…,p. The errors ε are assumed to be indepent and Gaussian with mean zero and covariance matrix Ω.

2.2. Data Sources

We empirically examined the relation between for crude oil price index and food price index using monthly data for a sampling period between January 1990 to August 2012. The food prices index were obtained from Food and Agricultural Organization (FAO) Database. The FAO Food Price Index consist of the average of five commodity group as price, meat, dairy, cereals, oils and fats and sugar, representing 55 quotations. Index is measure of the monthly change in international prices of a basket of food commodities, weighted with the average export shares of each of the groups. As a proxy for world oil prices we used Brent crude oil pride index explained by International Monetary Found (IMF).

3. Empirical Results

For all series we tested the null hypothesis of unit root, using Augmented Dickey-Fuller, Zivot-Andrews, Clemente-Monates-Reyes test. Using the augmented Dickey-Fuller unit root test (The lag lengths were selected by zero), each series tested for the presence of unit root. As presented in Table 1, test statistics suggest the presence of a unit root in the level, while first differencing the series yields the apparent lack of a unit root. Test statistics suggest the presence of a unit root in the logarithm of price index series. First differencing the logarithm of the price index series results of each series being stationary. We then check for the presence of cointegrating relations between crude oil and food price.

Table 1. ADF Unit Root Test

Lag(0)	Crude Oil Price Index		Food Price Index		5%
Level					
None	-1.204	Non-stationary	1.703	Non-stationary	-2.879
Noconstant	0.795	Non-stationary	0.465	Non-stationary	-1.950
Trend	-2.169	Non-stationary	-1.917	Non-stationary	-3.429
Drift	-0.282	Non-stationary	-1.181	Non-stationary	-1.651
1st Difference					
None	-10.166	Stationary	-12.794	Stationary	-2.879
Noconstant	-10.140	Stationary	-12.803	Stationary	-1.950
Trend	-10.184	Stationary	-12.788	Stationary	-3.429
Drift	-10.166	Stationary	-12.794	Stationary	-1.651
Log					
None	-1.000	Non-stationary	-1.596	Non-stationary	-2.879
Noconstant	1.065	Non-stationary	0.633	Non-stationary	-1.950
Trend	-2.503	Non-stationary	-1.867	Non-stationary	-3.429
Drift	-0.417	Non-stationary	-1.144	Non-stationary	-1.651
Log 1st					
None	-9.681	Stationary	-8.997	Stationary	-2.879
Noconstant	-11.753	Stationary	-13.190	Stationary	-1.950
Trend	-11.783	Stationary	-13.178	Stationary	-3.429
Drift	-11.780	Stationary	-13.182	Stationary	-1.651
Decision					
None		Unit Root		Unit Root	
Noconstant		Unit Root		Unit Root	
Trend		Unit Root		Unit Root	
Drift		Unit Root		Unit Root	

Zivot-Andrews test was used to test for unit-root allowing for one endogenously determined structural break. Table 2 shows the results of Zivot-Andrews test. Crude oil price index series around trend the null hypothesis of unit-root can not be rejected in the level and first differencing. The break date is 2008:08 for crude oil and 2008:07 for food, around both. Food price index series around mean the null hypothesis of unit-root can not be rejected in the level and first differencing. For this series around mean and trend the null hypothesis of unit-root can be rejected in first differencing logarithm of series. The break date is 2008:08 for crude oil and 2008:07 for food.

Table 2. Zivot-Andrews Unit Root Test Allowing for One Break

	Crude Oil T-stat lags()		at year	Food Index T-stat lags()		at year	5% critical value
Level							
Intercept	-4.523(3)	Non-stationary	2005m6	-5.004(2)	Stationary	2007m2	-4.80
Trend	-5.507(3)	Stationary	2001m11	-4.310(2)	Non-stationary	2003m5	-4.42
Both	-5.561(3)	Non-stationary	2005m1	-4.847(2)	Non-stationary	2007m2	-5.08
1st Diff.							
Intercept	-8.517(4)	Stationary	2008m7	-7.761(4)	Stationary	2008m7	-4.80
Trend	-8.197(4)	Stationary	2009m3	-7.506(4)	Stationary	2007m8	-4.42
Both	-9.237(4)	Stationary	2008m8	-7.914(4)	Stationary	2008m7	-5.08
Decision							
Intercept		Unit Root			Stationary		
Trend		Stationary			Unit Root		
Both		Unit Root			Unit Root		
Log							
Intercept	-4.413(1)	Non-stationary	2004m7	-4.632(2)	Non-stationary	2007m2	-4.80
Trend	-4.871(1)	Stationary	1998m4	-3.981(2)	Non-stationary	2003m2	-4.42
Both	-5.124(1)	Stationary	1999m3	-4.822(2)	Non-stationary	1998m1	-5.08
Log 1st Diff.							
Intercept	-11.934(0)	Stationary	1999m1	-7.825(4)	Stationary	2008m7	-4.80
Trend	-11.78(0)	Stationary	2005m2	-7.605(4)	Stationary	1999m2	-4.42
Both	-12.015(0)	Stationary	2008m8	-7.945(4)	Stationary	2008m7	-5.08
Decision							
Intercept		Unit Root			Unit Root		
Trend		Stationary			Unit Root		
Both		Stationary			Unit Root		

The Clemente-Monates-Reyes test, was used to test for unit-root allowing for two structural breaks. In the AO models changes are assumed to take place allowing for a break in the slope. In the IO model changes are assumed to take place gradually and allows for a break in both the intercept and the slope. Table 3 shows the results of the Clemente-Monates-Reyes tests. At the various transformation price index series, the null hypothesis of unit-root cannot be rejected in the AO. AO model picks 2008:08 and 2008:10 as the optimal break dates in first differencing logarithm of price index series. The null hypothesis of unit-root cannot be rejected in the IO in level and logarithmic tranformation price index series. The null hypothesis of unit-root cannot be rejected in the IO in level and logarithmic tranformation price index series. At the first differencing and first differencing logarithm of price index series, the null hypothesis of unit-root can be rejected in the IO. AI model picks 2008:08 and 2008:11 as the optimal break dates for this series. We examined to change form of the relation beetwen crude oil and food by considering before 2008:08 and after 2008:11.

Table 3. Clemente-Monates-Reyes Unit Root Test with Double Mean Shift

	Additive Outlier (AO)		Innovational Outlier (IO)	
	Min. t*	Optimal Breakpoint	Min. t*	Optimal Breakpoint
Crude Oil				
Level	-4.861	2005m9 and 2011m5	-5.486	2004m11 and 2006m12
1st Difference	-3.707	2008m8 and 2009m1	-6.381*	2008m6 and 2008m11
Log	-4.945	2000m3 and 2004m11	-4.380	1999m1 and 2004m11
Log 1st Difference	-4.815	2008m8 and 2008m10	-6.358*	2008m8 and 2008m11
Food Index				
Level	-2.845	2007m12 and 2011m1	-5.387	2006m12 and 2010m5
1st Difference	-4.429	2008m8 and 2008m10	-5.871*	2008m6 and 2008m11
Log	-2.665	2007m12 and 2011m1	-5.092	1997m12 and 2007m1
Log 1st Difference	-4.314	2008m8 and 2008m10	-6.203*	2008m8 and 2008m11

*Min. t, the minimum t-statistics calculated. 5% critical value for two breaks:-5.490

Johansen trace test were applied in a stepwise procedure for indicating the long-run relations among the two price index series. Results of the Johansen's trace test for cointegration are reported in Table 4. First differencing logarithm of crude oil and food price index series have a long-run relation at the 5% significance level, for full sample, before 2008m8 and after 2008m11. Meaning, having rank and therefore there is cointegration. Finally we investigate the presence of cointegrating relations between food and crude oil. Only one cointegrating relation is found.

Table 4. Johansen Test for Cointegration

Lags(2)	Null /Alternative	Trace Statistics	5% critical value	Max-Eigen Statistics	5% critical value
1st Difference					
Full Sample	r=0 / r≥1	114.2273*	15.49	68.8863*	14.26
	r≤1 / r≥2	45.3411*	3.84	45.3411*	3.84
Log 1st Difference					
Full Sample	r=0 / r≥1	115.9037*	15.49	69.9465*	14.26
	r≤1 / r≥2	45.9570*	3.84	45.9570*	3.84
1990m1-2008m8	r=0 / r≥1	107.7284*	15.49	64.8284*	14.26
	r≤1 / r≥2	42.8998*	3.84	42.8998*	3.84
2008m11-2011m8	r=0 / r≥1	20.9245*	15.49	12.2813	14.26
	r≤1 / r≥2	8.6433*	3.84	8.6432*	3.84

*indicates the test statistics are significant at the 1% level.

The Wald statistic indicates the short run causal effects between price index and food price index while the t-statistic on the error correction term depicts the long run Granger causal effects. As a result of VECM model applied in first differencing series for the full sample, Wald statistic (2.45) for food price index is statistically insignificant in crude oil price index equation. There is no therefore short-run causal relationship running from food price to crude oil price. The Wald statistic (6.15) for crude oil price is statistically significant at the 1% level in the food price equation. This suggests that in the short run there is Granger causality running from crude oil to food price. The adjustment parameter in the food ECM (-0.08) is statistically significant, suggesting that, in the long run, food price Granger-cause crude oil prices. (Granger, 1988). The adjustment coefficients indicate a slow adjustment to the long run equilibrium with an estimated value of -0.08.The adjustment parameter in the crude oil ECM (-0.0008) is statistically insignificant, suggesting that, in the long run, crude oil prices no Granger-cause food prices. For the crude oil–food price index pair, presented in Table 5, the estimated cointegrating parameter is -1.13, implying that a 10 percent increase in the price of crude oil brings about over 11.3 percent decrease. For the food price –crude oil price pair, the estimated cointegrating parameter is -1.35, implying that a 10 percent increase in the price of food brings about over 13.5 percent decrease in the price of food.

As a result of VECM model applied in first differencing series for the full sample, Wald statistic (14.05) for food price index is statistically significant in crude oil price index equation. This implies that food price in the short run has a effect on crude oil price. The Wald statistic (3.78) for crude oil price is statistically insignificant at the 1% level in the food price equation. Crude oil price therefore, has no short run temporary impact on food price. The adjustment parameter in the food ECM (-0.61) is statistically significant, suggesting that, in the long run, food price Granger-cause crude oil prices. The adjustment coefficients in the crude oil ECM indicate a fast adjustment to the long run equilibrium in the extreme regime with an estimated value of -0.61. The adjustment parameter in the crude oil ECM (-0.19) is statistically significant, suggesting that, in the long run, crude oil prices Granger-cause food prices. The adjustment coefficients in the food price ECM indicate a slow adjustment to the long run equilibrium in the extreme regime with an estimated value of -0.19. For the crude oil –food price pair, presented in Table 5, the estimated cointegrating parameter is -1.89, implying that a 10 percent increase in the price of crude oil brings about over 18.9 percent decrease in the price of crude oil. For the food price –crude oil price pair, presented in Table 3, the estimated cointegrating parameter is -0.52, implying that a 10 percent increase in the price of food brings about over 5.2 percent decrease in the price of food.

Table 5. Granger Causality Test by Vector Error Correction Model

Dependent Variable	Wald Statistics		ECT(-1)	Cointegration Equation	t-stat
	Crude	Food			
Full Sample					
ΔCrude Oil	-	2.4570 (0.2927)	-0.0880* (0.0000)	Δcrudeoil= 113.0683 -0.4397TREND - 1.1338*Δfoodprice + ECT	-3.44
ΔFood	6.1516* (0.0462)	-	0.0008 (0.8190)	Δfood= -1.3510*Δcrudeoil + ECT	-4.23
Full Sample					
ΔLogCrude Oil	-	14.0518* (0.0009)	-0.6191* (0.0000)	ΔLogcrudeoil= -0.0039 - 1.8950*ΔLogfoodprice + ECT	-5.03
ΔLogFood	3.7827 (0.1509)	-	-0.1927* (0.0004)	ΔLogfood= 0.0021- 0.5276*ΔLogcrudeoil + ECT	-8.54
1990m1-2008m8					
ΔLogCrude Oil	-	1.9296 (0.3811)	-0.7335* (0.0000)	ΔLogcrudeoil= -0.0080 - 0.5283*ΔLogfoodprice + ECT	-1.16
ΔLogFood	0.7344 (0.6927)	-	-0.0558* (0.0679)	ΔLogfood= 0.0044 - 1.0081*ΔLogcrudeoil + ECT	-7.41
2008m11-2011m8					
ΔLogCrude Oil	-	10.0695* (0.0065)	-0.7801* (0.0000)	ΔLogcrudeoil= -0.0213 + 8.6690*ΔLogfoodprice + ECT	2.79
ΔLogFood	7.6164* (0.0222)	-	-0.4947* (0.0000)	ΔLogfood= -0.0024 + 0.1153*ΔLogcrudeoil + ECT	0.82

*indicates the test statistics are significant at the 1% level.

As a result of VECM model applied in first differencing series for the 1990m1-2008m8 time period, the Wald statistic (1.92) for food price index is statistically insignificant in crude oil price index equation. There is therefore no short run causal relationship running from food price to crude oil price. The Wald statistic (0.73) for crude oil price is statistically insignificant at the 1% level in the food price equation. This suggests that in the short run there is no Granger causality running from crude oil to food price. For the crude oil equation, the adjustment parameter in the food ECM (-0.73) is statistically significant, suggesting that, in the long run, food price Granger-cause crude oil prices. The adjustment coefficients in the crude oil ECM indicate a fast adjustment to the long run equilibrium with an estimated value of -0.73. The adjustment parameter in the crude oil ECM (-0.05) is statistically significant, suggesting that, in the long run, crude oil prices Granger-cause food prices. The adjustment coefficients in the food price ECM indicate a slow adjustment to the long run with an estimated value of -0.05. For the crude oil-food price pair, the estimated cointegrating parameter is -0.52, implying that a 10 percent increase in the price of oil brings about over 5.2 percent decrease in the price of crude oil. For the food price-crude oil price pair, the estimated cointegrating parameter is -1, implying that a 10 percent increase in the price of food brings about over 10 percent decrease in the price of food.

As a result of VECM model applied in first differencing series for the 2008m11-2011m8 time period, Wald statistic (10.06) for food price index is statistically significant in crude oil price index equation. This implies that food price in the short run has a effect on crude oil price. The Wald statistic (7.61) for crude oil price is statistically significant at the 1% level in the food price equation. Crude oil price therefore, has short run temporary impact on food price. For the crude oil equation, the adjustment parameter in the food ECM (-0.78) is statistically significant, suggesting that, in the long run, food price Granger-cause crude oil prices. The adjustment coefficients in the crude oil ECM indicate a fast adjustment to the long run equilibrium. The adjustment parameter in the crude oil ECM (-0.49) is statistically significant, suggesting that, in the long run, crude oil prices Granger-cause food prices. The adjustment coefficients in the food price ECM indicate a fast adjustment to the long run equilibrium. For the crude oil-food price pair, the estimated cointegrating parameter is 8.66, implying that a 10 percent increase in the price of food brings about over 86 percent increase in the price of crude oil. For the food price-crude oil price pair, the estimated cointegrating parameter is 0.11, implying that a 10 percent increase in the price of food brings about over 1 percent increase in the price of food. In generally, we find that crude oil price are linked to food price at the long term. But, it's form structural difference at the this linkage. Cointegration regression coefficient is negative at the pre-break sub-sample, but adversely positive at the post-break sub-sample.

4. Conclusion

This study investigated the relation between crude oil and food price, using January 1990 and August 2011 data period. Result of ADF, Zivot-Andrews ve Clemente-Monates-Reyes unit root test indicated that this series are stationary in first differencing logarithm. And first differencing logarithm price index series have a two structural breaks, after 2008:08 and 2088:11. Results of Johansen cointegration test show this series are cointegrated. The results of the Granger causality tests indicated that in the long-run there was a two direction relationship between crude oil price and food price. In our paper we made several conclusions about the relationship between Brent crude oil price index and food price index. There exist significant relationship between the two variables and causation is two direction. At the before 2008:08, results of Vector Error correction model (VECM) showed on average 1% increase first differencing logarithm food price index induces by 0.52% decrease in crude oil price. As our Vector Error correction model (VECM) indicated on average 1% increase first differencing logarithm crude oil price index induces by 1% increase in food price, this means that increase in food price causes petrolium price decrease. At the after 2008:11, results of Vector Error Correction Model (VECM) showed on average 1% increase first differencing logarithm food price index induces by 8.66% increase in crude oil price, this means that increase in food price causes petrolium price increase.

The results provide evidence that the relationship between crude oil and food, which is indicative of the growing use of food for biofuil, has increased over time. As our Vector Error correction model (VECM) indicated on average 1% increase first differencing logarithm crude oil price index induces by 0.11% increase in food price, this means that increase in food price causes petrolium price increase. We find a clear long-run relationship between these series for the full sample, 1990:01-2008:08 and 2008:11-2011:08 sub-samples. Cointegration regression coefficient is negative at the full sample and 1990:01-2008:08 time period, but adversely positive at the 2008:11-2011:08 time period. This finding is in accordance with study of Gilbert (2010).

The protection of the ecological balance, that became gradually important, increased the demand for biofuels whose carbon emission is lower instead of fosil fuels. The results of the study also show that change in food prices get to affect oil prices in recent years. While increases in oil prices caused food prices to decline before the structural break, afterwards increase in food prices led to a rise oil prices. Sustainable resources will gradually continue to change balances in global economy. This situation requires all economic agents to plan their future within this framework.

References

Askari, H. , Krichene, N. (2008), *Oil price dynamics (2002-2006)*, Energy Economics, 30(5), 2134-2153.

Baffes, J. (2007), *Oil spills on other commodities.* Policy Research Working Paper 4333. Washington, DC: World Bank.

Balcombe, K., Rapsomanikis, G. (2008), *Bayesian Estimation and Selection of Nonlinear Vector Error Correction Models: The Case of the Sugar-Ethanol-Oil Nexus in Brazil,* American Journal of Agricultural Economics, 90, 658-668.

Barrett, C.B., Li, J.R., (2002), *Distinguishing Between Equilibrium and Integration in Spatial Price Analysis*, American Journal of Agricultural Economics, 84, 292-307.

Campiche, J.L., Bryant, H.L., Richardson, J.W., Outlaw, J.L., (2007), *Examining the evolving correspondence between petroleum prices and agricultural commodity prices*. The American Agricultural Economics Association Annual Meeting, Portland, OR. July 29-August 1, 2007.

Chen, S., Kuo, H., Chen, C. (2010), *Modeling the relationship between the oil price and global food prices,* Applied Energy, 87, 2517-2525.

Clemente, J., Montanes, A., Reyes, M. (1998), *Testing for a unit root in variables with a double change in the mean,* Economics Letters, 59, 175-182.

Cooke, B., Robles, M., (2009), *Recent food price movements: A time series analysis*, IFPRI Discussion Paper, No.00942. IFPRI, Washington, DC.

Dickey, D.A., Fuller, W.A. (1979), *Distribution of the Estimators for Autoregressive Time Series with a Unit Root,* Journal of the American Statistical Association, 74, 427-431.

Engle, R.F., Granger, C.W.J. (1987), *Cointegration and Error Correction: Representation, Estimation and Testing,* Econometrica, 55, 251-276.

Gilbert, C.L. (2010), *How to understand high food prices,* Journal of Agricultural Economics, 61, 398-425.

Gohin, A., Chantret, F. (2010), *The long-run impact of energy prices on world agricultural markets: The role of macro-economic linkages*, Energy Policy, 38, 333-339.

Granger, C. W. J. (1980), *Testing for Causality.* Journal of Economic Dynamics and Control, 4, 229-252.

Hameed, A. A., Arshad, F. A., (2008), *The impact of the petroleum prices on vegetable oil prices: evidence from cointegration test*, In: Proceedings of the 3rd International Borneo Business Conference (IBBC), 504-514.

Harri, A., Nalley, L., Hudson, D. (2009), *The Relationship between Oil, Exchange Rates, and Commodity Prices,* Journal of Agricultural and Applied Economics, 41, 501–510.

Johansen, S. (1988), *Statistical Analysis of Cointegration Vectors,* Journal of Economic Dynamics and Control, 12, 231-254.

Johansen, S., Juselius, K. (1990), *Maximum Likelihood Estimation and Inference on Cointegration-With Application to the Demand for Money,* Oxford Bulletin of Economics and Statistics, 52, 169–210.

Johansen, S. (1991), *Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models*, Econometrica, 59, 1551–1580.

Johansen, S. (1992), A *Representation of Vector Autoregressive Processes Integrated of Order 2*, Econometric Theory, 188–202.

Lombardi, M.J., Osbat, C., Schnatz, B., (2010), *Global Commodity Cycles and Linkages: A FAVAR Approach*, European Central Bank Working Paper, No. 1170.

Masih, A.M.M., Masih, R., (1997), *On the temporal causal relationship between energy consumption, real income, and prices: some new evidence from Asian-energy dependent NICs based on a multivariate cointegration/vector error-correction approach,* Journal of Policy Modeling, 19(4), 417-440.

Mutuc, M., Pan, S., Hudson, D., (2010), *Response of cotton to oil price shocks*, The Southern Agricultural Economics Association Annual Meeting, Orlando, FL, February 6-9, 2010.

Nazlıoğlu, S. (2011), *World oil and agricultural commodity prices: Evidence from nonlinear causality*,Energy Policy, 39(5), 2935-2943.

Nazlioglu, S., Soytas, U., (2011), *World oil prices and agricultural commodity prices: evidence from an emerging market*, Energy Economics, 33, 488-496.

Prakash, A.B., (1999), *The Transmission of Signals in a Decentralised Commodity Marketing System: The Case of the UK Pork Market*, PhD. Thesis, Wye College, University of London.

Rapsomanikis, G., Hallam, D., Conforti, P., (2003), *Market Integration and Price Transmission in Selected Food and Cash Crop Markets of Developing Country Review and Applications*, Commodity Market Review, 2003-2004, 51-76, FAO, Rome, Italy

Reboredo, J.C. (2012), *Do food and oil prices co-move?,* Energy Policy, 49, 456-467.

Saghaian, S.H. (2010), *The Impact of the Oil Sector on Commodity Prices: Correlation or Causation?,* Journal of Agricultural and Applied Economics, 42(3), 477-485.

Tyner, W.E. (2010), *The integration of energy and agricultural markets,* Agricultural Economics, 41, 193-201.

Yu, T-H., Bessler, D.A., Fuller, S. (2006), *Cointegration and Causality Analysis of World Vegetable Oil and Crude Oil Prices,* American Agricultural Economics Association Annual Meeting, Long Beach, CA, July 23-26.

Zhang, Q., Reed, M. (2008), *Examining the Impact of the World Crude Oil Price on China's Agricultural Commodity Prices: The Case of Corn, Soybean, and Pork.* The South Agricultural Economics Association Annual Meeting, Dallas, TX, February 2-5, 2008

Zhnag, Z., Luanne, L., Cesar, E., Michael, W., (2010), *Food versus fuel: What do prices tell us?*, Energy Policy, 38(1), 445-451.

Zivot, E., and Andrews, D.W.K. (1992), *Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis.* Journal of Business & Economic Statistics,10, 251-270.