THE IMPACT OF PETROLEUM PRICES ON VEGETABLE OILS PRICES: EVIDENCE FROM COINTEGRATION TESTS[1]

Amna Awad Abdel Hameed
and
Fatimah Mohamed Arshad

Research Fellow and Director, Institute of Agricultural and Food Policy Studies, Institute of Agricultural and Food Policy Studies, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor Darul Ehsan, Malaysia

Tel: (+603)-8946 8896
Fax: (+603)-8946 8897

Email: amna.awad@gmail.com, fatimah@econ.upm.edu.my

ABSTRACT

A widespread and commonly shared concern about food price inflation is now a worry that has seldom been felt in the world before, and is fuelling debates about the present and future situation of global food commodity prices. Increasing petroleum prices are suggested to be one of the factors that contributed to the rise in agricultural commodity prices. Vegetable oils are among the commodities that have experienced high prices growth. This study seeks to investigate the long-term relationship between the prices of petroleum and vegetable oils prices represented by palm, soybean, sunflower and rapeseed oils prices. To that end, the bivariate cointegration approach using Engle-Granger two-stage estimation procedure is applied. The study utilises monthly data over the period of January 1983 through March 2008. The results provide a strong evidence of long-run equilibrium relation between the two products prices. The estimates of the error correction models reveal a unidirectional long-run causality flowing from petroleum to each of the vegetable oils prices under study.

Key Words: Vegetable oils prices, petroleum prices, cointegration, causality tests

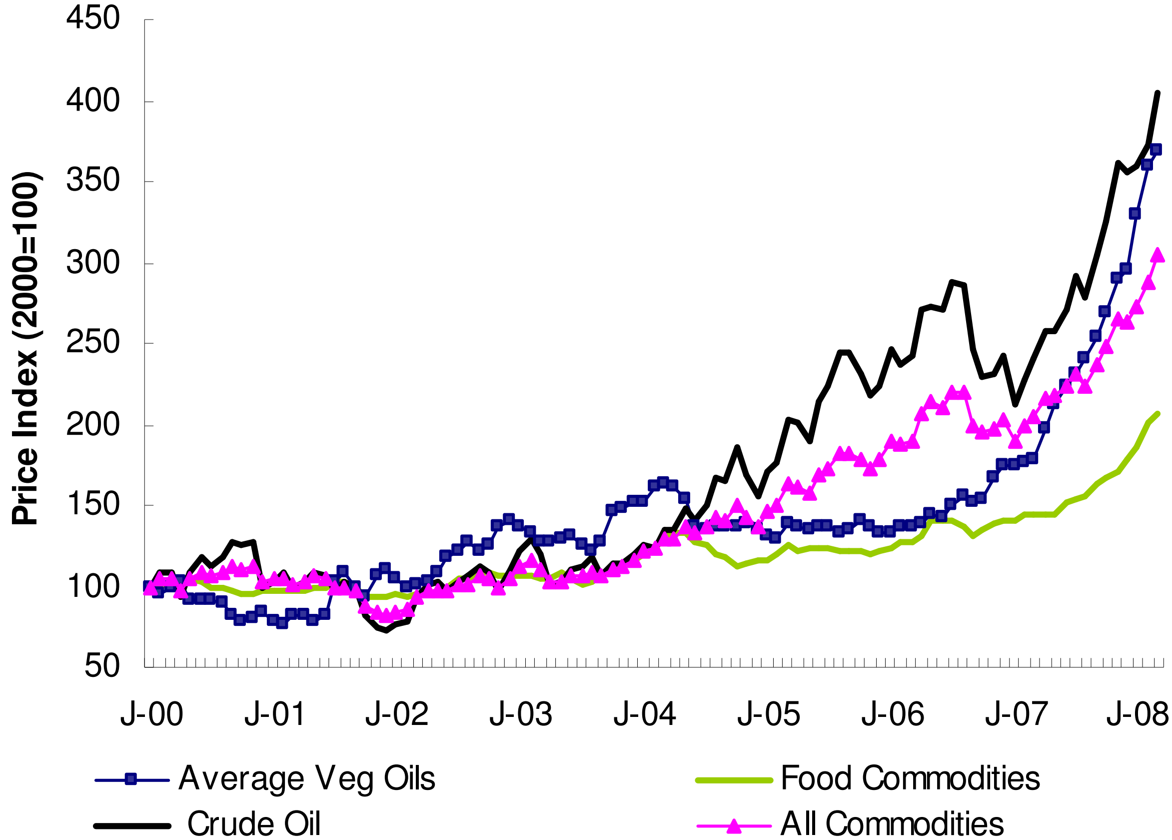
1. Introduction

The last few decades saw an increase in primary commodity prices after a downward trend in the 1970s until the beginning of the 21st century (World Bank, 2007). As shown in Figure 1, the price index for all commodities has tripled between January 2000 and March 2008 (International Monetary Fund, 2008). The major source of increase is the rise in petroleum price which registered an increase of more than 300% i.e., it quadrupled while food has increased by 107% during the said period.

---

[1] Paper presented at the International Borneo Busines Conference on Global Changes: Corporate Responsibility, organized by The School of Business and Economics of Universiti Malaysia Sabah (UMS) and the Faculty of Economics and Business of Universiti Malaysia Sarawak (UNIMAS), 15-17 December, 2008.

Among the food items, vegetable oils have experienced a considerable increase of 192%. In fact, the vegetable oils prices have undergone the largest increase (144%) compared to all commodities (60%) and food commodities (62%) between January 2006 until March 2008.



Note: Average vegetable oils price refers to trade weighted average.

FIGURE 1: Price Indices of Different Commodities (Jan 2000- March 2008)
Source: International Monetary Fund, 2008.

Figure 2, shows that, beginning from late 2006, the prices of major vegetable oils have shot up at a relatively higher rate. For instance, sunflower oil prices more than tripled over the period March 2006-March2008 (307%). Comparing prices of March 2008 with those at the same month in 2006 the prices of crude palm and soybean oils more almost tripled with 171% and 168% increments, respectively, while those of rapeseed more than doubled with 107% rise. Meanwhile, average crude oil price increased by 67%, during the said period.

The increase in the vegetable oils prices was largely attributed to inadequate supply against the growing demand of these commodities worldwide. On the supply sector, the production was constrained by a number of factors. A fall in global oilseed production was mainly caused by a shift of plantings from soybean to maize in northern hemisphere countries, the production was affected by poor weather in the major producing areas such as Russia and Ukraine. Rising energy prices is cited to be one of the prime reasons behind the surge in the vegetable oils prices (USDA, IFAD, FAO, 2008). Rapid economic growth in developing countries has resulted in very rapid growth in the demand for energy for electricity and industrial uses, as well as for transportation fuel. The associated increase in petroleum use in developing countries has contributed to rapidly rising oil prices since 1999. The oil imports of China alone grew 20 percent per year from 166 million barrels in 1996 to 1.06 billion barrels in 2006. Crude oil price index has increased 272% between January 2000 and March 2008 (Figure1). High energy prices led to the increase in agricultural cost of production and also triggered the demand for alternative energy sources such as biofuels.

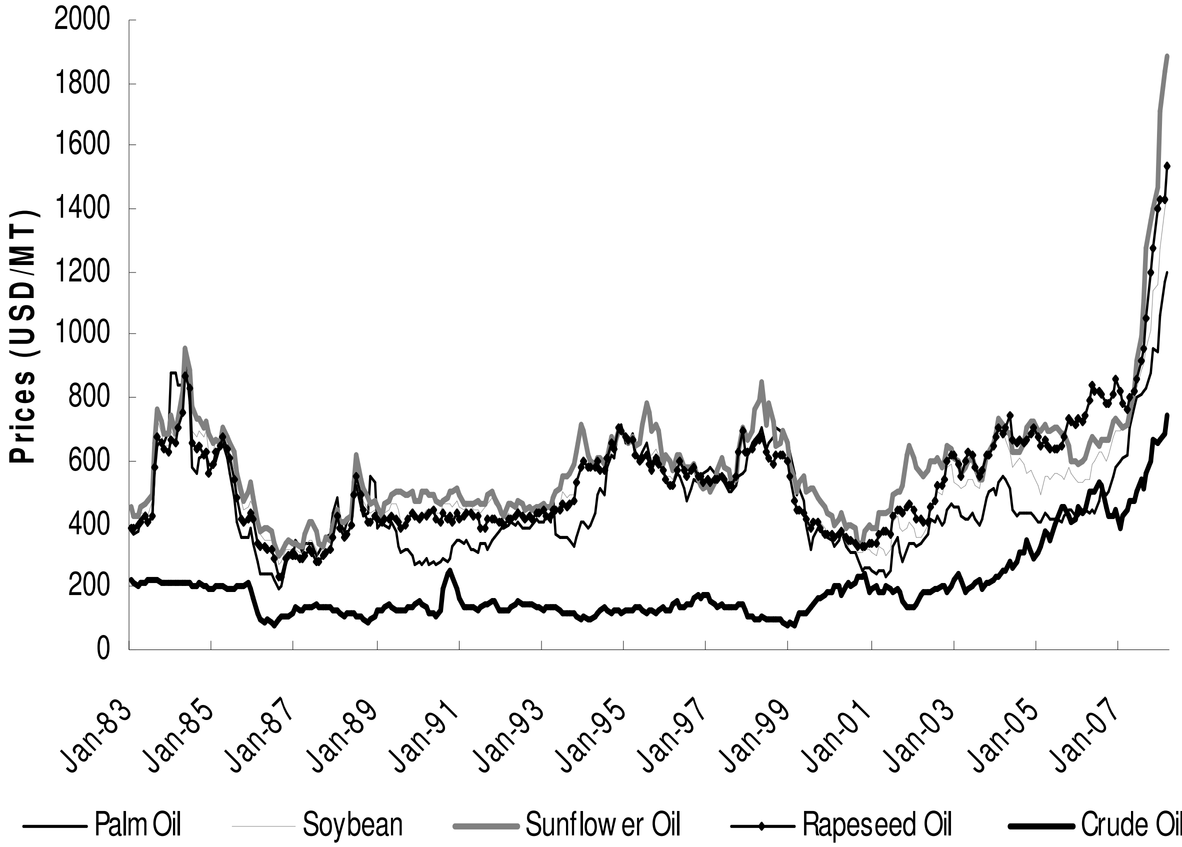


FIGURE 2: Vegetable Oils Prices, January 1983 -March 2008
Source: ISTA Mielke, various issues; International Monetary Fund, 2008.

The escalation in vegetable oils prices is a major concern to most of the developing countries as they are a major source of fat in the developing world, especially in the poorest countries where consumers are not able to afford nutritional staples. Hence, an increase in their prices will affect the poor consumers much more than the well to do ones. The apparent high correlation between petroleum and vegetable oils prices raises the question as to the nature of the relationship of the two variables. Hence, this paper intends to examine the co-movements of the petroleum and vegetable oils prices and explain the cointegration and causality between them.

The remainder of the paper is organized as follows: Section II briefly reviews the literature on previous studies vegetable oils prices and the methodologies used for examining price transmission for different commodities, Section III outlines the empirical methodology and Section IV reports and discusses the results while a summary and some conclusions are presented in Section V.

2. Literature Review

Studies on spatial and vertical price relationships of commodities aim at examining the extent of price transmission and market integration. Spatial relationships provide indications whether prices are fully transmitted between locations. Theoretically, in an undistorted world, the law of one price is supposed to regulate prices (Fackler and Goodwin, 2001). A number of previous studies have endeavoured to measure the interdependence among vegetable oil prices with annual or monthly data and generally researchers have found similar price patterns for evaluated prices (Duncker; In and Inder; Griffith and Meilke; Labys and Owen *et al*.). However, some studies have obtained variant outcomes regarding the long-run relationship among selected vegetable oil prices. For example, Owen, Chowdhury and Garrido found no evidence of cointegration among the five major internationally traded vegetable oils over the 1971 to 1993 period. However, using similar vegetable oil prices over same study period, In and Inder observed a long-run co-movement relationship among edible oil prices. Yu *et al*.(2006) tried to investigate the relationship between vegetable oil and crude oil prices using weekly data extending from the first week of January in 1999 to the fourth week of March in 2006 using multivariate cointegration technique. Their study suggests that shocks in crude oil prices have insignificant influence on the variation of edible oil prices.

This study focuses on the relationship between petroleum and selected vegetable oils prices in the world market. Such a study may provides some information on how shocks in one market are transmitted to another; thereby reflecting the competitiveness of markets, effectiveness of arbitrage, efficiency of pricing and the extent to which markets are insulated (Abdulai, 2006). In the developed markets, the transmission of prices is efficient as compared to the less developed or developing economies. In the later case this could be attributed to protective policies as well as market rigidities.

Many techniques have been used to examine the dynamics of the price transmission process (Balcombe and Morrison (2002) and Rapsomanikis *et al.,* (2003)). The cointegration technique has been widely used as the standard test for market integration. Co-integration between the price series suggests that two prices may behave in a different way in the short run, but that they will converge toward a common behaviour in the long run (Barrett and Li, 2002). Prices may drift apart in the short run due to policy changes or seasonal factors, but if they continue to be too far apart, economic forces, such as market mechanisms may bring them together, in the long run (Palaskas, 1995; Enders, 1995).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 of this type of model is used to measure of the speed of price transmission, while the long run multiplier is used to indicate the degree of price transmission of one price to the other (Prakash, 1999). The properties of co-integrated series also imply the existence of a causality relation, as defined by Granger, that can be tested by assessing if the past observations of one of the two prices (fail to) predict those of the other (Granger, 1969 and 1980).

3. Methodology

The study adopts a simple model to express the relationship between petroleum and each of the major vegetable oils prices and test the hypothesis of whether or not changes in petroleum prices play an important role in changing them.

$$O_i P_t = \alpha_0' + \alpha_1' PP_t + v_t' \qquad (1)$$

where O_iP_t is vegetable oil (i) price at time t, PP_t is crude oil price, and v_t' is the error term.

To investigate whether or not a stable linear steady-state relationship exists between the variables under study, we need to conduct unit-root and cointegration tests for them. Unit-root tests show if a time-series variable is stationary. This study applies both The Augmented Dicky-Fuller (ADF) (Dickey and Fuller, 1981) and Phillips Perron (PP) (1989) unit-root tests to decide the order of integration of the series of the two variables.

According to Engle and Granger (1987), two I(1) series are said to be cointegrated if there exists some linear combination of the two which produces a stationary trend (I(0)). In other words, cointegrated series are related over time. Any non-stationary series that are co integrated may diverge in the short run, but they must be linked together in the long run. Therefore, co integration suggests that there must be Granger causalities in at least one direction, at least one of the variables may be used to forecast the other. 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”, that restricts the long run behaviour of the endogenous variables to converge to their counterbracing relationships, while allowing a wide range of short-run dynamics.

Thus, the second step of this investigation is to check for the existence (or absence) of cointegration. Here, the Johansen (1991) test, which has the advantage that both estimation and hypothesis testing are performed in a unified framework, is utilized. The Johansen approach has been extensively documented so we will only briefly describe the setup and testing procedure (Johansen, 1988 and Johansen and Juselius, 1990).

The final step of our investigation is to examine the underlying causal relationship between the two variables within a bivariate framework. We employ the Granger (1969, 1980) causality test because of its favourable finite sample properties as reported in Guilkey and Salemi (1982) and Geweke et al. (1983). In the bivariate case, the causal or error correction model can be written as follows:

$$\Delta y_t = \alpha_0 + \delta e_{t-1} + \sum_{m=1}^{M} \alpha_m \Delta y_{t-m} + \sum_{n-1}^{N} \beta_n x_{t-n} + \varepsilon_t \quad (2)$$

where y_t is the dependent variable(can be PP or CiP), x_t is the independent variable and e_{t-1} is an error-correction term (ECT). According to Granger (1988) and Miller and Russek (1990), there are two potential sources of causation of y_t by x_t in the error correction model similar to Equation 2, either through β_n or through the ECT (i.e., whether or not $\delta=0$). In contrast to the standard Granger causality test, this method allows for the detection of a Granger causal relation from x_t to y_t, even if the coefficients on lagged difference terms β_n in y_t are not jointly significant. Thus, ECT measures the long run causal relationship while β_n determine the short run causal relation. Granger (1988) further notes that cointegration between two or more variables is sufficient to indicate the presence of causality at least in one direction.

The sign and the magnitude of the coefficient of the error correction term (ECT) helps in figuring out the short-term adjustment process. If the value of the coefficient lies between 0 and -1, the ECT tends to cause the dependent variable to converge monotically to its long-run equilibrium track in relation to variations in the exogeneous “forcing variables”, and the greater the magnitude of the coefficient of the error term the greater the response (speed of adjustment) of the dependent variable to the corresponding error correction term. A negative value of the coefficients of the ECT, or a value smaller than -2, will cause dependent variable to diverge. If the value is between -1 and -2, then the ECT will produce dampened fluctuations in the dependent variable about its equilibrium route (Alam and Quazi, 2003).

3.1 Data

The sample periods chosen for this study extend from January 1983 to the March 2008. Prices of Palm and and sunflower oils refer to FOB and CIF prices respectively, in North West European ports, Soybean and Rape seed oil prices are represented by their Dutch FOB ex-mill prices, whilst the world average crude petroleum prices represent petroleum prices. All price variables are nominal (in USD per ton) and are expressed in the normal form. The data on vegetable oils prices is provided by ISTA Mielke (Oil World) and the data on petroleum prices is obtained from the International Financial Statistics (IFS) online service.

4. Discussion of Findings

4.1 Unit Root Tests

Table 1 shows the results of ADF unit root tests for the underlying price series in levels and first differences. The null hypothesis of existence of unit root cannot be rejected for each of the variables in the level and thus it is concluded that all the series are non stationary with the presence of unit root. However, the null hypothesis is rejected at the 1% level of significance for all of them in their first differences, which indicates that stationarity is achieved for them after the first differencing i.e. the series are all I(1).

TABLE 1: Unit Root Tests Results for Petroleum and Major Vegetable Oils Prices

Commodity	Symbol	Without Trend		With Trend	
		Level	1st Difference	Level	1st Difference
Palm Oil	CPO	-1.142 (4)	-5.448***(4)	-0.703 (3)	-5.573***(4)
Soybean Oil	SBO	1.506 (2)	-4.649***(5)	1.070 (2)	-11.925*** (1)
Sunflower Oil	SNO	0.643 (6)	-3.812**(5)	0.030 (6)	-4.125***(5)
Rapeseed Oil	RSO	0.877 (6)	-4.672***(5)	0.045 (6)	-4.972*** (5)
Crude Oil (petroleum)	PETR	2.784 (14)	-2.841*(11)	1.509 (14)	-4.087***(12)

Notes: numbers in parenthesis represent the optimal length of lag on the dependent variable in the Augmented Dickey-Fuller test based on AIC .
Asterisks *, **, *** denote 10%, 5% and 1% significance levels respectively.

4.2 Cointegration Tests

Using Johansen's maximum likelihood approach, we test the bivariate relationship between oil and each of the major vegetable oils, as in Equation (1) .The trace and Max-eigenvalue (λ_{max}) statistics for testing the rank of cointegration are shown in Table 2. The results of both tests deny the absence of cointegrating relation between petroleum and vegetable oils price series at 5% level. Cointegration among the nonstationary prices of petroleum and the four vegetable oils means that a linear combination of them is stationary and, consequently, prices tend to move towards this equilibrium relationship in the long-run.

TABLE 2: Johansen Cointegration Tests Results

Commodity	Test Statistics	H_0: No Cointegrating Relation	H_0: At Most One Cointegrating Relation	Cointegration Rank
Palm oil/Petroleum(2)	Trace	17.923* [0.0211]	3.605 [0.058]	1
	λ_{max}	14.318* [0.0490]	3.605 [0.0576]	
Rapeseed oil /Petroleum(2)	Trace	24.619 * [0.002]	7.070* [0.008]	2
	λ_{max}	17.549* [0.015]	7.070 [0.008]	
Soybean oil/Petroleum(2)	Trace	21.106* [0.006]	3.434 [0.064]	1
	λ_{max}	17.672* [0.014]	3.434 [0.064]	
Sunflower oil /Petroleum(2)	Trace	19.825* [0.010]	0.011 [0.070]	1
	λ_{max}	16.559* [0.021]	3.2654 [0.071]	

Notes: Numbers in square brackets give the asymptotic significance level (*p* values) estimated in MacKinnon *et al.* (1999), numbers in parentheses are the lag intervals
* denotes rejection of the hypothesis at the 5% level or better.

4.3 Causality Tests

Granger causality tests highlight the presence of at least unidirectional causality linkages as an indication of some degree of integration. Unidirectional causality inform about leader-follower relationships in terms of price adjustments. An optimal lag order of 18 was selected for the four VAR models by minimizing the Akaike Information Criterion, where a maximum of 24 lags is considered. The four models passed all the diagnostic tests presented in Table 3, rejecting the existence of any sign of misspecification. Moreover, the Cumulative Sum of Recursive Residuals (CUSUM) test for examining the stability of the models (see Appendix) shows that the cumulative sum of residuals are within the critical bands, indicating a high level of parameter stability and lending more support to the robustness of the estimated models.

The results of Granger causality test are presented in Table 3. On the basis of those results, this paper detects long run unidirectional causality from oil price to vegetable oils prices. However, it denies the presence of a similar relation in the opposite direction. In addition, this paper finds that the coefficients of the ECT in the models with ΔO_iPs as dependant variables carry negative signs and are statistically highly significant. This suggests that the ECT acts as a significant force which causes the integrated variables to return to their long run relation when they deviate from it in all the cases. Furthermore, the magnitudes of the error correction term indicate that it tends to correct the deviation at a low speed. With regard to the causality results, the following points merit emphasis. First, the inclusion of an error correction term in these causal models ensures a proper test of the existence or absence of a material relationship between petroleum and vegetable oils prices. Second, the error correction term not only measures disequilibrium, but also captures deviations from it. According to the results presented in Table 3, the coefficients of the error-correction term which measures the speed of adjustment of palm, rapeseed, soybean and sunflower oils prices to their equilibrium levels equals to 0.017, 0.032, 0.032 and 0.034 respectively indicating that only 2 percent of the disequilibrium in the crude palm oil and about 3% of the disequilibrium for the other three vegetable oils are corrected each month, which is relatively low speed. As for the short run causality, the results deny the existence of such relationship between oil prices and vegetable oils prices in the short run.

TABLE 3: F-statistics for Tests of Granger Causality

Dependent Variables	Independent Variable(ΔPP) (F-statistic)	Coefficients of ECT	Causal Reference	Diagnostic Tests			
				χ^2_{auto}	χ^2_{reset}	χ^2_{norm}	χ^2_{hetro}
ΔCPO	1.1818 [0.2766]	-0.017* (-3.104)	$PET \xrightarrow{LR} PO$ $PET \not\xrightarrow{SR} PO$	1.888	4.679	3.484	57.460
ΔRSO	0.845 [0.0277]	-0.032* (-3.635)	$PET \xrightarrow{LR} RO$ $PET \not\xrightarrow{SR} RO$	0.773	1.246	0.856	85.880
ΔSOY	1.198 [0.263]	-0.0315* (-3.546)	$PET \xrightarrow{LR} SOY$ $PET \not\xrightarrow{SR} SOY$	0.531	1.410	4.761	88.684
ΔSUN	1.415 [0.1246]	-0.034* (-3.546)	$PET \xrightarrow{LR} SUN$ $PET \not\xrightarrow{SR} SUN$	0.564	0.634	0.511	71.268

Note: Numbers in parentheses are t statistics, numbers in square brackets are *p* values and * denotes significance at 1% level.

The symbol "$\xrightarrow{LR}$"represents unidirectional causality in the long run.

The symbol" $\not\xrightarrow{SR}$ "denote absence of causality in the shortrun.

χ^2_{auto} is Breusch-Godfrey Serial Correlation LM Test.

χ^2_{reset} is Ramsey RESET Test.

χ^2_{norm} is Normality Test based on Skewness of the residuals.

χ^2_{hetro} is White Heteroskedasticity Test.

5. Conclusion

The results of Granger causality tests show that there exist a long run unidirectional causality from petroleum price to each of the four vegetable oils prices, i.e., palm, rapeseed, soybean and sunflower oil. The said is not true for the reverse. These results suggest that petroleum price factor is growing in significance in the vegetable oils complex. In the past, crude oil used to enter the aggregate production function of the agricultural commodities through the use of various energy-intensive inputs (such as fertilizer and fuel for agricultural commodities) as well as for transportation. However, lately, the high price of crude oil has boosted the demand for biofuels such as biodiesel which utilises vegetable oils as feed stocks. Clearly, further analysis on the workings of the vegetable oils markets will have to incorporate crude oil prices as one of the major market determinants as well as the structural and behavioural aspects of the markets. The results of this study differ from those obtained by Yu *et al.*(2006), most probably due to the difference in utilized techniques, data frequency and time span, which lends support to Hakkio and Rush (1991) argument that increasing the number of observations does not add any robustness to the results in tests of cointegration; the time span is more essential. Another difference is that our study uses more recent data.

6. References

Abdullai A. 2006, "Spatial Integration and Price Transmission in Agricultural Commodity Markets in Sub-Saharan Africa", in : Alexander S. and Hallam, D. *Agricultural Commodity Markets and Trade: New Approaches to Analyzing Market Structure and Instability,* Edward Elgar Publishers, pp. 163-186.

Bakucs and Ferto (2006), "Marketing Margins and Price transmission on the Hungarian Beef Market", Food Economics - Acta Agricult Scand C, no. (3):pp. 151-160.

Balcombe, K. & Morrison J., 2002, "*Commodity Price Transmission: A Critical Review of Techniques and an Application to Selected Tropical Export Commodities',* a study for FAO - ESCR, 2002.

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

Dickey, D. A. and Fuller, W. A. 1981, "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica*, Vol. 49, pp.1057-72.

Duncker, J.W. "World Price Behavior of Edible Oils and Fats." Canadian Farm Economics, 12(1977):14-22.

Enders W. 1995, *Applied Econometric Time Series*, John Wiley & Sons, Inc.

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

Fackler, P.L and Goodwin, B.K., 2001, "Spatial Price Transmission", i*n* Gardner B. and Rausser, G. (eds.) *Handbook of Agricultural Economics*, Volume 1, Chapter 17. Elsevier Science.

Food and Agriculture Organisation (FAO) 2008, "Food Outlook: Global Market Analysis". Available at
http://www.fao.org/docrep/010/ai466e/ai466e00.htm [Retrieved: on 20 May 2008]

Geweke, J., Meese, R. and Dent, W. 1983, "Comparing Alternative Tests of Causality in Temporal Systems: Analytic Results and Experimental Evidence", *Journal of Econometrics*, vol. 21, pp. 161-94.

Granger, C. W. J. 1969, "Investigating Causal Relations by Econometric Models and Cross-spectral Methods", *Econometrica*, 37, 424-38.

Granger, C. W. J. 1980, "Testing for Causality", *Journal of Economic Dynamics and Control'*, Vol. 4, pp. 229-52.

Granger, C. W. J. 1988, "Some Recent Developments in the Concept of Causality", *Journal of Econometrics'*, vol. 39, pp. 199-221.

Griffith, G.R. and K.D. Meilke. "Relationship Among North American Fats and Oil Prices."American Journal of Agricultural Economics 61(1979):335-41.

Guilkey, D. K. and Salemi, M. K. 1982, "Small Sample Properties of the Three Tests of Causality for Granger Causal Ordering in a Bivariate Stochastic System, *Review of Economics and Statistics'*, vol. 64, pp. 668-80.

Hakkio, Craig S., and Rush, M. (1991). *Cointegration: how short is the long run?*. Journal of International Money and Finance, 10, 571-581.

In, F. and B. Inder. "Long-run Relationships between World Vegetable Oil Prices." Australian Journal of Agricultural and Resources Economics 41(1997):455-70

International Fund for Agricultural Development (IFAD) (2008). "Growing Demand on Agriculture and Rising Prices of Commodities: An Opportunity for Smallholders in Low-income, Agricultural-based Countries?" Available @http://www.fao.org/es/esc/common/ecg/538/en/RisingPricesIFAD.pdf > [Retrieved: 20 May 2008]

International Monetary Fund (IFS) 2008, IFS online database. Available at <http://www.imfstatistics.org/imf/logon.aspx> [Accessed on 16 May 2008]

International Monetary Fund 2008, IMF Primary Commodity Prices [Online], Available athttp://www.imf.org/external/np/res/commod/index.asp [Retrieved: 20 May 2008)

ISTA Mielke GmbH, Oil World Annual, various issues, Hamburg.

Johansen, S. 1988, "Statistical Analysis of Cointegration Vectors", *Journal of Economic Dynamics and Control*, vol. 12, pp. 231 54.

Johansen, S. 1991, "Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian Autoregressive Models", *Econometrica*, vol. 59, pp. 1551-80.

Johansen, S. and Juselius, K. 1990, "Maximum Likelihood Estimation and Inference on Cointegration-*w*ith Applications to the Demand for Money", *Oxford Bulletin of Economics and Statistics*, vol. 52, pp. 169- 210.

Labys, W.C. "Multicommodity Substitution Patterns in the International Fats and Oils Markets."
European Review and Agricultural Economics 4(1977):75-84.

Miller, S. and Russek, F. S. 1990, "Co-integration and Error-correction Models: The Temporal Causality between Government Taxes and Spending", *Southern Economic Journal*, vol. 57, pp. 221-9.

Owen, A.D., K. Chowdhury, and J.R.R. Garrido. "Price Interrelationship in the Vegetable and Tropical Oils Market." Applied Economics 29(1997):119-24.

Palaskas, T. B. (1995) "Statistical Analysis of Price Transmission in the European Union", *Journal of Agricultural Economics*, vol. 46,60-9.

Perron, P. 1989, "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis", *Econometrica*, Vol. 57, pp. 1361- 401.

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 Countries: Review and Applications", in FAO, *Commodity Market Review*, FAO Commodities and Trade Division, Rome.

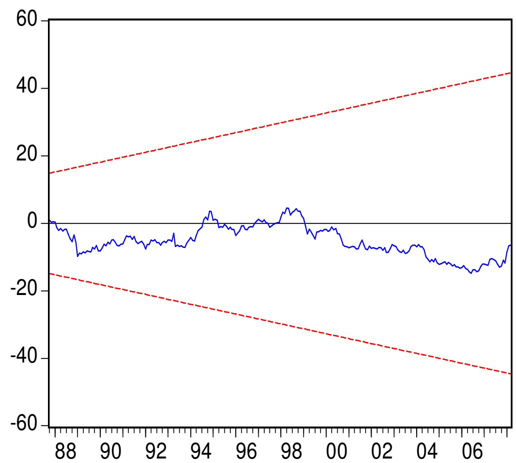
United State Department of Agriculture (USDA), 2008, "Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices". Available @http://www.ers.usda.gov/Publications/WRS0801/WRS0801.pdf> [Retrieved: May 2008].

World Bank 2007, "Rising food prices: Policy Options and World Bank Response". Available @: http://siteresources.worldbank.org/NEWS/Resources/risingfoodprices_backgroundnote_apr08.pdf [Retrieved 20 May 2008]

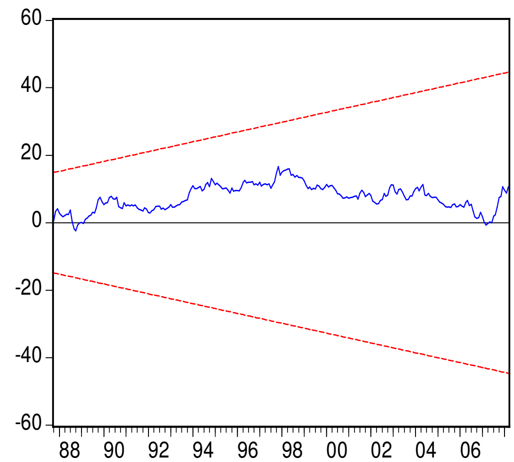
Yu, T.H., Bessler, D. A. and Fuller, S. (2006) "Cointegration and Causality Analysis of World Vegetable Oil and Crude Oil Prices", Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Long Beach, California July 23-26, 2006.

Appendix

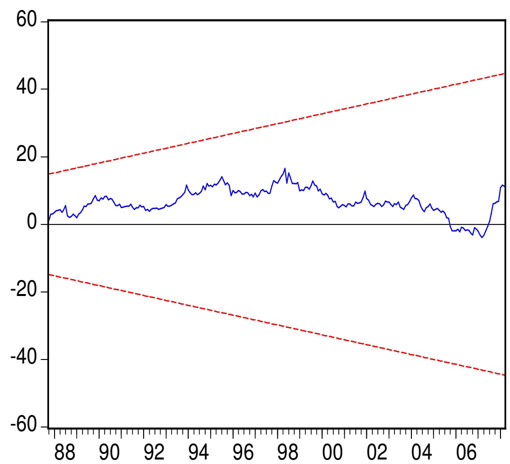
Plots of Cumulative Sum of Recursive Residuals



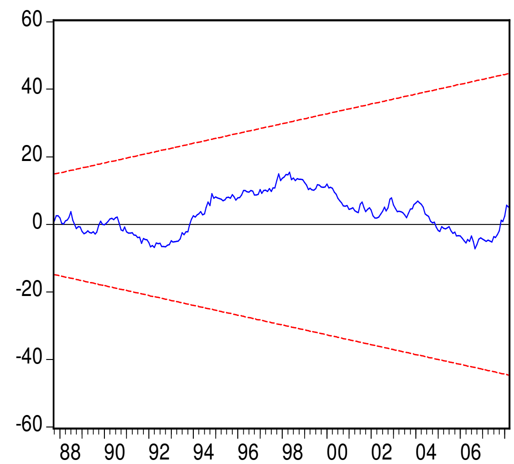
CPO



RSO



SOY



SUN

Note: The broken lines represent critical bounds at 5% significance level.