The Impact of Petroleum Prices on Vegetable Oils Prices: Evidence from Co-integration Tests

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ABSTRACT

The prices of petroleum and vegetable oils appear to be moving in tandem, a trend which was not observed before. This study seeks to investigate the long-term relationship between the prices of crude oil and selected vegetable oils. To that end, the bivariate co-integration approach using the Engle-Granger two-stage estimation procedure was applied. The study utilized monthly data over the period of January 1983 through March 2008. The results provide strong evidence of a long-run relationship between the two product prices.

INTRODUCTION

The last few decades saw an increase in primary commodity prices after a downward trend that began in the 1970s and continued until the beginning of the 21st century (World Bank, 2007). As shown in *Figure 1*, the price index for all commodities tripled between January 2000 and March 2008 (IMF, 2008). The major cause of the increase was the rise in petroleum price which registered an increase of more than 300%, *i.e.*, it quadrupled, while food prices increased by 107% during the same period. Among the food items, vegetable oils experienced a considerable increase of 192%. In fact, the vegetable oil prices had undergone the largest increase (144%) compared to all commodities (average of 60%) and food commodities (average of 62%) between January 2006 and March 2008.

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

The increase in the vegetable oil prices was largely attributed to an inadequate supply against the growing demand for these commodities worldwide. On the supply sector, production was constrained by a number of factors. A fall in global oilseed production was caused mainly, by a shift from planting soyabean to planting

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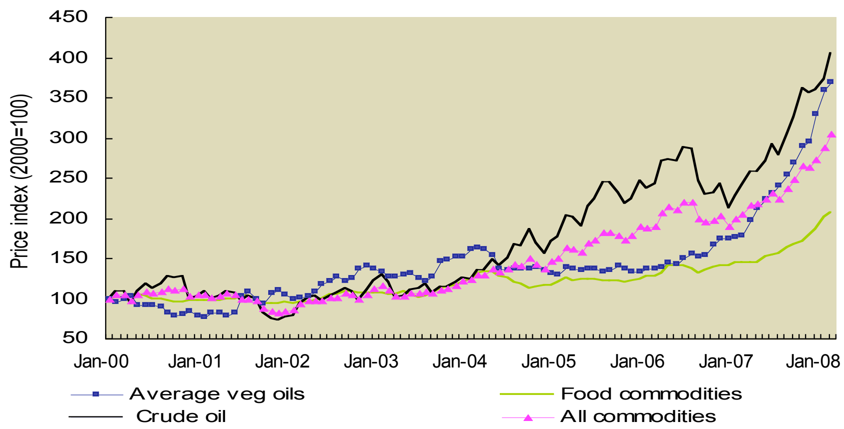
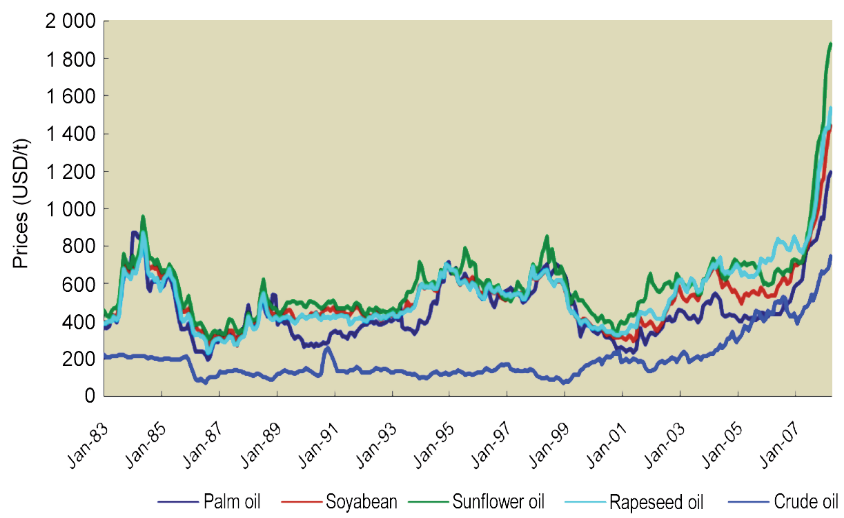


Note: Average vegetable oil price refers to the trade-weighted average.
Source: IMF (2008).

Figure 1. Price indices of different commodities (January 2000-March 2008).

maize in countries in the northern hemisphere, and production was also affected by poor weather conditions in the major producing areas such as Russia and Ukraine. Rising energy prices were cited as one of the prime reasons behind the surge in vegetable oil prices (FAO, 2008; IFAD, 2008; USDA, 2008). Rapid economic growth in developing countries has resulted in a very rapid growth in demand for energy for electricity generation 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. Oil imports into China alone grew by 20% per year from 166 million barrels in 1996 to 1.06 billion barrels in 2006. The crude oil price index has increased by 272% between January 2000 and March 2008 (*Figure 1*). This upsurge in energy prices led to an increase in the costs of agricultural inputs and also triggered the demand for alternative energy sources such as biofuels, which, in turn, increased the demand for its feedstocks such as palm and rapeseed oils for biodiesel production. The diversion of these oils from their normal use (particularly edible) to energy purposes has led to a temporary supply squeeze and hence, the price increase.



Source: ISTA Mielke (various issues); IMF (2008).

Figure 2. Vegetable oil prices (January 1983 - March 2008).

The general pattern of the relationship between the prices of petroleum and the selected vegetable oils can be gauged by looking at the correlation statistics before and after 2006. The year of 2006 was chosen as it marked the beginning of the price rally and the commercialization of biodiesel worldwide, particularly in Europe and Asian countries (including Malaysia). The biodiesel development is expected to impact the vegetable oil prices when they are used as feedstocks. *Table 1* indicates that the correlation statistics of crude oil and all the selected vegetables oils increased significantly after 2006, suggesting that the series moved in tandem to each other, and hence there existed some 'causation' pattern among the series. This conclusion however has been proven to be a serious fallacy because one variable may have fluctuated in relation to the others mainly due to chance, or, as is often the case, each was strongly affected by one or more (confounding) variables that were outside the equation. Hence, a more rigorous technique is required to establish the causation pattern between the variables. This article, therefore, intends to examine the co-movements and causality of

TABLE 1. CORRELATIONS BETWEEN PRICES OF PETROLEUM AND SELECTED VEGETABLE OILS (January 1983 - March 2008)

Vegetable oil	Pre-2006	Post-2006
Palm oil	0.022	0.821**
Soyabean oil	0.07	0.920**
Sunflower oil	0.522**	0.860**
Rapeseed oil	0.384**	0.942**

Note: **Denote correlation coefficient is significant at 1% level.

the petroleum and vegetable oil prices using the 'Granger causality technique' which has proven to be a better indicator than the correlation statistics.

The remainder of the article is organized as follows: the second section briefly reviews the literature on previous studies on vegetable oils prices, and the methodologies used for examining price transmission for different commodities, the third section outlines the empirical methodology, and the fourth section reports and discusses the results, while a summary and some conclusions are presented in the final section.

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 on 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, 1977; In and Inder, 1997; Griffith and Meilke 1979; Labys, 1973; Owen *et al.*, 1997). However, some studies have obtained variant outcomes regarding the long-run relationship among selected vegetable oil prices. For example, Owen *et al.* (1997) found no evidence of co-integration among the five major internationally traded vegetable oils over the 1971 to 1993 period. However, using similar vegetable oil prices over the same study period, In and Inder (1997) observed a long-run co-movement relationship among edible oil prices. Yu *et al.* (2006) tried to investigate the relationship between vegetable oil and petroleum prices using weekly data extending from the first week of January in 1999 to the fourth week of March in 2006 and the multivariate co-integration technique. Their study suggests that shocks in petroleum prices have an insignificant influence on the variations in edible oil prices.

This study focuses on the relationship between petroleum and selected vegetable oil prices in the world market. Such a study may provide some information on how shocks in one market are transmitted to another; thereby reflecting the competitiveness of the markets, effectiveness of arbitrage, efficiency of pricing and the extent to which markets are insulated (Abdulai, 2006). In developed markets, the transmission of prices is more efficient as compared to the less developed or developing economies. In the latter 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; Rapsomanikis *et al.,* 2003). The co-integration technique has been widely used as the standard test for market integration. 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). 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 (Enders, 1995; Palaskas, 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 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 (or fail to predict) those of the other.

METHODOLOGY

The study adopted a simple model to express the relationship between the price of petroleum and the price of each of the major vegetable oils, and tested the hypothesis of whether or not changes in petroleum prices played an important role in changing the price of the vegetable oils. The model followed this equation:

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

where O_iP_t is the price of vegetable oil (i) at time t, PP_t is the petroleum price, and v'_t is the error term.

To investigate whether or not a stable linear steady-state relationship existed between the variables under study, we needed to conduct unit-root and co-integration tests for them. Unit-root tests show if a time-series variable is stationary. This study applied both the Augmented Dickey-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 co-integrated if there exists some linear combination of the two which produces a stationary trend [I(0)]. In other words, the co-integrated 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, and 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', which forces the variables to move closely together over time, while allowing a wide range of short-run dynamics.

Thus, the second step of this investigation was to check for the existence (or absence) of co-integration. Here, 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.

The final step of our investigation was to examine the underlying causal relationship between the two variables within a bivariate framework. We employed 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_t or O_iP_t), 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 the lagged difference terms β_n in y_t are not jointly significant. Thus, ECT measures the long-run causal relationship while β_n determines the short-run causal relation. Granger (1988) further noted that co-integration between two or more variables is sufficient to indicate the presence of causality in at least one direction.

The sign and the magnitude of the coefficient of the ECT help in figuring out the short-term adjustment process. If the value of the coefficient lies between 0 and -1, 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 will be the response (speed of adjustment) of the dependent variable to the corresponding ECT. A negative value of the coefficient of ECT, or a value smaller than -2, will cause dependent variables to diverge. If the value is between -1 and -2, then ECT will produce dampened fluctuations in the dependent variable about its equilibrium route (Alam and Quazi, 2003).

Data

The sample periods chosen for this study extended from January 1983 to March 2008. Prices of palm and sunflower oils referred to FOB and CIF prices, respectively, in north-western European ports, soyabean and rapeseed oil prices were represented by their Dutch FOB ex-mill prices, whilst the world average crude petroleum prices represented petroleum prices. All price variables were nominal (in USD per tonne) and were expressed in the normal form. The data on vegetable oil prices were provided by ISTA Mielke (*Oil World*) and the data on petroleum prices were obtained from the International Financial Statistics (IFS) online service.

DISCUSSION OF FINDINGS

Unit Root Tests

Table 2 shows the results of ADF unit root tests for the underlying price series in levels and first differences. The null hypothesis of the existence of unit root could not be rejected for each of the variables in the level, and thus it was concluded that all the series were non-stationary with the presence of unit root. However, the null hypothesis was rejected at the 1% level of significance for all of them in their first differences, which indicates that stationarity was achieved for them after the first differencing, *i.e.* the series were all I(1), I refers to level of integration. In this case, the series are all integrated at level 1.

Co-integration Tests

Using Johansen's maximum likelihood approach, we tested the bivariate relationship between crude 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 co-integration are shown in *Table* 3. The results of both tests deny the absence of a co-integrating relationship between the petroleum and vegetable oil price series at 5% level. Co-integration among the non-stationary prices of petroleum and the four vegetable oils means that a linear combination of them was stationary and, consequently, the prices tended to move towards this equilibrium relationship in the long-run.

TABLE 2. UNIT ROOT TEST RESULTS FOR PETROLEUM AND MAJOR VEGETABLE OIL 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)
Soyabean 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)	PET	2.784 (14)	-2.841*(11)	1.509 (14)	-4.087***(12)

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

TABLE 3. JOHANSEN CO-INTEGRATION TESTS RESULTS

Commodity	Test statistics	H_0: No co-integrating relation	H_0: At most, one co-integrating relation	Co-integration 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]	
Soyabean 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]	

Note: 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.

Causality Tests

Granger causality tests highlight the presence of at least unidirectional causality linkages as an indication of some degree of integration. Unidirectional causality indicates 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 was 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 (*Appendix 1*) showed that the cumulative sum of residuals were 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 4*. On the basis of those results, this article detected a long-run causal relationship from crude oil price to vegetable oil prices, *i.e.* changes in petroleum prices affected the vegetable oil prices. However, the results deny the presence of a similar relation in the opposite direction. In addition, this article found that the coefficients of ECT in the models with ΔO_iPs as dependant variables carried negative signs and were highly significant statistically. This suggests that ECT acted as a significant force which caused the integrated variables to return to their long-run stable condition when they deviated from it in all

TABLE 4. F-STATISTICS FOR TESTS OF GRANGER CAUSALITY

Dependent variable	Independent variable (ΔPP) (F-statistic)	Coefficients of ECT	Causal reference	Diagnostic test			
				χ^2_{aut}	χ^2_{reset}	χ^2_{norm}	χ^2_{hetro}
ΔCPO	1.1818 [0.2766]	-0.017* (-3.104)	PET $\xrightarrow{LR}$ PO PET $\overset{SR}{\nrightarrow}$ PO	1.89	4.68	3.48	57.46
ΔRSO	0.845 [0.0277]	-0.032* (-3.635)	PET $\xrightarrow{LR}$ RO PET $\overset{SR}{\nrightarrow}$ RO	0.77	1.25	0.86	85.88
ΔSOY	1.198 [0.263]	-0.0315* (-3.546)	PET $\xrightarrow{LR}$ SOY PET $\overset{SR}{\nrightarrow}$ SOY	0.53	1.41	4.76	88.68
ΔSUN	1.415 [0.1246]	-0.034* (-3.546)	PET $\xrightarrow{LR}$ SUN PET $\overset{SR}{\nrightarrow}$ SUN	0.56	0.63	0.51	71.27

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 ‘$\overset{SR}{\nrightarrow}$’ denotes absence of causality in the short-run.
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.

the cases. Furthermore, the value of ECT indicated that it tended to correct the deviation at a low speed. With regard to the causality results, the following points merit emphasis. First, the inclusion of an ECT in these models ensured a proper test of the existence or absence of a significant relationship between petroleum and vegetable oil prices. Second, ECT not only measured disequilibrium, but also captured deviations from it. According to the results presented in *Table* 3, the coefficients of ECT which measured the speed of adjustment of palm, rapeseed, soyabean and sunflower oil prices to their stability levels equaled 0.017, 0.032, 0.032 and 0.034, respectively, indicating that only 2% of the disequilibrium in crude palm oil and about 3% of the disequilibrium for the other three vegetable oils were corrected every month, which was a relatively low speed.

CONCLUSION

The results of the Granger causality tests show that in the long-run there was a one direction relationship between petroleum price and the prices of each of the four vegetable oils, *i.e.*, palm, rapeseed, soyabean and sunflower oils. The reverse was not true, *i.e.*, petroleum price was not influenced by the price of any of the vegetable oils under study. These results suggest that petroleum price is a factor growing in significance in the vegetable oils complex. In the past, petroleum 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 petroleum has boosted the demand for biofuels such as biodiesel which utilizes vegetable oils as feedstocks. Clearly, further analysis on the workings of the vegetable oil markets will have to incorporate petroleum price as one of the major market determinants as well as an influence on 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 differences in the adopted techniques, data frequency and time span, which lend support to Hakkio and Rush's (1991) argument that increasing the number of observations does not add any robustness to the results in tests of co-integration, and that the time span is more important. Another difference is that our study used more recent data.

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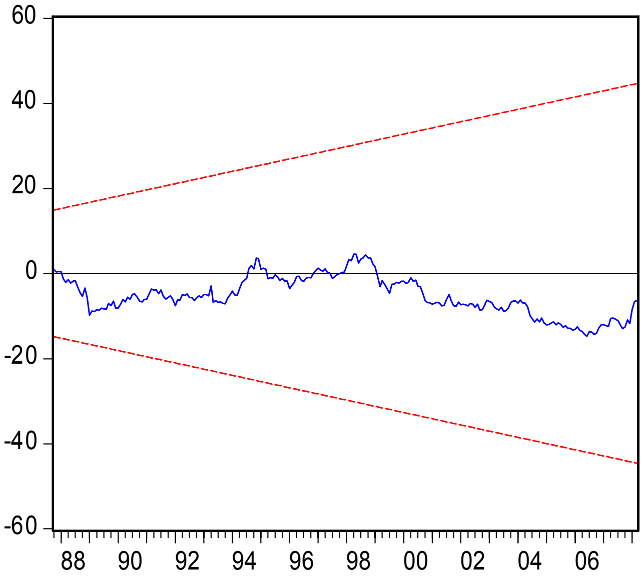
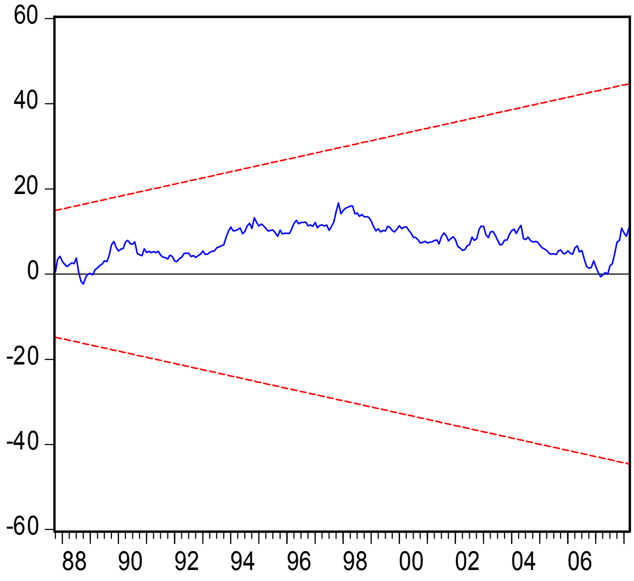
Appendix 1

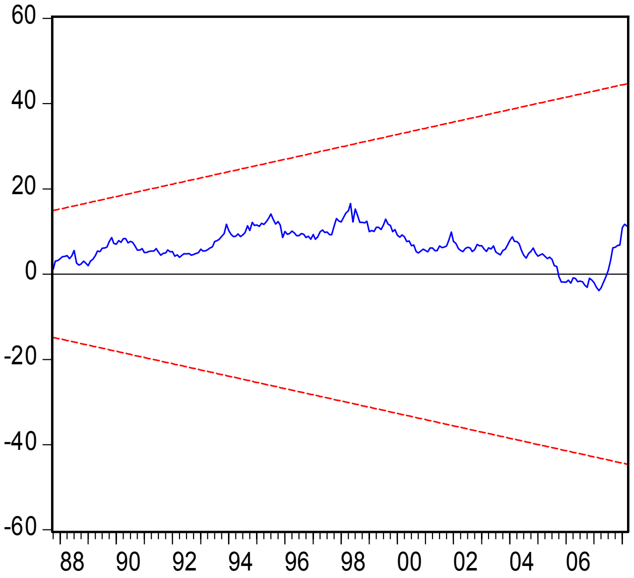
PLOTS OF CUMULATIVE SUM OF RECURSIVE RESIDUALS



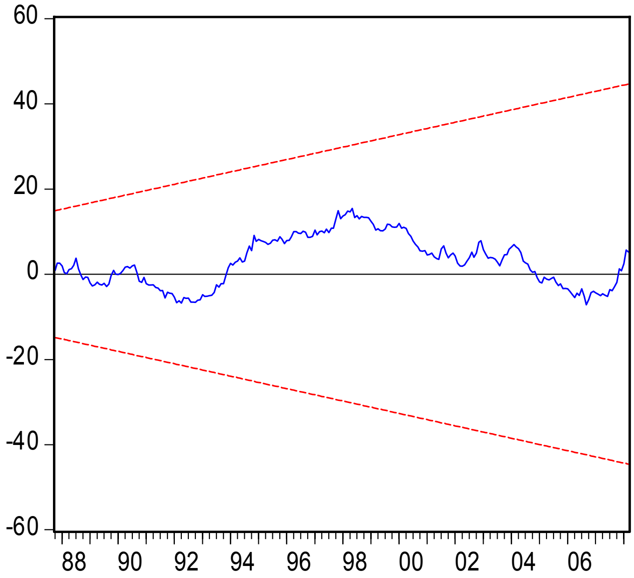
CPO/PET



RSO/PET



SBO/PET



SNO/PET

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