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The Long Run Relationship Between Petroleum and Cereals Prices

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This study seeks to investigate whether or not there is a long-term relationship between petroleum or crude oil and cereals 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 1980 through March 2008. The results show that there is 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 cereals prices

Field of Research: Agricultural Economics, Price Analysis

1. Introduction

The last few years saw a phenomenal increase in primary commodity prices. As shown in Figure 1, the price index for all primary commodities has increased 204% between January 2000 and March 2008 (IMF, 2008a). The major source of this increase is the rise in petroleum price which registered an increase of more than 300% while food has increased by 107% during the said period. Among the food items, the cereals have experienced a considerable rise of 192%. In fact, during the period from January 2006 until March 2008, the cereals prices have undergone the largest increase of 132%, compared to all commodities (60%) and food commodities (68%).

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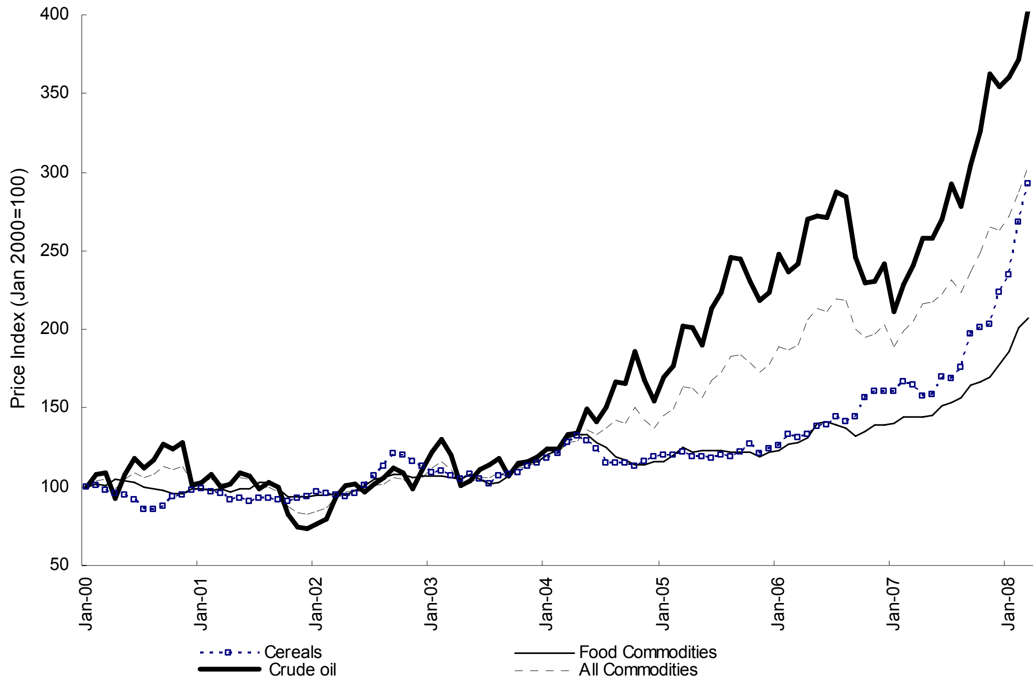
Figure 1: Price Indices of Commodities, January 2000-February 2008



Notes: Cereals price refers to trade weighted average of the three cereal crops under study (maize, corn and rice) calculated by the authors. Food prices refers weighted average of food Items (including cereals, vegetable oils and protein meals, meat, seafood, sugar and fruits) based on world export earnings prepared by IMF (series code 00176EXDZF). "Food" items account about 45% of the world export weights. As for "Food" export weights, "Cereals" (which include maize, corn, rice and barley) account for 21%.

Source: IMF (2008a).

Narrowing to cereals, it is clear that their prices have shot up at a relatively higher rate beginning from late 2006. For instance, the price of wheat has increased from USD196 per tonne to USD425 per tonne in February 2008 while that of rice has increased from USD313 per tonne to USD481 (IMF, 2008a). Rising energy prices is cited to be one of the prime reasons behind the surge in the cereal prices (USDA, IFAD and FAO, 2008). Crude oil price index has increased 272% between January 2000 and March 2008 (IMF, 2008a). High energy prices led to an increase in the production cost and, additionally, it triggered the demand for alternative energy sources such as biofuels. The U.S. government has been subsidizing farmers to grow crops for energy production resulting in a massive shift in corn cultivation. Approximately 30% of U.S. corn output is channelled towards ethanol production in 2008 instead of going into world food and feed markets. Ethanol production has also resulted in the conversion of planted area of cereal crops such as wheat and rice to corn and this further reduces the world food supply.

The increase in cereal prices is a major concern to most of the developing countries as they are the staple diet of the population and an increase in the price of rice will affect the poor consumers much more than the well to do ones. The apparent high correlation between petroleum and cereal prices begs 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 cereal prices and explain the cointegration and causality between them.

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). On the other hand, vertical relationships represent interactions between prices along the supply chain (Bakucs and Ferto, 2006). This study focuses on the relationship between petroleum and cereal 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 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 from world to domestic commodity markets is more efficient compared to the less developed or developing economies. This could be attributed to protective policies as well as market rigidities in the later case.

A number of 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. Cointegration 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 economic forces, such as market mechanisms may bring them together, in the long run (Palaskas, 1995 and 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 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 cereals prices and test the hypothesis of whether or not changes in petroleum prices play an important role in changing them.

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

where C_iP_t is cereal (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 whether 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 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 cointegrated may diverge in the short run, but they must be linked together in the long run. Therefore, cointegration 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 cointegrated, 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 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:

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

where y_t is the dependent variable (can be PP or C_iP), 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 (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 one. 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 exogenous “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).

The sample periods chosen for this study extend from January 1980 to the March 2008. Maize and wheat prices are represented by United States maize and wheat (Gulf Ports) prices, Thailand Rice (Bangkok) represents rice prices (in USD per ton) whilst the world average crude petroleum prices represent petroleum prices (USD per barrel). All price variables are nominal and are expressed in the normal form. The data is provided by the International Financial Statistics (IFS) online service (IMF, 2008b).

4. Results and Discussion of Findings

4.1 Unit Root Tests

Table 1 shows the results of ADF and PP 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 the series are non stationary. However, the null hypothesis is rejected at the 1% level of significance for all of them in their first differences. This indicates that stationarity is achieved for them after the first differencing i.e. all the series are I(1).

Table 1: Unit Root Tests for Petroleum and Major Cereals Prices

Commodity	Variable	ADF		PP	
		Level	1st difference	Level	1st difference
Petroleum	PP	1.977(1)	-14.527**(0)	2.502(4)	-14.417**(3)
Maize	MP	-2.344(1)	-13.240**(0	-1.599(2)	-12.931**(8)
Rice	RP	-1.454(1)	-11.567**(0)	-1.365(5)	-11.468**(2)
Wheat	WP	2.229(1)	-14.263**(0)	2.261(6)	-14.797**8

** denote 1 % significance level. Figures in parentheses give the bandwidth/lag length based on Newey-West and Schwarz (SIC) criteria, respectively.

4.2 Cointegration Tests

Using Johansen's maximum likelihood approach, we test the bivariate relationship between oil and each of the major cereals, as in Equation (1) with 2 lags in all the cases. 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 cereals prices series. Furthermore, both tests suggest the presence of one cointegrating equation at 5% level or better between the nonstationary prices of petroleum and each of the three cereals which means that the linear combinations of them are stationary and, consequently, prices tend to move towards this equilibrium relationship in the long-run.

Table 2: Johansen Cointegration Tests

Commodity	Test statistics	Lag	H_0: No Cointegrating Relation	H_0: At Most One Cointegrating Relation
Maize/Petroleum	Trace	2	15.58439* (0.0292)	0.035123 (0.8513)
	λ_{max}		15.54927* (0.0312)	0.035123 (0.8513)
Rice/Petroleum	Trace	2	20.75881* (0.0073)	1.468301 (0.2256)
	λ_{max}		19.29050 * (0.0074)	1.468301 (0.2256)
Wheat/Petroleum	Trace	2	33.62453* (0.0044)	8.670427 (0.2017)
	λ_{max}		24.95410* (0.0070)	8.670427 (0.2017)

Notes: Numbers in parentheses give the asymptotic significance level (*p* values).
* denotes rejection of the hypothesis at the 5% level

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 2 was selected for the three VAR models by minimizing the Akaike Information Criterion, where a maximum of 12 lags is considered. On the basis of Granger causality test results presented in Table 3, long run unidirectional causality from oil price to cereals prices is detected. However, the presence of a similar relation in the opposite direction is denied. Additionally, this paper finds that the coefficients of the ECT in the models with ΔC_iPs as dependant variables carry negative signs and are statistically significant suggesting that the ECT acts as a force which causes the integrated variables to return to their long run relation when they deviate from it in all the cases. 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 cereals 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 maize, rice and wheat prices to their equilibrium levels equals to 0.03, 0.05 and 0.02, respectively, indicating that only 3 percent, 5 percent and 2 percent of the disequilibrium is corrected each month for each of them, respectively, which is relatively low speed. However, the prices of maize adjust at a higher speed compared to the others while rice prices adjust at the lowest speed. As for the short run causality, the results deny the existence of such relationship between oil prices and cereals prices.

Table 3: F-statistics for Tests of Granger Causality

Dependent Variables	Independent Variable(ΔPP) (F-statistic)	Coefficients of ECT	Causal Reference
ΔMP	1.962482 [0.1421]	-0.048587* (-3.84971)	$PP \xrightarrow{LR} MP$ $PP \overset{SR}{\not\longrightarrow} MP$
ΔRP	2.779343 [0.0964]	-0.023036* (-3.92207)	$PP \xrightarrow{LR} RP$ $PP \overset{SR}{\not\longrightarrow} RP$
ΔWP	0.729027 [0.4832]	-0.029602* (-3.42104])	$PP \xrightarrow{LR} WP$ $PP \overset{SR}{\not\longrightarrow} WP$

Note: Numbers in parentheses are t statistics, numbers in square brackets are *p* values;
* denotes significance at 5% level.
The symbol " $\xrightarrow{LR}$ "represent unidirectional causality in the long run.
The symbol " $\overset{SR}{\not\longrightarrow}$ "denote absence of causality in the short run.
According to AIC, the optimal lag order in the three cases was 2.

5 Conclusion

The results of Granger causality tests show that there exist a long run unidirectional causality from petroleum price to the three cereals prices, i.e., maize, rice and wheat. The said is not true for the reverse. These results suggest that petroleum price factor is growing in significance in the cereal complex. This is a plausible result since modern agriculture depends heavily on the use of fossil fuel in every stage of food production and marketing. The universal adoption of seed fertilizer technology (SFT) is energy intensive; that is, production of food is heavily dependent on chemical fertilisers, which uses fossil fuel as its primary inputs. The increases in fuel prices have raised the costs of producing cereal crops. For instance, the prices of some fertilizers (e.g. triple super phosphate and muriate of potash) in US dollar increased by more than 160 percent in the first two months of 2008, compared to the same period in 2007. Higher costs for fertilizer, fuel, and seeds could cause farmers without access to credit to produce less than they otherwise would have, or to shift to crops with fewer inputs requirements. Secondly, gasoline and diesel fuel are heavily used in ploughing, planting, cultivating and harvesting. Irrigation pumps use diesel fuel, natural gas, and coal-fired electricity. Thirdly, fertilizer production is also energy intensive as the mining, manufacture, and international transport of phosphates and potash all depend on oil. Lastly, with freight rates doubling within a one-year period beginning in February 2006, the cost of transporting food to importing countries also has been affected.

The increase in petrol price has added a new dimension in the cereal equation, that is, the demand for biofuel particularly ethanol which utilised maize as a feedstock. This in turn has increased maize production at the expense of wheat and, consequently, led to the current price hikes of these two commodities. This explains for the relatively faster response of maize and wheat to changes in petroleum price compared to rice. Rice is being consumed largely for food purposes worldwide. Clearly, further analysis on the workings of the cereal markets will have to incorporate crude oil prices as one of the major market determinants as well as the understanding of the structural and behavioural aspects of the industry.

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