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Crude Oil, Palm Oil Stock and Prices: How They Link[1]

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Abstract: This paper reviews the nature of links or relationships between crude, palm oil prices and stocks and its short term implications on the palm oil price trend in 2013. An econometric method is used to empirically forecast the palm oil price movements in the year 2013 using monthly historical data over the period of January 2002 to December 2012. A single equation model using Autoregressive Distributed Lag (ARDL) procedure was estimated to achieve the stated objective. The results provide a strong evidence of long-run equilibrium relation between crude palm oil price, its stock level and the crude oil prices. The study also uses the findings to provide projections for the palm oil prices during 2013.

JEL Classifications: Q13, Q17, Q27, Q49

Keywords: Crude oil, Palm oil prices, Palm oil stock, Causality, ARDL

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). The Food and Agriculture Organization of the United Nations (FAO) food price index rose by 23 percent in 2011 compared with the previous year. The surge in prices has been led primarily by the cereals and oil price indices with highest increments of 35% and 30% respectively, but prices of other commodities, have also increased significantly (Figure 1). The excessive price changes or high volatility of agricultural commodities created anxiety about world food security in the future. The Business and Industry Advisory Committee to the OECD (BIAC) claims that these changes are caused by structural factors such as supply and demand and market adjustment processes, and unexpected shocks such as severe weather incidents, disease epidemics and hasty and misdirected policy decisions. Both sorts of factors can affect each other, potentially augmenting their individual effects. Therefore, it is important for policy makers to differentiate between them, as each set of factors requires different policy responses, with policies to address structural factors by alleviating risk, and policies to deal with exogenous factors by attempting to handle jeopardy (BIAC, 2011).

Income and population growth in emerging and developing countries, particularly in Asia, have and are expected to further increase the demand for food in the forthcoming decades. The demand for food is expected to increase by between 70% - 100% by 2050, mainly due to the world's

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population growth, which will affect commodity prices. An Organisation for Economic Co-operation and Development (OECD)/FAO medium term outlook projections indicated that during the next decade, the prices of crops and most livestock products will exceed those in the decade before the 2007/08 price spikes (FAO, *et al.*, 2011).

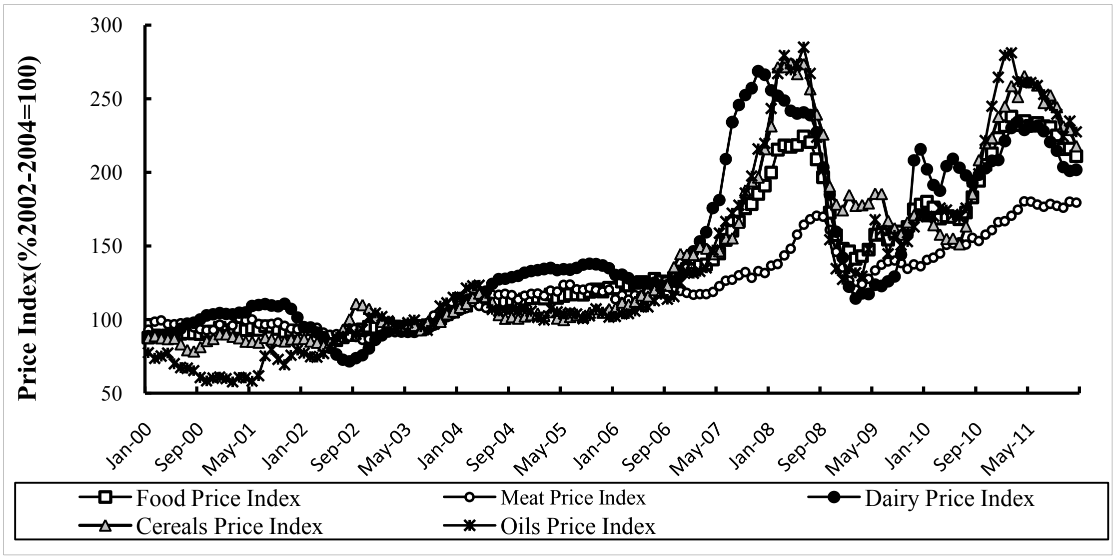

Figure1. Monthly Food Price Indices, Jan. 2000-Dec. 2011 (2002-2004=100)

Note: Oil price index consists of an average of 12 different oils (including animal and fish oils) weighted with average export trade shares of each oil product for 2002-2004.

Data Source: FAO

Another factor that contributes to the high and volatile prices is the low stocks relative to use, and uncertainty about stock levels in some countries. Expected diminishing stocks cause prices to rise sharply. Stocks can be drawn down in response to a supply or demand shock. However, supply cannot be increased until new production arrives. Figure 2 demonstrates the relationship of palm oil prices and the changes in its opening stocks. On the whole, both variables are increasing but considering year to year movement we can notice the negative relationship between them.

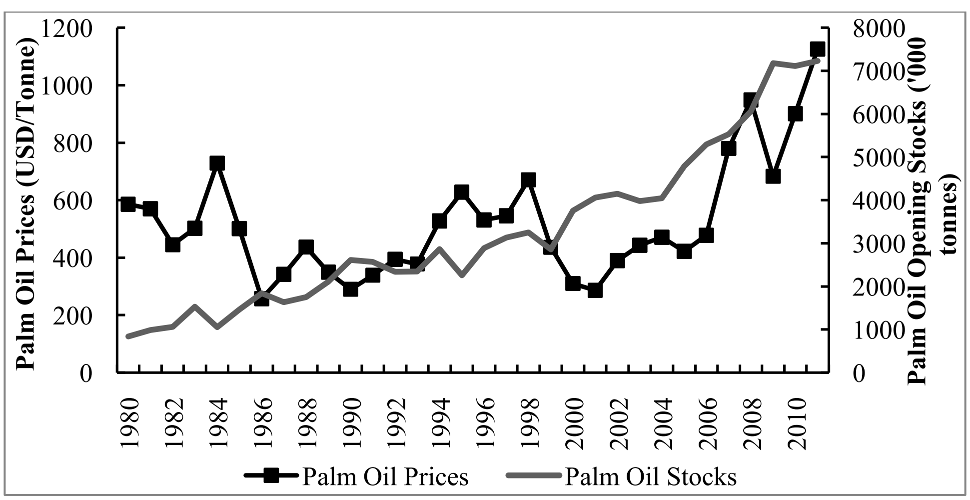

Figure 2. Annual Movements in the Prices and Opening Stocks of Crude Palm Oil (1980-2011)

Data Source: Malaysian Palm Oil Board (MPOB), Malaysian Oil palm Statistics, Various issues

The recent upward trend in international prices of most agricultural commodities, particularly vegetable oils, is a partial manifestation of tightening supplies in the face of expanding demand. In addition to the normal supply and demand factors, there are also other factors that affect the agricultural prices. Continuous increase in crude oil prices have contributed to the increase in prices of most agricultural crops directly and indirectly by increasing input costs through the price of fuel and fertiliser, etc , on one hand, and by pushing up demand for agricultural crops used as feedstock in the production of alternative energy sources (e.g. bio fuel) on the other. Figure 3 displays the monthly price co-movements of crude oil and vegetable oils prices from January 1990 through December 2011. The figure demonstrates the obvious growing interrelationship between those commodities, which became closer with the expansion of the bio fuel industry which uses vegetable oils as feed stocks.

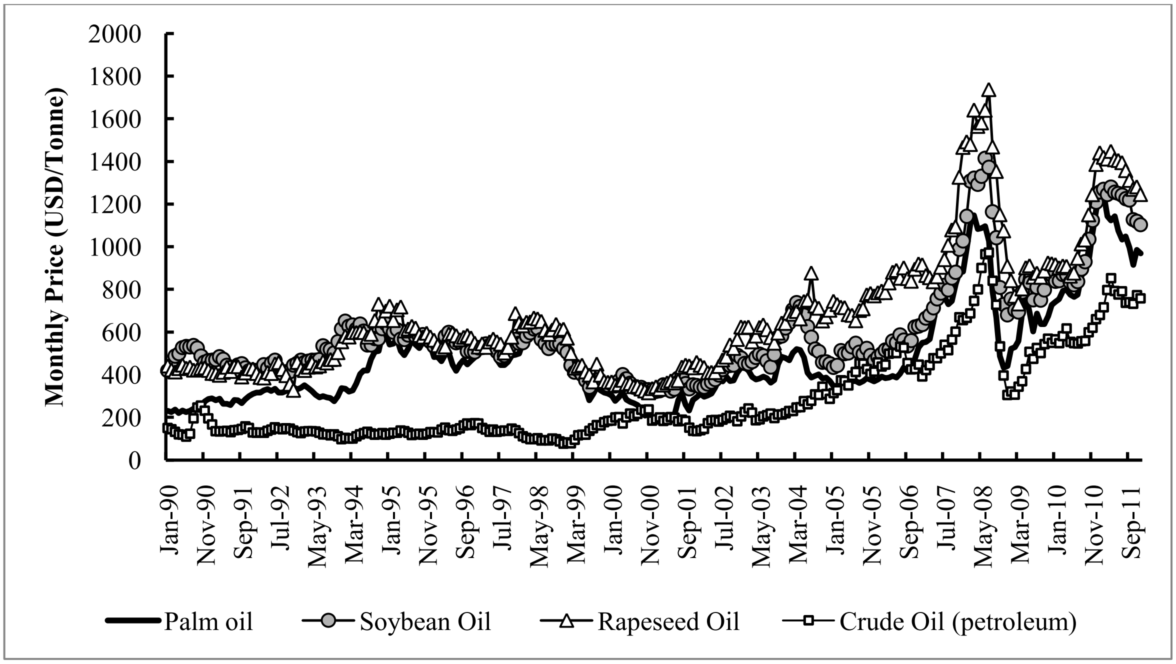

Figure 3. Vegetable Oils and Crude Oil Prices, January 1990-December 2011
Data Source: IMF Primary Commodity Prices, accessible at
http://www.imf.org/external/np/res/commod/index.aspx

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. Tropical vegetable oils are playing a major role in the global market of vegetable oils since they account for major share in the global production and trade of vegetable oils due to their relatively cheaper prices.

In this paper, we attempt to investigate the relationship between palm oil price and two variables; i.e., crude oil prices and stock levels as they have shown to be play a significant role in impacting the palm oil prices in the recent decade and the past respectively. In order to perform our empirical analysis we have utilised the information embedded in the monthly historical prices. Specifically, we analyze crude palm oil price historical data over the period January, 2002 to December 2012, utilizing the autoregressive distributed lag (ARDL) procedure. The study attempts to make projections of the crude palm oil prices in 2013.

The paper proceeds as follows. Section 2 outlines the empirical methodology and Section 3 reports and discusses the results while a summary and some conclusions are presented in Section 4.

2. Methodology

2.1 Model Specification

The existing literature on palm oil prices including inter alia the works of Shamsudin and Arshad (1993 a and b) and Talib *et al.* (2007) modelled the palm oil price as a function of one or more competitive oil prices, the demand and palm oil stock level. The variables used in this study are dictated by the availability of data. It is worth mentioning that the price of other vegetable oils were included in the initial model but when they are included along with the crude oil prices, they produced erroneous result and since this study is interested to evaluate the effect of crude oil price as a new player, the prices of vegetable oils were dropped from the model during the general to specific exercise to select the best specification.

The study adopts a simple model to express the relationship between palm oil price, palm oil ending stock and petroleum (crude oil) price as follows:

$$POP_t = \alpha_0 + \alpha_1 \, PETP_t + \alpha_2 \, POST_t + \varepsilon_t \quad (1)$$

Where, POP is palm oil price at time t, $PETP_t$ is crude oil price; $POST_t$ is the ending stock of palm oil and ε_t is the error term.

2.1 Model Estimation Method

Co-integration and general-to-specific approaches are utilized to model the above mentioned relationships. First, the variables must be tested for stationarity, since regressions between non-stationary variables may be subject to the problem of spurious regression. An important exception is where the non-stationary variables are integrated of orders one, or I (1), so that first-differencing makes them stationary. In this case there may be one or more co integrating relationships between the I(1) variables and the problem of spurious regression does not arise. In some cases, a difference stationary variable may also contain a deterministic trend, and this possibility must be considered in the co integrating regression. Second, it is necessary to determine which of the explanatory variables in the general model should be included in the final co integrating regressions. Third, given the existence of a co integrating or long-run equilibrium relationship, it is always possible to build an error correction model (ECM) (Granger, 1983; Engle and Granger, 1987) to specify the nature of the short-run disequilibrium relationship between the variables.

The literature on co integration estimation (and the related problem of testing for unit roots) is very extensive, and a number of estimation methods have been recommended, including the Engle and Granger (1987) procedure, Johansen's (1996) full information maximum likelihood procedure, Philips and Hansen's(1990) fully modified ordinary least squares (OLS) procedure and a relatively recent procedure known as autoregressive distributed lag (ARDL) procedure that uses the bounds test developed by Pesaran *et al.* (2001) for testing co integration, have been proposed in the econometric literature for investigating the long-run equilibrium relationship among time-series variables. The Engle- Granger method has been criticized in the literature for several weaknesses which include the following: (a) small sample bias due to the exclusion of the short-run dynamics, (b) the problem of normalization in systems with more than two variables and (c) the inability to test hypotheses in connection with the estimated coefficients in the long-run relationships. Although the procedures developed by Johansen and Philips and Hansen avert some of these problems, they (along with the Engle-Granger method) entail that the variables included in the model are integrated of order one i.e. the variables are I(1). On the other hand, the most important advantage of the bound test procedure it is applicable irrespective whether the underlying variables are purely I(0), purely I(1) or fractionally integrated.

Thus, we use the ARDL approach proposed by Pesaran and Shin (1999). In the first stage of this procedure we test for the presence of the long-run relation between the variables under check using the bounds test. If a stable long-run relationship is verified, then in the second stage, a further two-step procedure to estimate the model is carried out. In the first step of the second stage, the lag order of the ARDL model is selected by Akaike or Schwartz information criteria. In the second step, we estimate the parameters of the long-run relationship and the associated short-run dynamic error correction model (ECM)[2]. To explain the (BT), let us assume the error correction version of the ARDL model pertaining to the variables in equation (1) as follows:

$$\Delta p_t = \gamma_0 + \pi_{pp} p_{t-1} + \pi_{px,x} x_{t-1} + \sum_{i=1}^{\rho-1} \varphi \Delta y_{t-i} + \omega \Delta x_t + u_t \qquad (2)$$

where P represents the dependent variable (palm oil price), x represents the regressors (POST and PETP), y represent all the variables used in the specified model, π_{PP} and $\pi_{Px,x}$ are the long-run multipliers, φ_i and ω are the short-run dynamic coefficients and ρ is the order of the underlying model and the error term ($u_{t)}$ is uncorrelated with Δx_t and the lagged values of x_t and P_t. For specific significance level, if the computed *F*-statistic falls outside the critical bounds, conclusion can be reached without considering the order of integration of the explanatory variables. For example, if it is higher than the critical bound, then the null hypothesis of no cointegration is rejected and the next step is to estimate the ARDL ECM where the short-run and long-run elasticities can be determined. In the case when the *F*-statistic falls between the upper and lower bounds, a reliable conclusion cannot be made. Here, the order of integration for the explanatory variables must be known, through unit root test, before proceeding to the next step.

2.3 Forecasting Method

In order to project the changes in palm oil price we use the estimated long run elasticities obtained by estimating the model and we assumed constant growth rates for the crude oil price and stock level to the base month (December 2012). Given the increasing uncertainty in the world market variables the projections have been based on assumed low, moderate and high crude oil and stock level growth rates, to give guidance on the level of confidence to frame our projections. The rates are calculated as follows. Firstly, the assumed moderate growth rate for the variables refers to the average rate during the last year of the study period. Secondly, the standard deviation of the monthly growth rate during the same period have been subtracted from, and added to the moderate growth rates to obtain the assumed low and high growth rates respectively. Due to the high volatility of the variables in both cases, deducting the high standard deviation from the average growth rates produced negative results which suggest negative growth rates or decreasing trend. The projections are made under nine scenarios assuming different combinations of the assumed growth rates as shown in Appendix II.

2.4 Data Sources and Description

The sample period chosen for this study extend from January 2002 to December 2012. The price of palm oil refers to FOB price in North West European ports whilst the world average crude petroleum prices represent petroleum prices. Since sufficient precise monthly data on the aggregate palm oil stock is not available, and as the Malaysian palm oil stock (in tonnes) accounts for a big share in the global stocks, it is used as a proxy in this study[3]. All price variables are nominal (in USD per tonne) and they have been obtained from the International Financial Statistics (IFS) online service.

[2] For further details, refer to Section 18.19 and Lesson 16.5 in Pesaran and Pesaran (1997).

[3] Data on the world stock of palm oil is incomplete in particular before 2006.

3. Results and Discussion

3.1 Models Estimation Results

The first step in applying the bounds testing is to specify an optimal lag length for the UECM. The Schwartz Bayesian (SBC) and Akaike Information (AIC) criteria are used in this study to choose an appropriate lag order of the model specification with the maximum lag length set equal to 12. According to the results the lag length of 6 is selected. The bounds test F statistic obtained was 5. 9068 and the upper bound for Pesaran (2001) with two variables at 5% significance level is 4.9 and that of Narayan (2005) calculated with 80 observations and two variables is 5.043 at 5% significance level. Thus the existence of long relationship between the crude palm oil and the crude oil and palm oil stock is confirmed.

3.2 The Robustness of the Empirical Model

Having found a long-run relationship, the model is estimated using the Schwarz Bayesian Criterion (SBC) and Akaike Information Criterion for model selection. The SBC selected ARDL (2, 4, 6). In order to confirm the robustness of the model specification suggested in this study, several diagnostic tests are conducted. The diagnostic test statistics of the specified ARDL models are displayed in Table 1, attached to the Error Correction Model results. Furthermore, the Cumulative Sum of the Recursive Residuals (CUSUM) test for examining the stability of the model is conducted and its plot is displayed at the Appendix I. The model has a high degree of explanatory power, and it is free from misspecification errors. The plot of CUSUM examining the stability of the model is within the critical bands, rejecting any evidence of parameter instability. Those findings suggest that the price model used in this study is properly specified and verified its stability throughout the sample period and, accordingly; estimations of the long and short-run dynamics based on this model are reliable.

Table 1. Error Correction Representations for the Selected ARDL Models
(Dependent Variable = dlnPOP)

Regressors	Coefficient (t- Ratio)	Diagnostic Tests	
dlnPOP(-1)	.46141*** (5.3622)		
dlnPOST	-.058467 (-1.2594)	Serial Correlation(χ^2_{Auto})	17.5567[0.130]
dlnPOST(-1)	-.089798* (-1.8326)	Functional Form(χ^2_{Reset})	.098187[0.754]
dlnPOST(-2)	.18048 *** (3.8648)	Normality(χ^2_{Nor})	.69276[0.405]
dlnPOST(-3)	.094126 ** (2.1229)	Heteroscedasticity(χ^2_{Hetero})	.041431[0.839]
dlnPETP	0.30784*** (4.9259)	$\overline{R}^2$	0.98
dlnPETP(-1)	-.21058*** (-3.1096)		
dlnPETP(-2)	.026142 (.42404)		
dlnPETP(-3)	-.18588*** (-2.9710)		
dlnPETP(-4)	.036418 (.57510)		

dlnPETP(-5)	-.21624*** (-3.5277)
dC	1.2631** (2.5622)
ect(-1)	-.069394** (-2.5287)

Notes: d denotes the first difference of the variables; ect is the error correction term. Figures in parentheses below the coefficient values are the T-ratio values and numbers in square brackets are *p* values. Asterisks *, **, *** denote 10%, 5% and 1% significance level, respectively.

3.3 Estimating the Long-run Parameters

The static long-run model corresponding to palm oil price function is as follows:

$$\underset{}{\mathrm{Ln}pop} = \underset{(2.8442)}{18.2017^{***}} \underset{(-2.4782)}{-1.456\mathrm{Ln}cpost^{**}} + \underset{(4.2400)}{1.428\mathrm{Ln}petp^{***}}$$

Notes: Figures in parentheses below the coefficients are the t-Ratio values. Asterisks *, **, *** denote 10%, 5% and 1% significance level respectively.

Since we are estimating the double log (log linear) form of the models, the long run coefficients are the long run elasticities. The findings of the long–run (static) model estimations displayed above show that, the crude oil prices and the stock variables are significantly related to crude palm oil.

3.3 The Short-run Dynamics and the Adjustment towards the Long-run Equilibrium

The results of the Error Correction Model (ECM) corresponding to the selected ARDL model are displayed in Table 1. They reveal the following. The error correction terms were found to be highly significant and have negative signs, giving additional evidence as to the existence of long term causal relationships between the variables of all the equations. Meanwhile, the low magnitude of the lagged error correction term coefficient reflect a low rate of adjustment (7%) of the crude palm oil prices to the shocks in crude oil prices and stock changes.

3.4 Long and Short-run Elasticities

Table 2 summarizes the estimated long-run and short-run elasticities of the price with respect to the two variables. All the long-run elasticities are greater in absolute value than their short-run counterparts, which is consistent with economic theory. The crude palm oil price elasticities with respect both variables are highly elastic in the long run but not in the short run, which reflects high sensitivity of the price to these variables over time. The high elasticity of the price of palm oil with respect to crude oil price shocks suggests the growing importance of the crude oil factor in the palm oil price equation. This is certainly a new development to the normal framework of supply and demand analyses. The high negative elasticity with respect to opening stock level is consistent with the theory.

Table 2. Short and Long-run Elasticities

Short-run Elasticities		**Long -run Elasticities**	
Crude Oil Price	Stock Level	Crude Oil Price	Stock Level
0.3078	-.0584	1.456	1.4284

3.5 The Crude Palm Oil Price Projections

3.5.1 Model Validation Tests

In order to ascertain the adequacy of the assumed model in forecasting the palm oil prices, a simulation exercise was done to evaluate the predictive power of the specified model based on the results of the Theil's inequality coefficients (U) criteria. The simulation results (Table 3) reveal that the values of U is less than one, suggesting the superiority of the model over the naive no-change models. The value of U^M is very close to zero, indicating the non-existence of a systematic bias. Thus, revision of the model is not necessary. The value of U^S is also very small, which indicates that the model is able to replicate the degree of variability in the variables of interest. Furthermore, the value of U^C is large (close to one), suggesting the non–existence of unsystematic error in the model. The results of the stability tests discussed earlier, give further support of the adequacy of the estimated model for forecasting purposes.

Table 3. Historical Simulation Results of Selected Palm Oil Price Model

Test	U	U^M	U^S	U^C
Value	0.0174631	0.000012	0.00829	0.991700

Notes: U= Theil's Inequality Coefficient;
U^M =Fraction of error due to bias;
U^S = Fraction of error due to different variations;
U^C = Fraction of error due to different co-variations.

3.5.2 Projections

Appendix II displays the projected palm oil price under nine scenarios assuming different combinations of the assumed growth rates mentioned earlier. According to the calculated standard deviations and averages of the last year (January-December 2012) values of both series, the assumed rates for the stock levels are -6%, 1%, and 8% per annum respectively and those assumed for crude oil prices are -3%, 2%, and 7%.

All the forecasts are sensitive to changes in the assumed growth rates. Under Scenario 1, the low or negative growth of both variables is projected to increase the prices in 2013 by 2% from its previous year level. The second scenario of low and medium growth rates in the palm oil stock and crude oil price respectively, is expected to result in 61% increase in the palm oil price. Scenario 3 that assumes low growth rate in the level of stocks and high rate of growth in crude oil price projected to produce 156% increment in the palm oil price. Meanwhile, a moderate growth rate of the stock combined with low growth of crude oil price (Scenario 4) will decrease the price by 35%. Growing of both variables at medium rate will reduce the price by 15%. However, if the stock level maintains a medium rate of growth and the crude oil prices increase at the assumed high growth the prices are expected to increase by 32%. Under the seventh scenario that assumes a high rate increase in stock level together with low growth rate in the crude oil price, the palm oil prices are expected to dive by 58%. Under Scenario 8, assuming a high growth rate for stock level and moderate one of the other variable, the price will drop by 43%. Finally, the ninth scenario assuming high growth in both variables will produce 22% drop in the price. Reviewing the historical data on the palm oil prices over the last three decades, it is found that the maximum increase in the price recorded was 63% which occurred in 2007 and the maximum decrease of (-49%) was recorded in 1986. Therefore, we must bear in mind that extremes like 156% are unlikely as , in this study we assume constant growth rates in stock and crude oil prices while in real cases the governments and the industry may take counter measures to adjust to such excessive shocks.

4. Conclusion

All forecasts are invariably wrong but some give good clues and hints. There are many methods of forecasting involving both quantitative and qualitative approaches. The quantitative technique covers mainly econometric and time series analyses. This paper utilises the former method as it is relatively simple method to deploy and accurate over the short term. In this regard we have chosen an ARDL approach which has been proven to be efficient for short term projection.

The study chooses two major determinants that are highly correlated to the price movements of palm oil, specifically, crude oil price and palm oil inventory. The findings suggest that crude palm oil price both in the short and long terms, is causally related to changes in the two variables. Furthermore, the crude palm oil price elasticities with respect of the two variables are highly elastic in the long run which reflects high sensitivity of the price to these two determinants over time. This analysis implies that the movements of these two provide some indications on the expected price level of the crude palm oil. Of course, what will be the "realised" forecast is a function of multidimensional factors, beyond demand and supply which include weather, technical and geopolitical changes. A number of forecasts have been made by established international agencies such as *inter alia,* FAO and IFAD as well as web sites, companies and individual experts. There is no a clear agreement on the forecast as it depends on the assumptions made as well as the methodology chosen.

However, one definite implication of this analysis is that, with the growing competition of food and fuel use of palm oil, crude oil has become a pivotal variable in the market equation for palm oil specifically and vegetable oils at large. 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. With the growing interest in bio fuel, crude oil is an important factor to reckon with when one forecasts the future of palm oil. In short, the market link of palm oil has expanded to the energy sector, beyond the conventional agricultural supply and demand framework.

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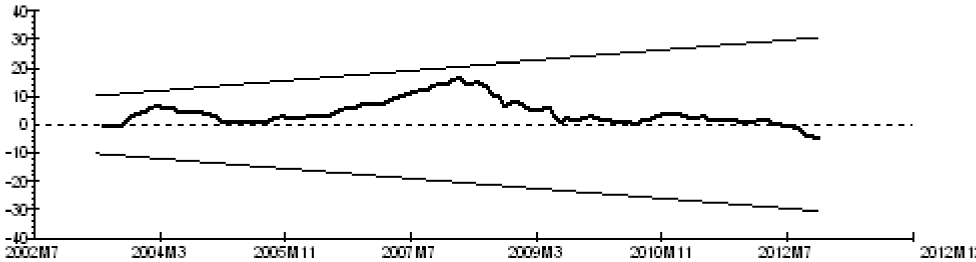
Appendix I. Plot of Cumulative Sum of Recursive Residuals



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

Appendix II. Crude Palm Oil Price Forecast in 2013 (USD/tonne)

Scenario	Stock GR (%)[1]	Crude Oil GR (%)	Average of 2013	Change[2]	Change (%)
1	-6	-3	1020.88	21.55	2%
2	-6	2	1606.97	607.64	61%
3	-6	7	2560.47	1561.14	156%
4	1	-3	652.98	-346.35	-35%
5	1	2	844.80	-154.53	-15%
6	1	7	1319.92	320.59	32%
7	8	-3	417.24	-582.09	-58%
8	8	2	564.86	-434.47	-43%
9	8	7	782.00	-217.33	-22%

Notes: 1) GR denotes the assumed growth rate.
2) Change refers to change from 2012 average price (USD 999.33/ tonne).