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The Price Discovery of the Malaysian Crude Palm Oil Futures Markets

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Abstract

This paper investigates the market efficiency of the Malaysian crude palm oil prices using data for the sample period spanning from 1998:01 – 2010:12. The univariate unit root test confirms that all series are non-stationary in their levels. The Johansen multivariate test provides empirical evidence for spot and futures prices are co-integrated. This implies that the market efficiency hypothesis can be easily rejected. The Error-Correction Model (ECM) also shows that there is a dynamics relationship between spot and futures prices. This provides further evidence that the crude palm oil prices do possess the price discovery function.

JEL classification numbers: G14, F36
Keywords: Market efficiency, price discovery, hedging, co-integration

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1 Introduction

Commodity futures' trading was formally introduced in Malaysia in October 1980 with two major purposes. Firstly, is to provide an efficient price discovery mechanism. Secondly, is to provide hedging facilities to market participants against the vagaries of price fluctuations. Prices of agricultural product have been found to be particularly volatile and susceptible to sharp fluctuations which expose producers and traders to increased risk in handling these products. Palm oil is currently the second most important vegetable oil in the world oils and fats market, accounting for 14.35% of world production of seventeen major oils and fats, ranking only behind soyabean oil, which contributed 20.23% of world output. In terms of world exports of oils and fats, palm oil is currently leading with a market share of 32% while soyabean oil has a share of 16.2%. Palm oil and palm kernel oil have become the production growth leaders in the oils and fats complex since the early seventies (Mielke, 1991).

The volume of crude palm oil (CPO) futures on the Kuala Lumpur Commodity Exchange (KLCE) or now on MDEX is slightly more than the production of the Malaysia palm oil. As the price of a palm oil is dependent on its consumption and the level of the stock, it is important to analyze these two variables simultaneously. The world stock or usage of palm oil usually higher than that of Malaysia, not only because of the large stocks in transshipment centers such as Singapore and Rotterdam, but also because of some consuming countries prefer to keep relatively large stocks (Mielke, 1991). It has become a common practice among major industrialized countries to use buffer stocks to stabilize the prices of agricultural commodities in the world market (Sarasorro and Gboroton, 1988), including palm oil. For countries like Malaysia which now depend on commodity earnings for a substantial portion of their inflow of foreign exchange severe fluctuations in prices could have unfavourable effects on the economy. The key feature of future markets is their ability to predict prices at a specific future date both efficiently and in unbiased fusion. Thus an empirical analysis of efficiency and unbiasedness is central to any assessment of the value of future markets. However, much attention have been focusing on issues relating to hedging strategies and the ability of futures markets to manage risk (Lapan and Moschini, 1994; Myers and Hanson, 1996; Sakong et al., 1993; Rosalan, 1995; Fatimah and Zainalabidin, 1991; Mad Nasir and Fatimah, 1992), rather less attention has been devoted recently to aggregate evaluations of market efficiency research (Kenyon et al., 1993; Milonas, 1994; A.J Aultan et al., 1997; Alexander,C. and Wyeth, J., 1992).

Previous research includes that are Oellermann and Farris (1985), Oellermann et al. (1989) and Koontz et al. (1990). However, these studies do not utilize co-integration techniques. They do establish empirical support for the concept of one market (i.e. the futures market) dominating another in terms of price discovery. The first two studies find that cattle futures prices play the leading price discovery role with respect to spot prices, and the third study demonstrates that this leadership role is time-varying.

Bessler and Covey (1991) investigates the relationship between cash and futures markets using co-integration analysis. They find weak evidence of co-integration between cash and nearby cattle futures prices. Their recognition of co-integration within the price discovery process is significant because previously-employed bivariate dynamic models used only first differences (and lagged first differences), thus resulting in model misspecification. These earlier models ignored the existence of intertemporal short-run adjustment to a long-run equilibrium relationship. Subsequent research, including Fortenbery and Zapata (1993), Fung and Leung (1993), Wahab and Lashgari (1993), Schwarz and Szakmary (1994), Beck (1994), and Hung and Zhang (1995), has confirmed the existence of co-integration between spot and futures prices and, as a consequence, utilized the properly-specified ECM.

Studies in agricultural economics have shows that the fluctuation of commodities prices is significant and persistent (Wilkinson, 1976; Brendt, 1985). According to Mad Nasir and Fatimah (1992), two of the salient features of agricultural commodities are the volatility and variability in prices. As far as volatility and variability of prices are concerned, the impact is more remarkable in the vegetable oils and fats market, notably palm oil, which is the most widely consumed edible oil in the world. If producers are in fact using futures prices as expected output prices when allocating resources, an assessment of the quality of the prices is important. Thus studies on the efficiency of futures markets have important implications on the issue of whether economics resources are being optimally allocated in the agricultural sector.

The research has two main objectives. First, to test for the market efficiency hypothesis for crude palm oil futures market in Malaysia, using the co-integration procedure due to Johansen (1988) and Johansen and Jeselius (1990). In this study no restrictions are imposed upon the long-run relationship between the spot and future prices. Instead we formally tested for the unbiasedness hypothesis using the likelihood ratio test. Second, is to investigate the lead-lag relationships (causality) between the spot and future prices using the Error-Correction Model (ECM) and Granger Causality. The next section discuss briefly on review of related literature, market efficiency and co-integration, methodology, data used empirical tests and finally the concluding remarks.

1.1 Review of related literature

There has been substantial empirical work, which has investigated the efficiency issue by testing the random walk model. Some of this work rejected the random walk hypothesis, for example, Stevenson and Bear (1970), Cargill and Rausser (1975), and Barnhart (1984); other studies accepted the hypothesis, for example, Larson (1960). Kamara (1982) noted that most of these studies found some evidence of serial correlation in futures prices in the short-run, but the evidence is not strong, and the result depend heavily on the technique as well as the sample period of the studies.

The literature survey indicates the increasing use of co-integration tests for studying the efficiency of futures markets (Kellard et al., 1999; Yang et al., 2001; McKenzie et al., 2002; McKenzie and Holt, 2002; Kellard, 2002; Liu, 2004; Wang and Ke, 2005). Wang and Ke (2005) elaborated the use of co-integration for exploring the efficiency in futures market as it provides predictive signal on price convergence. The co-integration between the spot price and futures price is a necessary condition for market efficiency. It ensures that there exists a long-run equilibrium relationship between the two series. The absence of co-integration implies that futures prices provide little information about movement in cash price, indicating that a futures market is not very efficient. The same approach has been used in the current study. After exploring the existence of co-integration between futures and spot prices, it is imperative to test the causality to assess the direction of relationship (Malliaris and Urrutia, 1998; Silvapulle and Moosa, 1999; Bryant et al., 2006). In the previous study, Granger causality test has been used to assess the direction of relationship between futures and spot prices (Bhattacharya, 2007; Kabra, 2007).

As cited by Liew and Brooks (1995) that Kok and Goh's (1994) study the random walk hypothesis in the Kuala Lumpur crude palm oil futures market, their results fail to find strong evidence against the random walk hypothesis. Mohammad Haji Alias and Jamal Othman (1997) used bivariate co-integration technique to determine the long-run relationship of palm oil price and the soybean oil price. Using quarterly data from 1980 through 1995 and Dickey-Fuller and augmented Dickey-Fuller to test for stationarity. The results showed that the time series on palm oil and soybean oil prices are co-integrated and each time series is non-stationary.

Owen et al. (1997) examine five major international traded oils: coconut, palm, palm kernel, soybean and sunflower to investigate the price inter-relationships in the vegetable and tropical oils market whether they are co-integrated or not. Using monthly data from 1971 through 1993, a vector autoregressive approach used to test for co-integration and augmented Dickey-Fuller and Phillips-Perron for unit root. The results showed that the relationships were not found to be strong enough to label them as co-integrated series.

Mukesh Chaudhry and Rohan Christie-David (1998) investigate the long-run stochastic properties of informationally linked futures contracts in diverge groups such as soft commodities, grain and oil seeds, livestock, precious metals, energy, foreign currencies, and interest-rate instruments. Using the Phillips-Perron test for unit root and Johansen's test for co-integration to analyse the monthly data covers the period July 1986 through March 1995. The results showed that most futures in the sample exhibit the presence of non-stationarity. The test for co-integration within groups provides strong evidence for soft commodities, precious metals, energy, and short-term interest rates. Weaker evidence for grains and oil seeds and livestock while foreign currency and long-term interest rate futures show evidence of segmentation.

2 Market efficiency and Co-integration

"*Efficient Markets*" are defined as markets in which asset prices always fully and instantaneously reflect all available information (Fama, 1970, p.383).This is the strong version of the "*Market Efficiency Hypothesis*". Related to this definition is the notion of the Efficient Market Hypothesis (EMH). The EMH describes an efficient market as one which consistently incorporates all information in determining prices. The three well-known assumptions of the EMH are:

(1) that there are no transaction costs;
(2) information is costlessly available to all market participants; and
(3) the implications of current information for both the current price and distributions of future prices are accepted by all market participants (Fama, 1970, p.389)

The implication of these assumptions is that, over the long run, no trader would earn more than average profits irrespective of the position on trading rule used in the market. In other words, if the markets are efficient, commodity prices do not follow any systematic pattern that could be the basis for excess profits.

The general formulation of the EMH is given as

$$E_t(S_{t+n} - F_{t,t+n} \mid \varphi_t) = 0 \tag{1}$$

where S_{t+n} is the market's prediction of the spot price at time $t+n$, $F_{t,t+n}$ is the future price quoted at time t for delivery at time $t+n$, ϕ_t is the information set at time t. Equation (1), therefore, suggests that $F_{t,t+n}$ should perfectly predict S_{t+n}, except for a purely random error. In other words, the futures price $F_{t,t+n}$ is an unbiased estimator of the spot price S_{t+n}, given the information available at time t when the futures price is quoted. Any systematic bias or any persistent pattern in the forecasting errors represents unexploited profit opportunities that may be extracted by utilizing the error pattern to enhance price prediction. A common starting point for empirical investigations of so-called market efficiency is

$$S_t = \alpha + \beta F_{t-1,t} + \varepsilon_t \tag{2}$$

where S_t is the spot price at time t, F_{t-1} is the price at time $t-1$ for the futures contract price, ε_t is a white noise error term and α and β are constant parameters. The majority of empirical investigations then focus on whether the data under investigation are consistent with the hypothesis that α is zero and β equals one (meaning that the future price does not consistently over-or under predict the spot price). This is what is commonly referred to as the unbiasedness hypothesis. More recently, empirical attention has turned to the statistical properties of the error term in (2); namely whether or not it is serially correlated (autocorrelation) (see Bera and Higgins (1993) and Bollerslev et al. (1992)). Unbiasedness presumes that ε_t has no systematic structure whatsoever; otherwise the forward or futures price cannot convey all relevant information embedded in the past history of the spot price.

A more fundamental problem, however, is that the validity of the hypothesis tests (i.e. $\alpha = 0$ and $\beta = 1$) may be seriously flawed if the time series data on which the tests are based are non-stationary. The possible non-stationarity behaviour of spot and futures price series raises doubts about the adequacy of conventional statistical procedures for inferential purposes. Engle and Granger (1987) have demonstrated that, on the assumption that non-stationary variables possess infinite variances which make the F-tests or t-tests invalid, standard hypothesis testing is no longer appropriate when the time series have unit roots. Applying Monte Carlo experiments, Elam and Dixon (1988) have also demonstrated that the F-test tends to be biased in favour of incorrectly rejecting market efficiency. In response to Elam and Dixon (1988), Shen and Wong (1990) suggest that the technique of co-integration developed by Engle and Granger (1987) may be used to test for market efficiency. The co-integration approach is attractive in that it can properly account for the nonstationarity in price series. Following Engle and Granger (1987), a test for an equilibrium relationship between S_t and $F_{t-1,t}$ proceeds as follows: estimate (2) as the co-integrating or equilibrium regression, and check its least squares residual for stationarity using a unit roots test. If the residual is found to be stationary, the null hypothesis of no equilibrium relationship between S_t and $F_{t-1,t}$ is rejected. A limitation of the Engle-Granger procedure is that no strong statistical inference can be drawn with respect to the parameters and which are of the main interest here. Although the coefficient estimator can be shown to be consistent, the estimated standard errors may be misleading for hypothesis testing (see Stock, 1987). In contrast, the Johansen procedure, applied in this study, can handle the problem of statistical inference in co-integrated systems. As discussed below, hypothesis tests on the co-integrating parameters, namely $\alpha = 0$ and $\beta = 1$ in (2), can be conducted using standard asymptotic chi-square tests under the Johansen approach.

In short, market efficiency implies that S_t and F_{t-1} are co-integrated, and for the co-integrating parameters, $\alpha = 0$ and $\beta = 1$. The test for market efficiency thus consists of two related part. The nonstationary series S_t and F_{t-1} are the first examined for co-integration. If they are found to be co-integrated, the restriction on the co-integrating parameters that $\alpha = 0$ and $\beta = 1$ is then tested under the condition of co-integrating using a likelihood ratio test.

2.1 Methodology

There are several unit root tests available in the literature to determine the order of integration of the individual series. However, the most widely used methods are Augmented Dickey Fuller test (ADF) which was proposed by Said and Dickey (1984) and Phillips and Perron test (PP) by Phillips and Perron (1988). In this study both the ADF and the PP are utilised in the analysis since Schwert (1987) has noted that the ADF statistics may reject the null hypothesis of unit root too often in the presence of the first order moving average process. However, recently Campbell and Perron (1991) have also shown that the ADF class of statistics has better small-sample properties.

Once we determine the order of integration of each series, the next step is to test for co-integration relationships among the series. The Johansen-Juselius is based on maximum-likelihood estimation is designed to test a number of linearly independent co-integrating vectors existing among the variables. The model also utilises the likelihood ratio test statistic that has an exact limiting distribution, which can be used to estimate co-integration relationships among a group of two or more variables. Besides it can estimate a number of linearly independent vectors, Perman (1991) pointed out that the advantage of Johansen-Juselius approach over E-G approach is that the procedure allows testing for linear restriction on the co-integrating parameters. The test statistic in the Johansen and Juselius also can be compared to known critical values.

2.2 Unit Root Test and Orders of Integration

The prerequisite condition for the series to be co-integrated is that the series must have the same order of integration. The order of integration of a series is determined by the number of times that the series must be difference before achieving stationary. A series, Y_t is said to be integrated of order *d* if the series achieves stationary after differencing d times and denoted as $Y_t \sim \mathrm{I(d)}$. For instance, if price series (Y_t) is not stationary at its level but becomes so after first differencing, (i.e. $Y_t - Y_{t-1}$ is stationary) we describe this as $Y_t \sim \mathrm{I}(1)$. If Y_t is stationary at its level before first difference, then we describe it as $Y_t \sim \mathrm{I}(0)$. Thus the very beginning step in the co-integration analysis is to determine the order of integration of the series.

There are several unit root tests available in the literature to determine the order of integration of the individual series. However, the most widely used methods are Augmented Dickey Fuller test (ADF) which was proposed by Said and Dickey (1984) and Phillips and Perron test (PP) by Phillips and Perron (1988). In this study both the ADF and the PP are utilised in the analysis since Schwert (1987) has noted that the ADF statistics may reject the null hypothesis of unit root too often in the presence of the first order moving average process. However, recently Campbell and Perron (1991) have also shown that the ADF class of statistics has better small-sample properties.

In testing the order of integration using ADF approach, the following two ADF regression equations could be estimated

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{i=1}^{L} \delta_i \Delta Y_{t-i} + \nu_t \tag{3}$$

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 T + \sum_{i=1}^{L} \delta_i \Delta Y_{t-i} + \tau_t \tag{4}$$

where ΔY_t is the first difference of the series, α_0 is intercept, α_1 and α_2 are constant, ν_t and τ_t are disturbance terms, *T* is time or trend variable and *L* is the number of lagged terms. To ensure disturbance term ν_t and τ_t are approximately white noise, a sufficient number of lagged differences *L* should be estimated. The optimum lag length *L* may be determined by using the Akaike Information Criteria (AIC) suggested by Akaike (1977).

The null hypothesis is that the level of the series, Y_t, contains a unit root

H_0 : Y_t is I(1), and the alternative hypothesis is that H_1 : Y_t is not I(1).

We reject the null hypothesis when α_1 is found to be negative and statistically significant. The rejection (or acceptance) of the null hypothesis is made by calculating a t-ratio of α_1 to its standard error. The critical value for the test is compared to critical values provided by Fuller (1979).

The unit root test in level is only necessary but not sufficient conditions for the series to be integrated of order one, I(1). To conform that the series is I(1), then the sufficient condition has to be tested using unit root test on the first difference for (3) and (4). The test is carried out by the following regression

$$\Delta^1 Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{i=1}^{L} \delta_{1,i} \Delta^1 Y_{t-i} + \nu_t \tag{5}$$

$$\Delta^1 Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 T + \sum_{i=1}^{L} \delta_{1,i} \Delta^1 Y_{t-i} + \tau_t \tag{6}$$

where $\Delta^1 Y_t$ is the first difference of the series. The null hypothesis is H_0: $Y_t \sim I(1)$, which is rejected in favour of I(2) if α_1 is found to be negative and statistically significant from zero. This test is known as unit root test in first difference.

Phillips Perron (PP) unit root test proposed by Phillips and Perron (1988) is more robust in the sense that PP allows for wide variety of serial correlation and time dependent heteroskedasticity. It is also has been considered to be powerful test to moderate and small sample size. The PP test estimates the following equations for a series Y_t,

$$\Delta Y_t = \mu_1 + \alpha_1 Y_{t-1} + \varepsilon_t \tag{7}$$

$$\Delta Y_t = \mu_t + \alpha_1 Y_{t-1} + \alpha_2 t + \varepsilon_t \tag{8}$$

where ΔY_t is the first difference of ΔY_{t-1}, t is trend variable. In (7), for Y_t to be stationary, the adjusted t-statistic $Z(t^*_\alpha)$ should be negative and significantly difference from zero. For Y_t to be stationary around linear trend in (7), the adjusted t-statistic $Z(\hat{t}_\alpha)$ should be negative and significantly different from zero. The critical values for PP tests are given in MacKinnon (1991). Like the ADF test, the PP test is also sensitive to the choice of truncated lag parameters. The criteria discussed in Schwert (1989) may be used to determine the appropriate lag length in the PP tests.

2.3 Johansen-Juselius Multivariate Co-integration Test

Once we determine the order of integration of each series, the next step is to test for co-integration relationships among the series. The Johansen-Juselius is based on maximum-likelihood estimation is designed to test a number of linearly independent co-integrating vectors existing among the variables. The model also utilises the likelihood ratio test statistic that has an exact limiting distribution, which can be used to estimate co-integration relationships among a group of two or more variables. Besides it can estimate a number of linearly independent vectors, Perman (1991) pointed out that the advantage of Johansen-Juselius approach over E-G approach is that the procedure allows testing for linear restriction on the co-integrating parameters. The test statistic in the Johansen and Juselius also can be compared to known critical values.

To illustrate this approach, let Y_t be a vector of N time series variables, each of which is integrated of order 1. Assume that Y_t can be modelled by the vector auto regression,

$$Y_t = \beta_1 Y_{t-1} + \cdots + \beta_k Y_{t-k} + \alpha + v_t, \quad \text{where } t = 1, 2, \ldots, T\,. \tag{9}$$

Here Y_t is $N \times 1$ vector of stochastic variables; all Y_{t-k} are assumed predetermined; α is a $N \times 1$ vector of constant; v_t is a vector of normal distributed error with zero mean and constant variance; and k is the maximum number of lag length processing the white noise. The lag length of k is chosen by using the Akaike Final Prediction Errors (FPE) criterion. In brief, the technique chooses the length which minimise the forecast error of the series. The following formulation is used;

$$FRE = \frac{T+k}{T-k}\sigma^2 \tag{10}$$

where T is the number of observations, k is the number of lags and σ^2 is variance.

The system of equation (9) can be rewritten in the first difference and in the reduce form as follows:

$$\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \cdots + \Gamma_{k-1}\Delta_{t-k-1} + \prod Y_{t-k} + e_t \quad (11)$$

where

$$\Gamma_1 = -\left[\mathrm{I} - \Pi_1 - \cdots - \Pi_i\right], \quad (i = 1,\ldots,k-1)$$

and

$$\Pi = -\left[\mathrm{I} - \Pi_1 - \cdots - \Pi_k\right].$$

Equation (11) is in the form of traditional VAR model of Sims (1980) in first differences except for the ΠY_{t-k} term. The matrix Π is called the long-run impact matrix. This term determines whether or not, and to what extend, the system of equation is co-integrated. The number of co-integrating vectors is determined by the rank of the Π matrix. If the value of the matrix Π is r, then there are r co-integrating relationships among the elements of Y_t. When r = 0, there is no long run relationship among the price series. In the case of $0 < rank(\Pi) = \mathrm{r} < \mathrm{p}$, where r is the rank of the matrix and p is the number of variables in the system, there exist one or more co-integrating relationship among the variables. Johansen's procedure is to determine the rank of the Π matrix by testing whether the eigenvalues of Π, the estimated of Π, are significantly different from zero. If the matrix Π is full rank, then any linear combination of Y_t is stationary. If $rank(\Pi) = 0$, the matrix Π is null matrix then equation (11) collapse to the traditional VAR model with first differences.

To test the null hypothesis that are at most r co-integrating vectors in a set of p variables, first regress ΔY_t on $Y_{t-1}, Y_{t-2}, \ldots, Y_{t-k+1}$ and output the residuals, D_t. For each t and D has an n element. Second, regress Y_{t-k} on ΔY_{t-1}, $Y_{t-2}, \ldots, Y_{t-k+1}$ and output the residuals, L_t. For each t and L_t has n elements. Then compute squares of the canonical correlation between the two residual, denoting them as Q_i^2 ($Q_1^2 > Q_2^2 > \cdots > Q_i^2$). The likelihood-ratio test of the null hypothesis is obtained by the trace test defined as;

$$\text{Trace Tests} = -T \sum_{i=r+1}^{p} \ln(1 - Q_i^2) \quad (12)$$

where T is the number of time period available in the data. The null hypothesis for trace test is that whether there is r or less co-integrating vector. The null of $\mathrm{r} = 0$ is test against the general hypothesis of $\mathrm{r} \le 1, \ldots, \mathrm{r} \le \mathrm{p}$. Equivalently we can also use the maximal eigenvalue test. The test is that there are *r*-co-integrating vectors in a set of p variables against $\mathrm{r} + 1$. In other words, the null of $\mathrm{r} = 0$ is test against the specific hypothesis of $\mathrm{r} = 1, \ldots, \mathrm{r} = \mathrm{p}$. It is defined as;

$$\text{Maximal Eigenvalue Tests } = -T\ln(1-Q_{r+1}^2) \quad (13)$$

The test statistics of the trace and maximum eigenvalues may be compared with the critical values provided by Osterwald-Lenum (1992).

2.4 Granger Causality and Vector Error Correction Model (VECM)

There is several causality degrees, which were proposed by Granger (1969) as widely used in the literature;
a. Unilateral,
b. Bilateral,
c. No relationship or Independence.
These definitions of degree of causality were based on the predictability of time series variables. The summary is as follow:

1. Unilateral
   If $\sigma^2(Y_t \mid A^t) < \sigma^2(Y_t \mid A^t - X^t)$, i.e. the prediction using past X is more accurate than without using past X, in the mean squares error sense, we say that X causes Y, denoted by $X \Rightarrow Y$.
2. Feedback or bi-directional
   If $\sigma^2(Y_t \mid A^t) < \sigma^2(Y_t \mid A^t - X^t)$, and $\sigma^2(X_t \mid A^t) < \sigma^2(X_t \mid A^t - Y^t)$, we say that feedback occurs, denoted by $Y \Leftrightarrow X$.
3. Independence
   If $\sigma^2(Y_t \mid A^t, X^t) < \sigma^2(Y_t \mid A^t)$, then the two series are temporally unrelated and therefore they are independent of each other.

However standard causality relationship suggested by Granger (1969) is only valid if the original series are not co-integrated. For the co-integrated series, any causal references derived from this standard test will be invalid. The argument lies under the proposition was, if the series are co-integrated, the relevant error-correction mechanism (ECM) obtained from co-integrating regression must be included in the standard causality test to avoid the problem of misspecification (see Granger 1986).

Engle and Granger (1987) provided a linking concept of co-integration and error correction mechanism (ECM) in solving misspecification problem. The concept is that in long term, the co-integrated time series variables that move together are in equilibrium but in the short run, there may be in disequilibrium. Thus for a co-integrated series there should be an adjustment mechanism that pushes back the variables to the long run equilibrium. This short run correction to equilibrium process to form long run equilibrium is known as error correction term (ECTs). In system of equations (vector) the ECTs are applied to capture the short run dynamic adjustment of co-integration variables. If there is one co-integrating factor in N endogenous variables, there should be one ECT. Each additional co-integrating factor contributes other additional ECTs.

Let Y_t be a vector of n component time series, each time series are I(0) after applying the differencing filter once, zero mean and purely nondeterministic stationary process. By the Granger Representation Theorem (E-G), if two or more series in Y_t are co-integrated of order r, then there exists r error correction representation. The restricted VAR enable us to have the following VECM formulation

$$\Delta Y_t = \sum_{i=1}^{n} A_i \Delta Y_{t-i} + \sum_{i=1}^{r} \zeta_i \Theta_{t-1} + v_t \tag{14}$$

where Y_t is an $n \times 1$ vector of variables, A's are estimable parameters, Δ is a difference operator, v_t is a vector of impulses which represent the unanticipated movements in Y_t and Θ contains the r individual error-correction terms derived from the r long run co-integrating vectors through the Johansen Maximum Likelihood estimation procedures.

The following VECM model could be derived from equation (14):

$$Y_t \equiv \begin{pmatrix} \Delta Y_{1t} \\ \Delta Y_{2t} \\ \vdots \\ \Delta Y_{nt} \end{pmatrix} = \begin{pmatrix} A_{11}(L) & A_{12}(L) & \cdots & A_{1n}(L) \\ A_{21}(L) & \cdot & \cdot & A_{2n}(L) \\ \vdots & \cdot & \cdot & \vdots \\ A_{n1}(L) & A_{n2}(L) & \cdots & A_{nn}(L) \end{pmatrix} \begin{pmatrix} \Delta Y_{1t} \\ \Delta Y_{2t} \\ \vdots \\ \Delta Y_{nt} \end{pmatrix} + \begin{pmatrix} \zeta_{11} & \cdots & \zeta_{1r} \\ \vdots & \cdot & \vdots \\ \zeta_{r1} & \cdots & \zeta_{rr} \end{pmatrix} \begin{pmatrix} \Theta_{1,t-1} \\ \vdots \\ \Theta_{r,t-1} \end{pmatrix} + \begin{pmatrix} c_1 \\ c_2 \\ \vdots \\ c_n \end{pmatrix} + \begin{pmatrix} \varphi(L) & 0 & \cdots & 0 \\ 0 & \varphi(L) & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & \varphi(L) \end{pmatrix} \begin{pmatrix} \zeta_{1,t} \\ \vdots \\ \zeta_{n,t} \end{pmatrix} \tag{15}$$

where the term $\varphi(L)$ is a finite polynomial in the lag operator L, such that $(L^m)\zeta t = \zeta t\text{-}m$ and the order $\varphi(L)$ is the same for the *n* equation in (11). The term Θ represents the error correcting adjustments that maintain the long run equilibrium relationship between series (Y_{nt}). The terms $\left[\zeta_{1,t} \quad \cdots \quad \zeta_{n,t}\right]$ are joint white noise processes and the c's representing a vector of constants.

A consequence of the relationships described by (15) is that if the term $\Theta_{1,t-1}$ is insignificant, Y_1 does not respond to differences from $Y_2, Y_3, \ldots, Y_n$ and Y_1 are considered exogenous within the system. Similarly, if $\Theta_{2,t-1}$ is insignificant, Y_2 is exogenous. The error correction terms in this system give an additional channel of Granger-causality so far ignored by the standard causality test. If the constant c_n in each system is statistically insignificant, this implies that the process is not generated by a linear trend. The significance of estimable A's indicating the short run granger causality between variables.

The hypothesis derived from the above discussion can be summarised as follows:

H_0: $\Theta_1 = \Theta_2 = \Theta_3 = \ldots = \Theta_n = 0$

H_1: $\Theta_{jk} \neq 0$, where j, $k = 1, 2, \ldots, n$

Null hypothesis states that Y_t does not respond to the previous period's deviation from long run equilibrium or there is no error correction representation in the model. Alternatively the hypothesis states that Y_t does respond to previous period's deviation from long run equilibrium or there is error correction representation in the model. Rejection of null hypothesis means the existence of error correction terms.

2.5 The Data

The two variables required are the spot price (SPT) and futures price. The futures price are the futures contract at 14 days(FPC), one month(FPM1),two months(FPM2) and three months(FPM3) before maturity. Each futures contract will mature at the 15^{th} of each month and if 15^{th} is a non-market day; the preceding business day is selected. There is only one contract for each month and thus for every month, only one futures contract will mature.

Futures price are collected from KLCE (COMMET) for contracts maturing at each month from Jan 1998 to December 2010, providing a total of 156 observations. Consecutively, the cash (spot) prices totalling 156 observations, with one cash price corresponding to one futures price, are gathered from the same period from MPOB Update Report. All price series are transformed into logarithm.

3 Empirical test

A prerequisite for a set of series to be co-integrated is that they should be integrated of the same order. Thus, the first step in the co-integration analysis is to determine the order of integration of each price series. Several methods are available to determine the order of integration of a series. Example are Dickey and Fuller (1979, 1981), Sim's Bayesian tests (Sim, 1980) and Phillip and Perron (1988). In this study, we utilised both Augmented Dickey-Fuller (ADF) (Said and Dickey, 1984) and Phillip Perron (PP) (Phillip and Perron, 1988) tests on the logarithms of each price series to determine the order of integration[4]. For each of these tests, two equations have been estimated, one with constant and no trend and second with constant and time trend.

Table 1: Tests of the Unit Root Hypothesis on Palm Oil Prices 1998-2010

	Augmented Dickey-Fuller		Phillips-Perron	
	t_μ	t_τ	$Z(t_{\alpha\mu})$	$Z(t_{\alpha\tau})$
A. Levels				
SPT	-1.6663(1)	-3.2951(1)	-1.4329(1)	-2.9861(1)
FPC	-1.4973(0)	-3.0359(0)	-1.6384(1)	-3.1476(1)
FPM 1	-1.2696(2)	-3.3345(2)	-1.3003(1)	-2.8946(1)
FPM 2	-1.1819(2)	-3.3019(2)	-1.2286(1)	-2.8725(1)
FPM 3	-1.1250(2)	-3.3002(2)	-1.1785(2)	-2.8795(1)
B. First Differences (Δ)				
SPT	-4.0969(5)*	-4.2404(5)*	-10.185(1)*	-10.273(1)*
FPC	-3.7890(6)*	-3.8798(6)*	-11.145(1)*	-11.222(1)*
FPM 1	-4.0148(5)*	-4.1648(5)*	-9.5492(1)*	-9.6525(1)*
FPM 2	-3.4788(9)*	-3.5501(9)*	-9.5075(1)*	-9.6200(1)*
FPM 3	-3.3656(9)*	-3.4524(9)*	-9.5685(1)*	-9.6866(1)*

Note: Augmented Dickey-Fuller (ADF) t_μ no trend;
t_τ with trend, Phillips-Peron $Z(t_{\alpha\mu})$ no trend;
$Z(t_{\alpha\tau})$ with trend. Critical value at 5 percent level is –2.86 for no trend and –3.41 for trend regression. The number in parenthesis is the optimum lag length;
ADF and PP use either autocorrelation or partial autocorrelation function criteria.
A single asterisk (*) indicates significant at the 5 percent level.

[4] The ADF was used in addition to the PP since Schwert (1987) has noted that the ADF statistics may reject the null hypothesis of unit root too often in the presence of the first order moving average process However, recently Campbell and Perron (1992) have also shown that the D-F class of statistics has better small-sample properties.

The test statistics of ADF (t_μ no trend; t_τ with trend), and PP ($Z(t_{\alpha\mu})$ no trend; $Z(t_{\alpha\tau})$ with trend) are compared with critical values given in MacKinnon (1991). To ensure the disturbance in all these equations are white noise, a sufficient number of lagged differences or truncated lag *l* have been estimated using Akaike information criteria (AIC).

Results of unit root test in level are presented in Table 1 the computed values of t_μ, $Z(t_{\alpha\mu})$, t_τ and $Z(t_{\alpha\tau})$ statistics in both time periods are all insignificant at the five percent significance level for both ADF and PP tests. The results fail to reject the null hypothesis of unit roots in their level form in the autoregressive representation of the price series, that is, they are all not I(0). Thus, implying that there is no possibility of the series to be stationary around a constant mean or around deterministic linear trend.

Unit root tests on the first difference on all series were also conducted. Table 1 shows the values of no trend t_μ and $Z(t_{\alpha\mu})$, and with trend t_τ and $Z(t_{\alpha\tau})$ statistics for both sub-periods are significant at the five percent level. Indicating the rejection of null hypothesis of the existence of a unit root for each of the price series in their first difference. Thus all the prices series needed to be differenced once in order to achieve stationarity and they are confirmed to be integrated of order one.

4 Labels of Figure and Tables

Given the common properties of the series, the next step in the analysis is to test for the presence of co-integration in one five-dimensional vector models of price series:[SPT,FPC,FPM1,FPM2, FPM3] In this study we employ the Johansen (1988), and Johansen and Juselius (1990) multivariate co-integration procedure to test for the presence (or absence) of co-integration relationships.

Results in the Table 2, suggest that both the **λ-*Max*** and ***Trace*** test are significant at 1 percent level for the null hypothesis of no co-integrating vector hypothesis (r = 0) for crude palm oil prices. In general, the more co-integrating vectors (i.e. the less common trends) in the system, the more stable the system and the more constrained the long run relationship among the variables. This implies that there is a strong long-run relationship between the spot price and the futures prices for the period under investigation. In other words, the price series are co-integrated. The fully integrated market implies that the price series do not adjust simultaneously to new information coming into the market. This shows the market efficiency hypothesis is rejected.

Evidence of co-integration does not imply the direction of causality among variables in the system and does not distinguish between short term and long term causality. We extend the analysis by using a five-dimensional vector error-correction modelling (VECM) to gain some insights into the short-run and long run lead-lag causal relationships between price series. The Akaike's Final

Prediction Errors (FPE) is used to determine the optimal lag structure in the VECM model (See Table 3). In all models the Q-statistics show the absence of serial correlation.

Table 2: Johansen-Juselius's Test for Multiple Co-integrating Vectors of Palm Oil Prices 1998-2010

Hypotheses		Test Statistics	
H_0:	**H_1:**	***λ-Max***	***Trace***
A: Vector : SPT FPC FPM1 FPM2 FPM3			
R = 0	r > 0	307.6**	506.9**
R ≤ 1	r > 1	113.4**	216.2**
R ≤ 2	r > 2	76.9**	102.88**
R ≤ 3	r > 3	23.38**	25.89**
R ≤ 4	r =5	2.51	2.51

Notes: The optimal lag structure for each of the VAR models is selected by using the Akaike's FPE criteria. Critical values are sourced from Osterwald and Lenum (1992).
** and * indicates rejection at the 1 and 5 percent critical values.

The dynamic VECM representation provides us with a framework to test for the causal dynamics in the Granger sense among the price series through both short-run and error-correction channels (ECTs) of causation. Short-run market causality test will determine whether spot price in different markets respond instantaneously to changes in future prices. The coefficient of the lagged error-correction term (ECTs) shows the portion by which the long-run disequilibrium in the dependant variable is being corrected in each short period to have stable long-run relationship. If both short-run causality coefficient and ECTs are insignificant, the market can be treated as exogenous to the system (see for example Masih and Masih 1997a and b).

The VECM results in Table 3, shows that, there is evidence of four co-integrating vectors that signal four ECTs embedded in the system. Secondly, short-run channels of Granger-causality are statistically significant at 5 percent in the price series. This suggests there is a causal relationship from the futures prices to the spot price. Thirdly, we find that there is a bidirectional flow of information of two-week future price(FPC) with the spot price(SPT) and unidirectional flow of information of one-month(FPM1),two-month (FPM2) and three-month (FPM3) futures prices with the spot price.

Table 3: Causality Results Based on Vector Error-Correction Model (VECM) of Palm Oil Prices 1998-2010

	ΔSPT	ΔFPC	ΔFPM1	ΔFPM2	ΔFPM3	$ECT[_{e1,t-1}]$	$ECT[_{e2,t-1}]$	$ECT[_{e3,t-1}]$	$ECT[_{e4,t-1}]$	A- R^2	SE
Dep. Variable							*t*-statistics				
ΔSPT	-	2.1754*	0.2500	0.6504	-0.8958	0.2685	-6.5138*	4.0836*	-1.8287	0.6186	0.0230
ΔFPC	-2.4402*	-	-0.9407	1.4242	-1.4367	1.4680	-10.0183*	5.1763*	-1.9919*	0.7628	0.0199
ΔFPM1	-2.4300*	1.7349	-	0.8571	-1.0197	1.2711	-5.1123*	2.1775*	1.6633	0.4301	0.0264
ΔFPM2	-2.4104*	1.5238	0.0916	-	-0.9182	1.0895	-4.6874*	3.1509*	-2.3430*	0.4307	0.0257
ΔFPM3	-2.6961*	1.5599	0.3377	0.6594	-	1.2645	-4.3624*	2.8658*	-2.1737*	0.3973	0.0258

NOTE: All variables are in first differences (denoted by Δ). VECM was estimated including an optimally determined criteria [Akaike's FPE].
**, and * indicates significance at the 1percent and 5 percent level.

5 Conclusion

The sustainability of agricultural commodity futures markets depends on the transparency and efficiency of its functioning in terms of price discovery, price risk management, flexible contact specification, controlling unfair speculation, commodity delivery system and coverage, infrastructural support, etc (Bryant et al., 2006). In this study, Johansen multivariate co-integration test and Error-Correction Model (ECM) were used to examine the market efficiency hypothesis. First, the results suggest that each price series is non-stationary in levels but stationary in first difference. This indicates that the crude palm oil spot and future prices are integrated of order one. Second, the spot and futures prices of crude palm oil are co-integrated. This implies that the crude palm oil prices are tied together in a long-run equilibrium relationship. Finally, Error-Correction Model (ECM) is used to study the dynamics relationship between spot and futures prices. The result shows that changers in the lagged crude palm oil future prices do effectively influence changers in the spot price. This provides further evidence that the crude palm oil future prices does possess the price discovery function, therefore future prices may be used by producers and traders as the relevant price signal for decision making purposes.

The findings in this study are useful for various stakeholders active in agricultural commodities markets such as producers, traders, commission agents, commodity exchange participants, regulators and policy makers. The direction of relationship between futures and spot prices show that in general, the direction of causality is stronger for futures prices to spot prices in case of Malaysian crude palm oil, suggesting futures prices tend to affect spot prices in the short run. Based on the analysis, it can be concluded that although futures markets play a greater role in the price discovery process, the price discovery in spot markets still exist for some of the commodities in the short run. Although there are several limitations in using co-integration test and Error-Correction Model (ECM) in analyzing efficiency in commodity futures markets, these techniques provide useful understanding of futures trading system in Malaysia. Major limitation in using co-integration test and Error-Correction Model (ECM) is much to do with the nature of time-series data and meeting the non-stationary requirements. It is also criticized that the Granger causality does not imply a cause and effect relationship in the strict sense. Kellard et al. (1999) argued that a limitation of existing tests is the rigid classification of markets as either efficient or inefficient with no scope to assess the degree to which efficiency is present.

The most important implication is that a good price transmission system is essential to ensure that future prices do not diverge from fundamentals. The futures market has to be closely related to actual demand and supply conditions in order for futures prices to be good indicators for the cash market. Therefore the government should take great care on the policy of replanting of palm oil trees, so that the production of crude palm oil can be enhance to reflect the price of the crude palm oil. Stock level of palm oil should be maintained in order the supply of palm oil to the market are at a consistent to the needs of the market so that it can be justified to the demand in order to maintained the price of crude palm oils. The potential uses of these findings are numerous. Hedgers may benefit from this information when deciding upon the appropriate futures contract to be used. They should be aware that any information about the supply conditions of the crude palm oils will have an effect on spot prices, which make it more concern in identifying the appropriate tools to analyse it. The co-integration results imply that it may be possible to hedge whether in the long term or short term in the Malaysian crude palm oil futures market in order to reduce their risks. Investors also have to realise that by hedging in the futures market can benefit them not only reduce losses but can diversify the risk to it. On the other hand, the causal relationships discovered in the studies may be useful to both traders and speculators in using their arbitrage opportunities between the cash (spot) and futures contracts.

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This paper examines the price discovery function of Malaysian crude palm oil futures (FCPO) before and after Shari'ah-compliance. The sample used in the study is composed of crude palm oil futures (FCPO) and crude palm oil (CPO) prices for the January 2007 until December 2011 period. The period is divided into two sub-periods: Period I (January 2007-July 2009) before Shari'ah-compliance and Period II (August 2009-December 2011) after Shari'ah-compliance.Â Furthermore, the study observes that the price discovery function of the crude palm oil futures market is increasingly more prominent after the Shari'ah Advisory Board (SAC) classified the product as Shari'ah-compliant (Period II) Â© Asian Academy of Management and Penerbit Universiti Sains Malaysia, 2015. Malaysia Palm Oil Prices are measured as the oil price in US Dollars per metric ton. Malaysia is one of the largest palm oil producers in the world, making it an important metric to look at when studying the Malaysian economy. Malaysia Palm Oil Price is at a current level of 1017.47, down from 1156.00 last month and up from 656.49 one year ago. This is a change of -11.98% from last month and 54.99% from one year ago. Report. Commodity Markets Review. Category. Agriculture and Livestock. This paper examines the price discovery function of Malaysian crude palm oil futures (FCPO) before and after Shari'ah-compliance. The sample used in the study is composed of crude palm oil futures (FCPO) and crude palm oil (CPO) prices for the January 2007 until December 2011 period.Â Furthermore, the study observes that the price discovery function of the crude palm oil futures market is increasingly more prominent after the Shari'ah Advisory Board (SAC) classified the product as Shari'ah-compliant (Period II). Keywords: Price discovery, crude palm oil futures, Shari'ah-compliant, Vector Error Correction model, Granger causality. INTRODUCTION.