Testing market efficiency of crude palm oil futures to European participants

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Abstract

Palm oil is the most consumed and traded vegetable oils in the EU and the world. Increasing non-food uses for vegetable oils in especially feedstock of biofuels in recent years have caused the price volatility to rise in both EU and global market. The most efficient pricing of crude palm oil (CPO) is to found on Bursa Malaysia (BMD), and it provides by far the world's most liquid palm oil contract. The goal of this study is to investigate CPO futures market efficiency of BMD for the European participants whose delivery location in EU. Both Johanson cointegration test and Vector Error Cointegration Mechnism (VECM) are conducted to test long-run and short-run efficiency test for the European spot market and four different futures forecasting horizons that are one week, two weeks, one month and two months. Evidence suggests that a long-run equilibrium relationship exists between the futures price and spot price for all forecasting horizons. The unbiasedness of futures price with respect to the spot price in the long-term can be approved for all but the forecasting period of two weeks. Furthermore, the short-term efficiency hypothesis is rejected for the forecasting periods of one week and two month but is approved for the forecasting periods of two weeks and two months.

Keywords: CPO, BMD, efficiency, futures, cointegration, VECM.

1. Introduction

Palm oil is a form of edible vegetable oil obtained from the fruit of the oil palm tree. It is the world's biggest vegetable oil crop, accounted for 22% of the world's oil and fats production ahead of soybean oil. Palm oil is the leading vegetable oil traded in the international markets. Palm and soybean oils together constitute around 68% global edible oil trade volume, with palm oil constituting 78%. Over 90% of the world's palm oil exports are produced in Malaysia and Indonesia. Traditionally, palm oil is still mostly used in the manufacture of food products, however, in the recent years, the non-food uses for vegetable oils in especially biodiesel are expected to become an increasingly important factor in future demand. The EU imports 17.9 percent of Malaysian palm oil and is therefore a significant market for Malaysian palm oil.1

Using biofuels have potential advantages: less greenhouse gas emissions, increasing the sources of income employment in rural areas and most importantly diversifying fuel supply sources. In general, biofuel can be produced from a large number of agricultural commodities. First, there is the group of conventional or "first –generation" biofuels which use grins, roots and tubers and vegetable oils as feedstock. Today, global biofuel consumption is dominated by ethanol which is derived primarily from sugar, maize and other starchy crops. biodiesel using vegetable oils as feedstock comes only second. However, in EU the biodiesel is growing stronger compared to ethanol with a current level of more than 6 million tons of biodiesel while ethanol production in Europe is about 3 million tonne. The main cost of producing biodiesel comes from the cost of feedstock. In EU and Finland the production of biodiesel very much relies on two kinds of feedstock: vegetable oil (mainly rapeseed oil) and palm oil. Rapeseed oil has been the major feedstock in production of biodiesel in EU due to the high level of public support provided in EU countries. In Finland, most feedstock used by the only biodiesel plant build by Nestel Corporation is mainly palm oil imported from Malaysia and Indonesia. In 2007, Nestel Corporation built the biggest biodiesel refinery in Singapore due to the close location to the palm oil producing countries. As a substitute and competitor of other vegetable oil, Crude Palm Oil (CPO) is of many unique features which is not be able to be substituted by other vegetable oil. Seeing Figures 2, we may agree that "In the absence of public support, rapeseed based biodiesel should not be competitive even on a long term basis" (Thoenes, 2006). In fact, during the last decade, the vegetable oil price especially rapeseed oil price has doubled due to the strong growth in demand of biofuels. Meanwhile, EU palm oil imports have already doubled during the 2004-2006 period, mostly to substitute for rapeseed oil diverted from food to fuel

[1] http://www.palmoiltruthfoundation.com/index.php?option=com_content&task=view&id=409&Itemid=300

uses. With respect to filling future gaps in EU food oil supplies, continuing expanding the diversion of domestic rapeseed oil into fuel uses would remain constrained by the limitations of the Blair House agreement (with a maximum production of 1 million tonnes of soybean meal equivalent on set aside land). Despite the 9 million ton increase in oilseed production projected until 2014, the EU will continue to remain a large net importer of oilseeds and vegetable oils (F.O.Lidchts, 2008) There is a growing trend of importing more palm oil in the future for the use of production of biodiesel. Therefore, the price of palm oil is becoming very important issue in the analysis of biodiesel price. How has the palm oil price behaved historically and how the palm oil m in countries like Malaysia affects the palm oil price in EU becomes very interesting (See Figure 1.)

(Insert Figure 1 here)

In general, agricultural producers, traders and other market participants apply futures prices to forecast price in the future in order to assist in making decision today (Schroeder and Goodwin 1991; Carter and Mohapatra, 2008). Thus, unbiased and efficient futures market provides unambiguously greater income risk insurance than perfect price stabilization (Newbery and Stiglitz, 1989). For CPO, commodity futures trading in Malaysia called Bursa Malaysia Derivatives (BMD) since 1980 has been acted as an efficient price discovery and hedging mechanism for the palm oil industry and other agricultural commodities in Malaysia (Fatimah at al., 1994). However, whether futures market in BMD to an EU or a Finnish biodiesel industry is efficient is unknown and never had research on it.

Futures market efficiency implies that futures price will totally reflect the expected future spot price with random risk error terms. It indicates that all new information is immediately incorporated into the expectations about future prices. The aim of this study is to test the efficiency of (BMD) futures market in crude palm oil sector for the participants in EU. An efficient futures market can provide effective signals for the spot market price in EU and minimize the arbitrage possibility of a speculator. Thus the futures price could reflect the equilibrium value for both suppliers and buyers in the market (Wang and Ke, 2005). The study could provide EU policy maker an alternative other than market intervention through policies; show oilseed producers if BMD futures market provide a reliable forecast of spot price in the futures, which may allow them to effectively manage their market risks in advance; If the futures forecast power is low, then decision making based on such forecasts will be adversely affected. At last, this study could give a view to traders of palm oil, in which they are able to see if there is arbitrage opportunity in this particular market.

2. Previous research and methodology review

Market efficiency has been very popular in both theoretical and empirical research in the context of either financial assets (Dwyer and Wallace 1992, Alexander 1999) or of commodities (Brenner and Kroner, 1995, McKenzie and Holt, 2002). Various futures markets have been tested throughout the years, but theses studies have mainly focused on developed commodity markets such as CBOT (Bigman et al. 1983, Liu, 2005) and NYMEX (Ripple et. al., 2005) for the corresponding commodity products (Carter and Mohapatra, 2008, Switzer and El-Khoury, 2006, Wang and Ke, 2005, Peroni and McNown, 1998). Only few studies have dealt with the developing markets. For instance, Wang and Ke in 2005 run the efficiency tests of agricultural commodity futures markets in China. Many studies have focused on the interaction between commodity futures prices and spot price in the same market with respect to different products (Singh and Shanmugam, 2007). The efficiency of futures market of palm oil products is rare. Fatimah et. al in 1994 examined the forward pricing efficiency of the local CPO futures market to the local traders, in which they concluded that BMD futures market is efficient. The futures market for a commodity is considered to be efficient, when the n-period futures rate (Ft, n) is equal to the future ready rate (St+ n). The efficient market ensures that the average difference between futures rate with n day maturity and the subsequent ready rate n days later is zero. The difference, if any, represents both the futures rate's forecasting error and the opportunity for gain (or loss) from open positions in the market" (Kumar, 2004). However, there has not been too much studied in the case when the spot market and futures market are located in different markets. In our case, when the participants are Europeans and the futures market in located in Malaysia.

One way of testing market efficiency is based on the research of Fama (1970), and further developed by Tomek and Gray (1970), Leuthold and Hartman(1979), and Martin and Garcia (1981). The form of the tests is called weak form market/speculative market efficiency:

$$S_{(t,n)} = \alpha + \beta F_{(t-i,n)} + \varepsilon_t \qquad (1).$$

Here, S_t and F_t represent cash price and futures price in respective; i represents the time before contract maturity date; n refers to the contract periods; α and β are the parameters, and ε_t is an error with the classical properties of a zero mean and constant variance. In this form, market efficiency requires that futures prices should be unbiased predictors of future spot prices. Therefore, simple empirical tests of market efficiency are based on tests of the joint hypothesis $\alpha = 0, \beta = 1$ in equation (1). Rejection of the restrictions imposed to the parameters α and β means that either the market is inefficient or a risk-free arbitrage exists in futures markets.

Nevertheless, this approach is widely criticized by neglecting the long-term tandem between the spot and futures price, thus the empirical tests turn often contradicting results. The other reason of the contradicting results by using equation (1) is that often the price series in commodity market are not stationary (Beck, 1994), then the standard statistical tests of simply regression analysis as (1) are not reliable (Elam and Dixon, 1988; Yang et. al 2001). Even though the stationarity problem could be solved by differencing the price series of equation (1) (Hansen and Hodrick, 1980), the result of such simple regressing is still misspecified if cointegration relationship between the future and spot price exists (Mckenzie and Holt, 1998).

If spot and futures prices are both non-stationary and require differencing to make them stationary, cointegration technique (Engle and Granger, 1987) is widely used due to the fact that asset price data are characterized by stochastic trends (Crowder et. al, 2003). Johansen (1991) and Johansen and Juselius (1990) further developed statistical procedures using Error Correction Model (ECM) for testing for long-run market unbiasedness. This approach has been widely recommended (Lai and Lai, 1991). The results of future market efficiency using have been unclear and remain somewhat confusing. Many confirm the efficiency of futures market especially in storable commodity futures markets such as grain (Rausser and Carter, 1983), livestock (Covey and Bessler, 1995; Fortenbery and Zapate, 1993; Garcia et. al, 1988) energy (Coppola, 2008), and financial futures markets (Leitch and Tanner; Hafer and Hein), others conclude that futures prices are not efficient forecasters of future spot prices, many of which investigate in non-storable commodities (Purcell and Hudson, 1985; Schroeder and Goodwin, 1991). There are various reasons for the failure of finding cointegration relationship between cash and futures, such as time series properties of the cost of carry (Yang et.al, 2001). Even though ECMs provide a convenient tools to distinguish futures market efficiency in long run and short run unbiasedness, it is not convincing in estimating the short-run efficiency through the empirical estimation of an ECM alone, Thus out-of-sample forecasting performance of ECM to futures is always recommended. (Mckenzie, 2003)

3. Data

The data used in the study consist of two time series: One is weekly European cash price, collected and cross-checked with trading agents by oilworld2 every Thursday during year 2001 and year 2007. The price is referred to the CIF forward price of the nearest shipment at north-west European harbors before tariffs and taxes3; the other is daily futures price data on crude palm oil (CPO) listed in BMD in Malaysia. The futures contracts in BMD include spot month and the next 5 succeeding months, and thereafter, alternate months up to 24 months ahead. The futures price is daily based spot month price listed in BMD. Both prices use USD/metric ton as the unit. Original data of futures price are valued of

[2] Thanks www.oilworld.org to provide the data

[3] Since the spot price is for delivery within the following one month, the cash price at the date matching the futures prices is not necessary at the same date. Thus, please note that the cash price series used in the paper represented the bst available data set

Malaysian currency Ringgit, and the exchange rate between Ringgit and US dollar is daily data provided by Forex Trading4

In this study, spot price is sampled on a monthly basis: every third week of each month from October, 2001 to August, 2007 to present the maturity spot price, and correspondingly CPO one month futures prices and two months futures prices during 2001 and 2007 are sampled. Futures market efficiency is tested for two-month horizon of two-month contract and for three horizons of one-month contract prior to contract maturity: 1 week; 2 weeks and 1 month. There are three reasons why one month and two month contracts were chosen: Firstly, preliminary analysis of data indicated that in terms of volume and open interest, one month and two month contracts were most actively traded contracts. Secondly, the prediction period from 1 week till two month can clearly see if the length of forecasting period could difference the result of efficiency test. Thirdly, delivery period of the cash prices is approximately one month, and one-month futures contract matches the cash prices the best. Taking the forecasting period of one month as an example (See Figure 2), futures price with one-month forecasting period is taken on 16th of October (first trading day of one-month contract in October), correspondingly the spot price is taken at the maturity date after one month, which is the closest date before the 15th of November, when the futures contract becomes matured. Using the same contract of one month futures, the futures price with forecasting period of one week is taken then one week before the maturity date, and the forecasting period of two week is taken two weeks before the maturity date.

Therefore, there are one cash price series and sampled futures price series, in which it consists of two month futures contract and one month futures contract with forecasting periods of one week, two week and one month. Constructing the pooled data series in this way provided us with price series consisting of 71 observations. Figure 1 plots the graph of four selected price series, in which the vertical ax represents the price/metric ton and the horizontal ax represents contract maturity time. To stabilize the data, the spot and futures prices are converted to logs and displayed in Table 1, labeled by LBMD 1wk_futures, LBMD 2wks_futures, LBMD 1m_futures, LBMD 2m_futures and LSpot price_EU.
(Insert Table 1 here)

4. Methodology and results

As discussed earlier, error-correction model compared to the classic equation (1) provides more satisfactory methods for efficiency test especially on the applications in circumstances where data are non-stationary. Thus in this chapter, the first stage of test is to examine stationarity properties of the univariate time series of futures and spot price and result is displayed and explained in chapter unit root test. Then it is followed by cointegration test , long-term efficiency test and short-term efficiency.

4.1. Unit root test

If the both price series of futures and spot are non-stationary and integrated with the same order, then cointegration technique provides a suitable method to investigate the long-term and short-term market efficiency tests. Therefore, the first of stage of the research is to examine stationarity properties of the univariate time series of futures and spot price.

Several procedures exist to test for the presence of unit root in time series data. The most commonly applied is the Augmented Dickey and Fuller (ADF)(1976), and a test developed by Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (1992). While the ADF test states the null hypothesis of non-stationarity or the presence of a unit root, the KPSS test defines stationarity as the null. The Monte Carlo simulations by Schwert (1989) showed that the ADF tests have low power and are sensitive to the choice of lag-length. The unit root tests are known to have low power problems in small samples, particularly, if the series include structural breaks (Kwiatkowski et al.1992; Leybourne & Newbold 2000). As a result, rejecting the null hypothesis does not necessarily imply acceptance of a unit root. The KPSS tests, on the other hand, have good power properties in identification of unit root for the series with. Since neither unit root tests are without some statistical shortcomings, in terms of size and power properties, two alternative unit root tests are applied to statistically determine the order of integration of the time-series used in cointegration analyses.

[4] See. http://www.oanda.com/convert/fxhistory

The results of unit root test including both intercept and linear trend are listed in Table 2. All the ADF test results cannot reject the null hypothesis of nonstationarity at 5% significant level. In the KPSS test BMD 2m_futures reject the null hypothesis of stationarity at 5% level when intercept and linear time trend are included, but it cannot rejected as the critical value extends to 10%. Combining ADF and KPSS unit root tests together, we can draw a prudent conclusion that all the price series are non-stationary in level. Furthermore, unit root tests on the first differencing prices are also performed. The results shows that first differencing is adequate to render the series statationary[5], which indicate that each of the price series is I(1). (Insert Table 2 here)

4.2. Cointegration Test

Given that the cash and futures prices are both nonstationary and I(1), Johanson's cointegration techniques (Johanson 1991, 1995) can be used to identify the long-term cointegration relationship between two prices. Johansen's tests is conducted through vector error correction model (VECM) specified as follows

$$\Delta Y_t = \Pi Y_{t-1} + \Psi X_t + \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \qquad (2),$$

where Y_t here is an (2×1) vector of I(1) dependent variables (cash and futures prices); X_t is a vector of deterministic variables such as linear trend and seasonal trend etc. In our case we include linear trend as the clear upward linear trend can be visualized from Figure 1. $\Delta Y_t = Y_t - Y_{t-1}$; ε_t denotes a (2×1) vector of innovations, assumed to be serially uncorrelated with zero mean and constant variance. $\Pi, \Psi,$ and Γ are the coefficient matrices. Π is a matrix of the form $\Pi = \alpha\beta'$, where α and β are both ($2\times r$) matrices of full rank. β containing the r cointegrating relationships is called a cointegrating vector and α carrying the corresponding adjustment coefficients in each of the r vectors is called as a loading factor. Thus, the cointegrating relationship can be determined by examining r , i.e. the rank of Π equals the number of cointegrating vectors (Johanson, 1990). $r < n$, where n is the number of price series, which is two in this study. In practice, Johansen (1988) proposed two sequential likelihood ratio tests to determine the cointegration rank, which are trace statistic denoted by LR_{tr} and maximum eigenvalue statistic denoted by $LR_{\max}$. The trace statistics is shown in function (3)

$$LR_{tr}(r \mid k) = -T\sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i) \qquad (3),$$

where $\hat{\lambda}_i$ denote the i-th largest eigenvalue of the matrix Π in function (2). The maximum eigenvalue statistic tests the null hypothesis of r cointegrating relations against the alternative of $r+1$ cointegrating relations. This test statistic is computed as function (3):

$$LR_{\max}(r \mid r+1) = -T\ln(1-\lambda_{r+1}) = LR_{tr}(r \mid k) - LR_{tr}(r+1 \mid k) \qquad (4),$$

for r=0, 1, 2….., k-1.

In details, Johanson tests according to equation (3) and (4) could test both unrestricted model (with trend) and restricted model (without trend). Thus, the test for futures and cash market cointegration, where n=2, becomes the test for the null hypothesis: r =0 and r =1 with trend and without trend, starting without trend. If r =0 is rejected and r =1 cannot be rejected, then cointegrating relations is found between the futures and spot market. Otherwise, if r =0 cannot be rejected, then there is no cointegration relationship between the futures and cash market.

The result of Johanson tests is listed in Table 3. Akaike Information were used to determine the optimal order of lags (number of p), it suggest that the best specification is p= 1 for two weeks, one month and

[5] The unit root test results of first difference are not reported but are available upon request.

two month forecasting periods, p=3 for one week forecasting periods. Both Trace and Max-Eigen test statistics result suggest that cointegration relationship between futures and spot price is found significant for all the forecasting period with linear trend included at 1% significant level. Therefore, long-run equilibrium relationship is confirmed between CPO's spot price in the EU and futures price in BMD for all the investigated forecasting periods.
(Insert Table 3 here)

Cointegration relationship between the CPO futures and spot prices only satisfies a necessary condition for market efficiency (Hakkio and Rush, 1989, Schroeder and Goodwin 1991[6], Zapata and Fortenbery, 1996). Given cointegration relationship, the market efficiency requires still two conditions: Long-term efficiency and short-term efficiency tests. (Carter and Mohapatra, 2008; Alizadeh and Nomikos, 2004). To be able to separates out the short-term and long-term components, error correction model derived from (2) is used here.

$$\Delta Y_t = \alpha(\beta' Y_{t-1} + \beta_0 + \beta_1 t) + \Phi_0 + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \quad (5),$$

where Y_t here is an (2×1) vector of I(1) dependent variables (spot and futures prices). Equivalent to ΠY_{t-1}, $\alpha\beta' Y_{t-1}$ is considered as long-term equilibrium component, i.e. it represents long-term cointegration relations. Short-run component $\sum_{i=1}^{p-1}\Gamma_i \Delta Y_{t-i}$ in function (5) is the same as function (2), measuring short-term adjustment component. Thus, the efficiency tests can be carried out through a series of hypothesis tests on the parameters on (5). To further clarify the vector form, function (5) could be represented as follows.

$$\begin{bmatrix} \Delta y_t^{spot} \\ \Delta y_t^{futures} \end{bmatrix} = \begin{bmatrix} \alpha_{spot} \\ \alpha_{futures} \end{bmatrix} \left(\begin{bmatrix} \beta_{spot} \, \beta_{futures} \end{bmatrix} \begin{bmatrix} y_{t-1}^{spot} \\ y_{t-1}^{futures} \end{bmatrix} + \beta_0 + \beta_1 t \right) + \begin{bmatrix} \phi_0^{spot} \\ \phi_0^{futures} \end{bmatrix}$$

$$+ \begin{bmatrix} \varphi_{11}^{spot} \, \varphi_{12}^{spot} \cdots \varphi_{1i}^{spot} \, \varphi_{11}^{futures} \, \varphi_{12}^{futures} \cdots \varphi_{1i}^{futures} \\ \varphi_{21}^{spot} \, \varphi_{22}^{spot} \cdots \varphi_{2i}^{spot} \, \varphi_{21}^{futures} \, \varphi_{22}^{futures} \cdots \varphi_{2i}^{futures} \end{bmatrix} \begin{bmatrix} \Delta y_{t-1}^{spot} \\ \Delta y_{t-2}^{spot} \\ \vdots \\ \Delta y_{t-i}^{spot} \\ \Delta y_{t-1}^{futures} \\ \Delta y_{t-2}^{futures} \\ \vdots \\ \Delta y_{t-j}^{futures} \end{bmatrix} + \varepsilon_t \quad (6).$$

[6] Check (Carter and Mohapatra, 2005)

4.3. Long-term efficiency tests

According to function (6), normalized cointegrating vectors (normalization on spot price) β contains the long-run equilibrium of the cash and futures palm prices; loading factor α determines the speed of adjustment toward long-run equilibrium. If the value α is close to zero, it means that it takes a long period of time for the series to revert to their long-run equilibrium after a shock. The results of the α and β for are listed in Table 4.

The cointegrating coefficient β on the futures price series for all the forecasting periods from one week to two month are likely to be close to -1 and significantly different from zero at 5% level, which satisfies the necessary condition of the hypothesis of unbiased futures prices. However, all of values of the loading factor α on futures series and the values of α on spot price series for the forecasting period less than one month turn significantly positive at 5% significant level. These results imply that for the forecasting periods less than one month in a long-term futures price and spot price interact closely with each other in adjustment toward equilibrium after a shock. In this case, both the futures price and spot price play an equal role in correcting the disequilibrium that is created from previous period's deviation in the long run. The insignificant figures of α on spot price series for the forecasting periods of one month and two month suggest firstly that for these two forecasting periods, the futures price plays a major role in adjustment toward equilibrium after a shock; secondly, the spot price does not adjust significantly to the equilibrium when a short-run shock comes cross.

Under cointegration relationship, two important conditions for the long-term efficiency test of futures prices are also required for efficiency test: one is the futures prices should be unbiased forecasts of cash prices, and the other is that futures prices should be weakly exogenous of the spot price in the long-run. Long-run unbiasedness of futures price implies that the coefficients of the long-run vector β = (β_{spot}, $\beta_{futures}$) = (1, -1) specified in equation (6). Weak exogeneity of futures price means that futures oil prices as exogenous is based on the assumption that it is the price of futures oil that determines spot prices in EU, and the changes in futures prices will map directly to spot prices whilst changes in spot prices are not thought to feeding back to futures prices. In other words, the futures price should lead spot price. Thus, the weak exogeneity test can be examined by imposing restriction on the parameters of the assumption $\alpha_{futures}=0$ and $\alpha_{spot} \neq 0$ in. At last long-run unbiasedness and weak exogeneity test are estimated though joint hypothesis tests of β =(1,-1) and $\alpha_{futures}=0$.

The results of two conditions are listed in Table 4 and Table 5. From Table 4, the hypothesis test of β = (1,-1) cannot be rejected at 5% significant level for all the forecasting periods but for the forecasting period of two weeks. The result supports that BMD palm oil futures price as an unbiased predictor for the European spot price in the long-run for most of forecasting periods. For forecasting period of two week, the evidence is not significant. However, many argued that the unbiasedness hypothesis may be too strong to imply market efficiency. Especially when the delivery location is far from exchange market, the existence of transaction cost such as risk premium, a transportation cost and insurance cost will cause the rejection of β = (1,-1) (Wang and Ke, 2005).

(Insert Table 4 and Table 5)

The weak exogeneity hypotheses test results are listed in Table 5. The weak exogeneity can be found only in the forecasting period of one month for spot price. Only the result for the forecasting period of two week rejects the exogenity hypothesis for both spot and futures prices at 5% significant level. Others found long-term weak exogeneity of spot price. For forecasting period of two week, spot price and futures price interact with each other in order to be able to reach a long-run equilibrium. Thus, there is not a clearly real price leader between two price series. In comparison, the assumptions $\alpha_{futures}=0$ and $\alpha_{spot} \neq 0$ are rejected for both forecasting period of one week, one month and two month, which suggest that for these forecasting periods, the spot price that leads the futures prices in the long-run. In short, the weak exogeneity hypothesis test results suggest two things: One is the rejection of weak exogeneity hypothesis for the forecasting period of two weeks; the other is the evidence of the weak exogeneity of spot price instead of futures price for the forecasting period of one week, one month and two month. These two implications together with the previous result shown in Table 3 suggest that CPO futures price is not weakly exogenous with respect to CPO spot price of EU. Thus it is inconsistent with an efficient market under which the futures price should lead spot price.

Table 5 displays also the results that combine both weak exogeneity hypotheses and unbiasedness tests. For all of the forecasting periods but forecasting period of two week, the hypotheses of long-run weak exogeneity of spot price and unbiasedness cannot rejected at 5% significant level. It further implies that in the long-term, it is the spot price lead the futures price. For the forecasting period of two week, there is no price leader. All of the result suggest that there is indeed market inefficiency in the long-run, the cause of market efficiency may be caused by the far distance between the futures market and delivery location. Noticeably, the price discovery function of a futures market for the European participants is weakened by the fact that the spot market information in EU does have a large impact on the future market in BMD.

4.4. Short-term efficiency tests

Apart from long-term equilibrium test, short-term efficiency test may tell us about the direction of causality of futures prices to spot prices or spot prices to future prices. The test can be carried out through hypothesis tests on if the lagged explanatory variable coefficients φ_{1i}^{spot} and $\varphi_{2i}^{futures}$ equal to zero. If the futures market is efficient, the coefficient of lagged spot and futures prices difference should not be significant, i.e. the past information of either futures market or spot price cannot be provide any forecasting power in the current spot/futures prices.

The result of short-term efficiency test is shown in Table 6. Regarding the impact on changes in futures/spot prices from lagged differenced form of spot/futures prices, the results are mixed. In details, for the forecasting period of one week, bivariate short-run causality is found significant in both directions – i.e. lagged difference spot prices affecting futures prices and lagged differenced futures prices affecting differenced spot prices; for the forecasting period of two week and one month, however, no short-run causality is found in either way – i.e. lagged differenced spot prices and differenced futures prices show no interaction between each other in the short-run; for the forecasting period of two months, short-run causality is found significant only in one way as the significant level is extended to 10%– i.e. lagged differenced spot prices affecting differenced futures prices but not the other way around. The implications of results above can be listed as follows: Firstly, for the forecasting period of one week, which is the shortest in this study, the result shows that the short-run interaction between futures prices and spot prices were significant and exist in rather long period (lag 3). It indicates that short time before the contract matured time, the speculation and over trading behavior become likely increasing, thus the past information becomes useful for predicting the current spot/futures price, which bring inefficiency into the market. Thus the futures market during this time in the short-run is the most inefficient. Secondly, for the forecasting period of two month, it shows that in the short-run the futures prices lead movements in the spot price, but the spot price does not lead the futures price. Thus the market in short-run still exist inefficiency, however, the magnitude of inefficiency is much smaller than the forecasting period of one week. Thirdly, for the forecasting period of two weeks and one month, the hypotheses of both the lagged spot price differenced terms in the futures equation and the lagged futures price differenced term in the spot equation are jointly zero cannot be rejected at the 1% significant level . The results suggest that all the relevant information from past prices is incorporated into current futures prices, which is consistent with the short-run efficiency hypothesis, thus the futures contracts for the forecasting periods of two weeks and one month are found efficiency for the European participants in the short-term. Noticeably, for the forecasting period of two month, both long-term and short-term efficiency test suggest that the spot price in EU lead the futures price. It clearly implies that at least for the forecasting period of two months the futures market BMD for the European participants has not behave as an efficient market, thus the role of the futures market BMD as a price discovery can not be played properly.
(Insert Table 6)

For all the forecasting periods, the residual tests including serial residual Lagrange Multiplier test LM and White's heteroskedastic tests also were conducted. The result is displayed in Table 7. No serial residual is found significant. White's heteroskedastic tests indicate possible heteroskedasticity for the forecasting period of one week and two weeks, so all *t* and Wald statistics were calculated using White's heteroskedastic-consistent standand errors.
(Insert Table 7)

5. Conclusion

Palm oil is one of the most important oilseed oil in the global market. The growing demand of palm oil caused by the increasing biofuel consumption and the unique feature of palm oil as a food oil had driving the price of palm oil up during last 5 years until the recession hit the global market at the end of 2008. Theoretically, the futures prices are considered as the best price discovery mechanism and unbiased predictor for the expected spot price if the futures market is efficient. Consequently, futures participants could transfer and hedge the price risk in futures market in the long-run. Malaysia is the one of the biggest palm oil producer, and futures of crude palm oil listed in Bursa Malaysia Derivatives (BMD) is considered as the most efficient futures exchange. Europe, as one of the biggest importer of palm oil has no futures market for it, most of the hedging decisions and price prediction are based on the futures price listed in BMD. Thus, the purpose of this research is to test the efficiency of the crude palm oil futures contracts listed in BMD for the European participants.

The empirical results in this research show the hypothesis of unbiasedness of futures with respect to the spot price cannot rejected for most of tested samples in the long term, which implies that the CPO futures prices in BMD futures market is an unbiased predictor of spot price in the long-term. Nevertheless, the paper also find the futures market of BMD is still not a very efficient market for the European market. The reason is that the research found in both short-term and long-term efficiency test that the European spot price has strong tendency to lead the CPO futures prices for many forecasting periods. The result is inconsistent with an efficient market under which the futures price should lead spot price. It suggests that in these cases European participants could use the advantage of pricing signaling and even make arbitrage out of it. It also implies that Europe shall bear more responsibilities in the development of palm oil futures market. Finally further attention has to be drawn on the price volatility in examining futures market efficiency. Using price volatility methods may offer additional means to further study the hedging opportunity in BMD for the European participants.

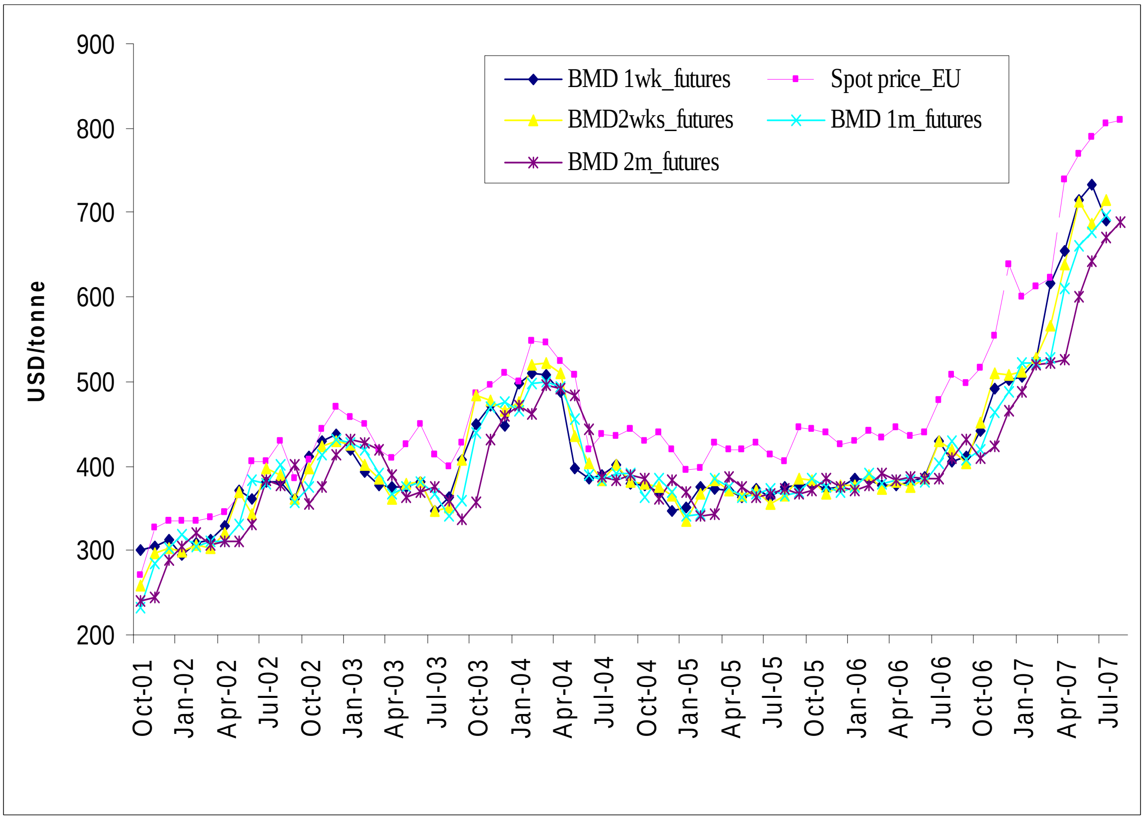

Figure 1. EU spot price versus BMD future prices of CPO with various forecasting periods.

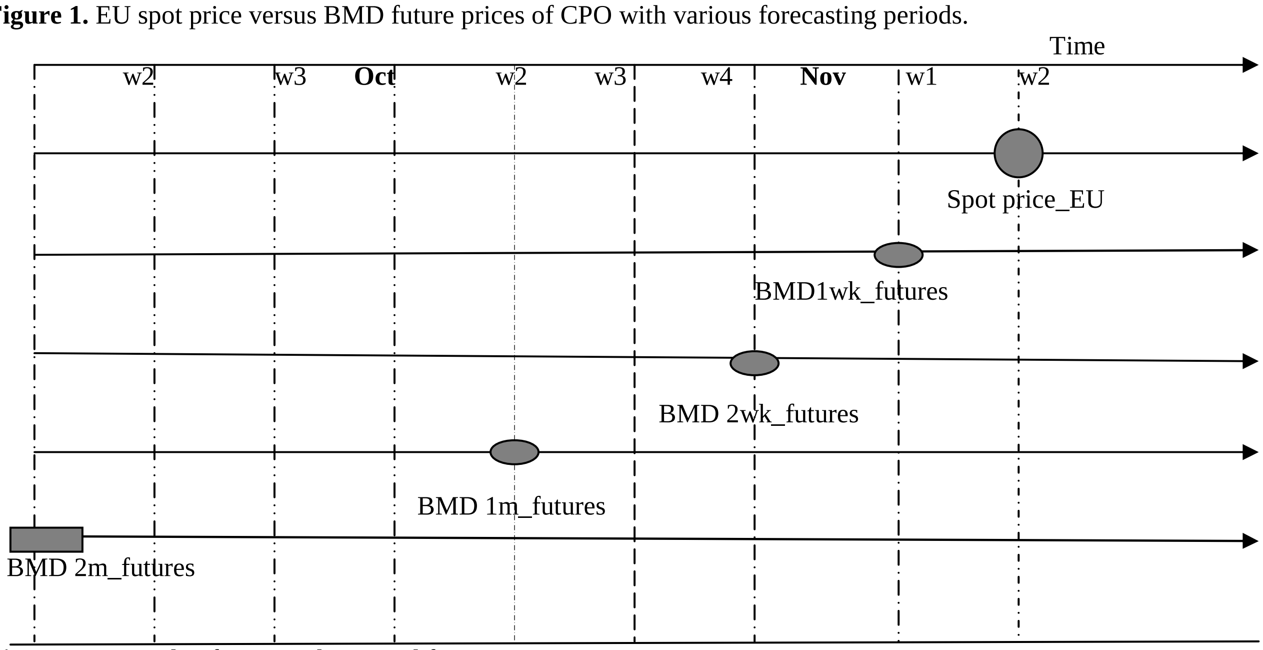

Figure 2. Example of extracted spot and futures prices

Table 1. Descriptive statistics of Spot and futures prices

	Spot price_EU	1wk_futures	2wk_futures	1m_futures	2m_futures
Mean	6.124	6.013	5.997	5.975	5.983
Median	6.082	5.940	5.951	5.948	5.953
Maximum	6.697	6.599	6.572	6.547	6.535
Minimum	5.598	5.687	5.468	5.451	5.481
Std. Dev.	0.213	0.203	0.209	0.200	0.195
Skewness	0.843	1.225	0.623	0.442	0.481
Kurtosis	4.248	4.337	4.122	4.412	4.334
Jarque-Bera	13.03	23.04	8.31	8.21	8.00
Observations	71	71	71	71	71

Note: Sample period is from October, 2001 to August 2007

Table 2: Unit root tests result

	Intercept included	Intercept and linear time trend included
Price Series	Test statistics[1)]for ADF t test[2)]	Test statistics[3)] for ADF t test
Spot price_EU		
BMD 1wk_futures	-0.32	-0.96
BMD 2wks_futures	-0.99	-1.59
BMD 1m_futures	-1.09	-1.53
BMD 2m_futures	-0.32	-0.93
	Test statistics[4)]for KPSS LM test[5)]	Test statistics[6)] for KPSS LM test
Spot price_EU		
BMD 1wk_futures	0.67**	0.14*
BMD 2wks_futures	0.51**	0.14*
BMD 1m_futures	0.52**	0.13*
BMD 2m_futures	0.56**	0.13*

Note: [1)]Critical values at 1%, 5% and 10% are -3.53,-2.9, and -2.59 respectively;
[2)] ADF test hypothesis H_0: Series has a unit root;
[3)]Critical values at 1%, 5% and 10% are -3.17,-3.48,-4.09 respectively;
[4)]Critical values at 1%, 5% and 10% are 0.21, 0.15 and 0.12 respectively;
[5)] KPSS hypothesis H_0: Series is stationary.
[6)]Critical values at 1%, 5% and 10% are 0.216, 0.146 and 0.119.

Table 3. Test for cointegration between the spot and futures prices with linear trend included

	LR_{tr}		LR_{max}	
	H_0: $r = 0$	H_0: $r = 1$	H_0: $r = 0$	H_0: $r = 1$
1 week (lag = 3)	28.87**	2.55	26.32***	2.55
2 weeks (lag=1)	34.78***	1.91	32.87***	1.91
1 month (lag=1)	40.56***	1.64	38.90***	1.65
2 month(lag=1)	32.66***	1.64	31.02***	1.64

Note: Critical values are from MacKinnon-Haug-Michelis (1999). (**),(***) represent 5% and 1 % significance level respectively.

Table 4. Long-term coefficients in function (5)

$$\Delta Y_t = \alpha(\beta' Y_{t-1} + \beta_0 + \beta_1 t) + \phi_0 + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t$$

Coefficients	Forecasting period	Test statistics	t-statistics
α_{spot}	One week	-0.13	0.63
	Two weeks	0.60**	2.55
	One month	0.27	1.16
	Two months	0.22	0.97
$\alpha_{futures}$	One week	0.86**	2.69
	Two weeks	1.11***	6.1
	One month	0.74***	6.97
	Two months	0.63***	6.06
β_{spot}	One week	1	-
	Two weeks	1	-
	One month	1	-
	Two months	1	-
$\beta_{futures}$	One week	-1.15***	-16.60
	Two weeks	-0.89***	-29.59
	One month	-0.95***	-31.09
	Two months	-0.99***	-25.97

Note. Figures in parentheses are standard errors. Double asterisk (**) and (***) denote variables significant at 5% and 1% level respectively

Table 5. Test for long-run efficiency

	Hypotheses	Forecasting period	LR test statistics [P-value]
Long-run unbiasedness of futures price	H_0: β = (-1,1)	One week	1.30[0.26]
		Two weeks	8.24[0.00]
		One month	2.36[0.12]
		Two month	0.06[0.81]
Long-run exogeneity of spot price	H_0: α_{spot} = 0	One week	0.42[0.52]
		Two weeks	6.24[0.01]
		One month	1.37[0.24]
		Two month	0.94[0.33]
Long-run exogeneity of futures price	H_0: $\alpha_{futures}$ = 0	One week	16.48[0.00]
		Two weeks	29.44[0.00]
		One month	36.86[0.00]
		Two month	29.26[0.00]
Long-run weak exogeneity of spot price and unbiasedness	H_0: α_{spot} = 0; β = (-1,1)	One week	1.41[0.49]
		Two weeks	15.54[0.00]
		One month	4.18[0.12]
		Two month	1.10[0.58]
Long-run weak exogeneity of futures price and unbiasedness	H_0: $\alpha_{futures}$ = 0; β = (-1,1)	One week	20.18[0.00]
		Two weeks	31.93[0.00]
		One month	37.31[0.00]
		Two month	30.17[0.00]

Table 6. Test for short-term efficiency

	Hypotheses	Forecasting period	LR test statistics [P-value]
Futures price does not Granger cause spot price	H_0: $[\varphi_{1i}^{futures}] = 0$	One week(i=3)	23.19[0.00]
		Two weeks (i=1)	0.89[0.35]
		One month (i=1)	1.17[0.28]
		Two month(i=1)	0.83[0.36]
Spot price does not Granger cause futures price	H_0: $[\varphi_{2i}^{spot}] = 0$	One week(i=3)	24.96[0.00]
		Two weeks(i=1)	0.001[0.98]
		One month(i=1)	0.62[0.43]
		Two month(i=1)	2.68[0.10]

Table 7.Residual diagnostic tests

	Forecasting period	Test result [P-value]
LM (4)serial correlation test	One week	2.10[0.72]
	Two weeks	0.93[0.93]
	One month	3.50[0.48]
	Two months	3.50[0.48]
White's heteroskedastic test	One week	41.67[0.49]
	Two weeks	25.32[0.12]
	One month	19.85[0.34]
	Two months	17.99[0.46]

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