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Is the Volatility Information Transmission Process between the Crude Palm Oil Futures Market and Its Underlying Instrument Asymmetric?

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This study employs bivariate ARMA(p,q)-EGARCH(p,q) model specifications investigate the effects of the Malaysian futures - cash market relationship. More specifically, it looks at whether there is information transmission process at mean and volatility level between crude palm oil futures (FCPO) market and its underlying cash market and also whether volatility transmission is asymmetric. The study covers the period from January, 1990 until December 31, 2003. Bidirectional information transmission process between FCPO and CPO is documented at mean as well as volatility levels. Findings also reveal that the volatility transmission is asymmetric in nature but the sign of asymmetric differs based on the direction of spillovers.

Field of Research: Finance, Developing Economies

1. Introduction

As a result of increased globalization as well as technology explosions, today's financial markets are found to be more interrelated and integrated. These developments have enhanced the transfer of information flows from one market to another. In response to these developments, growing empirical studies began to establish this information transmission mechanism. The early research, however, focuses on the prices or returns spillover effects between futures and its underlying cash markets (Herbst, McCormack & West, 1987; Kawaller, Koch & Koch, 1987; Khoury & Yourougon, 1991; Ollermann & Faris, 1987; Stoll & Whaley, 1990 among others) and across markets (Bekaert & Harvey, 1995; Liu, Pan & Shieh, 1998; Liu & Pan, 1997; Theodossius & Lee, 1995). The findings on the linkages between the futures and its underlying cash market indicate that most of the time futures prices influence cash prices.

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In terms of pricing information transmission across markets, empirical evidence finds significant cross markets interactions and that dominant market like US plays an influential role on other markets.

In a plethora of later studies, particularly after the stock market crash of 1987 and the Asian financial crisis 1997, the emphasis shifted to how information is transmitted at volatility level (e.g., Hamao, Masulis & Ng, 1999; Koutmos, 1995; Lin, Engle & Ito, 1991; Ng, 2000; Miyakoshi, 2003). Those periods of market turbulence have brought to light the significance of the transmission of volatility information not only within markets but also across markets. Volatility is an integral part of many financial decisions. Defined as dispersion around the mean returns, volatility means risk and represents a threat to the integrity and efficiency of the market affected. Chan, Chan and Karolyi (1991) and Ross (1989) demonstrate the importance of information-volatility relationship and state that volatility is related to the amount of information released. Hence volatility is an important source of information apart from asset prices themselves. In addition, previous studies conducted by Koutmos and Tucker, 1996; Koutmos and Booth, 1995; Engle, Ito and Lin, 1990; Iihara, Kato and Tokunaga, 1996 indicate that volatility is also time-varying. They argued that when information flows continuously into the market it will cause changes in the riskinesss of the financial markets which imply that volatility is not constant but time-varying.

This study attempts to determine the nature of transmission of information between Malaysian crude palm oil futures markets and their respective underlying cash markets as well as how this relationship will be affected by information transmitted across foreign futures markets, that is, the US soybean oil futures. Specifically the study would like to determine whether information transmission between the Malaysian crude palm oil futures and its underlying cash market occurs at first or second moments interdependencies or both. In addition, this article also investigates whether the Malaysian futures-cash relationship is affected by shocks from US futures market and at what level of interdependencies are they affected.

2. Background of the Malaysian Crude Palm Oil (CPO) futures and its underlying market

CPO futures contracts started trading in 1980 and are the first derivative instrument introduced in Malaysian capital market. The Kuala Lumpur Commodity Exchange (KLCE) before merging with Malaysian Monetary

Exchange (MME) in November 1998 to become the Commodity and Monetary Exchange (COMMEX) provided the trading place for the CPO futures. Malaysia's CPO futures are the only CPO contract traded in the world.

Before the migration to electronic trading on 29 December 2001, CPO futures contracts were traded based on an open-outcry system. CPO futures like any other futures contract are very standardized contracts. In CPO futures, 25 metric tones of palm oil constitute a contract. The price quoted for trading is in Ringgit Malaysia (RM) per metric tonne. The tick price is RM1.00 per metric tonne. The contract months available for trading are the spot month, 5 next succeeding months and thereafter alternate months up to 12 months forward. At maturity the contracts are physically settled, that is, at maturity the actual commodity is delivered to the buyer of the contract at the port specified by the seller. The seller has the option to deliver the actual commodity at Port Klang, Butterworth or Pasir Gudang. Summary of the contract specifications are tabled below. Since trading in 1980, the prices have ranged from as low as RM400 per metric tonne to as high as RM2,000 per metric tonne. These changes in prices are affected by factors like world demand, export, weather patterns and prices of other vegetable oils such as soya bean oil, rapeseed oil, sunflower oil and corn oil. CPO futures contacts performance has been quite volatile. As state in Table 2.4, between 1996 and 2001, the lowest average yearly volume was 308,662 lots (2000) and the highest was 498,118 lots (1996). On July 13, 2002, the contracts make history when it recorded the highest ever daily volume and open interest of 7,678 lots and 14,772 lots respectively.

Table 1

Performance of Crude Palm Oil Futures contract

Year	Volume	Average Daily Turnover	% Change	No. of Trading Days
1996	498,118	2009	-	248
1997	484,323	1,960	-2%	247
1998	353,680	1,438	-27%	246
1999	388,967	1,568	+9%	248
2000	308,622	1,270	-19%	243
2001	479,799	1,974	+55%	243
2002	909,073	3,666	+86%	248
2003	1,429,959	5,543	+57%	246

Source: www.mdex.com.my. dated 24 February 2004

The underlying asset for CPO futures is the palm oil. Malaysia is the world's largest producer of palm oil. In 2003, Malaysia earned RM20.2 billion in foreign exchange from the export of 12.2 million tonnes of palm oil to 140 countries. About 13.4 million tonnes was produced in that same year. Palm oil prices in 2003 range from RM1409 to RM 1911 per metric tonne (see Table 1).

Table 2

World Major Exporters of Palm Oil: 1994-2004 ('000 Tonnes)

Country	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Malaysia	6,750	6,513	7,212	7,490	7,465	8,911	9,081	10,618	10,886	12,248
Indonesia	2,173	1,856	1,851	2,982	2,260	3,319	4,140	4,940	6,379	6,830
Papua New Guinea	231	220	267	275	213	254	336	328	324	325
Cote d'Ivoire	148	120	99	73	102	101	72	75	65	63
Colombia	20	21	29	61	70	90	97	90	85	105
Singapore*	328	399	289	298	241	292	240	224	220	256
Hong Kong*	234	275	305	173	103	94	158	192	318	206
Others	0	0	0	0	0	0	0	0	0	0
TOTAL	**10,760**	**10,195**	**10,763**	**12,212**	**11,134**	**13,848**	**15,008**	**17,574**	**19,233**	**21,116**

Source :http://www.mpob.gov.my/ dated 24 February 2004

3. Methodology

3.1 Empirical Models

Numerous researchers have used the Autoregressive Conditional Heteroscedastic (ARCH) family models to examine the volatility relationship and spillovers effects between markets (Engle, Lin and Ito, 1990; Choudhry, 1996; Tse, 1998; Bhar, 2001 and Hahm, 2003). We adopt this model for various reasons. Firstly, compared to other volatility models, this model is simple and parsimonious. According to Knight and Satchell (1999), models like stochastic volatility models are not popular due to the problem of computing function since the volatility is an unobserved component in the model. Secondly, the ARCH family model is able to successfully capture the volatility clustering, heteroscedasticity and asymmetric features that time series data normally exhibit (Bollerslev, Chou & Kroner, 1992; Engle & Patton, 2001; McKenzie, 1999). Thirdly, since most of the previous studies use the ARCH related models, therefore comparison of the findings can be made.

Starting off with the ARCH model developed by Engle 1982) and later modified by Bollerslev (1986) as Generalized ARCH model (GARCH), these models have been empirically shown to capture the time variation in the volatility of daily and monthly returns (see Bollerslev, Chan and Kroner, 1992). Both the ARCH (p) and GARCH (p,q) model assumes that conditional volatility of an asset is affected symmetrically by positive and negative innovations. Previous empirical findings like Black, 1976; Christie, 1982; Engle and Ng, 1987 and Koutmos and Booth, 1996 among others have found volatility to response asymmetrically to news, particularly when it concerns bad (negative) news. In the case of equity returns, such responses are due to leverage effects.

In this study, the bivariate EGARCH model is employed and is modified to achieve the objectives of the study. The model can be written in the following form:

$$R_{1,t} = \alpha_{10} + \alpha_1 \sum_{i=m}^{m} R_{1,t-1} + \lambda_i \sum_{i=1}^{n} R_{2,t-1} + \theta_1 \varepsilon_{1,t-1} + \gamma_1 Z_{t-1} + \varepsilon_{1,t} \tag{1}$$

$$\begin{aligned} \log h_{1,t} &= \omega_{10} + \alpha_1 \left(\left| u_{1,t-1} \right| - E\left| u_{1,t-1} \right| + \delta_1 u_{1,t-1} \right) \\ &+ \alpha_{12} \left(\left| u_{2,t-1} \right| - E\left| u_{2,t-1} \right| + \delta_2 u_{2,t-1} \right) + \beta_1 \log h_{1,t-1} + \phi_1 \log Z_{t-1} \end{aligned} \tag{2}$$

$$R_{2,t} = \alpha_{20} + \alpha_2 \sum_{i=m}^{m} R_{2,t-1} + \lambda_2 \sum_{i=1}^{n} R_{1,t-1} + \theta_2 \varepsilon_{2,t-1} + \gamma_2 Z_{t-1} + \varepsilon_{2,t} \qquad (3)$$

$$\begin{aligned} \log h_{2,t} &= \omega_{20} + \alpha_2 \left(\left| u_{2,t-1} \right| - E\left| u_{2,t-1} \right| + \delta_2 u_{2,t-1} \right) \\ &+ \alpha_{21} \left(\left| u_{1,t-1} \right| - E\left| u_{1,t-1} \right| + \delta_1 u_{1,t-1} \right) + \beta_2 \log h_{2,t-1} + \phi_2 \log Z_{t-1} \end{aligned} \qquad (4)$$

$$h_{12,t} = \rho \sqrt{h_{1,t} h_{2,t}} \qquad (5)$$

Equations (1) and (3) describe the returns of the market 1 and market 2, where the conditional mean in each market is a function of its own lagged returns, $\left(R_{1,t-1}\right)$, lagged returns of market 2, $\left(R_{2,t-1}\right)$ as well as past error correction terms,(Z_{t-1}). Following Susmel and Engle (1994), Hamao et al., (1990), Baille and Bollerslev (1991) and Lo and MacKinley (1990), the autoregressive, $\alpha_i R_{t-1}$ and moving average, $\vartheta_i \varepsilon_{t-1}$ processes are included in equations (1) and (3) to account for any autocorrelation that may arise due to nonsynchronous trading. α_i and ϑ_i are the coefficients of the autoregressive and moving average processes respectively, where as m is the lag length of the autoregressive (AR) process. As such this model is known as bivariate ARMAX(p,q)-EGARCHX(p,q) model. The letter X implies that error correction terms are included in the model.

The conditional variance in equation (2) for market 1 represents its own lagged standardized residuals (α_1), lagged cross-market standardized residual (α_{12}), lagged conditional variance (β_1) and lagged error correction representation (ϕ_1). Equation (2) enables the lagged cross-market standardized residuals to influence the conditional variance of the market 1 asymmetrically. For example, let market 1 = CPO and market 2 = FCPO. Based on equation (2), α_{12} is the coefficient of spillovers from FCPO (market 2) to CPO (market 1). A significant positive α_{12} together with a negative δ_2 implies that negative innovations in market 2 (FCPO) have a higher impact on the volatility of market 1 (CPO) returns than positive innovations. In other words, the spillover is asymmetric. The short-term deviation term, ϕ_i (where i = market 1 or 2) is also included in the equation (Bhar, 2001 & Lee, 1994).

Equation (4) describes the conditional variance of the futures return for market 2. Coefficient α_{21} measures the volatility spillovers from market

1(CPO) to market 2 (FCPO). A significant positive α_{21} together with a negative δ_1 implies that negative innovations in market 1 (CPO) have a higher impact on the volatility returns of market 2 (FCPO). This implies that the spillover effects between the futures market and the foreign markets are asymmetric.

Equation (5) implies a bivariate ARMAX (p,q)-EGARCHX (p,q) model with a constant conditional correlation ρ as in the studies conducted by Bollerslev (1990), Baille and Bollerslev (1990), Koutmos and Tucker (1996), Lin et al., (2002), Yu (2000) among others. Here all the variations over time in the conditional covariances are due to changes in each of the corresponding two conditional variances, $h_{s,t}$ and $h_{f,t}$. According to Bollerslev (1990) this assumption can simplify the estimation and inference procedure and suggests that the validity of the assumption of constant correlation be evaluated by testing for serial correlation in the cross product of standardized residuals.

4. Data and Empirical Results

4.1 Data and Descriptive Statistics of Returns

All data are the daily closing price data. Our measurements include Kuala Lumpur Crude Palm Oil futures (FCPO) and Crude Palm Oil (CPO). The sample period ranges from 1 January 2, 1990 until December 31, 2003. In this study, conditional variance of the returns is used to measure the futures price volatility. The returns, R_t is calculated as the log of the price relative, where P_t is the closing price at day *t* and P_{t-1} is the closing price of the previous day. This can be written as:

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{5}$$

To overcome the data gap caused by different public holidays and other non-working days, we adjusted the time series studied by dropping the same date data that correspond to a holiday in a particular country.

The means of returns of the FCPO and CPO are positive (see Table 3). The variances range from 0.0235 (CPO) to 0.0248 (FCPO). The measures for skewness and kurtosis indicate that the distributions of returns for all three markets are positively skewed and leptokurtic relative to the normal distribution. The Jarque-Bera statistics test rejects normality at any level of significance in all cases. The Ljung-Box statistic test for 20 lags applied on returns and squared returns reported serial correlations for FCPO and

CPO. There are also ARCH effects for FCPO and CPO returns. Volatility clustering can be visually seen in Figure 1 for commodity futures returns. Overall, the descriptive statistics provide evidence that all the daily data series are not normally distributed and the variances are changing over time. Therefore, the ARCH-type models, that allow for such features are appropriate for analyzing these data series.

Table 3

Descriptive statistics for returns

	FCPO	CPO
Mean	0.0006	0.0006
Median	0.0000	0.0006
Maximum	0.1824	0.1933
Minimum	-0.1768	-0.1875
Std. Dev.	0.0248	0.0235
Skewness	0.2897	0.2527
Kurtosis	17.1368	21.7736
Jarque-Bera	13570.81 [0.0000]***	23910.32 [0.0000]***
LB(20)	41.3200 [0.0030]***	76.3070 [0.0000]***
$LB(20)^2$	105.1400 [0.0000]***	66.0690 [0.0000]***
ARCH (1)	14.9864 [0.0018]***	20.89095 [0.0001]***
Observations	1627	1627

Note: p-value in parentheses. ***, **and * denote significance level at 1%, 5% and 10% respectively. Critical values at 1%, 5% and 10% level for Jarque-Bera test are 9.21, 5.99 and 4.61 respectively. Critical values at 1%, 5% and 10% level for skweness and kurtosis tests are +/- 2.58, +/- 1.96 and +/- 1.28. LB (20) and LB $(20)^2$ is the Ljung-Box test for autocorrelation at lag 20. Critical value at 1%, 5% and 10% level are 37.57, 31.41 and 28.41 respectively.

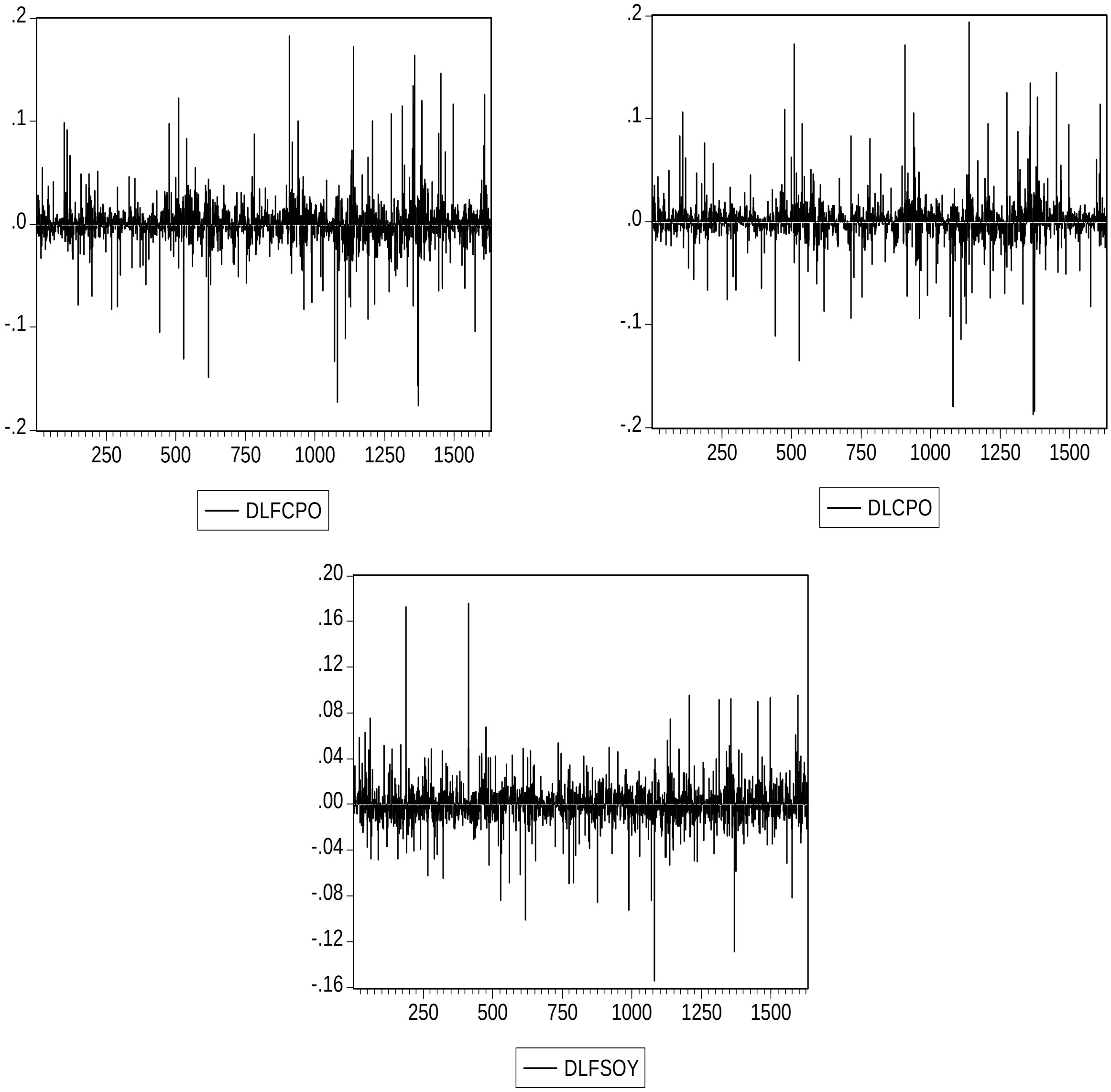

Figure1. Returns of FCPO, CPO and FSOY

4.2 Unit Root Tests

The results of the ADF unit root tests and PP test (both with and without time trend) are presented in Table 4. The lag for each series is also presented for both at levels as well as for the first differenced variables. Akaike Information Criteria (AIC) is used to determine the lag length. As evident from Table 4, both tests suggest that all the series are found to be non-stationary at level form. The null hypothesis of the presence of unit root cannot be rejected even at 10% significance level. When first differences were used, unit root non-stationary was rejected in all cases. Thus we conclude that all indices are integrated of order one I (1) and therefore the need to consider the first differences of all the series under study.

Table 4

Summary Statistics of Unit Root Tests for the Whole Period[a]

Variables	FCPO	CPO
Lag Length (AIC)	4 4	16 11
ADF (Level)	-1.9098(NT) -2.1622 (T)	-1.7893 (NT) -2.1081(T)
P-value	0.3280 0.5099	0.3861 0.0000
Phillip Perrons (Level)	-1.8751 (NT) -2.1106 (T)	-1.9810(NT) -2.1463 (T)
P-value	0.3444 0.5390	0.2954 0.5188
Lag Length (AIC)	4 3	15 15
ADF (First Difference)	-17.4221 (NT)*** -17.4172 (T)***	-11.3145 (NT)*** -11.3139 (T)***
P-value	0.0000 0.0000	0.0000 0.0000
Phillip Perrons (First Difference)	-41.1069 (NT)*** -41.0966 (T)***	-37.6604 (NT)*** -37.6514 (T)***
P-value	0.0000 0.0000	0.0000 0.0000

[a] Period for FCPO, CPO and FSOY is 1/1/1990 – 31/12/2003. *, **, *** denote significance level at 10%, 5% and 1% level respectively. NT indicates with time trend, T indicates with no time trend

4. 3 Cointegration Tests

Engle and Granger (1987) indicate that, if two nonstationary variables are cointegrated, then modeling of the first differences should include an error correction term. As such, a cointegration test is further conducted. Tests are conducted based on the Engle and Granger (1987) two-step method. Results of the cointegration tests are reported in Table 5. The ADF tests indicate the existence of long-term relationship between FCPO and CPO, where cointegration prevails at the 1% level of significance. This observation reinforces the notion that cointegration unites the long run relationship between the two series. Hence this indicates the need to incorporate the error-correction term in the bivariate models for FCPO and CPO.

Table 5

Engle-Granger Cointegration Tests for the Whole Period

Variables	ADF	P-value
FCPO & CPO	-4.2785	0.0005***

*** denotes significance at 1% level

In order to identify the most appropriate model specifications, the likelihood ratio (LR) tests are employed. Specifically the restricted ARMA (1,1)-GARCH(1,1) and ARMA(1,1)-EGARCH(1,1) are tested against a series of alternative unrestricted models.

5. Empirical findings

5.1 Mean and volatility spillover effects between FCPO and CPO markets.

The short-term disequilibrium on the conditional mean, and respectively has a positive and significant effect on the FCPO futures and its cash returns (refer to Table 6). The ECT parameters have also significant effects on the conditional volatility of the futures and cash markets. However, they are negatively related. The results reported that when the futures and cash prices differences become larger the conditional volatility of both markets decreases. Results from this study also reveal that the error correction term, γ_f and γ_s ,which represents the short-run deviations from the long-run cointegrated relationship between the futures and cash markets, have significant effect on both the conditional mean and volatility of the FCPO futures and cash markets in Malaysia. As argued by Lee (1994), if markets are related through their first and second moments, then inclusion of this impact in the conditional mean and volatility is appropriate. This finding contributes to the growing but still limited empirical literature that includes the cointegrating residual (ECT terms) in both the conditional mean and volatility (see Bhar, 2001; Choudry, 2003; and Lee, 1994). Evidence from the findings may have an important implication on the dynamic hedging behavior of the futures contracts. Specifically, the effects of the short-run deviations can influence the effectiveness of the time-varying hedge ratio between the market pair of FCPO-CPO. Besides, excluding them would result in model misspecification.

Results from Table 6 reveal that there are statistically significant bidirectional spillover effects between the FCPO and the CPO markets at mean and volatility levels. The cross market terms from the conditional mean equation, λ_{fs} and λ_{sf} are statistically significant at 1% level. The terms represent the impact of the CPO returns on the FCPO returns and vice-versa. It can be seen that magnitude of parameter λ_{fs} (0.4585) is greater than parameter λ_{sf} (0.2175). This indicates that the impact of FCPO is stronger on the CPO market than the other way around.

Table 6

Bivariate EGARCH Models Estimations between FCPO and CPO Markets for the Whole Period

	FCPO		CPO
Mean Parameters		Mean Parameters	
$\alpha_{f,0}$	-0.000009468 (-0.0538)	$\alpha_{s,0}$	-0.0000568 (-0.3066)
$\alpha_{f,t-1}$	0.4605 (6.1991)***	$\alpha_{s,t-1}$	0.2765 (5.2534)***
$\lambda_{fs,t-1}$	0.4585 (11.4694)***	$\lambda_{sf,t-1}$	0.2175 (5.7663)***
$\theta_{f,t-1}$	-0.6174 (-10.6717)***	$\theta_{s,t-1}$	-0.5908 (-13.1004)***
$\gamma_{f,t-1}$	0.0302 (3.0482)***	$\gamma_{s,t-1}$	0.0488 (4.1479)***
Variance Parameters		Variance Parameters	
$\omega_{f,0}$	-0.7064 (-9.7075)***	$\omega_{s,0}$	-0.6711 (-13.3589)***
$\alpha_{f,t-1}$	0.2552 (12.773)***	$\alpha_{s,t-1}$	-0.1060 (-7.5621)***
$\alpha_{fs,t-1}$	0.3091 (18.8850)***	$\alpha_{sf,t-1}$	-0.0697 (-3.9579)***
$\beta_{f,t-1}$	0.8882 (81.3343)***	$\beta_{s,t-1}$	0.8888 (118.8668)***
$\delta_{f,t-1}$	-0.0825 (-1.9882)	$\delta_{s,t-1}$	-0.1414 (-1.2199)
$\phi_{f,t-1}$	-0.0111 (-5.3346)***	$\phi_{s,t-1}$	-0.0165 (-10.6020)***
ρ_{fs}	0.8728 (268.9156)***		
LL ARMAX(1,1)_EGARCHX(1,1)[b]	8882.3100		

[b] The letter X indicates the inclusion of ECT terms in both the conditional mean and volatility.

The volatility cross-market terms of FCPO (α_{fs}) and CPO (α_{sf}) are also significant. The negative sign of parameter α_{fs} (-0.0697) indicates that the volatility spillover effect from CPO to FCPO is marginally reduced. Once again, in absolute values, the impact of volatility spillover is stronger from FCPO to CPO markets than from CPO to FCPO markets, that is, four times the size of the estimated coefficients.

The bidirectional volatility spillover effects between these two markets are consistent with the findings of Bhar (2001), Chan et al. (1991), Lin et al. (2002), Min and Najand (1999), Yakob (2004) and Yu (2000), among others. The reciprocal transmission of volatility between markets indicates that instability in one market can influence the stability of another market. However, findings also indicate that the past shocks in FCPO futures significantly influence the CPO volatility, while the volatility spillovers from cash to futures are weaker. In other words, this supports the notion of most studies that information disseminates in the FCPO futures market first and then to its underlying cash market. Overall, the dominant role of FCPO futures in price discovery is supported in terms of the returns and volatility transmission process.

With reference to the variance equation in Table 6, although the parameters measuring the asymmetric effects in both markets (δ_f and δ_s) are negative, however they are not statistically significant. The t-statistics for futures and cash markets are -1.9882 and -1.2199 respectively. This indicates that the conditional volatilities of markets studies response symmetrically to shocks transmitted into each other markets. In short, the asymmetry is not presence in these markets. Since the leverage effect is not a plausible explanation for the asymmetric behavior of volatility in the futures markets (see Koutmos & Tucker, 1996), it is presumed that other factors such as structural changes could cause in the asymmetric effect.

Residual based diagnostic tests show that the bivariate ARMA (1,1)-EGARCH(1,1) model satisfactorily explains the interaction of the Malaysian futures markets with their respective underlying cash markets (Table 7). The Ljung-Box statistics tests for market pair of FCPO-CPO indicate autocorrelations in both the standardized residuals and squared standardized residuals in both markets at 10% level of significance. Higher order ARMA(p,q)-EGARCH(p,q) models have been tried but do not improve the specifications diagnosis (see Kanas, 1998 and Tse, 1999). Hence caution should be taken when interpreting such results. The validity of the assumption of constant conditional correlations can be assessed by testing for serial correlation in the cross-product of the standardized residuals. Engle's first-order LM test for ARCH residuals found no evidence of time-varying volatility for FCPO and CPO data. This implies that the models are well-specified.

Table 7
Diagnostic Tests on Standardized Residuals, Standardized Squared Residuals and Cross Standardized Residuals: Whole Period for EGARCH Models Estimations

Residual – Market 1	FCPO(M1)-CPO(M2)
ARCH(1)	0.4128
	(0.5205)
$\mathrm{E}(\mu_1/\sigma_1)$	-0.0056
	(0.8215)
$\mathrm{E}(\mu_1/\sigma_1)^2$	1.0105
LB(20) for $\mathrm{E}(\mu_1/\sigma_1)$	28.7021
	(0.0521)*
LB(20)^2 for $\mathrm{E}(\mu_1/\sigma_1)^2$	31.4035
	(0.0258)*
Residual – Market 2	
ARCH(1)	0.0923
	(0.7613)
$\mathrm{E}(\mu_2/\sigma_2)$	-0.0088
	(0.7287)
$\mathrm{E}(\mu_2/\sigma_2)^2$	1.0344
LB(20) for $\mathrm{E}(\mu_2/\sigma_2)$	18.1600
	(0.4452)
LB(20)^2 for $\mathrm{E}(\mu_2/\sigma_2)^2$	30.7116
	(0.0311)*
Cross Product	
LB(20)	29.2534
	(0.0454)*
LB(20)^2	18.4693
	(0.4252)

Notes: p-value in parentheses. Critical value for Ljung-Box test at lag 20 is 37.56, 31.41 and 28.41 at 1%, 5% and 10% level of significance respectively. M1 and M2 indicate market 1 and market 2 respectively.

6. Conclusion

This paper examines the transmission of returns and volatilities information between Malaysian crude palm oil futures market and its respective underlying market as well as information transmission process at volatility level is asymmetric. In essence, it attempts to identify whether this transmission process occurs at first moments, second moments or both. The bivariate ARMAX(p,q)_EGARCHX(p,q) model is employed in order to capture the asymmetric effects of volatility transmission. In relation to information transmission mechanism between the FCPO and its associated cash market, our results indicate that these two markets are related at both mean and volatility levels but the volatilities of these markets and their respective assets are not asymmetric. Error correction terms have predictive power on the conditional mean and volatility of FCPO and CPO markets. Overall, the results are robust to diagnostic tests applied on the estimated models used. The findings of this study have important implications to investors and portfolio managers who are interested in developing effective trading and hedging strategies between these two markets and for regulators to formulate policy and implement control measures to enhance the integrity and stability of the Malaysian Crude Palm Oil futures market.

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