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The Impact of Crude Oil Price on Macroeconomic Variables: New Evidence from Malaysia

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Abstract:
An understanding of how volatilities of and correlations between crude oil and macroeconomic variables change over time including their directions and size is of crucial importance for both the domestic and international investors with a view to diversifying their portfolios for hedging against unforeseen risks. This paper is a humble attempt to add value to the existing literature by empirically testing for the 'time-varying' and 'scale dependent' correlations between selected commodities and selected macroeconomic variables taking Malaysia as a case study. Particularly, by incorporating the scale dependence, it is possible to identify unique portfolio diversification opportunities for different set of investors bearing different investment horizons or stock-holding periods. Our findings tend to suggest that there is a theoretical relationship between the selected macroeconomic variables and the selected commodities and that the crude oil, gold, KLCI, CPI, BLR and T-bill are exogenous but the corn, industrial production and M2 are endogenous. Consistent with these results, our analysis based on the application of Generalised variance decompositions (VDCs) tends to indicate that the gold commodity is the most exogenous variable that drives the other commodities and the Malaysian macroeconomic variables. Finally, the value added stemming from the findings of Continuous Wavelet Transformation (CWT) tends to indicate that an investor who has exposure in crude oil commodity and wants to invest in KLCI, industrial production and treasury bill in Malaysia, should not hold his/her portfolio for more than 8 months in order to obtain diversification benefit.

Key Words: Commodity, Malaysian Macro Variables, Continuous Wavelet Transformation, Diversification, Causality;

1. Introduction

Crude oil prices have remained low during the 1980s until 2000 with an average price of US$20 per barrel. From 2004 onward, the crude oil price has increased significantly with an increase from US$31 per barrel in 2004 to US$140 per barrel in 2008. By the year 2013, the crude oil price has remained within the range of US$100 – US$110. The demand for crude oil remained strong especially because of the growth of the emerging economies such as China and India and also with the capacity constraints on the supply side, oil prices are expected to remain within US$100 per barrel for the time being. Crude oil price changes affect almost all sectors of the economies. Many studies in the past on crude oil have focused their attention on whether and how oil price fluctuations impact on conventional stock market returns. Aloui, Jammazy et al. (2008) find that changes in crude oil (CO) prices cause significantly the volatility of the stock market returns of six developed countries using univariate and multivariate approaches (Aloui, Jammazy et al. 2008). Park and Ratti (2008) report that oil price shocks have a statistically significant impact on real stock returns for US and 13 European oil importing countries (Park and Ratti 2008). Cunado and Perez de Gracia (2005) investigate the crude oil prices relationship with macroeconomic variables by studying the impact of crude oil price shocks on both inflation and economic growth rates for some Asian countries. They find crude oil prices have a significant effect on both economic activity and price indexes, and the impact is limited to the short run and more significant when oil price shocks are defined in local currencies. Although many different studies have been done, there is no consensus about the effect of the crude oil shocks on the macroeconomic variables.

Due to the importance of crude oil in an economy, therefore, the changes in the crude oil price will have a significant impact on the macroeconomic variables. Investors and policy makers in Malaysia would like to know the correlation of crude oil with the Malaysian macroeconomic variables in order to obtain diversification benefit and to mitigate risk. The main objective of this paper is to examine the causal relationship between crude oil price and the Malaysian macroeconomic variables. Other commodities such as gold and corn prices also are included as control variables and for robustness test. We would like to find out the lead-lag relationship between the variables under review and to identify the direction of Granger-causality among those variables. We also would like to find any diversification benefits of the variables.

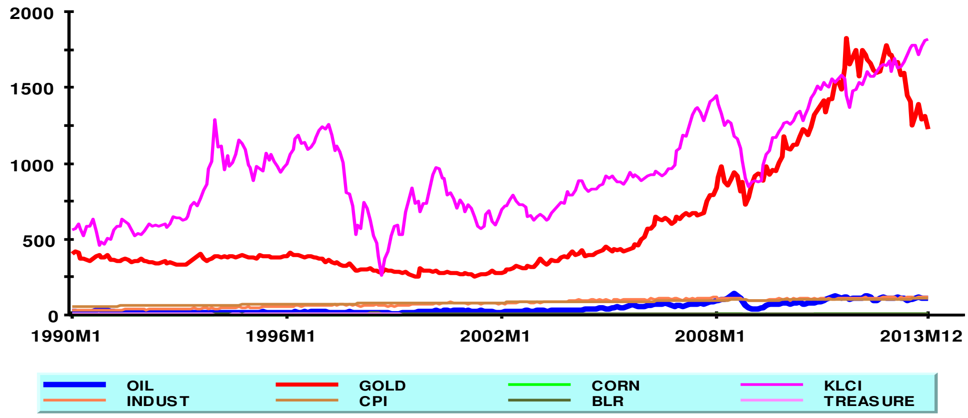
The unique contribution of the paper, among others, which enhances the existing literature is in empirically testing for the 'time-varying' and 'scale dependent' correlations between the sample variables. Particularly, by incorporating the scale dependence, the paper is able to identify unique portfolio diversification opportunities for different set of investors bearing different investment horizons or stock-holding periods. Hence, the specific research questions of this study are as follows:

i. Does cointegration exist between commodities such as crude oil, corn and gold with the Malaysian macroeconomic variables?
ii. Does the crude oil price cause the prices of the Malaysian macroeconomic variables to increase/decrease in which past values of crude oil price are able to improve the prediction of Malaysian macroeconomic variables and other commodities (gold and corn)?
iii. Among the exogenous variables, which one is more exogenous at different time horizons?
iv. Which Malaysian macroeconomic variables should the policy makers control and adjust to help a continuous economic growth in Malaysia?
v. How long does it take for the variables to get back to equilibrium when there is a system wide shock to the long-run equilibrium?
vi. Which Malaysian macroeconomic variables should an investor invest in along with the crude oil commodity in order to gain portfolio diversification benefits?
vii. How would the portfolio diversification benefits change given different investors' investment horizons or stock-holding periods?

The results from each of the research questions are expected to have significant implications for investor and policy maker in their decisions concerning portfolio allocations, investment horizons and policy for economic growth. In summary, using recent data and modern empirical methodologies, this paper humbly attempts to fulfil the strategic information needs of investors intending to diversify their portfolios in commodities market and in Malaysian macroeconomic variables. It also will assist policy makers in identifying important Malaysian macroeconomic variables in order to help her continuous economic growth.

The following sections of the paper are organized as follows. Section 2 reviews the relevant literature related to commodities portfolio diversification and macroeconomic variables. Section 3 briefly reviews the theoretical foundations being assumed in this paper. Section 4 details out the methodologies to be employed to achieve the research objectives of this paper. Section 5 contains the comprehensive data analysis and empirical results. Section 6 discusses the results obtained from the previous section using plausible explanations and past findings in literature. References make up the end of this paper.

Chart 1: Commodity Prices and South East Asian Islamic Stock Index



2. Literature Review

Many researchers have studied the impact of crude oil price on other commodities. Among the earliest study on the price co-movement is a research done by Pindyck and Rotemberg (1990) that introduce the excess co-movement hypothesis (ECH) between commodity prices. They argue that due to herd behaviour in financial markets, prices tend to move together. Pindyck and Rotemberg find that price of largely unrelated raw commodities have a persistence tendency to move together. Further study by Baffes (2007) estimates the degree of pass-through of crude oil price changes to the prices of 35 other internationally-traded primary commodities. The results indicated that the elasticity for the non-energy commodity index was estimated at 0.16 and the fertilizer index displayed the largest pass-through, followed by the index for food commodities. The implications of this finding is that if crude oil prices remain high, the recent commodities price increase are likely to last longer than previous boom cycle, especially for the food commodities, fertilizers, and precious metals (Baffes 2007).

Research on the impact of crude oil is not only with other commodities but also with stock market variables, exchange rate and macroeconomic variables. Cunado and Perez de Gracia (2005) investigate the oil prices relationship with macroeconomic variables by studying the impact of oil price shocks on both inflation and economic growth rates for some Asian countries over the period 1975Q1–2002Q2. They find different results when using world real oil price (expressed in $US) or a local real oil price for each of the countries measured in the domestic currency. The impact is higher when oil prices are measured in local currency, which could be due to the role of exchange rates or national price variations on macroeconomic variables. Secondly, they find that there is no cointegrating long-run relationship between oil prices and economic activity, which suggests that the impact of oil shocks on these variables are limited to the short run. Thirdly, when analysing short-run relationships between oil prices and economic growth rates, oil price shocks are found to Granger cause economic growth rates in Japan, South Korea and Thailand when several non-linear specifications are used to model the relationship between the variables. Fourth, they find that oil price shocks expressed in local currencies have a significant effect on inflation in all analysed countries. Fifth, they find evidence of asymmetries in the oil price changes relationship with inflation rate for the cases of Japan, Thailand, South Korea and Malaysia. Furthermore, the oil prices relationship with consumer prices appears to be more significant and more general than the oil prices relationship with economic activity for the Asian countries. Finally, they find some differences among the responses of each of the Asian countries to oil price shocks. For example, the oil prices relationship with macroeconomic seems to be less significant for the case of Malaysia than for the rest of the economies (Cunado and Pérez de Gracia 2005).

Park and Ratti (2008) investigate on the impact of oil price shock on real stock returns in the U.S. and 13 European countries. They find that Norway as an oil exporter shows a statistically significantly positive response of real stock returns to an oil price increase. The median result from variance decomposition analysis is that oil price shocks account for a statistically significant 6% of the volatility in real stock returns. They also find that for many European countries, increased volatility of oil prices significantly depresses real stock returns. The contribution of oil price shocks to variability in real stock returns in the U.S. and most other countries is greater than that of interest rate. An increase in real oil price is associated with a significant increase in the short-term interest rate in the U.S. and eight out of 13 European countries within one or two months (Park and Ratti 2008).

Jammazi and Aloui (2010) research on the impact of crude oil price on stock market and find that the stock market variables respond negatively and temporarily to the crude oil changes during moderate (France) and expansion (UK and France) phases but not at level to plunge them into a recession phase. However, the effect of West Texas Intermediate (WTI) changes occurred in the expansion period has driven the Japanese stock market into a recession phase. This illustrate the important role that policy makers has to play in order to counteract any inflationary impact of higher prices with monetary policy such as in UK and France. This is in contrary to policy maker in Japan, who may be unable to completely offset the increased variability of oil shocks which has contributed into the vulnerability of the stock market in Japan (Jammazi and Aloui 2010).

In summary, the literature studying crude oil price and its resulting impact on macroeconomic variables is limited and inconclusive with results reporting contradictory evidence. Hence this subject needs further investigation.

3. Theoretical Background

Two theories have been identified for this study. The first theory is by Pindyck and Rotemberg (1990) that introduce the excess co-movement hypothesis (ECH) between commodity prices, arguing that due to herd behaviour in financial markets prices tend to move together. They find that prices of largely unrelated raw commodities have a persistence tendency to move together.

The second theory is by Markowitz on portfolio diversification theory. Markowitz shaped the modern portfolio theory where the volatility of a portfolio is less than the weighted average of the volatilities of the securities it contains given that the portfolio consists of assets that are not perfectly correlated in returns. The variance of the expected return on a portfolio can be calculated as:

$$\sigma_p^2 = (\Sigma W_i^2 \sigma_i^2 + \Sigma\Sigma W_i W_j Cov_{ij})$$

Where the sums are over all the securities in the portfolio, W_i is the proportion of the portfolio in security i, σ_i is the standard deviation of expected returns of security i, and Cov_{ij} is the covariance of expected returns of securities of i and j. Assuming that the covariance is less than one (invariably true), this will be less than the weighted average of the standard deviation of the expected returns of the securities. This is why diversification reduces risk (Markowitz 1959).

One of the criticisms of the earlier models of modern portfolio theory was the assumptions that the portfolio variances are normally distributed. Markowitz thought normally distributed variance is inadequate measure of risk. The use of wavelet transform methodologies makes no assumptions and is tantamount to producing more realistic results (In and Kim 2013). The paper elaborates the methodologies to be adopted in achieving the research objectives in the following section.

4. Methodology

4. 1 Data

The data used in this paper is the monthly data of three commodities (crude oil, gold and corn) prices and Malaysia macroeconomic variables consist of Kuala Lumpur Composite Index (KLCI), industrial production, consumer price index (CPI), middle rate of base lending rate (BLR), 3 months treasury bill discount rate (T-bill) and money supply (M2) from 1 January 1990 until 1 December 2013. All data are obtained from DataStream at INCEIF (International Centre for Education in Islamic Finance).

4.2 Time Series Techniques

This study employs a time series technique namely cointegration, vector error-correction model (VECM), variance decompositions (VDC) and persistence profile (PP) in order to find empirical evidence of the nature of relations between crude oil price and Malaysia macroeconomic variables. Standard time-series approaches have been adopted to test the hypothesis whether crude oil price leads (or lags) the Malaysian macroeconomic variables under review. The recent time series studies based on cointegration have applied either vector error correction and/or variance decomposition methods for testing Granger causality or lead-lag relationship. We would apply the following standard procedures to test the lead-lag relationship: We will examine the unit-root tests and the order of the VAR, and then we will apply Johansen cointegration test. However, the evidence of cointegration cannot tell us which variable is leading and lagging. Therefore, we have to test through vector error correction model (VECM) that can indicate the direction of Granger causality both in the short and long run. The VECM, however, cannot inform us which variable is relatively more exogenous or endogenous. The variance decomposition (VDC) technique is designed to indicate the relative exogeneity/endogeneity of a variable by decomposing (or partitioning) the variance of the forecast error of a variable into proportions attributable to shocks (or innovations) in each variable in the system, including its own. The proportion of the variance explained by its own past shocks can determine the relative exogeneity/ endogeneity of a variable. The variable that is explained mostly by its own shocks (and not by others) is deemed to be the most exogenous of all. Finally, one could find out the persistence profiles. They are designed to estimate the speed with which the variables get back to equilibrium when there is a system wide shock to the long-run equilibrium (Masih, Al-Elg et al. 2008; Masih, Al-Sahlawi et al. 2010).

4.4 Continuous Wavelet Transformation (CWT)

To answer the sixth and seventh objective of our research, we need to apply continuous wavelet transform (CWT). The CWT maps the original time series, which is a function of just one variable time-separate into function of two different variables such as time and frequency. One major benefit CWT has over Discrete Wavelet Transform (DWT) and Maximum Overlap Discrete Wavelet Transformation (MODWT) is that one need not define the number of wavelets (time-scales) in CWT which generates itself according to the length of data. Other than that, the CWT maps the series correlations in a two-dimensional figure that allows us to easily identify and interpret patterns or hidden information. We use the Daubechies (1992) least asymmetric wavelet filter of length L=8 denoted by LA (8) based on eight non-zero coefficients (Daubechies 1992). Previous studies on high-frequency data have shown that a moderate-length filter such as

L = 8 is adequate to deal with the characteristic features of time-series data (Gençay, Selçuk et al. 2001; Gençay, Selçuk et al. 2001; In and Kim 2013). In the literature, it is argued that an LA (8) filter generates more smooth wavelet coefficients than other filters such as Haar wavelet filter.

The continuous wavelet transform (CWT) $W_x(u,s)$ is obtained by projecting a mother wavelet ψ onto the examined time series $x(t) \in L^2(\mathbb{R})$, that is:

$$W_x(u,s) = \int_{-\infty}^{\infty} x(t) \frac{1}{\sqrt{s}} \psi\left(\frac{t-u}{s}\right) dt$$

The position of the wavelet in the time domain is given by *u*, while its position in the frequency domain is given by *s*. Therefore, the wavelet transform, by mapping the original series into a function of *u* and *s*, gives us information simultaneously on time and frequency. We need to apply a bivariate framework which is called wavelet coherence to be able to study the interaction between two time series, how closely X and Y are related by a linear transformation. The wavelet coherence of two time series is defined as:

$$R_n^2(s) = \frac{\left|S(s^{-1}W_n^{xy}(s))\right|^2}{S(s^{-1}|W_n^x(s)|^2 . S(s^{-1}\left|W_n^y(s)\right|^2}$$

Where *S* is a smoothing operator, *s* is a wavelet scale, $W_n^x(s)$ is the continuous wavelet transform of the time series X, $W_n^y(s)$ is the continuous wavelet transform of the time series Y, $W_n^{xy}(s)$ is a cross wavelet transform of the two time series X and Y (Madaleno and Pinho 2012). For further details, interested readers may refer to Gencay et al (2001; 2002) and In and Kim (2013).

5. Empirical Findings and Interpretations

5.1 Findings and Interpretations of standard Time-Series Techniques

We tested the unit roots of all the variables and found that they could be taken as I(1) on the basis of ADF tests. We also find that the optimal order of the VAR is two for AIC meanwhile for SBC, the optimal order of VAR is one. Therefore, we rely on AIC test by taking the optimal level of VAR as two. We applied the standard Johansen cointegration test (Table 1) and found them to have one cointegrating vector at 95% significance level on the basis of maximal eigenvalue statistics and four cointegration vectors under trace statistics. An evidence of cointegration implies that the relationship among the variables is not spurious and indicates that there is a theoretical relationship among the variables and they are in equilibrium in the long run. Therefore, diversification benefits for variables under review is minimised in the long run due to the co-movement of the variables toward the same direction. The cointegration test, however, cannot inform us the direction of Granger causality as to which variable is leading and which variable is lagging. We have applied the vector error correction modelling technique (Table 2) with one cointegrating vector to identify the exogeneity and endogeneity of the variables. From Table 2, we identify that the crude oil, gold, KLCI, CPI, BLR and T-bill are exogenous but the corn, industrial production and M2 are endogenous. That tends to indicate that the corn, industrial production and M2 would respond to the crude oil, gold, KLCI, CPI, BLR and T-bill. The error correction model helps us distinguish between the short-term and long-term Granger causality. The error correction term stands for the long-term relations among the variables. The impact of each variable in the short term is given by the 'F '-test of the joint significance or insignificance of the lags of each of the 'differenced' variables. The diagnostics of all the equations of the error correction model (testing for the presence of autocorrelation, functional form, normality and heteroskedasticity) tend to indicate that the equations are more or less well-specified.

The proportion of the variance explained by its own past shocks can determine the relative exogeneity/endogeneity of a variable. Although the error-correction model tends to indicate the endogeneity/exogeneity of a variable, we had to apply the generalized variance decomposition technique (Table 3) to distinguish the relative degree of endogeneity or exogeneity of the variables. The relative exogeneity or endogeneity of a variable can be determined by the proportion of the variance explained by its own past. The variable that is explained mostly by its own shocks (and not by others) is deemed to be the most exogenous of all.

We apply Generalized variance decompositions (VDCs), which are invariant to the ordering of variables and more reliable than Orthogonolised VDC to identify the most leading and laggard variable. The results are presented in Table 3. From the results, we can make the following key observations:

- The Generalized VDCs confirm the results of the VECM in that gold, crude oil, T-bill, CPI, KLCI and BLR are the most exogenous variables.
- The relative rank in exogeneity is stable as time passes for gold price. Between 24 months to 150 months, there are no changes in the ranking for the gold where gold remain the most exogenous variable.
- Crude oil price leads the Malaysian macroeconomic variables in the horizon of 60 months and above. This finding is contrary to the findings of Cunado and Perez de Gracia (2005). That indicates that the oil price relationship with macro variables seems to be less significant in the case of Malaysia.
- Treasury bill (T-bill), which is the third most exogenous variable, is the only variable under the control of the Malaysian government that can be adjusted in order to influence the other macroeconomic variable. The gold price and crude oil price are beyond the control of policy makers since their prices are based on demand and supply in the international market.

Finally, an application of the persistence profile analysis (Figure 1) indicates that if the whole cointegrating relationship is shocked, it will take about ten months for the equilibrium to be restored.

Table 1: Johansen ML results for multiple cointegrating vectors of Malaysia economic and commodities prices

Ho	H1	Statistic	95% Crit.	90% Crit.
Maximum Eigenvalue Statistics				
$r = 0$	$r = 1$	69.95	61.27	58.09
$r \leq 1$	$r = 2$	52.23	55.14	52.08
Trace Statistics				
$r = 0$	$r \geq 1$	291.06	222.62	215.87
$r \leq 1$	$r \geq 2$	221.10	182.99	176.92
$r \leq 2$	$r \geq 3$	168.87	147.27	141.82
$r \leq 3$	$r \geq 4$	121.72	115.85	110.60

Table 2: VECM of Malaysia macroeconomic variables and commodities prices

Dependent Variable	DOil		DGold		DCorn		DKLCI		DIndust		DCPI		DBLR		DTbill		DM2	
DOil(1)	0.1021	(0.06)	0.04968	(0.03)	-0.038	(0.05)	-0.02	(0.04)	0.052	(0.02)	0.0036	(0.002)	-0.018	(0.01)	-0.003599	(0.04)	0.002	(0.007)
DGold(1)	-0.195	(0.15)	-0.1674	(0.06)	-0.13	(0.12)	0.031	(0.10)	0.109	(0.06)	0.0008	(0.005)	0.044	(0.03)	0.041965	(0.10)	-0.02	(0.02)
DCorn(1)	0.1365	(0.07)	0.06094	(0.03)	0.048	(0.06)	0.025	(0.05)	0.05	(0.03)	0.0017	(0.003)	0.018	(0.01)	-0.025598	(0.05)	0.002	(0.009)
DKLCI(1)	0.0117	(0.09)	0.02172	(0.04)	0.177	(0.07)	0.07	(0.06)	-0.025	(0.03)	0.0041	(0.003)	0.042	(0.02)	0.15651	(0.06)	0.009	(0.01)
DIndust(1)	0.0561	(0.14)	-0.1105	(0.06)	-0.331	(0.11)	0.032	(0.10)	-0.462	(0.05)	-0.006	(0.005)	0.047	(0.03)	-0.051684	(0.10)	-0.02	(0.02)
DCPI(1)	0.5356	(1.69)	0.25519	(0.72)	2.114	(1.39)	1.914	(1.17)	-0.671	(0.66)	0.2346	(0.06)	0.374	(0.33)	0.18095	(1.16)	0.511	(0.20)
DBLR(1)	-0.159	(0.29)	-0.1403	(0.12)	-0.28	(0.24)	-0.728	(0.20)	-0.092	(0.11)	0.0001	(0.01)	0.291	(0.06)	0.18975	(0.20)	-0.01	(0.03)
DTbill(1)	0.0338	(0.09)	0.01558	(0.04)	0.037	(0.08)	0.007	(0.06)	0.073	(0.04)	-0.002	(0.003)	0.071	(0.02)	0.12561	(0.06)	-0.02	(0.01)
DM2(1)	-0.844	(0.51)	0.21832	(0.22)	-0.405	(0.42)	0.595	(0.35)	-0.312	(0.20)	0.0184	(0.02)	0.033	(0.10)	-1.0113	(0.35)	0.022	(0.06)
ECM (-1)	-0.015	(0.01)*	-0.0015	(0.01)*	-0.041	(0.01)	2E-04	(0.01)*	0.018	(0.005)	-8E-04	0.001)*	-0.003	(0.003)*	-0.013206	(0.009)*	-0.01	(0.002)
Chi - square SC(1)	23.169	(0.03)	11.473	(0.49)	20.54	(0.06)	33.3	(0.001)	83.13	(0.00)	12.052	(0.44)	21.4	(0.05)	3.34E+01	(0.001)	25.62	(0.01)
Chi - square FF(1)	6.1609	(0.01)	4.4562	(0.04)	0.656	(0.42)	0.079	(0.78)	3.885	(0.05)	0.2972	(0.59)	14.32	(0.00)	4.1314	(0.04)	1.511	(0.22)
Chi - square N(2)	18.061	(0.00)	26.6193	(0.00)	40.18	(0.00)	303	(0.00)	2.912	(0.23)	11559	(0.00)	1852	(0.00)	470.2689	(0.00)	17.71	(0.00)
Chi - square Het(1)	6.2035	(0.01)	3.8152	(0.05)	0.062	(0.80)	5.197	(0.02)	0.568	(0.45)	1.1674	(0.28)	36.42	(0.00)	20.2722	(0.00)	4.075	(0.04)

Notes: SEs are given in parenthesis. The diagnostics are chi-squared statistics for: serial correlation (SC), functional form (FF), normality (N) and heteroskedasticity (Het). The equations, therefore, are more or less well specified.
* Indicate significance at the 5% level.

Figure 1: Persistence Profile

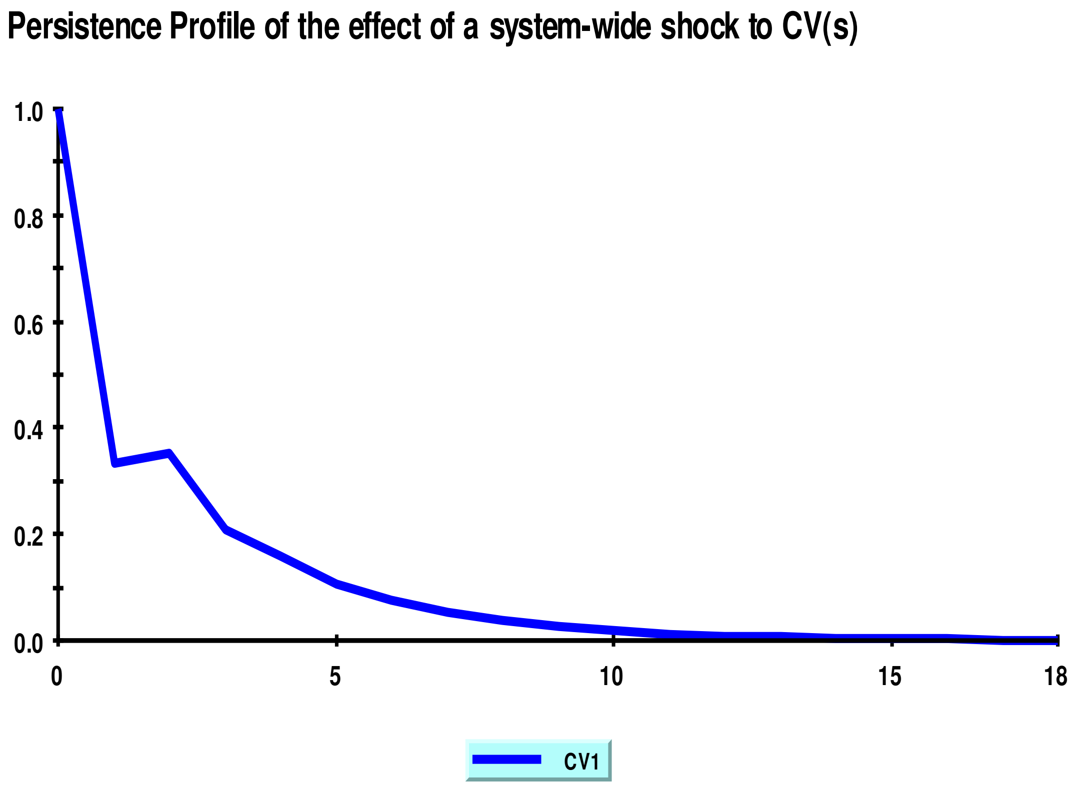


Table 3: Generalised Variance Decomposition

		Percentage of Forecast Variance Explained by Innovations in:								
		ΔLOIL	ΔGOLD	ΔCORN	ΔKLCI	ΔINDUST	ΔCPI	ΔBLR	ΔT-BILL	ΔM2
Months	Relative Variance in ΔLOIL									
24		83.9%	4.7%	0.3%	0.1%	6.3%	0.2%	0.0%	0.8%	3.7%
60		82.8%	5.0%	0.3%	0.1%	6.9%	0.1%	0.0%	0.9%	3.8%
120		82.4%	5.1%	0.3%	0.1%	7.1%	0.1%	0.0%	1.0%	3.9%
150		82.3%	5.2%	0.3%	0.1%	7.2%	0.1%	0.0%	1.0%	3.9%
Months	Relative Variance in ΔGOLD									
24		7.0%	86.0%	2.9%	0.7%	1.1%	0.1%	1.9%	0.3%	0.0%
60		6.8%	86.1%	2.6%	0.6%	1.5%	0.1%	1.9%	0.2%	0.0%
120		6.8%	86.1%	2.5%	0.6%	1.7%	0.2%	2.0%	0.2%	0.0%
150		6.8%	86.1%	2.5%	0.6%	1.7%	0.2%	2.0%	0.2%	0.0%
Months	Relative Variance in ΔCORN									
24		0.4%	11.6%	67.4%	2.8%	13.7%	1.4%	1.6%	0.8%	0.3%
60		0.4%	14.4%	59.2%	1.9%	18.4%	2.2%	1.8%	1.2%	0.5%
120		0.4%	14.8%	58.1%	1.8%	19.1%	2.3%	1.8%	1.3%	0.5%
150		0.4%	15.0%	57.6%	1.8%	19.3%	2.3%	1.8%	1.3%	0.5%
Months	Relative Variance in ΔKLCI									
24		0.1%	0.9%	2.1%	77.1%	1.9%	0.2%	7.6%	8.3%	1.8%
60		0.1%	1.0%	2.1%	76.3%	2.1%	0.1%	8.0%	8.4%	1.8%
120		0.1%	1.1%	2.0%	76.1%	2.2%	0.1%	8.1%	8.5%	1.8%
150		0.1%	1.1%	2.0%	76.0%	2.2%	0.1%	8.1%	8.5%	1.8%
Months	Relative Variance in ΔINDUST									
24		17.5%	4.7%	8.9%	6.6%	59.6%	1.3%	0.0%	1.0%	0.4%
60		20.4%	7.9%	12.0%	9.1%	47.9%	2.0%	0.0%	0.5%	0.2%
120		21.6%	9.3%	13.3%	10.1%	43.0%	2.3%	0.0%	0.3%	0.2%
150		21.8%	9.6%	13.6%	10.3%	42.0%	2.3%	0.0%	0.2%	0.2%
Months	Relative Variance in ΔCPI									
24		3.9%	5.1%	0.3%	0.2%	3.5%	85.3%	1.0%	0.2%	0.7%
60		4.1%	7.0%	0.2%	0.1%	5.4%	81.6%	0.8%	0.3%	0.5%
120		4.2%	7.7%	0.1%	0.1%	6.1%	80.3%	0.8%	0.4%	0.4%
150		4.2%	7.8%	0.1%	0.0%	6.2%	80.0%	0.8%	0.4%	0.4%
Months	Relative Variance in ΔBLR									
24		0.0%	2.4%	0.4%	1.0%	5.8%	1.6%	69.5%	19.0%	0.4%
60		0.0%	3.0%	0.3%	0.8%	7.2%	1.1%	67.0%	20.1%	0.4%
120		0.0%	3.2%	0.3%	0.8%	7.7%	0.9%	66.2%	20.4%	0.5%
150		0.0%	3.3%	0.3%	0.8%	7.8%	0.9%	66.0%	20.4%	0.5%
Months	Relative Variance in ΔT-BILL									
24		0.1%	0.1%	0.2%	0.1%	0.9%	0.0%	4.7%	81.8%	12.1%
60		0.1%	0.2%	0.2%	0.1%	1.0%	0.0%	4.6%	81.6%	12.3%
120		0.1%	0.2%	0.2%	0.1%	1.1%	0.0%	4.5%	81.5%	12.3%
150		0.1%	0.2%	0.2%	0.1%	1.1%	0.0%	4.5%	81.5%	12.3%
Months	Relative Variance in									

	ΔM2									
24		0.2%	7.5%	0.7%	0.5%	35.9%	1.9%	0.5%	2.2%	50.6%
60		0.2%	9.5%	0.9%	0.7%	41.8%	2.7%	0.6%	1.1%	42.5%
120		0.1%	10.1%	0.9%	0.7%	43.6%	3.0%	0.6%	0.8%	40.1%
150		0.1%	10.2%	1.0%	0.7%	43.9%	3.0%	0.6%	0.7%	39.7%

5.2 Correlation of Crude Oil Price Return (PR) with the Malaysian Macroeconomic Variables at Different Time and Investment Horizons Based on the Continuous Wavelet Transform

Chart 2 to 9 present the estimated continuous wavelet transform and phase difference for variables under review from scale 1 (one month) up to scale of 6 (128 months). Time is shown on the horizontal axis in terms of number of trading days, while the vertical axis refers to the investment horizon. The curved line below shows the 5% significance level which is estimated using Monte Carlo simulations. The figure follows a colour code as illustrated on the right with power ranges from blue (low correlations) to red (high correlations).

Any investor that has exposure in crude oil commodity and want to invest in Malaysia macroeconomic variables in order to obtain diversification benefit, will need to know the correlation between the crude oil price and the Malaysia macroeconomic variables. From Chart 2 below, any investor that would like to invest in Kuala Lumpur composite index (KLCI) and at the same time having exposure in crude oil, should not hold his/her portfolio more than 8 months in order to obtain diversification benefit. The correlation between KLCI and crude oil is high in high scale (8 months and above) period starting from July 2006 onward. For investment horizon of 32 months and above, the correlations between the crude oil price return and KLCI return is very high from the beginning of the sample data period (January 1990) until now. For the period between 8 months to 24 months, the correlation is low from January 1990 until 2006. Beyond year 2006, the correlation between the two variables is very high. 2006 is a period where crude oil price start to increase significantly from USD60 to USD140 by year 2008.

An investor who is interested to hold portfolio in the Malaysian T-bill and at the same time has an exposure in crude oil, should hold that investment for not more than 8 months in order to obtain diversification benefit. If his/her investment is beyond 8 months up to 32 months, he/she will be exposed to high correlation (please refer to Chart 3) especially starting from year 2006 onward. However, if the holding period for investment is more than 32 months, he/she will obtain diversification benefit since the correlation between the two variables is very low. T-bill is less correlate with crude oil compare to KLCI. This is mainly due to KLCI comprise of companies that has exposure to fluctuation of crude oil price in their daily production and activities. Meanwhile for T-bill, it interest rate is quite stable throughout investment period and it also hardly rely on crude oil price in determining it interest rate.

The correlation of crude oil price return with industrial production return is quite similar with the correlation of crude oil price return with KLCI return. By referring to Chart 4, we notice that the correlation between the two variables is high after 8 months horizon starting from year 2006 onward. From 1 month to 8 months horizon, the correlation between the two variable is low which indicates that crude oil price has no impact on industrial production in short term, but in the long term, it is highly affected. This can be observed in Chart 4 at the 32 months investment horizon from the beginning of the data (January 1990) that indicate high correlation between the two variables. Investors in industrial production should be aware of the impact of crude oil price in the long term that will affect their profit and business strategy. Therefore, certain action can be taken by the investor such as hedging their investment to mitigate their exposure.

Malaysia inflation (represented by CPI) is mildly affected by crude oil price before 2006. By year 2006, for the horizon between 8 months to 32 months, the correlation between inflation and crude oil is very high. This informs us that crude oil price does affect our inflation in the long term starting from year 2006 onward. Therefore, policy maker should monitor closely crude oil price in order not to be surprised by an increase in inflation due to increase in crude oil price. For the horizon beyond 32 months, the correlation between the two variables is low. This indicate that inflation in Malaysia is not influence by crude oil price fluctuation in the long run.

Money supply return, corn price return and gold price return are mildly affected by crude oil price return for all scales. Diversification benefit can be obtained in these three variables for investor who has exposure in crude oil commodity as presented in Chart 6, 8 and 9.

BLR is also mildly affected by crude oil price return with the exception of year 2006 onward where the 8 - 32 months scale is highly correlate. After the 32 months scale, the correlation is low as illustrated in Chart 7 which indicate that diversification benefits is available for the two variables.

We can clearly see the contributions of the continuous wavelet transformations in helping us understand portfolio diversification opportunities for investors with different investment horizons.

Table 6: Date for Horizontal Axis

Horizontal Axis	Date
50	January 1994
100	March 1998
150	May 2002
200	July 2006
250	September 2010

Chart 2: CWT – Crude Oil PR vs. KLCI Return

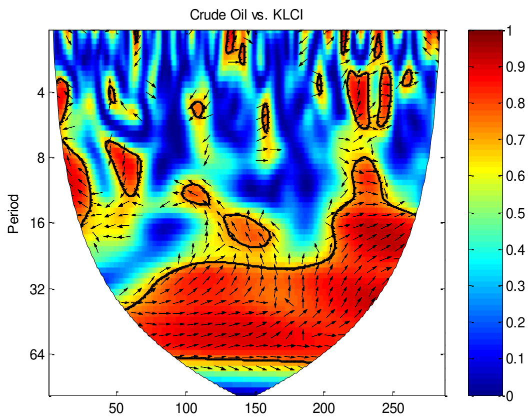


Chart 3: CWT – Crude Oil PR vs. Treasury Bill Return

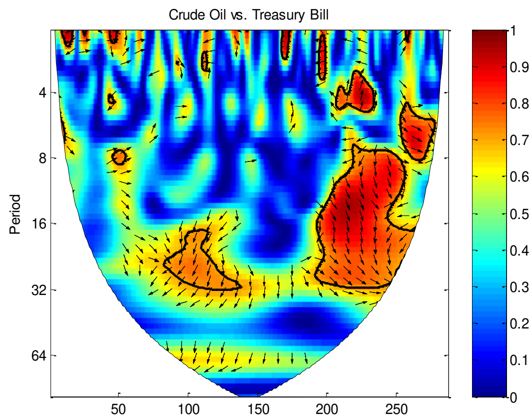


Chart 4: CWT – Crude Oil PR vs. Industrial Production Return

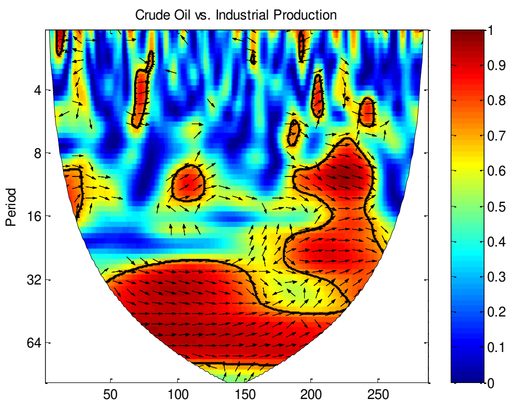


Chart 5: CWT – Crude Oil PR vs. CPI Return

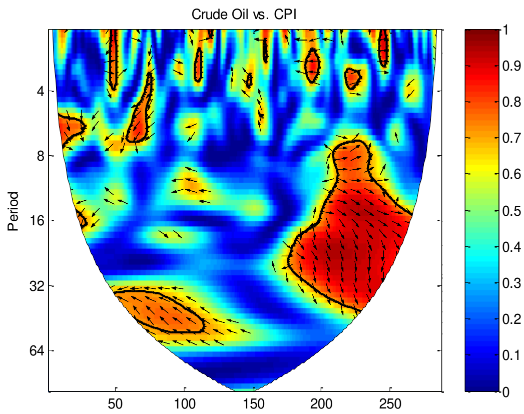


Chart 6: CWT – Crude Oil PR vs. Money Supply Return

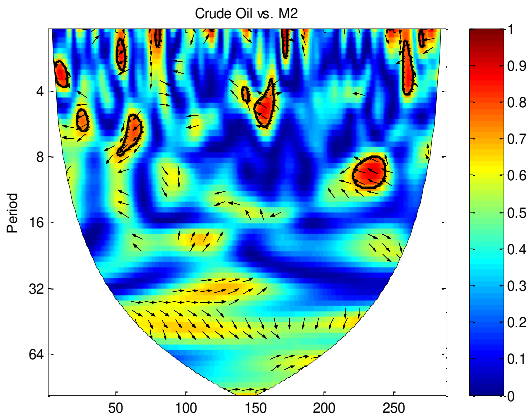


Chart 7: CWT – Crude Oil PR vs. Base Lending Rate Return

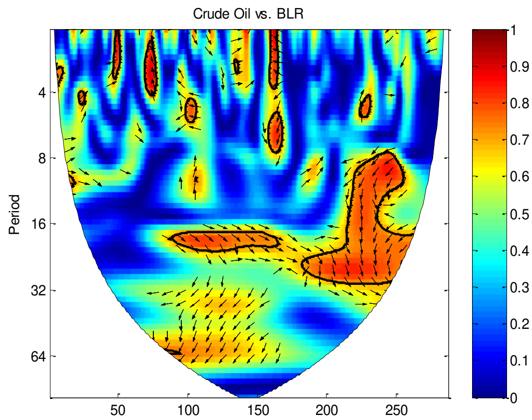


Chart 8: CWT – Crude Oil PR vs. Corn PR

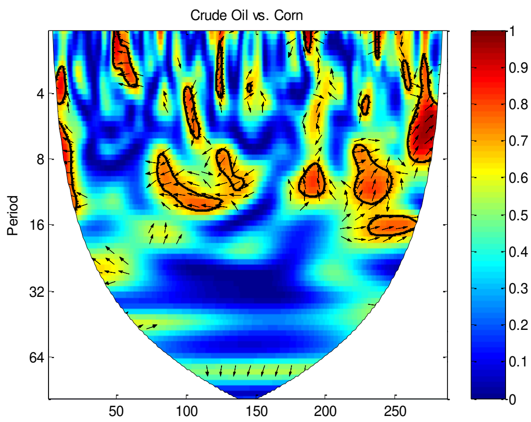
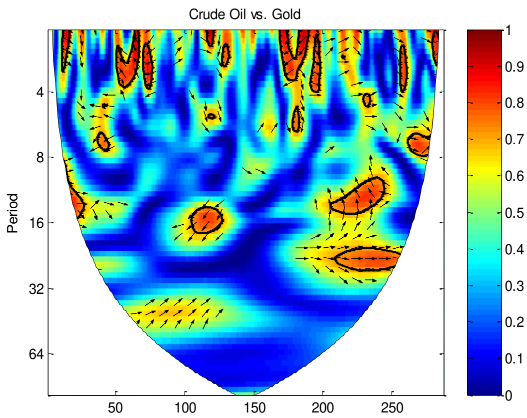


Chart 9: CWT – Crude Oil PR vs. Gold PR



6. Concluding Remarks

In order to address research objectives, we have applied the standard time series tests and recently applied econometric technique - Continuous Wavelet Transformation (CWT). Our major findings are as follows, firstly, we found that cointegration does exist between the Malaysian macroeconomic variables and selective commodities as evidenced from cointegration test. This imply that the diversification benefits for variables under observation is minimised in the long run because they tend to move toward the same direction. The VECM results show that the crude oil, gold, KLCI, CPI, BLR and T-bill are exogenous but the corn, industrial production and M2 are endogenous. That tends to indicate that the corn, industrial production and M2 would respond to the crude oil, gold, KLCI, CPI, BLR and T-bill.

Secondly, the Generalised VDCs results conform to our finding in VECM test that crude oil, gold, KLCI, CPI, BLR and T-bill are exogenous. Crude oil price is found to be the second most exogenous variable from all variables under review and it lead Malaysia macroeconomic variables in the horizon of 60 months and above. This finding is contrary to the findings of Cunado and Perez de Gracia (2005). That indicates that the oil price relationship with the Malaysian macro variables seems to be less significant.

Thirdly, the relative rank in exogeneity is stable as time passes for gold commodity. Between 24 months to 150 months, there are no changes in the ranking for the gold commodity where gold remains as the most exogenous variable. It is very surprising to find gold price as the most exogenous variables among all variables under review and this lead to an opportunity for further research in the future due to no satisfaction explanation can be provided for time being.

Fourthly, we find that T-bill, which is the third most exogenous variable, is the only variable under the control of the Malaysian government that can be adjusted in order to influence the other macroeconomic variables. Gold price and crude oil price are beyond the control of policy makers since their price fluctuations are based on demand and supply in the international market. However, a long period of time is needed to adjust the rate of T-bill because it is not a daily transaction instrument. Therefore, T-bill is a long term instrument for policy maker to control the direction of Malaysian economy.

Fifthly, we find that if the whole cointegrating relationship is shocked, it will take about ten months for the equilibrium to be restored. The period taken to get back into equilibrium is quite long and cautious reaction should be taken by policy makers and investors in order to ensure the economy and their investment not to be eroded further after the shock.

Finally, the value added stemming from the findings of the Continuous Wavelet Transformation (CWT) tends to indicate that an investor who has exposure in crude oil commodity and wants to invest in KLCI, industrial production and T-bill in Malaysia, should not hold his/her portfolio for more than 8 months in order to obtain diversification benefit. The correlation between KLCI, industrial production and T-bill with crude oil is very high in high scale investment horizon (above 8 months) starting from year 2006 onward. For the investment horizon above 32 months, the correlations between the crude oil price return with KLCI and industrial production is very high from the beginning of the sample data period (January 1990) until current. This is mainly due to companies in Malaysia are highly depend on the crude oil as energy resource. Therefore, any fluctuation in the crude oil price will give impact to them.

The Malaysia inflation (represented by CPI) is mildly affected by crude oil price before 2006 but crude oil price does affect our inflation in the long run starting from year 2006 onward. Therefore, the policy makers should monitor closely the crude oil price in order not to be surprised by an increase in inflation rate due to an increase in crude oil price. For the horizon beyond 32 months, the correlation between the two variables is low which indicate that inflation in Malaysia is not influence by crude oil price fluctuation in the long run. Consumer may shift to other energy resource such as gas to substitute crude oil in the long run.

We also find that money supply return, corn price return and gold price return are mildly affected by crude oil price return for all scales. Diversification benefits can be obtained in these three variables for an investor who holds crude oil commodity. The BLR is also mildly affected by crude oil price return with the exception of the year 2006 onward where the 8 - 32 months scale is highly correlated. After the 32 months scale, the correlation is very low which indicate that diversification benefits is available for the two variables.

We can clearly see the contributions of the continuous wavelet transformations in helping us understand portfolio diversification opportunities for investors with different investment horizons.

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