Long Run Dynamic Relationships between Oil Prices, Exchange Rates, Stock Market and Interest Rate in Malaysia

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***Abstract*— This study intends to identify the long run relationships between oil price, exchange rates, stock market and interest rate in the context of Malaysia. Weekly data from 1 January 2006 until 22 April 2018 were used. Unit root tests of ADF and PP reveal that all variables are non-stationary at level and become integrated and stationary at first differential series, hence ratify that these variables can be used for further long run investigation. An ARDL bound test and Johansen and Juselius cointegration test suggest the existence of actual long-run relationship between oil price, stock price index, exchange rate and interest rate in Malaysia. Results of Granger causality indicates the presence of unidirectional causality between oil prices and Malaysian stock market running from oil prices to the stock price index. Results also suggest that there is a presence of bi-directional causality between interest rate and oil prices which means causality is running from interest rate to oil prices and from oil prices to the interest rate. Lastly, the results also propose that there is an existence of uni-directional causality between exchange rate and oil prices, running from the exchange rate to the oil prices at 10 percent significance level. Even the results of wavelet coherence approach confirm long run relationships between the underlying variables.**

***Keywords*—** *Oil price, ARDL bound test, Granger causality, Wavelet theory*

1. Introduction

Oil has for decades been perceived as a necessary and important energy commodity, stimulating the world economy. It is considered as a vital resource for most of the oil consumer countries, and it is an important source of revenue for the oil supplier countries. Any changes in the oil price will affect the entire world economy, either through gross domestic product (GDP), consumer price index (CPI) etcetera. According to [1], low price elasticities of demand and supply of oil would cause sharp price fluctuations whenever there are disturbances on either side of the market. Nevertheless, the extent to which the oil-price fluctuations matter for the economy depends on the perspective of whether it is that of the macro economy, international trade or firm strategies. Generally, the oil price is affected by the supply and demand condition of the resources in the market. Due to the important role of oil in the world economy, it is important to analyze factors that cause changes in the oil price.

There are three important indicators of a country, namely stock market index, exchange rate and interest rate. The behaviour of these indicators reflect the condition of an economy. A stock market plays a crucial role in the development of a country through its function of facilitating the movement of funds between surplus and deficit units. The liquidity function embarked by the stock market instills confident in investors to take part in the financial market. Nevertheless, the stock market fluctuates (refer to Figure 1), and fluctuations in the stock market indices are normally associated with the general performance of a country's economic condition. There are various factors that explain the stock market performance. These factors can be explained by underpinning theories of Capital Asset Pricing Model (CAPM) and Arbitrage Pricing Theory (APT). CAPM indicates that the stock returns are solely determined by the market return. The systematic risk assumed by beta would justify the return expected by the investment. On the other hand, the APT reveals that stock returns

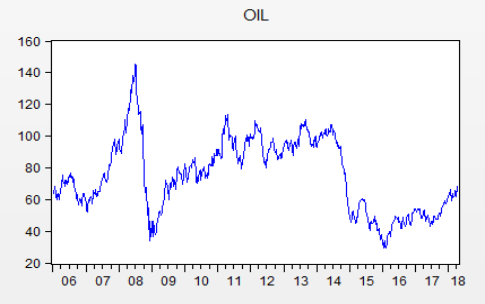
International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

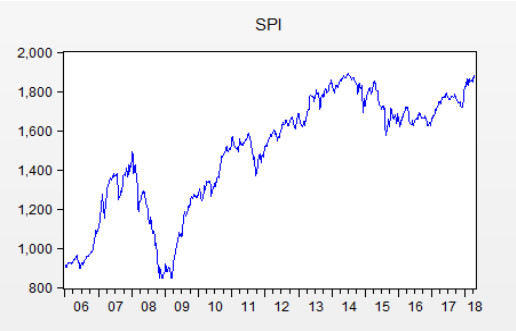
are influenced not just by the market return, but also by macroeconomic variables.

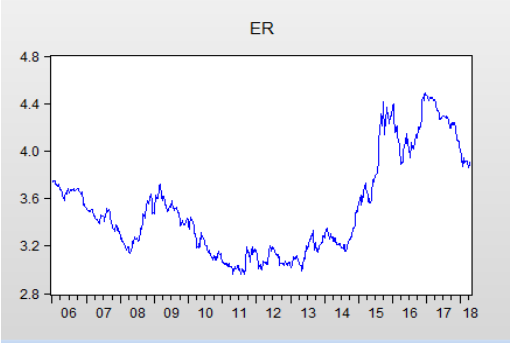
A stock market condition reflects investors' confidence in the economy. A higher price index indicates that investors are willing to invest, hence this helps businesses to be able to get more capital and expand. In other words, the demand would increase, assuming that the supply does not change. When the demand increases, a higher price is expected, and this is where the relationship between stock market index and oil price could be determined. The rational lies in the situation where the stock market can enhance the demand for the oil, thus causing the oil price to increase which can be translated into an expected positive relationship between the two variables. The relationship between the stock market and economic activity has long being discussed by economists. For instance, [2] manage to show that the stock market and economic activity move in similar cyclical patters with the changes in the stock market tend to precede changes in business conditions.

Meanwhile, exchange rates play a vital role in an economy especially in the level of trade. The depreciation of exchange rates is said to be able to attract foreign direct investment due to the lower cost of establishment. However, the depreciation of a currency is not always preferred. The lower value of currency would burden local participants of the foreign exchange market when there is a need to purchase foreign currency. Hence, stability in the currency value has been the main agenda of most economies. As highlighted by [3], a stable monetary environment is crucial to acieve economic stability. Nevertheless, the fact is exchange rates fluctuate (refer to Figure 1). The fluctuations of exchange rates are because of various factors. A study by [4] reveals that the exchange rates of a number of small commodity exporters are found to have remarkably robust forecasting power over global commodity prices. Furthermore, they highlight that the exchange rate is considered to be a forward-looking variable that embodies information about the future movements of commodity prices. Since Malaysia can be considered as an oil producing country, examining the relationship between exchange rates and the oil price can provide a valuable insight.

Another variable that is considered of equal important as stock market index and exchange rates is the interest rate. There is a negative relationship between an interest rate and the money supply. A larger money supply lowers the interest rate and vice versa. Apart from that, the interest rate is also considered as a cost of borrowing. Changes in the interest rate as a reflection of changes in the money supply is the conduct of monetary policy whereby used by the Government to influence the economic condition of a country. According to [5], the oil price are more responsive to long term real interest rates. The fact is interest rate fluctuates (refer Figure 1). These three variables can be easily observed in the market, and they tend to fluctuate due to supply and demand conditions and macroeconomic factors. Their movements could provide meaningful explanation on other indicator, such as the oil price, and allow us to predict the movement of the targeted variable.







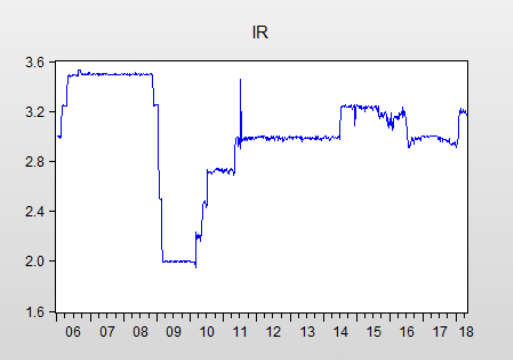


Figure 1: Multiple Graphs of Oil Price (OIL), Stock Price Index (SPI), Exchange Rate (ER) and Interest Rate (IR)

2. Literature Review

Since the first oil price shock in 1973-74 and the second shock in 1979-80, the movement of oil price have attracted the attention of academics and practitioners [6]. In the literature, the impacts of the oil price movement have been explained via different channels, it can be explained as an input for producing and consuming goods, thus, the economic activity could be reduced. Furthermore, the oil price movement could impose a direct rise in the inflation level, particularly for these oil-dependent economies. Oil prices movement could also have an impact on the consumer confidence which consequently could affect the economic growth, especially for oil-importing countries due to the limited access to international capital markets, low foreign exchange reserves and weak policy frameworks. Despite the fact that the oil price is affected by a number of factors, particularly the supply and demand condition of the oil itself, this study will only focus on three variables which are considered to be significant in affecting the fluctuation in the oil prices: the stock market, the exchange rate and the interest rate. In a way, these variables could have an impact on the supply and demand condition of the crude oil. Followings are discussions on a number of empirical studies which consider those three variables in their evaluation of the oil price fluctuations.

2.1 Stock Markets

[7] investigate the interactive relationships between oil price shocks and the Nigeria stock market. By applying the multivariate vector auto-regression of generalized impulse response function and the forecast variance decomposition error, their results reveal that the stock market returns exhibit insignificant positive response to oil shocks. However, the positive response reverts to negative effects after a period of time depending on the nature of the oil price shocks.

[8] aim to investigate the dynamic relationships between oil price shocks and Indian stock market. The study used daily data for the period starting from January 2001 to March 2013. The cointegration result indicates the existence of long-term relationship. Further, the error correction term of VECM shows a long-run causality moves from Indian stock market to oil price but not the vice versa. The results of the Granger causality test under the VECM framework confirm that no short-run causality between the variables exists. The VDCs analysis reveals that the Indian stock markets and crude oil prices are strongly exogenous. Finally, from the IRFs, analysis reveals that a positive shock in oil price has a small but persistence and growing positive impact on Indian stock markets in short run.

In Malaysia, [9] used VAR model and found that the Islamic Malaysian share prices have a positive and significant relationship with the crude oil price. [10] further justify the relationship between stock market indexes in Malaysia and oil price, gold price and the exchange rate over the period of 1995-2014. Their findings support that there are long-run linkages between the three variables and sectoral indices specifically for the Technology sector, while the short-run linkages are supported for the Financial, Industrial, Consumer Product, Industrial Product, Properties and Trade and Service. These results further strengthen the findings by [11] where their study suggests that the reactions of stock return to oil price changes differ among activity sector.

On the other hand, a study by [12] on emerging countries and with selected variables of oil price, exchange rate, and stock prices supports the interaction in the short run only. [13] find a significant long-term relationship between the movement of crude oil price and the performance of the Kuala Lumpur Composite Index (KLCI) and Jakarta Composite Index (JCI), respectively. The study employs the Engle-Granger Cointegration test using time series data from January 1986 through December 2006. The test results from

Impulse Response Function and Variance Decomposition show the presence of a dynamic interaction between the movement in crude oil prices and the two stock market indices. In contrast, a study by [14] finds that there is no relationship in the long run between oil price, exchange rate, and stock prices.

A causal relationship is also examined in the literature. [15] tests the existence of a causal relationship between the oil price and stock market growth. By using VECM Model, his findings show that there exists a long run unidirectional causal relationship from the oil price changes to stock market growth. This study will focus on the following hypothesis regarding the relationship between the world oil price and Malaysian stock market index:

H1: There is a significant relationship between the world oil price and the Malaysian stock market performance in the long run.

2.2 Foreign Exchange Rates

The other channel that has been examined by several studies is the relationship between oil prices and exchange rates. Earlier studies such as [16] has highlighted the link between oil prices and exchange rates. A decade later, [17] examined the relationship between oil price and exchange rate in the US context and supported empirically the negative correlation. They have developed their hypothesis of how exchange rate movements can affect oil prices in line with the law of one price argument. Oil' buyers will pay more dollars for oil if the dollar weakens relative to other currencies. Several studies empirically support the relationship between the movements in oil prices and exchange rates [18],[19]. [20] have considered both the long and short run and their findings show a significant impact of the US exchange rate on oil prices in the long run, but for the short run, the impact is limited. Other study done by [21] found that when the effects of two structural breaks of November 1986 and February 2005 were controlled, the relationship between the real price of oil and the real effective exchange rate of US dollar is supported.

A study done by [22] in the US context, uses causality tests and show that shocks of oil price has long-run effects on real exchange rates. Using structural VAR models for quarterly date over the period of 1990Q1 – 2007Q4, [23] reveals that a weaker dollar leads to higher commodity prices. [24] using a wavelet based approach, discovers a unidirectional causality between the oil price and US Dollar at high frequency bands, while a strong bidirectional causality is found for medium and low frequency bands. Based on the above arguments, it can be hypothesized that there is a long run and causal relationship between exchange rate and oil price, as the exchange rate could affect the oil price. Therefore, the second hypothesis of this study is developed as follow:

H2: There is a significant relationship between the world oil price and Malaysian exchange rates in the long run.

2.3 Interest Rates

Interest rates are considered as the cost of borrowing. Generally, when the interest rate goes up, the cost of borrowing increases. Hence, this causes less amount of money borrowed by organizations and individuals, and reduces the spending activities of these entities. Consequently, the demand for goods and services would drop, causing the prices of these goods and services to drop as well. [23] shows that a reduction in real interest rates causes commodity prices to increase significantly. Empirically, [25] find a strong connection between oil price and long run nominal interest rate. The third hypothesis for this study is as follows:

H3: There is a significant relationship between the world oil price and Malaysian interest rates in the long run.

3. Methodology

This study intends to analyze the relationship between oil prices (OIL), Malaysian stock market (SPI), exchange rate (ER) and interest rate (IR). The data on crude oil price, Malaysian stock market index and Malaysian exchange rate are gathered from Investing.com, while data on the Malaysian interest rate is obtained from the Bank Negara website. The study employs weekly data of 1 January 2006 until 22 April 2018. Table 1 highlights descriptive statistic of the variables. The oil price is based on the world oil price of $/bbl, the Malaysian stock market index is represented by FBMKLCI, the exchange rate is MYR/USD and the interest rate is represented by the conventional

interbank rate. The interbank lending rate is used because it serves as a reference rate in the pricing of numerous financial instruments (source: https://en.wikipedia.org). The mean values OIL, SPI, ER and IR are USD75.03/bbl, 1,484.37 MYR3.5184/USD and 3.015% respectively.

Table 1: Descriptive Statistics

	OIL	SPI	ER	IR
Mean	75.03044	1484.366	3.518339	3.015114
Median	74.09000	1568.530	3.424000	2.998000
Maximum	145.2900	1890.416	4.486000	3.534000
Minimum	29.42000	845.3700	2.963000	1.950000
Std. Dev.	22.95114	298.5772	0.417766	0.406881
Skewness	0.189615	-0.618844	0.760952	-1.127724
Kurtosis	2.308305	2.202096	2.458018	4.019337

Table 2 highlights the correlation matrix between the variables of crude oil price, stock market index, exchange rate and interest rate for Malaysia. Results of the correlation matrices show that the crude oil price has a positive correlation with stock market index and interest rate, while a negative correlation with the exchange rate.

Table 2: Correlation Matrix between Independent Variables

	OIL	SPI	ER	IR
OIL	1			
SPI	0.0421	1		
ER	-0.8035	0.1085	1	
IR	0.0497	0.0552	0.0966	1

4. Results and Discussion

The data analysis for this study is started by first checking the presence of trend in the sampled data. In doing so, we utilized two unit root approaches which are Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. The outcomes of ADF and PP tests are displayed in Table 3. Primarily, both tests are used on the level then on first differential series of variables. Table 3 displays that all variables are non-stationary at the level and become integrated and stationary at first differential series. It can be concluded that every variable is integrated at first differential series. Also, the structural break test displays the break period of every variable. The results confirm that oil price (OIL) has a break period in 2014 at level while a break period in 2008 at first difference series. Similarly, exchange rate (ER) has a breakpoint in 2014 whereas a break period in 2016 at first difference series. On the other hand, stock price index (SPI) have a breakpoint in 2008 and 2015, followed by interest rate that showed the breakpoint in 2008 and 2011 at first difference series. The results of unit root test ratify that these variables can be used for further long run investigation.

Variables	Augmented Dickey-Fuller				Structural Break		
	I(0)		I(1)		I(0)	I(1)	
	C	C&T	C	C&T	Break period	t-Stats	Break period
OIL	-1.89	-2.11	-24.59	-24.57	9/21/2014	-6.98	6/1/2008
SPI	-1.61	-2.17	-17.23	-17.23	4/19/2015	-17.99	3/9/2008
ER	-0.95	-1.74	-24.11	-24.14	8/24/2014	-24.89	1/24/2016
IR	-1.42	-1.41	-27.91	-27.89	11/16/2008	-7.47	7/10/2011

Note: The critical observations for ADF & PP tests with constant (c) and with constant & trend (C&T) at 1%, 5% & 10% level of significance are -3.596, -2.931, -2.604 and -4.194, -3.522, -3.219 respectively.

The results of Table 4 explain the outcomes of ARDL bound testing method cointegration. The outcome of ARDL suggested that we reject the null hypothesis of no cointegration in the framework since the value of the F-statistics is higher than the UBC of I(0) and I(1) at 1% level of significance. Because of this, we accept the alternate hypothesis which determines that an actual long-run relationship exists between oil price, stock price index, exchange rate and interest rate in Malaysia.

Table 4: Lag Length Selection & Bound Testing for Cointegration

Significance	I(0) Bound	I(1) Bound	F-test Statistics
10%	2.72	3.77	6.788*
5%	3.23	4.35	
2.50%	3.69	4.89	
1%	4.29	5.61	

* 1% level of significant.

In order to confirm the long term relationship, we also apply [26] cointegration analysis. The findings of Table 5 describe the trace statistics with its critical value and maximum eigenvalue with its critical value of [26] cointegration technique. The values show the rejection of null hypothesis which specifies that there is no cointegration in the framework at 1% level of significance. Consequently, we accept the alternate hypothesis which specifies the presence of more than one cointegrating vectors. The outcome ratify the presence of long run association among oil price, stock price index, exchange rate and interest rate in Malaysia.

Table 5: Johansen Juselius Cointegration Test

Null Hypothesis No. of CS(s)	Trace Statistics	5% critical values	Max. Eigen Value Statistics	5% critical values
None *	72.169	63.876	40.053	32.118
At most 1	32.116	42.915	20.855	25.823
At most 2	11.261	25.872	8.813	19.387
At most 3	2.447	12.518	2.447	12.518

* 1% level of significant.

The outcomes of Table 6 displays the estimation of ordinary least square (OLS) and dynamic ordinary least square (DOLS). The results proposed that stock price index, interest rate and exchange rate are the significant determinants of oil prices in Malaysia. The outcomes explain that stock price index and interest rate have a positive significant impact on oil prices in Malaysia. These findings confirm that higher growth in Malaysian stock price index and higher interest rate enhance the oil prices. The results further specify that there is a negative significant effect of exchange rate on oil prices in Malaysia. Among all the three variables, the exchange has a greater influence on oil price due to its high coefficient i.e. -2.395 which indicates that one unit increases in exchange rate decrease 2.395 unit of oil prices. Furthermore, the value of Adj. R¬2 is 0.714 which explains that oil prices are explained 71.4% of all the three predictors, i.e. stock price index, exchange rate and interest rate.

Table 6: Robustness of Long run Coefficients

Variables	OLS			DOLS		
	Coeff.	**t-stats**	**Prob.**	**Coeff.**	**t-stats**	**Prob.**
C	6.193	26.456	0.000	6.336	27.126	0.000
SPI	0.117	3.786	0.000	0.099	3.201	0.001
IR	0.198	4.313	0.000	0.163	3.524	0.000
ER	-2.395	-39.959	0.000	-2.372	-40.041	0.000
Adj. $\mathbf{R^2}$	0.714			0.727		

Dependent Variable: OIL PRICE

Table 6 also displays the results of dynamic ordinary least square (DOLS). The results confirmed that the coefficients of all variables, stock price index, interest rate, and exchange rate retain the significance and same sign after deploying advanced econometric techniques. Finally, it can be recommended that the interaction between the stock price index, exchange rate and interest rate with oil prices in Malaysia have the same sign and significance with its magnitude being same as that of the OLS-based coefficient model. These conclusions clarify that the earlier outcomes are robust.

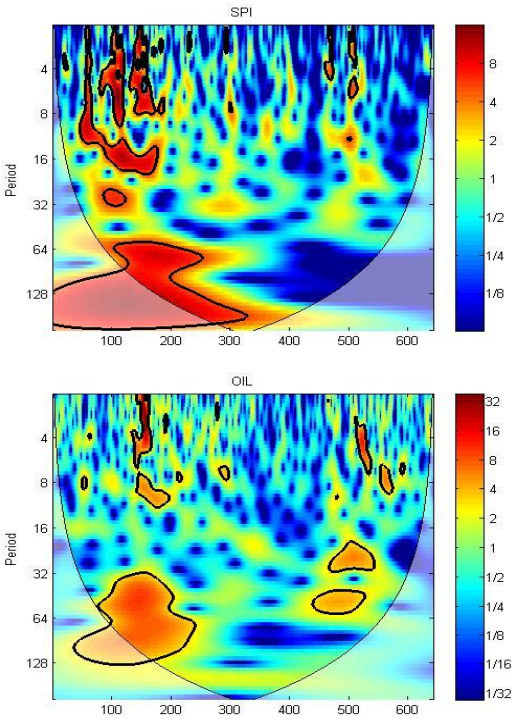
Table 7: Results of Pairwise Granger Causality

Null Hypothesis:	Obs.	F-Statistic	Prob.
SPI does not Granger Cause OIL	640	1.148	0.318
OIL does not Granger Cause SPI		10.579	0.000
IR does not Granger Cause OIL	640	3.374	0.035
OIL does not Granger Cause IR		3.909	0.021
ER does not Granger Cause OIL	640	2.781	0.063
OIL does not Granger Cause ER		1.226	0.294

Table 7 highlights the outcomes of Granger causality. The results explain that there is a unidirectional causal association between oil prices and stock prices which means causality is running from the oil prices to the stock price index. Furthermore, the outcome also suggested that there is a presence of bi-directional causality between interest rate and oil prices which means causality is running from interest rate to oil prices and from oil prices to the interest rate. Lastly, the result proposed that the there is an existence of uni-directional causality from the exchange rate to the oil prices in Malaysia at 10 percent significance level. To further justify the behaviour and causality function among the variables, this study further adopts the Continuous Wavelet Transform and Wavelet Coherence Transform approaches which consider nonlinear behaviour of the variables.

4.1 Continuous Wavelet Transform

The foremost objective of wavelet transform analysis is to combine the time and frequency domain, however, this description is not easy as the frequency information has varied resolution at every stage. The continuous wavelet analysis is easy to identify the time-frequency association as it provides more noticeable and visual frequency indication in the form of graphs.



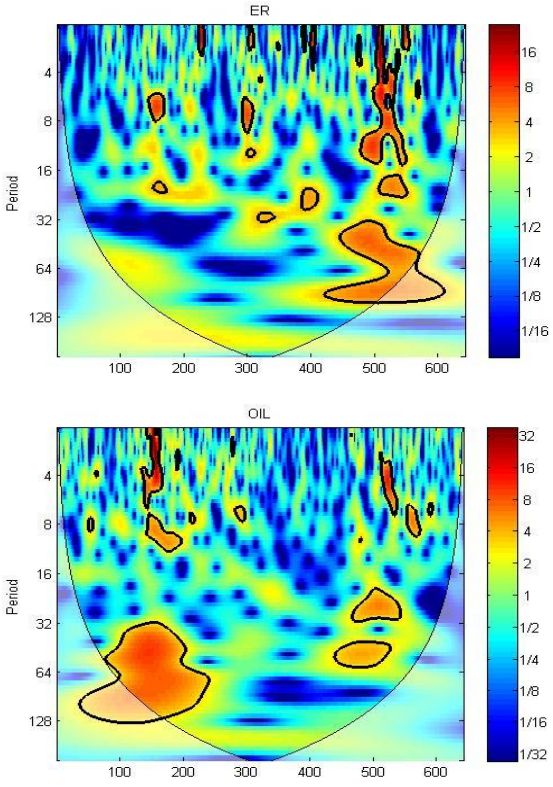
No. of Obs	Time Period
0-100	2006-2007
101-200	2007-2009
201-300	2009-2011
301-400	2011-2013
401-500	2013-2015
501-600	2015-2017
600-643	2017-2018

Note: The thick black contour represents the 5% significance level against the red noise. The color code for power ranges from blue (low power) to red (high power).

Figure 2: Continuous wavelet power spectra of the SPI and OIL.

Figures 2, 3 and 4 show the results of continuous wavelet analysis for all series with oil prices. The continuous wavelet power spectrum displays the activities of the series in a three dimensions' graph representing the frequency, color code and time period. Figure 2 clearly shows that both series of SPI and OIL have dissimilar features in various frequency and time domain. It is evident that in the case of SPI we detect a constant variance in the short (0-8 week period), medium (8-16 week

period), long (16-64 week period) and very long-run (64-128 week period). These outcomes propose that variance in the stock price index occurs in all the periods but mostly in the long run than short run and medium run. On the other hand, in the case of OIL, a low variance in the short run and a stable variance in the medium run is observed. Moreover, a strong variance is noticed in the long run. So, these findings suggest that the variance in the OIL also occurs confidently in the short and long run as well. Overall, both SPI and OIL display a similar pattern in a 0-8 week period and 64-128 week period.



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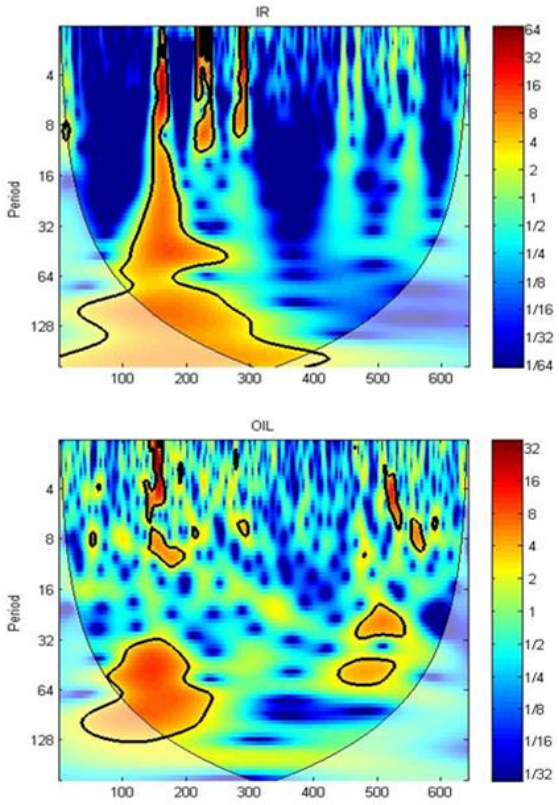
Note: The thick black contour represents the 5% significance level against the red noise. The color code for power ranges from blue (low power) to red (high power).

Figure 3: Continuous wavelet power spectra of the ER and OIL.

Figure 3 displays the results of the continuous wavelet transform of ER and OIL. Figure 3 evidently presents that both series of ER and OIL have different features in the various time-frequency domain. It is shown that in the case of ER we perceived a constant variation in the short (0-8 week period), medium (8-16 week period) and long (16-64 week period). However, we observed no variance in the very long-run (64-128 week period). The outcomes propose that variance in the exchange rate occurs in all periods except very long run period but mostly in the long run rather than short run and medium run. In combination, both ER and OIL display a similar pattern in 32-64 week period.



No. of Obs	Time Period
0-100	2006-2007
101-200	2007-2009
201-300	2009-2011
301-400	2011-2013
401-500	2013-2015
501-600	2015-2017
600-643	2017-2018

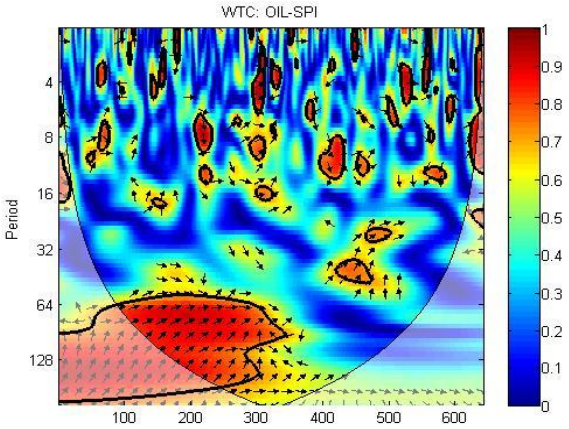
Note: The thick black contour represents the 5% significance level against the red noise. The color code for power ranges from blue (low power) to red (high power).

Figure 4: Continuous wavelet power spectra of the IR and OIL.

Figure 4 displays the results of the continuous wavelet transform of IR and OIL. Figure 4 clearly shows that in both series of IR and OIL have dissimilar features in the varied frequency and time domain. It is proved that in the example of IR we detect constant variation in the short (0-8 week period), medium (8-16 week period), long (16-64 week period) and very long-run (64-128 week period). The outcomes establish that the variance in the interest rate occurs in all the periods but mostly in the long-run rather than short-run and medium run. In combining both IR and OIL, we noticed that a similar pattern is observed in a 0-8 week period and 64-128 week period in IR-OIL relationship.

4.2 Wavelet Coherence Transform

The current study applied wavelet coherence transform to classify the existence of causal association between SPI & OIL, ER & OIL and IR & OIL in the time-frequency domain in Malaysia. Figure 5, 6 and 7 display the results of wavelet coherence analysis between SPI and OIL, ER and OIL and IR and OIL in Malaysia respectively.



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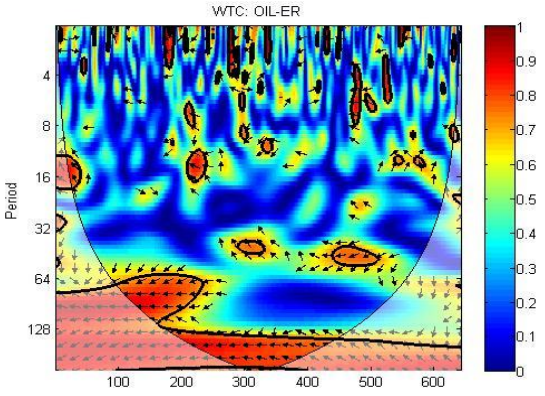
Note: The thick black contour represents the 5% significance level against the red noise. The color code for power ranges from blue (low power) to red (high power).

Figure 5: Wavelet Coherence power spectra of the OIL and SPI.

The results suggest that the significant causal association occurs between stock price index and oil prices in the short run as well as in the long run (refer Figure 5). In the short run, we notice some very small clusters for almost entire period from 2006-2017 in which some arrows are right-side up and right-side down reflecting that OIL and SPI are leading each other (i.e. SPI has a bi-directional influence with OIL indicating that oil prices and stock price index attracts each other in short and medium run). However, a visible large cluster is observed in the long and very long period during the time of 2006-2011 in which majority of the arrows are right side upward direction reflecting that SPI is leading over OIL (i.e. SPI has a causal influence over OIL in long and very long period). Therefore, the results of wavelet coherence confirm

that there is a bi-directional causal relationship between SPI and OIL. Whereas, a uni-directional causal relationship exists in a long and very long period where causality is running from stock price index to oil prices.



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501-600	2015-2017
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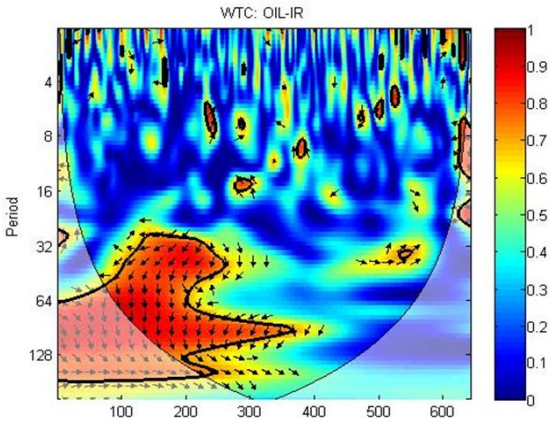
Note: The thick black contour represents the 5% significance level against the red noise. The color code for power ranges from blue (low power) to red (high power).

Figure 6: Wavelet Coherence power spectra of the OIL and ER.

Figure 6 explains the wavelet coherence results between OIL and ER. The results suggest that the significant causal connection occurs between exchange rate and oil prices in short and long run. In the short run, we notice some very small clusters for almost entire period from 2006-2017 in which some arrows are right-side up and down reflecting that OIL and ER are leading over each other (i.e. ER has a bi-directional influence with OIL indicating that oil prices and exchange rate attracts each other in short and medium run). However, a noticeable large cluster is detected in the long and very long period during the time of 2009-2013 in which majority of the arrows are left side upward direction reflecting that ER has an anti-cyclic effect on OIL (i.e. ER has a negative influence over OIL in long and very long period). Consequently, the results of wavelet coherence confirm that there is a bi-directional causal relationship between ER and OIL in short and medium run. Whereas, a uni-directional causal relationship exists in a long and very long period where causality is running from exchange rate to oil prices.



No. of Obs	Time Period
0-100	2006-2007
101-200	2007-2009
201-300	2009-2011
301-400	2011-2013
401-500	2013-2015
501-600	2015-2017
600-643	2017-2018

Note: The thick black contour represents the 5% significance level against the red noise. The color code for power ranges from blue (low power) to red (high power).

Figure 7: Wavelet Coherence power spectra of the OIL and IR.

Figure 7 highlights the wavelet coherence results between OIL and IR. The results propose that the significant causal connection exists between interest rate and oil prices in the long run. No evidence of substantial clusters is found in the 0-16 week period, which are the short run and medium

run periods. Therefore, we can conclude that there is no causal connection between OIL and IR in the short and medium run period. However, a noticeable large cluster is detected in the long and very long periods during the time of 2007-2013 in which majority of the arrows are left side down and also right side down direction reflecting that IR has a cyclic and anti-cyclic effect on OIL (i.e. IR and OIL has a causal influence over each other long and very long period). Consequently, the results of wavelet coherence confirm that there is a bi-directional causal relationship between IR and OIL.

5. Conclusion

Similar to most studies, this study reveals the existence of long run relationship between oil price, stock market index, exchange rate and interest rate through the ARDL bounds test and Johansen-Juselius Cointegration test (refer to [8], [10], [13] [20], [25]). Even though the oil price is represented by the world oil price, and the other variables are measured in terms of Malaysian indicators, all variables tend to move together in the long run because they are affected by global factors. For instance, the Malaysian stock market index has a strong correlation with the S&P 500, which is more than 0.7 (based on own calculation). According to [27], the Malaysian lending interest rate has a significant and positive relationship with China, Thailand and the United States. Therefore, changes of interest rates in these countries would positively affect the Malaysian interest rate. As for the exchange rates, the condition of an economy would definitely affect its exchange rate.

Results of Granger Causality indicate a unidirectional causality from oil price to stock market index (similar to [15]), bidirectional causality between oil price and interest rate and a unidirectional causality from exchange rate to oil price (similar to [23], [24]) but at a low significance level. To further strengthen the causality results, this study adopts the Wavelet Coherence Transform. Unlike the results of Granger Causality, results of Wavelet Coherence Transform indicate that there is a unidirectional causality from the stock price index to the oil price in the long and very long periods. Similarly, the wavelet coherence results indicate a unidirectional causality from the exchange rate to the oil price in the long run. Nevertheless, the approach also reveals short and medium runs bidirectional relationships between the exchange rate and the oil price. As for the IR and OIL causal relationship, the results of wavelet coherence justify a bidirectional relationship between the oil price and interest rate in the long run, and this result is similar to the results provided by Granger Causality.

Acknowledgments

This research project has been funded wholly by Universiti Utara Malaysia's Geran Penjanaan (Geran Penjanaan, S/O CODE 13900), UUM.

References

[1] R. Arezki et al., "*Oil Prices and the Global Economy*," IMF Working Paper: WP/17/15, 2017.

[2] B. Bosworth, S. Hymans, and F. Modigliani, "*The Stock Market and the Economy*," Brookings Papers on Economic Activity, Vol. 1972, No. 2, pp. 257-300, 1975.

[3] M.D. Bordo, and A.J. Schwartz, "*The Importance of Stable Money: Theory and Evidence*." In A. J. Schwartz (Ed.), Money in Historical Perspective (pp. 255-270): University of Chicago Press, 1987.

[4] Y.-C. Chen, K. Rogoff, and B. Rossi, "*Can Exchange Rates Forecast Commodity Prices?*" NBER Working Paper Series. Working Paper 13901, 2008.

[5] V. Arora, and M. Tanner, "*Do Oil Price Respond to Real Interest Rates?*" Energy Economics, Vol. 3 (March), pp. 546-555, 2013.

[6] R. Masih, S. Peters, and L. De Mello, "Oil Price Volatility and Stock Price Fluctuations in an Emerging Market: Evidence from South Korea," Energy Economics, Vol. 33, No. 5, pp. 975–986, 2011.

[7] M.A. Babatunde, O. Adenikinju, and A.F. Adenikinju, "*Oil Price Shocks and Stock Market Behaviour in Nigeria,"* Journal of Economic Studies, Vol. 40, No. 2, pp. 180-202, 2013.

[8] T.N. Sahu, K. Bandopadhyay, and D. Mondal, "*Crude Oil Price, Exchange Rate and Emerging Stock Market: Evidence from India*," Jurnal Pengurusan, Vol. 42, pp. 75-87, 2014.

[9] M.Y.M. Hussin, F. Muhammad, M.A. Hussin, and A.A. Razak, "*The Relationship between Oil Price, Exchange Rate and Islamic Stock Market in Malaysia*," Research Journal of Finance and Accounting, Vol. 3, No. 5, pp. 83-92, 2012.

[10] J. Pyeman, and I. Ahmad, "An Empirical Analysis of Sectoral Indices Movement in

Malaysian Stock Market," Journal of Business and Retail Management Research, Vol. 11, No. 4, pp. 52-58, 2017.

[11] M.E.H. Arouri, and D.K. Nguyen, "*Oil Prices, Stock Markets and Portfolio Investment: Evidence from Sector Analysis in Europe over the Last Decade*," Energy Policy, Vol. 38, No. 8, pp. 4528-4539, 2010.

[12] S.A. Basher, A.A. Haug, and P. Sadorsky, "*Oil prices, exchange rates and emerging stock markets*," Energy Economics, Vol. 34, No. 1, pp. 227-240, 2012.

[13] A.R.A. Hadi, M.H. Yahya, and A.H. Shaari, "*The Effect of Oil Price Fluctuations on the Malaysian and Indonesian Stock Markets*," Asian Journal of Business and Accounting," Vol. 2, No. 1 & 2, pp. 69-91, 2009.

[14] M.S. Shirodkar, "*Cointegration and causal relationship among crude oil prices, exchange rate and stock market performance: evidence from India*," Researchers World, Vol. 8, No. 3, pp. 111-119, 2017.

[15] O.O. Akinlo, "*Oil Price and Stock Market: Empirical Evidence from Nigeria*," European Journal of Sustainable Development, Vol. 3, No. 2, pp. 22-40, 2014.

[16] S.S. Golub, "*Oil Prices and Exchange Rates*," The Economic Journal, Vol. 93, No. 371, pp. 576-593, 1983.

[17] S.B. Bloomberg, and K.S. Harris, "*The Commodity-Consumer Price Connection Fact or Fable? Federal Reserve Board of New York*," Economic Policy Review. October, pp. 21-38, 1995.

[18] Y. Huang, & F. Guo, "*The Role of Oil Price Shocks on China's Real Exchange Rate*," China Economic Review, Vol. 18, No. 4, pp. 403-416, 2007.

[19] R.A. Lizardo, and A.V. Mollick, "*Oil Price Fluctuations and US Dollar Exchange Rates*," Energy Economics, Vol. 32, No. 2, pp. 399-408, 2010.

[20] Y.J. Zhang, Y. Fan, H.T. Tsai, and Y.M. Wei, "*Spillover Effect of US Dollar Exchange Rate on Oil Prices*," Journal of Policy Modeling, Vol. 30, No. 6, pp. 973-991, 2008.

[21] Y. Zhang, "*The Links between the Price of Oil and the Value of US Dollar*," International Journal of Energy Economics and Policy, Vol. 3, No. 4, pp. 341, 2013.

[22] K. Chaudhuri, and B.C. Daniel, "*Long-Run Equilibrium Real Exchange Rates and Oil Prices*." Economics letters, Vol. 58, No. 2, pp. 231-238, 1998.

[23] F. Akram, "*Commodity Prices, Interest Rates and the Dollar*," Energy Economics, Vol. 31, No. 6, pp. 838-851, 2009.

[24] F. Benhmad, "*Modeling Nonlinear Granger Causality between the Oil Price and U.S. Dollar: A Wavelet Based Approach*," Economic Modelling, Vol. 29, No. 4, pp. 1505-1514, 2012.

[25] C.P. Reicher, and J.F. Utlaut, "*The relationship between oil prices and long-term interest rates*," Kiel Working Paper, No. 1637, Kiel Institute for the World Economy (IfW), Kiel, 2010.

[26] S. Johansen, and K. Juselius, "*Maximum Likelihood Estimation and Inference on Cointegration with Applications to Demand for Money*," Oxford Bulletin of Economics and Statistics, Vol. 52, pp. 169-210, 1990.

[27] N.A. Auzairy, and C.Y. Thing, "*Lending Interest Rates' Relationships of Malaysia and Other Countries*," Acta Universitatis Danubius. Œconomica, Vol. 12, No. 3, pp. 127-137, 2016.