Short - and long-run relationship between oil price and exchange rate: evidence from Malaysia based on Markov regime switching approach

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Abstract

There has been an increase in irregularities in fluctuation of oil price globally with high unpredictability that have badly hit oil-producing countries including Malaysia as well as oil and gas companies that remains unresolved. We attempt to examine the short-and long run relationship between crude oil price and exchange rate using a combination of vector auto regression and Markov regime switching techniques. Malaysia is used as a case study. The findings tend to indicate that there is a short run impact on exchange rate when price of oil fluctuates, whereby oil price fluctuation has negative impact on MYR and it takes a long time for the impact to taper off. It is recommended that policy makers, investors and oil companies to take note of the impact on MYR with peaks in the 4th month after oil price changes and prepare accordingly using the right tools to manage and minimise risk of the impact.

Keywords: oil price, exchange rate, Markov regime switching, Malaysia

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1. Introduction

Energy prices play an important role in the global economy as they are the fuel used in driving productivity of an economy. Over the years, crude oil price have been fluctuating and hits below US$50 per barrel for Oklahoma West Texas Intermediate (OK WTI) on 6th January 2015 with previous spot price that ranged below US$50 between December 2008 until April 2009. The time of incident coincides with the period of the global economic slowdown in 2008 caused by the sub-prime crisis in the United States of America. Major oil producing countries are hit by the crises caused in the recent decades with uncertainty over prices of oil and this is affecting many oil producing countries that are predominantly Muslim countries.

Malaysia is one of the countries from the list of affected countries with uncertainty of oil price especially with a central government that relies on oil-based revenue to sustain its operation. However, changes in policy over the years of its National Transformation Programme has drastically reduced its reliance on oil-based revenue from more than 40% in years prior to 2010 to an estimated number of 14.6% which is in line with the objective set in the New Economic Model of Malaysia.

With such dynamics in movement of prices of oil since the beginning of the new millennium, it would be interesting to see how the price of oil would now affect the economic variables of an economy. Different executives and analysts from the lines of Wall Street and academic are predicting different sets of prices that ranges between US$40 to US$70 a barrel for Brent Crude Oil (Krauss, 2017). Political and economic instability in major oil producing country such as Venezuela could trigger another price hike. Krauss (2017) also highlighted the importance of domestic and foreign policy direction and decision by the Trump administration, which took over the administration of central U.S. government in December 2016 in relation to affecting the oil price.

2. Motivation of the Study

The Malaysian economy would be a good study material as it embarks on a series of transformation programmes to change the way of doing things in the central government beginning middle of 2009. With the reduction of reliance of oil-based revenue by the central government and the depreciation of the Malaysian Ringgit that begin in 2015, it would be an interesting study to test if there is a relationship between the price of oil with Malaysia's exchange rate as we are a net importer of fuel despite being an oil producing country. Reason being is that Malaysia exports high-grade oil for profit and import regular grade oil for domestic consumption.

In this study, Malaysia is set as the focus economy in comparison with the giant economy, i.e. the United States (U.S.) with variables to focus on is the exchange rate of Malaysian Ringgit (MYR) tested on the price of crude oil, OK WTI in the U.S. As the exchange rate is used as the main focus variable due to its function as a medium of exchange for goods and services between countries, we will be covering monetary economic theory as well in this paper in the concluding discussion.

Usage of WTI pricing is because the Malaysia's managed float pricing of fuel is based on a mechanism called Automatic Pricing Mechanism that uses WTI and Means of Platt, Singapore as reference in the mechanism.

To analyse the issue of the dynamic movement of oil price, OK WTI and the weakened position of the ringgit, MYR, we humbly attempt to predict the movement using the Markov Switching instrument that would enable us to produce the following according to Mandilaras & Bird (2010):

i. calculate the probabilities of a shift between two regimes;
ii. as well as their duration; and
iii. answer the question whether the correlations between variables vary across regimes.

To determine the relationship between price of oil and the exchange rate, we will be attempting to use the Granger Causality method, which allows me to decompose the relationships between the two variables into short term and long-term relationship. Our humble view is that this would be sufficient as oil prices would have immediate impact on exchange rate and will be reflected in a lagged period.

3. Literature Review

There are plenty of studies on the impact of oil price and supply on various economic and social variables available worldwide in top journals. There are studies with connect the dot between stock prices with change of oil price for example, Jones and Kaul (1996) for four countries, namely the United States, Canada, Japan and the UK. Their study found that fluctuation of oil prices affect stocks in the first two countries mentioned while the latter two were inconclusive.

Atems, Kapper and Lam (2015) which focus on oil supply mentioned that oil supply shocks have no significant effects on exchange rate however global aggregate demand and oil-specific demand shocks will lead to depreciation of currency. Amano and Van Norden (1998) has provided evidence that a 10% increase in oil price causes Japanese Yen to depreciate by 1.7% and an appreciation of

2.6% of the U.S. Dollar (USD). Similar researches in subsequent decade such as Basher et al. (2012) and Cheng (2008) documented depreciation of the USD during oil price shock.

A micro-econometric approach to study the exchange rate and oil price relationship was carried out by Ozmen and Akçelik (2017) for the Turkish market, focusing on price pass-through in motor fuel market. They found that the smaller the magnitude of positive cost shock the higher the pass-through is. It was noted that the sign asymmetry is reversed during crisis as market structure is suggested as the main explanation of the asymmetry. However, there are factors limiting the use of market power.

Brashmasrene, Huang and Sissoko (2014) discovered that the exchange rate shock has a significant negative impact on crude oil prices while the impulse response of the exchange rate variable to a crude oil price shock was statistically insignificant. They have also noted that the impact of extreme price volatility in June 2008 on exchange rates was significant and suggested that when world oil prices are stabilized, currency fluctuations and uncertainty can be minimized. Based on Reboredo (2012)'s oil price and exchange rate co-movement analysis, it was noted that the increase in oil price and depreciation in USD are weakly associated with two ways of causalities for different countries. It was also noted that the relationship seems to be stronger for oil exporting countries as compared to oil importing countries.

In relation with Malaysia being an oil producing country, Malaysia behaves differently over the past decade due to reduction in production is now a net importer of oil. Abdullah (2015) mentioned that Malaysia has turned into a net importer of crude oil and petroleum products beginning 2014. The export value of crude oil for the first 11 months of 2014 totals MYR7.7 billion while imports of petroleum products totals MYR8.9 billion.

With the interest in attempting to examine the relationship between oil price and MYR exchange rates, I am trying to replicate the method used by Brashmasrene, Huang and Sissoko (2014) using the Granger-causality test for the purpose of determining the relationship. The second step would be an attempt in using Markov Switching technique to identify the switching regimes for the period of January 1986 until April 2017 using the same monthly data.

4. Methodology and Data

4.1 Determining short-run and long-run dynamic relationship

The empirical specification used is the same to that of Brashmasrene, Huang and Sissoko (2014) whereby vector autoregression (VAR) technique are to be used to establish the relationship between the Oklahama West Texas Intermediate (OKWTI) oil price and the strength of the MYR exchange rate with the USD with monthly data from January 1986 until April 2017. The data provided is in forms of their natural logarithm. These data are obtained from the Energy Information Administration (EIA) database and the Federal Reserve data from the United States of America.

The two variables stated above are treated as endogenous jointly and are assumed to have no restriction on the structural relationship in the analysis. The mathematical representation of a VAR model is as follows:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t$$

where

y_t	is a k vector of endogenous variables,
x_t	is a d vector of exogenous variables,
$A_t, \ldots, A_p$ and B	are matrices of coefficients to be estimated, and
ε	is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

Panel Unit Root Test

The status of the data whether the data are stationary or nonstationary are examined using panel unit root test for both OKWTI and MYR (to a unit of USD) in their natural logarithm form. From the Augmented Dickey-Fuller test shown, both variables are nonstationary.

Null Hypothesis: MYR has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.273960	0.6427
Test critical values:	1% level	-3.447627	
	5% level	-2.869050	
	10% level	-2.570838	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: OKWTI has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.894214	0.3350
Test critical values:	1% level	-3.447627	
	5% level	-2.869050	
	10% level	-2.570838	

*MacKinnon (1996) one-sided p-values.

Panel Cointegration Test

The panel cointegration test is used to test on variables in order to show evidence of panel cointegration among variables. However, prior to running the cointegration test, I have decided to check on the lag order used to select the best lag for the set of variables i.e. OKWTI and MYR. Based on the VAR, it can be shown that the lag required is two with both AIC and SC pinpointing the lag of two. AIC and SC are commonly used for this method.

VAR Lag Order Selection Criteria
Endogenous variables: OKWTI MYR
Exogenous variables: C
Date: 05/17/17 Time: 21:35
Sample: 1986M01 2017M04
Included observations: 366

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-219.3729	NA	0.011492	1.209688	1.231014	1.218162
1	1305.392	3024.535	2.83e-06	-7.100505	-7.036528	-7.075082
2	1337.701	63.73485*	2.42e-06*	-7.255198*	-7.148569*	-7.212827*
3	1340.213	4.926874	2.44e-06	-7.247064	-7.097783	-7.187744
4	1343.520	6.451930	2.45e-06	-7.243279	-7.051346	-7.167010
5	1347.316	7.363421	2.45e-06	-7.242163	-7.007579	-7.148946
6	1350.962	7.034033	2.46e-06	-7.240232	-6.962995	-7.130066
7	1353.489	4.847081	2.48e-06	-7.232183	-6.912295	-7.105068
8	1354.772	2.444960	2.52e-06	-7.217331	-6.854791	-7.073268
9	1358.501	7.071140	2.52e-06	-7.215851	-6.810659	-7.054839
10	1361.678	5.990392	2.53e-06	-7.211356	-6.763513	-7.033396

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

With the lag order determined, the Johansen cointegration test is used to examine if evidence of panel cointegration among variables occurs. Evidence from the test for both the Trace test and maximum Eigenvalue test shows that there is no cointegration between the variables as the p-value are higher than 0.05 level.

Date: 05/17/17 Time: 21:39
Sample (adjusted): 1986M04 2017M04
Included observations: 373 after adjustments
Trend assumption: Linear deterministic trend
Series: OKWTI MYR
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.017271	7.525773	15.49471	0.5174
At most 1	0.002751	1.027469	3.841466	0.3108

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.017271	6.498304	14.26460	0.5501
At most 1	0.002751	1.027469	3.841466	0.3108

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

OKWTI	MYR
-1.578989	3.985985
-0.463653	-4.865764

Unrestricted Adjustment Coefficients (alpha):

D(OKWTI)	0.010704	0.000298
D(MYR)	-0.000564	0.000982

1 Cointegrating Equation(s): Log likelihood 1357.816

Normalized cointegrating coefficients (standard error in parentheses)

OKWTI	MYR
1.000000	-2.524390
	(1.44428)

Adjustment coefficients (standard error in parentheses)

D(OKWTI)	-0.016902
	(0.00667)
D(MYR)	0.000890
	(0.00158)

It would also be good to highlight the covariance between the two variables with high deviations of the two variables from their respective means.

	OKWTI	MYR
OKWTI	0.440495	0.044759
MYR	0.044759	0.030678

Granger Causality Test

Based on the earlier Johansen cointegration test that shows both variables are not correlated to each other, we can now run on the unrestricted VAR and subsequently the Granger Causality Test using the VAR instead of using the vector error correction model (VECM) that is used if the variables are cointegrated. Using the VAR model, the result shown from the Granger Causality Test is as follows

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 05/17/17 Time: 21:45
Sample: 1986M01 2017M04
Included observations: 374

Dependent variable: MYR

Excluded	Chi-sq	df	Prob.
OKWTI	3.635094	2	0.1624
All	3.635094	2	0.1624

Dependent variable: OKWTI

Excluded	Chi-sq	df	Prob.
MYR	2.419510	2	0.2983
All	2.419510	2	0.2983

The Granger causality test shows that neither variables Granger-cause each other with p-value that are much higher than 0.05 level. The interpretation of these data will be discussed in the next section.

Variance Decomposition

The following table shows the result of the variance decomposition with numbers showing the percentage of forecast error using montecarlo method in each variable that can be attributed to innovations in other variables across the monthly period for 24 months. This is an indication of short-run and long-run.

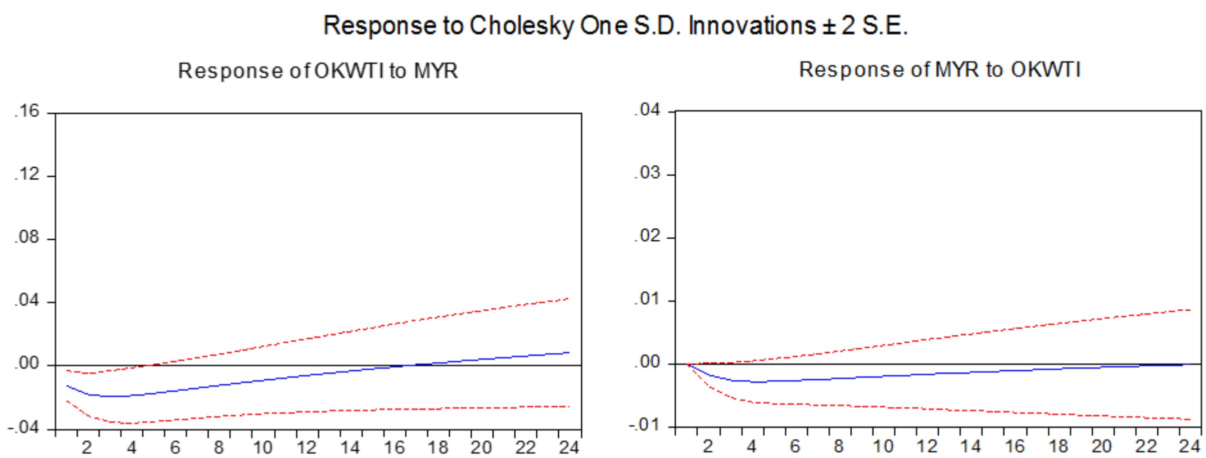
As shown on the in the table, the variability in MYR exchange rate to USD is explained by its own innovation with reduction to 99.3% at end of first year and subsequently at end of 24 months, increased a little bit to 99.5%. This literally shows that the exchange rate of MYR can sustain on its own. Looking at the decomposition of the OKWTI against MYR, there is little impact on changes of oil price with the MYR's strength against USD. The highest potential shock is in the 4th month with 3.02% and it is worth noting that percentage on the higher side, above 2.5% between 2nd month to 8th month, indicating slightly higher effect in short run as compared with long run, at 1.45% in the 24th month. This finding supports the finding of Roberedo (2012) and Brahmasrene, Huang and Sissoko (2014) whereby there is a weak linkage between exchange rate and oil price.

Period	Variance Decomposition of MYR: S.E.	MYR	OKWTI	Variance Decomposition of OKWTI: S.E.	MYR	OKWTI
1	0.019323	100.0000	0.000000	0.081988	2.301516	97.69848
		(0.00000)	(0.00000)		(1.47451)	(1.47451)
2	0.031362	99.69756	0.302440	0.131826	2.798964	97.20104
		(0.30038)	(0.30038)		(1.74765)	(1.74765)
3	0.040817	99.42632	0.573682	0.170126	2.991384	97.00862
		(0.57574)	(0.57574)		(2.00084)	(2.00084)
4	0.048571	99.26236	0.737636	0.200921	3.017505	96.98249
		(0.76033)	(0.76033)		(2.15257)	(2.15257)
5	0.055160	99.17613	0.823871	0.226601	2.957429	97.04257
		(0.88054)	(0.88054)		(2.23016)	(2.23016)
6	0.060912	99.13710	0.862901	0.248607	2.854092	97.14591
		(0.96278)	(0.96278)		(2.26297)	(2.26297)
7	0.066034	99.12582	0.874176	0.267846	2.730254	97.26975
		(1.02392)	(1.02392)		(2.27018)	(2.27018)
8	0.070662	99.13097	0.869032	0.284914	2.598278	97.40172
		(1.07382)	(1.07382)		(2.26329)	(2.26329)
9	0.074892	99.14593	0.854067	0.300226	2.465169	97.53483
		(1.11815)	(1.11815)		(2.24915)	(2.24915)
10	0.078790	99.16678	0.833218	0.314083	2.335084	97.66492
		(1.16018)	(1.16018)		(2.23198)	(2.23198)
11	0.082407	99.19108	0.808921	0.326709	2.210605	97.78939
		(1.20185)	(1.20185)		(2.21452)	(2.21452)
12	0.085783	99.21726	0.782736	0.338281	2.093403	97.90660
		(1.24431)	(1.24431)		(2.19874)	(2.19874)
13	0.088947	99.24431	0.755693	0.348936	1.984587	98.01541
		(1.28828)	(1.28828)		(2.18621)	(2.18621)
14	0.091924	99.27151	0.728488	0.358787	1.884914	98.11509
		(1.33419)	(1.33419)		(2.17834)	(2.17834)
15	0.094735	99.29840	0.701601	0.367926	1.794900	98.20510
		(1.38232)	(1.38232)		(2.17647)	(2.17647)
16	0.097397	99.32463	0.675368	0.376433	1.714895	98.28510
		(1.43283)	(1.43283)		(2.18195)	(2.18195)
17	0.099923	99.34998	0.650023	0.384372	1.645130	98.35487
		(1.48584)	(1.48584)		(2.19610)	(2.19610)
18	0.102325	99.37427	0.625731	0.391801	1.585747	98.41425
		(1.54140)	(1.54140)		(2.22022)	(2.22022)
19	0.104616	99.39739	0.602605	0.398768	1.536816	98.46318
		(1.59955)	(1.59955)		(2.25548)	(2.25548)
20	0.106802	99.41928	0.580721	0.405317	1.498355	98.50164
		(1.66027)	(1.66027)		(2.30289)	(2.30289)
21	0.108893	99.43987	0.560127	0.411483	1.470336	98.52966
		(1.72354)	(1.72354)		(2.36326)	(2.36326)
22	0.110896	99.45915	0.540852	0.417302	1.452695	98.54731
		(1.78934)	(1.78934)		(2.43710)	(2.43710)
23	0.112816	99.47709	0.522906	0.422801	1.445335	98.55466
		(1.85761)	(1.85761)		(2.52464)	(2.52464)
24	0.114660	99.49371	0.506290	0.428008	1.448136	98.55186
		(1.92828)	(1.92828)		(2.62582)	(2.62582)

Cholesky Ordering: MYR OKWTI
Standard Errors: Monte Carlo (100 repetitions)

Impulse Reponses

Using the same concept as the study from Brahmasrene, Huang and Sissoko (2014), I am also using the impulse response functions to analyse the time profile of effects of shocks on movements of the oil price and strength of MYR in the future. Looking at the chart themselves, the MYR reacts almost negatively to price change in WTI over the period of 24 months with negative effect tapering off beginning from the 5th month to near zero at the end of 24 months. The movement of OKWTI is reflected in a similar manner with main difference that the price effect will turn positive from month 17th onwards and as they are shown, the long run positive impact of OKWTI to MYR is responding better than the MYR to the OKWTI with a steeper line.



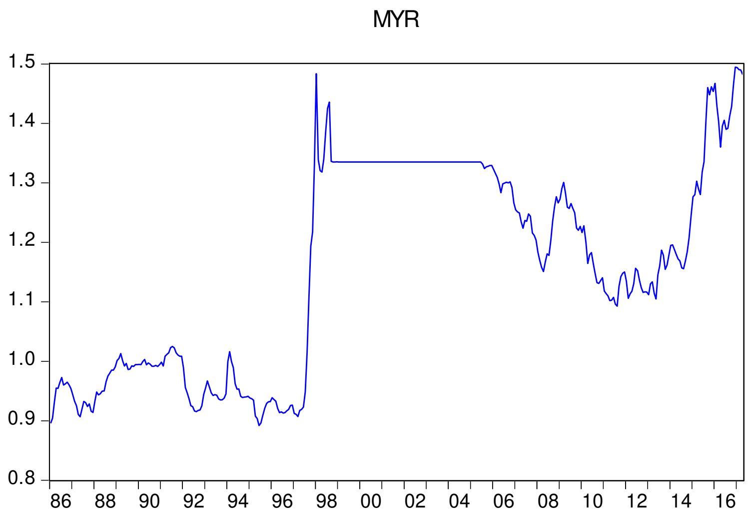
From the variance decomposition and impulse response for both variables are significant with expected response of MYR to OKWTI is higher due to the significance difference in size of economy between Malaysia and the United States.

4.2 Markov Switching Regime to Determine Probability of Regime Switching in MYR against USD

Upon identifying the dynamic relationship between the variables, whereby, MYR is weakly linked to the change in oil price, OKWTI, we would now move to testing the data on MYR strength from 1986 until 2017 using Markov Switching technique for the following:

i. calculate the probabilities of a shift between two regimes;
ii. as well as their duration; and
iii. answer the question whether the correlations between variables vary across regimes.

This technique allow us to predict the potential movement of the MYR during especially taking into account the weakening position of MYR in recent years. It is noticeable by looking at the chart in which the data shown is in its natural logarithm form, a continuation from the earlier usage of data form from the Granger causality test.



The same Markov Switching technique with Hamilton (1989) is used and it has provided us with the following results with a regime 1 duration continues to happen for 185.7 months while regime 2 only happens for a short while of 2 months. P-11 denotes 99.5% probability with a coefficient of 1.27 of remaining in regime 1, which can be indicated due to the policy of the Government of Malaysia in pegging the MYR to USD post Asian Financial Crisis 1998.

The regime 2 would be a more appropriate use for the policy makers in an attempt to make adjustment to the monetary policy in ensuring a stable exchange rate against USD however, probability wise would be quite close as p-22 denotes 49% with 2 months as maximum duration.

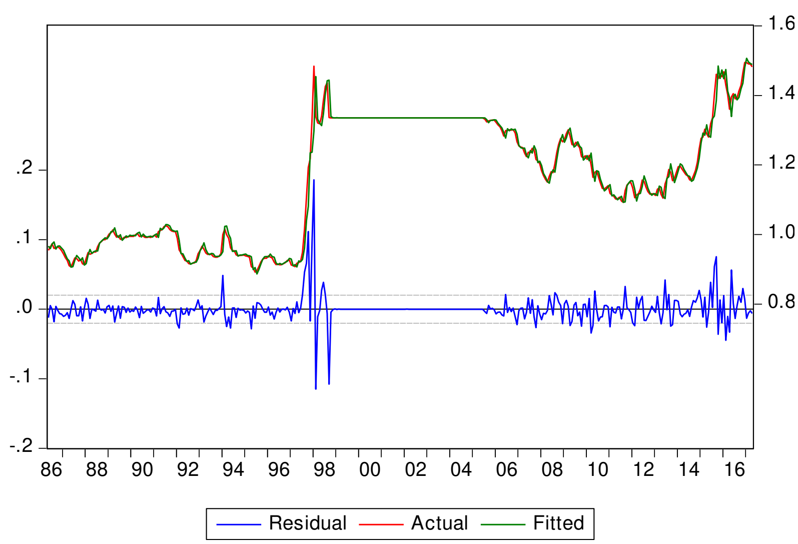
Date: 05/17/17 Time: 21:56
Transition summary: Constant Markov transition probabilities and expected durations
Sample (adjusted): 1986M05 2017M04
Included observations: 372 after adjustments

Constant transition probabilities:
P(i, k) = P(s(t) = k | s(t-1) = i)
(row = i / column = j)

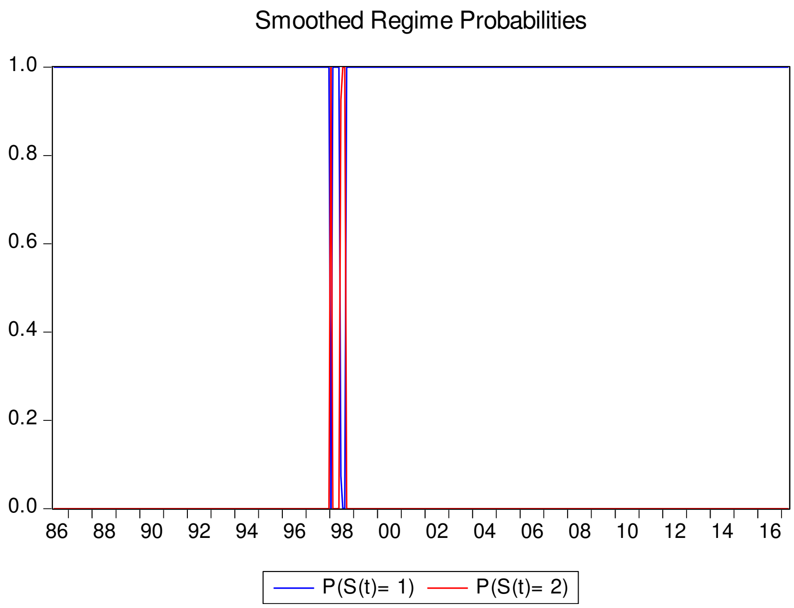
	1	2
1	0.994614	0.005386
2	0.510786	0.489214

Constant expected durations:

1	2
185.6542	1.957767



Open



5. Contributions, Implications and Conclusion

The results from this paper's examination support the contribution made by Roberedo (2012) and Brahmasrene, Huang and Sissoko (2014) whereby despite adding the additional data for the last couple of years, it is still safe to mention that the relationship between movement of exchange rate and oil price for at least Malaysia is not as dynamic as one would expect. The argument of potential stronger relationship between MYR exchange rate and oil price is not as solid as one would have thought of despite Malaysia's reliance on importation of crude oil for domestic consumption.

There are some differences in the nature of data whereby unlike the Brahmasrene, Huang and Sissoko (2014)'s dataset, the dataset in this paper are both nonstationary. The Johansen cointegration test has also shown that there is no cointegration between the variables which is proven later during the variance decomposition and impulse responses analysis test that their long run relationship are not as significant.

Similar to the previous analysis prepared by other researchers, there is a short run impact on exchange rate when price of oil fluctuates. For Malaysia itself, it takes a long time for the negative impact to taper off. For the policy makers, it would be useful to manage MYR using monetary instruments such as interest rate to keep the currency stable whenever oil price fluctuates. This is important to keep the currency competitive to improve export of Malaysia with the gap of trade balance closing up its gap over the past few years. This is especially important to keep MYR from further depreciation as changes of regime 2 (~50% probability) to happen shown in the section for Markov Switching for 2 months that almost coincides with the high impact period of oil price change on exchange rate.

Oil companies in Malaysia should also find this piece of information to be useful as the oil that they are purchasing is affected by the fluctuation in oil price and exchange rate. This study will be useful for them to be used as a guide for hedging purpose for the commodity itself as well as the medium of exchange. The final impact would be lowering the risk of oil and exchange rate shock in managing profit of the company. This is especially important as the oil produced for domestic market in Malaysia is mostly imported as the locally produced oil is of higher quality that is worth more if they are exported instead of consumed locally. Production cost can be significantly controlled as the automatic pricing mechanism for fuel price in Malaysia is still under the control of the government. Similar to oil companies, investors may also find this information to be useful for managing their portfolios especially when their investment is heavy on commodity or on currency trading.

As this paper focuses more on the economic context of Malaysia, future research can be replicated as well for other countries with different economic, social and political setup which may impact the outcome of the study differently despite having the same set of methodology and literature review.

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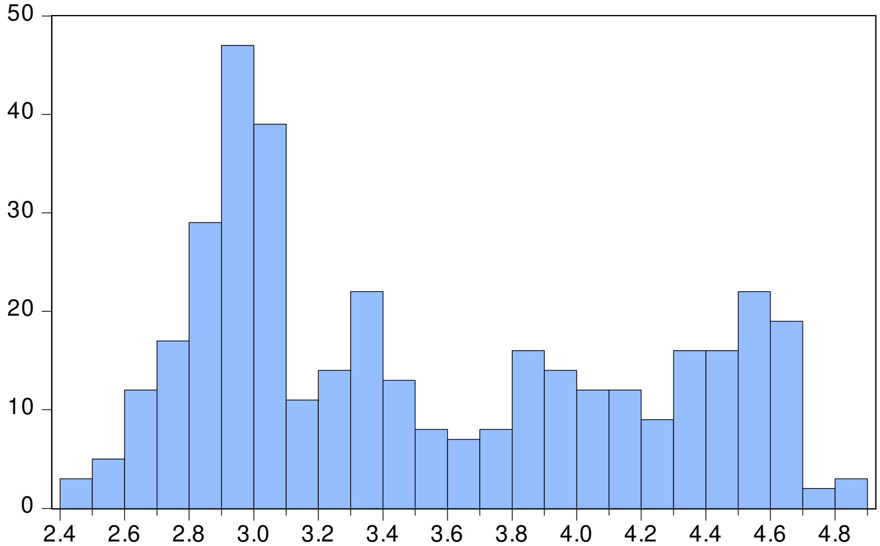
Appendix



Series: OKWTI
Sample 1986M01 2017M04
Observations 376

Mean	3.533554
Median	3.346900
Maximum	4.896900
Minimum	2.429200
Std. Dev.	0.664583
Skewness	0.380235
Kurtosis	1.739750
Jarque-Bera	33.94250
Probability	0.000000

Null Hypothesis: MYR has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=16)

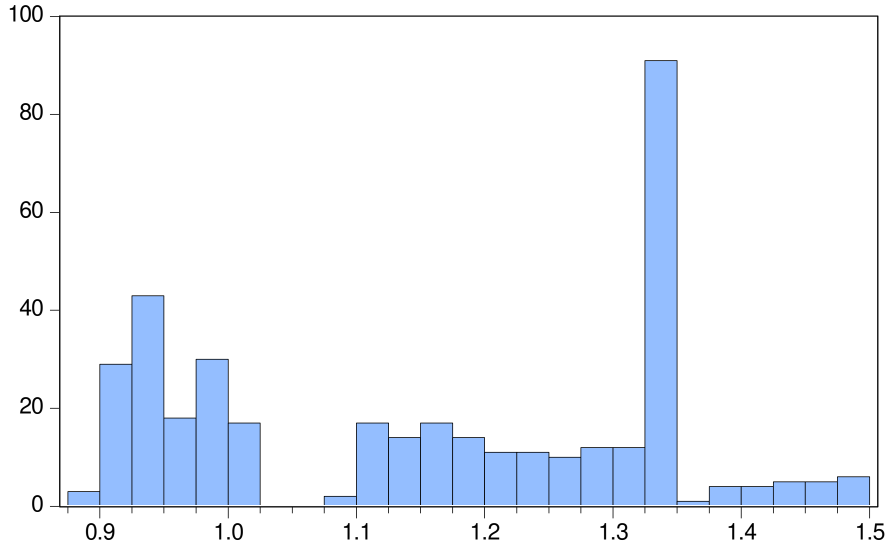
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.273960	0.6427
Test critical values:	1% level	-3.447627	
	5% level	-2.869050	
	10% level	-2.570838	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MYR)
Method: Least Squares
Date: 05/17/17 Time: 21:32
Sample (adjusted): 1986M03 2017M04
Included observations: 374 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MYR(-1)	-0.007340	0.005761	-1.273960	0.2035
D(MYR(-1))	0.286027	0.049854	5.737242	0.0000
C	0.009586	0.006738	1.422743	0.1557

R-squared	0.083137	Mean dependent var	0.001545
Adjusted R-squared	0.078194	S.D. dependent var	0.020170
S.E. of regression	0.019366	Akaike info criterion	-5.042628
Sum squared resid	0.139138	Schwarz criterion	-5.011150
Log likelihood	945.9714	Hannan-Quinn criter.	-5.030130
F-statistic	16.82020	Durbin-Watson stat	1.978300
Prob(F-statistic)	0.000000		



Series: MYR	
Sample 1986M01 2017M04	
Observations 376	
Mean	1.157586
Median	1.169350
Maximum	1.494500
Minimum	0.891800
Std. Dev.	0.175385
Skewness	-0.041224
Kurtosis	1.557763
Jarque-Bera	32.69392
Probability	0.000000

Cannot reject null hypothesis as Prb is higher than 0.05, OKWTI is non stationary

Null Hypothesis: OKWTI has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=16)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.894214	0.3350
Test critical values:	1% level	-3.447627	
	5% level	-2.869050	
	10% level	-2.570838	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(OKWTI)
Method: Least Squares
Date: 05/17/17 Time: 21:33
Sample (adjusted): 1986M03 2017M04
Included observations: 374 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
OKWTI(-1)	-0.012112	0.006394	-1.894214	0.0590
D(OKWTI(-1))	0.277296	0.048360	5.733989	0.0000
C	0.045425	0.022983	1.976463	0.0488

R-squared	0.086645	Mean dependent var	0.003194
Adjusted R-squared	0.081721	S.D. dependent var	0.085607
S.E. of regression	0.082035	Akaike info criterion	-2.155359
Sum squared resid	2.496717	Schwarz criterion	-2.123881
Log likelihood	406.0522	Hannan-Quinn criter.	-2.142861
F-statistic	17.59731	Durbin-Watson stat	2.013933
Prob(F-statistic)	0.000000		

Estimation Proc:
===============================
LS 1 2 MYR OKWTI @ C

VAR Model:
===============================
MYR = C(1,1)*MYR(-1) + C(1,2)*MYR(-2) + C(1,3)*OKWTI(-1) + C(1,4)*OKWTI(-2) + C(1,5)

OKWTI = C(2,1)*MYR(-1) + C(2,2)*MYR(-2) + C(2,3)*OKWTI(-1) + C(2,4)*OKWTI(-2) + C(2,5)

VAR Model - Substituted Coefficients:
===============================
MYR = 1.26153986118*MYR(-1) - 0.269312040691*MYR(-2) - 0.0212827847505*OKWTI(-1) + 0.021872920642*OKWTI(-2) + 0.00807263882918

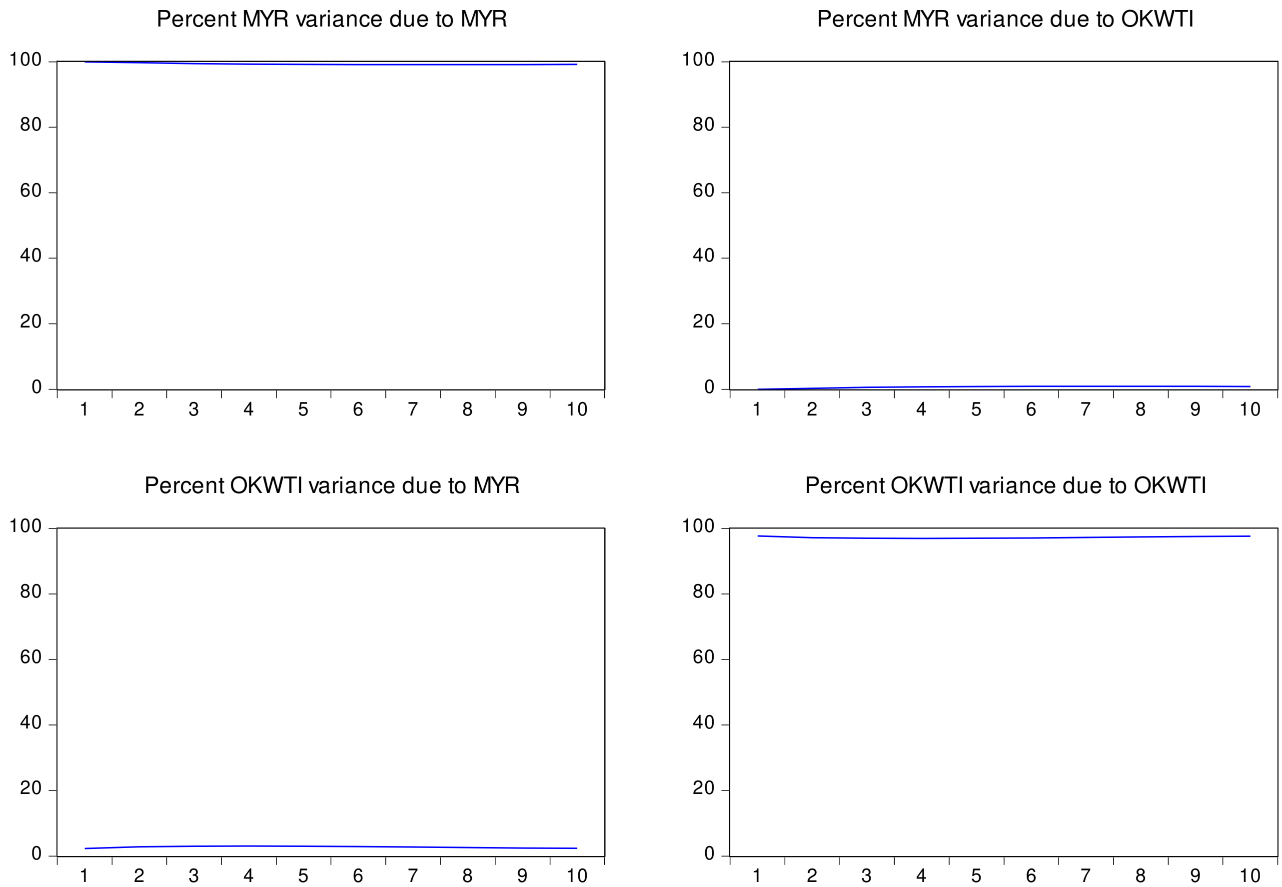
OKWTI = - 0.135445452866*MYR(-1) + 0.172750102079*MYR(-2) + 1.25381351398*OKWTI(-1) - 0.269873742686*OKWTI(-2) + 0.0164886395715

Vector Autoregression Estimates
Date: 05/17/17 Time: 21:44
Sample (adjusted): 1986M03 2017M04
Included observations: 374 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	MYR	OKWTI
MYR(-1)	1.261540	-0.135445
	(0.05056)	(0.21453)
	[24.9503]	[-0.63135]
MYR(-2)	-0.269312	0.172750
	(0.05083)	(0.21565)
	[-5.29874]	[0.80106]
OKWTI(-1)	-0.021283	1.253814
	(0.01164)	(0.04938)
	[-1.82883]	[25.3925]
OKWTI(-2)	0.021873	-0.269874
	(0.01160)	(0.04920)
	[1.88636]	[-5.48538]
C	0.008073	0.016489
	(0.00736)	(0.03123)
	[1.09678]	[0.52798]
R-squared	0.987916	0.984951
Adj. R-squared	0.987785	0.984788
Sum sq. resid	0.137780	2.480453
S.E. equation	0.019323	0.081988
F-statistic	7541.599	6037.873
Log likelihood	947.8046	407.2743
Akaike AIC	-5.041736	-2.151199
Schwarz SC	-4.989272	-2.098736
Mean dependent	1.158963	3.536753
S.D. dependent	0.174835	0.664756

Determinant resid covariance (dof adj.)	2.45E-06
Determinant resid covariance	2.39E-06
Log likelihood	1359.433
Akaike information criterion	-7.216219
Schwarz criterion	-7.111293

Variance Decomposition



Impulse Response Table

Period	Response of MYR: MYR	Response of MYR: OKWTI	Response of OKWTI: MYR	Response of OKWTI: OKWTI
1	0.019323	0.000000	-0.012438	0.081039
	(0.00075)	(0.00000)	(0.00448)	(0.00315)
2	0.024642	-0.001725	-0.018212	0.101608
	(0.00148)	(0.00099)	(0.00679)	(0.00515)
3	0.025998	-0.002566	-0.019478	0.105761
	(0.00198)	(0.00149)	(0.00842)	(0.00673)
4	0.026178	-0.002801	-0.018771	0.105233
	(0.00222)	(0.00170)	(0.00914)	(0.00753)
5	0.025996	-0.002769	-0.017333	0.103336
	(0.00234)	(0.00182)	(0.00945)	(0.00795)
6	0.025703	-0.002636	-0.015666	0.101056
	(0.00244)	(0.00193)	(0.00964)	(0.00826)
7	0.025379	-0.002470	-0.013955	0.098696
	(0.00253)	(0.00206)	(0.00984)	(0.00856)
8	0.025049	-0.002297	-0.012266	0.096354
	(0.00264)	(0.00220)	(0.01009)	(0.00889)
9	0.024721	-0.002124	-0.010622	0.094058
	(0.00277)	(0.00235)	(0.01040)	(0.00925)
10	0.024398	-0.001955	-0.009029	0.091819
	(0.00290)	(0.00252)	(0.01076)	(0.00962)

11	0.024082	-0.001791	-0.007488	0.089638
	(0.00304)	(0.00269)	(0.01115)	(0.01001)
12	0.023771	-0.001633	-0.005999	0.087515
	(0.00319)	(0.00286)	(0.01158)	(0.01041)
13	0.023466	-0.001479	-0.004560	0.085448
	(0.00335)	(0.00303)	(0.01202)	(0.01080)
14	0.023168	-0.001331	-0.003170	0.083436
	(0.00350)	(0.00321)	(0.01248)	(0.01119)
15	0.022875	-0.001187	-0.001829	0.081478
	(0.00366)	(0.00337)	(0.01294)	(0.01157)
16	0.022588	-0.001048	-0.000533	0.079572
	(0.00381)	(0.00354)	(0.01341)	(0.01194)
17	0.022307	-0.000914	0.000717	0.077717
	(0.00396)	(0.00370)	(0.01388)	(0.01229)
18	0.022030	-0.000784	0.001924	0.075910
	(0.00411)	(0.00386)	(0.01434)	(0.01263)
19	0.021760	-0.000659	0.003088	0.074152
	(0.00426)	(0.00402)	(0.01479)	(0.01296)
20	0.021494	-0.000538	0.004211	0.072440
	(0.00440)	(0.00417)	(0.01524)	(0.01328)
21	0.021233	-0.000421	0.005294	0.070774
	(0.00454)	(0.00431)	(0.01568)	(0.01358)
22	0.020977	-0.000308	0.006339	0.069152
	(0.00468)	(0.00445)	(0.01611)	(0.01386)
23	0.020726	-0.000199	0.007346	0.067572
	(0.00482)	(0.00459)	(0.01653)	(0.01413)
24	0.020480	-9.36E-05	0.008316	0.066035
	(0.00495)	(0.00473)	(0.01694)	(0.01439)

Cholesky Ordering: MYR OKWTI
Standard Errors: Monte Carlo (100 repetitions)

Markov Switching

Estimation Command:
=========================
SWITCHREG(TYPE=MARKOV,RNG=KN,SEED=1622990403) MYR C @NV AR(1) AR(2) AR(3) AR(4)

Estimation Equation:
=========================
1: MYR = C(1) + [AR(1)=C(3),AR(2)=C(4),AR(3)=C(5),AR(4)=C(6)]

2: MYR = C(2) + [AR(1)=C(3),AR(2)=C(4),AR(3)=C(5),AR(4)=C(6)]

SIGMA = @EXP(C(7))

Substituted Coefficients:
=========================
1: MYR = 1.26901680793 + [AR(1)=1.40731851539,AR(2)=-0.437464743365,AR(3)=0.133876240208,AR(4)=-0.109650013119]

2: MYR = 1.36799458545 + [AR(1)=1.40731851539,AR(2)=-0.437464743365,AR(3)=0.133876240208,AR(4)=-0.109650013119]

SIGMA = @EXP(-4.20326110448)

Dependent Variable: MYR
Method: Switching Regression (Markov Switching)
Date: 05/17/17 Time: 21:55
Sample (adjusted): 1986M05 2017M04
Included observations: 372 after adjustments
Number of states: 2

Initial probabilities obtained from ergodic solution
Ordinary standard errors & covariance using numeric Hessian
Random search: 25 starting values with 10 iterations using 1 standard deviation (rng=kn, seed=1622990403)
Convergence achieved after 38 iterations

Variable	Coefficient	Std. Error	z-Statistic	Prob.
		Regime 1		
C	1.269017	0.160197	7.921622	0.0000
		Regime 2		
C	1.367995	0.160428	8.527176	0.0000
		Common		
AR(1)	1.407319	0.053198	26.45444	0.0000
AR(2)	-0.437465	0.095149	-4.597672	0.0000
AR(3)	0.133876	0.095153	1.406960	0.1594
AR(4)	-0.109650	0.053283	-2.057895	0.0396
LOG(SIGMA)	-4.203261	0.037190	-113.0209	0.0000
		Transition Matrix Parameters		
P11-C	5.218485	0.717503	7.273120	0.0000
P21-C	0.043150	0.784578	0.054998	0.9561

Mean dependent var	1.160125	S.D. dependent var	0.174580
S.E. of regression	0.020155	Sum squared resid	0.148268
Durbin-Watson stat	1.841798	Log likelihood	1020.872
Akaike info criterion	-5.440170	Schwarz criterion	-5.345358
Hannan-Quinn criter.	-5.402518		

Inverted AR Roots	.99	.65	-.11+.40i	-.11-.40i