Granger-causality between oil price, exchange rate and government bonds: evidence from Malaysia

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Granger-causality between oil price, exchange rate and government bonds: evidence from Malaysia

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Abstract:

This investigation aims to study the Granger-causality between the oil price, exchange rate and the Malaysian and US government bonds namely, the US Treasury Bills (UST), the Government Investment Issues (GII) and Malaysian Government Security (MGS). Furthermore, this study also aims to study whether GII or MGS to be first affected in response to a movement in the US market and the global oil price. We used the standard time series techniques for the analysis and used Malaysia as a case study. From the results and findings in this investigation, we found that the (i) US Treasury yield rate, global oil price and the USD/MYR exchange rate are related to the Malaysian Islamic and conventional bond yields (ii)the US Treasury rate is the most influential variable to affect Malaysian Islamic and conventional bond yields; and (iii) in the Malaysian context, the GII is more influential than the MGS and hence more stable. However, this would require further study to verify this claim as we believe that the GII must be a function of the MGS. Thus, we expect MGS should influence GII. The findings are plausible and contain strong policy implications.

Keywords: Granger-causality, oil price, exchange rates, Government bonds, VECM, VDC, Malaysia

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OBJECTIVE AND MOTIVATION OF THE STUDY

To motivate the study, we take resort to a past election year response of the concerned variables before and after the 2016 US Presidential election. The year 2016 was an interesting year whereby the world has been paying attention to the US Presidential Election. We have seen that Donald Trump had won and the market had been in mixed reaction before and after the announcement.

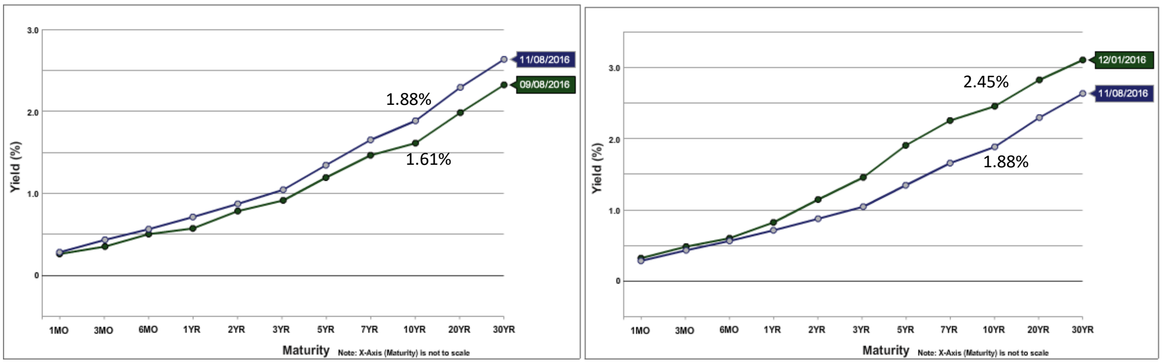


Figure 1: US Treasury bills yield curves before and after US General Election on 8th November 2016

Source: U.S. Department of the Treasury

The 3-months data from the US Department of Treasury shows that the 10-Year US Treasury bills shifts up by 27 bps between August 2016 and November 2016. However, in December 2016, the yield curve shifts upward by 57 bps.

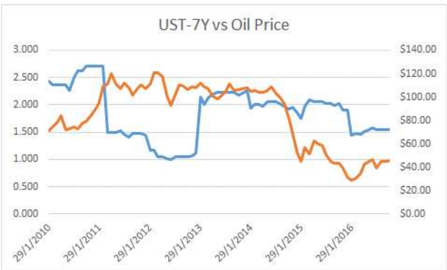


Figure 2: US 7y vs Oil Price

Besides that, another parameter that is the most crucial in any economy is the oil price. Figure 2 shows the trend of oil price versus 7-year US Treasury bills from 2010 to 2016. A simple correlation analysis found that the oil price and the 7-year US Treasury Bills is negatively correlated.

In relation to Malaysia, we are curious to study the causality between these important parameters i.e. the global oil price and exchange rate, to the US and Malaysian government bonds namely the US Treasury (or “UST”), the Government Investment Issues (or “GII”) and Malaysian Government Security (or “MGS”). Furthermore, this study will also look either GII or MGS which is affected in response to movement in the US market and the global oil price.

The variables used in this study are as follows:

1. The global Brent crude oil price or “OIL”
2. Exchange rate USD / MYR or “USD”
3. 7-year US treasury bills rate or “U”
4. 7-year GII rate or “G”
5. 7-year MGS rate or “M”

Data are monthly for seven years and starting from January 2010. The reason such timeframe is chosen is that we want to investigate the questions addressed in this study from post global economic crisis period (2008 – 2009).

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

There has been mixed opinion on the causality between global oil price and the US Treasury rate. Kang, Ratti and Yoon (2014) found that shocks to oil-market specific demand explain 31.2% on the variation of US Treasury 30-day bill. The shocks to oil-market specific demand also explains 24.4%, 13.2%, 11.1% and 16.1% of the variation in the real returns for 1-year, 5-year, 10-year and 30-year government bond indices in the long run.

Bernanke et al (1997) argues that there are two (2) reasons why oil price is an interesting macroeconomic parameter to which policy is likely to respond. Firstly, the periods of shocks dominated by oil price is easy to identify and oil price is exogenous enough (although there are also controversies about how these shocks should be modelled). Secondly, increases in oil price preceded the recessions of 1973-75, 1980-82 and 1990-91 and hence oil price was deemed as the leading alternative to monetary policy as the key factor in postwar US recession.

Hervé and Antonin (2011) in their research paper concludes that oil price significantly affects the risk premium of government bonds. Based on their empirical study, an increase of

1% in the oil price leads to an increase of 0.56% in the Emerging Market Bond Index Global ("EMBIG") index, from 1998 to 2008.

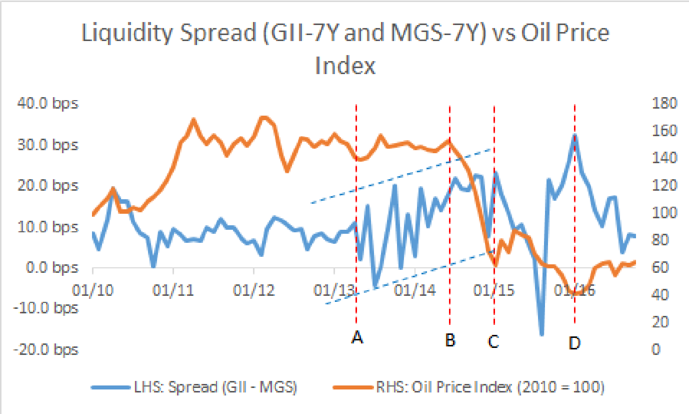


Figure 3: Liquidity premium between GII-7Y and MGS-7Y vs oil price index

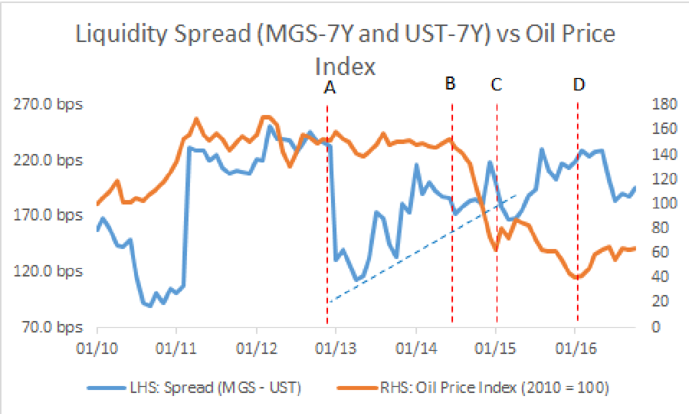


Figure 4: Liquidity premium between MGS-7Y and US Treasury Bill-7Y vs oil price index

In the case of Malaysian government securities, the liquidity premium of GII (which is measured against the MGS) and the liquidity premium of MGS (which is measured against the UST) shows similarity pre- and post- the oil price crisis. Between point A and B, there exist volatility in liquidity premia for both GII and MGS which is then succeeded by a deep plunged in oil price between point B and C. Between point C and D (Jan. 2015 to Jan. 2016), the liquidity premium for MGS shows more stability than GII liquidity premium given the downward trend in oil price index. Yet, we are still unsure the causality between these parameters.

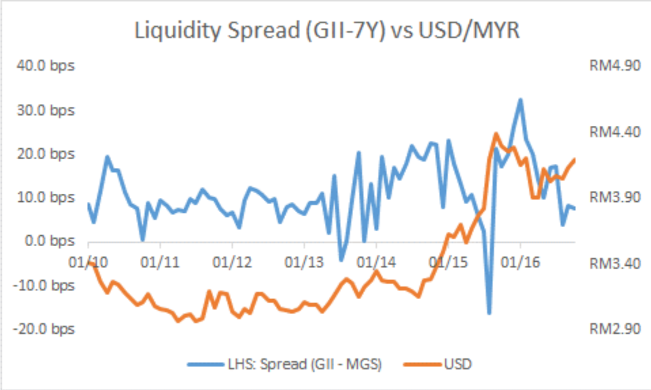


Figure 5: Liquidity spread GII-7Y vs USD/MYR

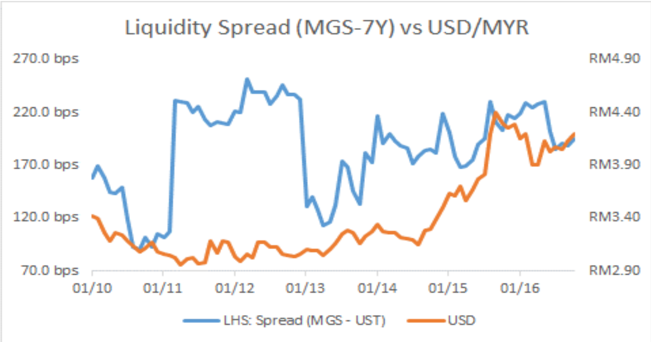


Figure 6: Liquidity spread (MGS-7Y) vs USD/MYR

Comparing Figure 5 and Figure 6, it seems that the GII has greater volatility in its spread than that of MGS. Between January 2015 and January 2016, the GII has liquidity spread between -10 bps to 30 bps, which renders a 40 bps range. Meanwhile for MGS, it also deviates between 170 bps to 220 bps, which shows a 50 bps range. The MGS also has an extraordinary period where the spread jumped from around 100 bps to close to 260 bps between year 2011 to year 2013.

This is an interesting observation given the movement in oil price and exchange rates, how would these parameters affect the Malaysian and the US government bonds? And, between GII and MGS, which security influences which?

RESEARCH METHODOLOGY, RESULTS AND INTERPRETATION

We collated the information required from various sources such as the US Department of Treasury, Bloomberg, and Bank Negara Malaysia. The main tool used in this study is the standard time series techniques, of which the Authors used the Microfit 5.0 software to conduct the study. The key steps in time series techniques are summarized in the following table:

STEP	TEST	INTERPRETATION
1. Determining the non-stationarity of each variable	ADF Ho: Non-Stationary	If t-stats < critical value, the Ho is accepted.
2. Determining the lags of the VAR model	AIC and SBC	Choose optimum lag with highest value of AIC and SBC.
3. Cointegration test	Engle-Granger Johansen Ho: No cointegration	If t-stats < critical value, the Ho is accepted.
4. Long Run Structural Modelling (LRSM)	Exact-identification Over-identification	Tests the significance of the coefficients against theoretical expectation.
5. Vector Error Correction Model (VECM)	Exogeneity and endogeneity of variables	If p-value < 5%, endogenous.
6. Variance Decompositions (VDC)	Orthogonalized VDC Generalized VDC	The variable explained the most by its own past shocks is the most exogenous.
7. Impulse Response Functions (IRF)	-	Graphical form of VDC
8. Persistence Profile	Applies a system-wide shock to the system	Indicate the time horizon required to get back to equilibrium.

TESTING STATIONARITY OF VARIABLES

This study started with testing of the stationarity of the variables. In the Microfit 5.0, we defined the level form and their first difference form as follows:

$$LU = \log(U)$$
$$DU = LU - LU_{t-1}$$

Equation 1: Log form and first level differenced form

After defining the level form and differenced form variables, we proceeded with Augmented Dickey-Fuller test (or "ADF") on each variable. The table 1 and 2 below presents the summary of the ADF test:

ADF LG(5); ADF LM(5); ADF LU(5); ADF LOIL(5); ADF LUSD(5);
ADF DG(5); ADF DM(5); ADF DU(5); ADF DOIL (5); ADF DUSD(5)

Equation 2: Command used for ADF test

VARIABLE	ADF		VALUE	T-STAT.	C.V.	RESULT
LG	AIC	1	163.1677	- 2.3322	- 3.4688	Non-stationary
	SBC	1	158.5062	- 2.3322	- 3.4688	Non-stationary
LM	AIC	1	139.7386	- 2.4789	- 3.4688	Non-stationary
	SBC	1	135.0772	- 2.4789	- 3.4688	Non-stationary
LU	AIC	1	53.6180	- 1.8758	- 3.4688	Non-stationary
	SBC	1	48.9565	- 1.8758	- 3.4688	Non-stationary
LOIL	AIC	1	76.5618	- 2.4002	- 3.4688	Non-stationary
	SBC	1	71.9003	- 2.4002	- 3.4688	Non-stationary
LUSD	AIC	1	168.9898	- 2.3195	- 3.4688	Non-stationary
	SBC	1	164.3294	- 2.3195	- 3.4688	Non-stationary

Table 1: ADF test for level form variables

VARIABLE	ADF		VALUE	T-STAT.	C.V.	RESULT
DG	AIC	1	159.4913	- 6.799	- 3.470	Stationary
	SBC	1	154.8564	- 6.799	- 3.470	Stationary
DM	AIC	2	136.0022	- 7.270	- 3.470	Stationary
	SBC	1	130.2926	- 6.918	- 3.470	Stationary
DU	AIC	1	51.2464	- 5.672	- 3.470	Stationary
	SBC	1	46.6114	- 5.672	- 3.470	Stationary
DOIL	AIC	2	73.4601	- 5.297	- 3.470	Stationary
	SBC	1	67.7150	- 4.863	- 3.470	Stationary
DUSD	AIC	1	163.7010	- 6.2481	- 3.470	Stationary
	SBC	1	159.0661	- 6.2481	- 3.470	Stationary

Table 2: ADF test result for first differenced form

Based on the ADF test, all level form variables are non-stationary while all differenced form variables are non-stationary. This is consistent with what we were expecting in the beginning of the test. The ADF regression order is taken by the highest AIC and / or SBC values.

The null hypothesis of this test is the variable is non-stationary. If t-statistics is lesser than the critical value (in absolute test), the null hypothesis is rejected. In this test, we have chosen 95% confidence level with its corresponding critical value of -3.470. By non-stationary variable, its mean, variance and co-variance are not constant over time.

DETERMINATION OF ORDER OF THE VAR MODEL

We then proceeded to determine the number of lags to be used or Vector Auto Regression ("VAR"). In Microfit 5.0, we chose Unrestricted VAR option, a sub-menu under Multivariate. The lag order is first set at 6 lags with differenced level forms variables and constant term being tested to determine VAR.

Equation 3: Command used for VAR test

Order	AIC	SBC	p-Value	C.V.
0	656.188	650.394	0.3340	5%

Table 3: Output of the VAR test

We take the highest AIC and SBC values and it shows that corresponding lag order is 0, with its p-value is 33.4%, which is greater than 5%. However, we also wanted to test if there are any serial correlations between the variables.

Variable	Chi-sq p-value	Implication (at 5%)
DG	0.055	There is no serial autocorrelation
DM	0.880	There is no serial autocorrelation
DU	0.144	There is no serial autocorrelation
DOIL	0.045	***There is serial autocorrelation***
DUSD	0.803	There is no serial autocorrelation

Table 4: Result of autocorrelation test

It seems that only one variable i.e. DOIL has serial autocorrelation, all others are fine.

Although the VAR test shows that there is no lag in the model, but we still believe that there should be at least one (1) lag for the investigation to be meaningful and further cointegration tests can be done.

TESTING COINTEGRATION

We then proceeded to the cointegration tests. We used two (2) cointegration tests namely (i) Engle-Granger test, and (ii) Johansen test. For both tests, we used level form variables as follows:

LG LM LU LOIL LUSD

The result from the Engle-Granger test is as follows:

ADF	t-stats	AIC	SBC	Remarks (at 5%)
4	-4.1017	202.7376	196.9108	Stationary
1	-3.9007	204.2052	199.8440	Stationary

Table 5: Engle-Granger cointegration test result

Using the highest AIC and SBC values computed, the corresponding t-statistics is greater than the critical value of 1.96 (in absolute term). Hence, the result shows that the model has one (1) or more cointegrations.

In Johansen test, we set the lag order in the VAR at 1 (as found in Step 2) and variables as per above level forms.

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	69.410	37.860	35.040
r <= 1	r = 2	22.853	31.790	29.130

Table 6: Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	117.437	87.170	92.880
r <= 1	r = 2	48.027	63.000	59.160

Table 7: Cointegration LR Test Based on Trace of the Stochastic Matrix

From the result of Johansen test in table 6 and 7, we found that there is at most 1 cointegration in the model.

LONG RUN STRUCTURAL MODELLING (LRSM)

The number of cointegration found in the previous step is set at 1. We first test the LRSM using exact-identification. The list of variables included in the cointegrating vector are as follows:

LG LM LU LOIL LUSD TREND

In the exact-identification LRSM test, we imposed restriction on the variable **LG** by setting **A1 = 1**. In this test, we expect the GII to be very significant.

Variable	Coefficient	Standard Error	t-ratio	Implication
LG	1.0000	-	-	-
LM	- 1.1268	0.0454	- 24.8090	Significant
LU	0.0129	0.0084	1.5445	***Not significant***
LOIL	0.0510	0.0163	3.1391	Significant
LUSD	0.2256	0.0720	3.1339	Significant

Table 8: Exact-identification LRSM result

We found that the variable LU, which refers to the 7Y US Treasury rate is not significant. Although it is puzzling, yet we tried to test the variable in the over-identification LRSM. The variable LU (or A3) is set to zero. The result from the over-identification LRSM is as follows:

Variable	Coefficient	Standard Error	t-ratio	Implication
LG	1.0000	-	-	-
LM	-1.0855	0.0370	- 29.3545	Significant
LU	-	-	-	-
LOIL	0.0445	0.0160	2.7871	Significant
LUSD	0.2011	0.0713	2.8192	Significant
Chi-sq p-value	*0.116*			***Restriction is correct***

Table 9: Over-identification LRSM result

The Ch-squared p-value is greater than 5%, which implies that the restriction is correct.

VECTOR ERROR CORRECTION MODEL (VECM)

The previous LRSM step has revealed that at least four (4) variables are cointegrated at significant degree namely LG, LM, LOIL and LUSD. However, we still found that LU is still an important variable for the study as the illiquidity premium of MGS is measured against the US Treasury Bill. We believe that for any investors who are investing in fixed income and sukuk instrument, firstly they will need to measure its spread against the US Treasury rate for any investment decision. Therefore, in the VECM test the variable LU is still included.

In the VECM process, we attempted to test the exogeneity of each variable, that is which variable is exogenous and which variable is endogenous. The result from the VECM test is as follows:

ecm1(-1)	Coefficient	Standard Error	t-stats [p-value]	C.V.	Result
dLG	-0.24286	0.17225	-1.4100[0.162]	5%	Exogenous
dLM	0.44915	0.23648	1.8993[0.061]	5%	Exogenous
dLU	-0.10511	0.72162	-0.1456[0.885]	5%	Exogenous
dLOIL	-0.16623	0.57620	-0.2885[0.774]	5%	Exogenous
dLUSD	-0.43398	0.16006	-2.7113[0.008]	5%	Endogenous

Table 10: VECM result

Only one variable is found to be endogenous, which is LUSD. Given this result, we was hoping to see dLM and/or dLG to be endogenous. This is because the US market is comparatively bigger than the Malaysian market size. Thus, it is likely the US market will influence Malaysian market. Thus, it is likely the US market will influence Malaysian market.

VARIANCE DECOMPOSITION (VDC)

This is an important step to explain the relative exogeneity of the variables. In the VECM, we are unsure which variable is leading and which variable is lagging. In this step, the VDC test will generate result that will show the relative exogeneity of each variable.

We started the test with orthogonalized VDC with forecast horizons of 12 months, 24 months and 36 month. The result is as follows:

Forecast horizon: 12 months

12	LG	LM	LU	LOIL	LUSD	TOTAL	Self-Dependency	Ranking
LG	97.75%	2.11%	0.01%	0.02%	0.11%	100.00%	97.75%	2
LM	92.30%	7.30%	0.02%	0.05%	0.34%	100.00%	7.30%	5
LU	1.05%	0.62%	98.32%	0.00%	0.00%	100.00%	98.32%	1
LOIL	0.17%	2.75%	1.11%	95.97%	0.01%	100.00%	95.97%	3
LUSD	23.52%	22.02%	0.21%	23.19%	31.06%	100.00%	31.06%	4

Table 11: Orthogonalized VDC 12 months forecast horizon

Forecast horizon: 24 months

24	LG	LM	LU	LOIL	LUSD	TOTAL	Self-Dependency	Ranking
LG	97.64%	2.22%	0.01%	0.02%	0.12%	100.00%	97.64%	2
LM	92.97%	6.59%	0.02%	0.05%	0.37%	100.00%	6.59%	5
LU	1.06%	0.63%	98.30%	0.00%	0.00%	100.00%	98.30%	1
LOIL	0.17%	2.79%	1.11%	95.92%	0.01%	100.00%	95.92%	3
LUSD	23.76%	22.67%	0.20%	23.02%	30.35%	100.00%	30.35%	4

Table 12: Orthogonalized VDC 24 months forecast horizon

Forecast horizon: 36 months

36	LG	LM	LU	LOIL	LUSD	TOTAL	Self-Dependency	Ranking
LG	97.60%	2.25%	0.01%	0.02%	0.12%	100.00%	97.60%	2
LM	93.22%	6.34%	0.02%	0.05%	0.38%	100.00%	6.34%	5
LU	1.06%	0.64%	98.30%	0.00%	0.00%	100.00%	98.30%	1
LOIL	0.17%	2.81%	1.11%	95.91%	0.01%	100.00%	95.91%	3
LUSD	23.84%	22.90%	0.19%	22.96%	30.11%	100.00%	30.11%	4

Table 13: Orthogonalized VDC 36 months forecast horizon

The test generates a more consistent and reliable results:

Rank	Variable Relative Exogeneity		
	12 months	24 months	36 months
1	LU	LU	LU
2	LG	LG	LG
3	LOIL	LOIL	LOIL
4	LUSD	LUSD	LUSD

5	LM	LM	LM

Table 14: Variables with relative exogeneity based on orthogonalized VDC

From the results, it is found that LM is the most endogenous variable while previously it was found that LUSD was the only endogenous variable. It is surprising to see LG to be more exogenous than LOIL, LUSD and LM. GII, which is the Islamic bond by the Malaysian government is very small compared to MGS and other global parameters. It can never influence the market.

However, it is totally understandable since orthogonalized switch-off other variables when a target variable is applied a shock. In Generalized VDC, such restriction is relaxed. Now, we proceeds with the Generalized VDCs. The outcome from the test are as follows:

Forecast horizon: 12 months

12	LG	LM	LU	LOIL	LUSD	TOTAL	Self-Dependency	Ranking
LG	46.97%	43.85%	0.44%	0.05%	8.68%	100.00%	46.97%	4
LM	42.98%	44.91%	0.67%	0.31%	11.12%	100.00%	44.91%	5
LU	1.00%	1.51%	94.70%	1.32%	1.47%	100.00%	94.70%	1
LOIL	0.13%	0.93%	1.15%	80.97%	16.82%	100.00%	80.97%	2
LUSD	13.62%	23.53%	0.84%	9.00%	53.02%	100.00%	53.02%	3

Table 15: Generalized VDC 12 months forecast horizon

Forecast horizon: 24 months

24	LG	LM	LU	LOIL	LUSD	TOTAL	Self-Dependency	Ranking
LG	46.85%	43.96%	0.44%	0.05%	8.69%	100.00%	46.85%	4
LM	43.20%	44.68%	0.67%	0.31%	11.13%	100.00%	44.68%	5
LU	1.00%	1.53%	94.67%	1.32%	1.48%	100.00%	94.67%	1
LOIL	0.14%	0.95%	1.15%	80.98%	16.78%	100.00%	80.98%	2
LUSD	13.73%	23.88%	0.84%	8.84%	52.71%	100.00%	52.71%	3

Table 16: Generalized VDC 24 months forecast horizon

Forecast horizon: 36 months

36	LG	LM	LU	LOIL	LUSD	TOTAL	Self-Dependency	Ranking
LG	46.81%	44.00%	0.44%	0.05%	8.69%	100.00%	46.81%	4
LM	43.28%	44.60%	0.68%	0.31%	11.14%	100.00%	44.60%	5

LU	1.01%	1.53%	94.66%	1.32%	1.48%	100.00%	94.66%	1
LOIL	0.14%	0.96%	1.15%	80.98%	16.77%	100.00%	80.98%	2
LUSD	13.77%	24.01%	0.84%	8.79%	52.60%	100.00%	52.60%	3

Table 17: Generalized VDC 36 months forecast horizon

In contrast to previous findings using orthogonalized VDC, the output from the generalized VDC makes more sense.

Rank	Variable Relative Exogeneity		
	12 months	24 months	36 months
1	LU	LU	LU
2	LOIL	LOIL	LOIL
3	LUSD	LUSD	LUSD
4	LG	LG	LG
5	LM	LM	LM

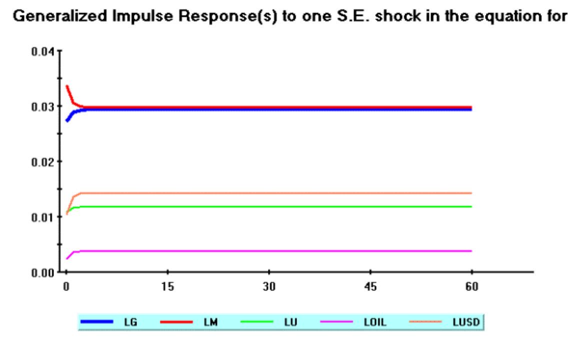
Table 18: Variables with relative exogeneity based on generalized VDC

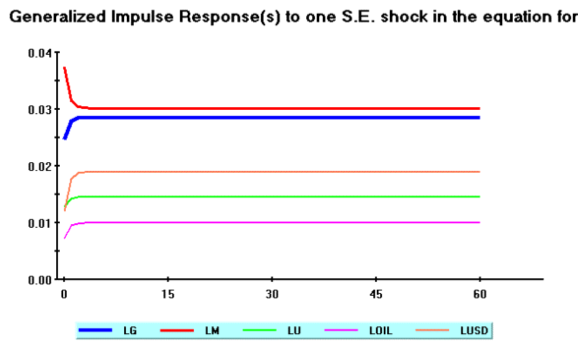
The result shows a switch in the exogeneity of the variables. The first three variables belong to LU, LOIL and LUSD which are of global parameters. This is then followed by Malaysian government bonds which are LG and LM. This agrees with our earlier hypothesis where Malaysian bonds shall be influenced by the US Treasury Rate, global oil price and the exchange rate.

IMPULSE RESPONSE FUNCTIONS (IRF)

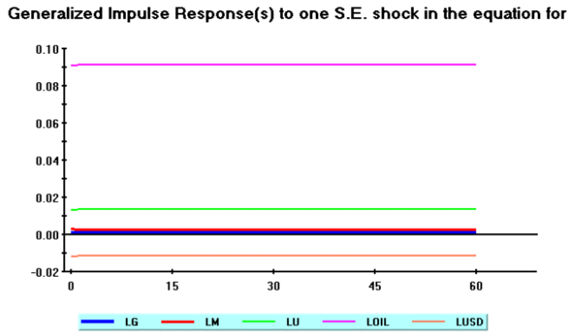
The IRF renders the same information as the VDC, but in graphical form. The Generalized IRF (which is the same as Generalized VDC) are as follows:

LG	LM

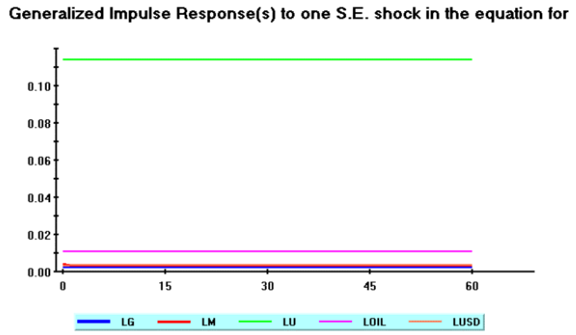




LOIL



LU



LUSD

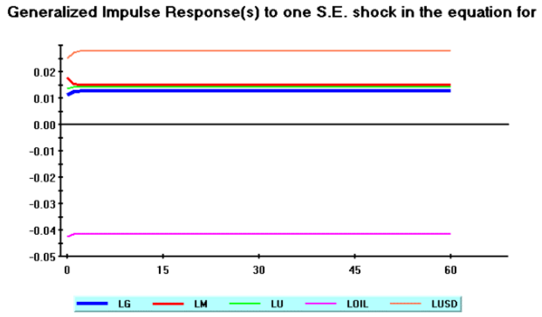


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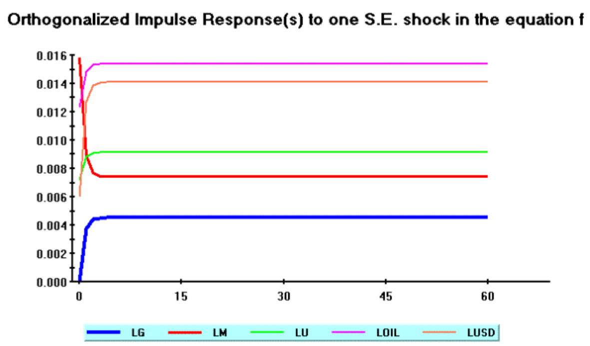
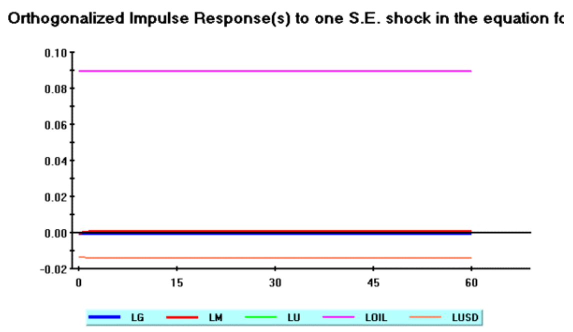
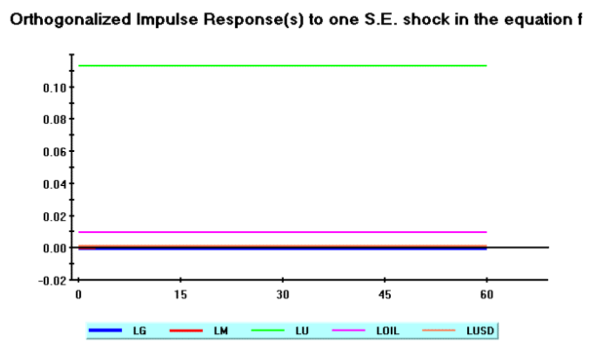
Figure 7: IRFs based on Generalized VDC

The IRFs based on the orthogonalized VDC are as follows:

LG

LM



LOIL	LU
	
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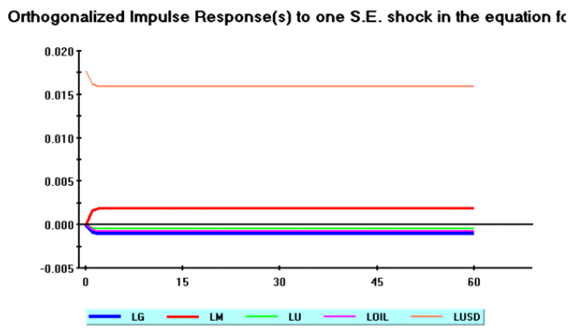	-BLANK-

Figure 8: IRF based on orthogonalized VDC

PERSISTENCE PROFILE

The chart below shows the Persistence Profile of this investigation when a system-wide shock is applied in the model:

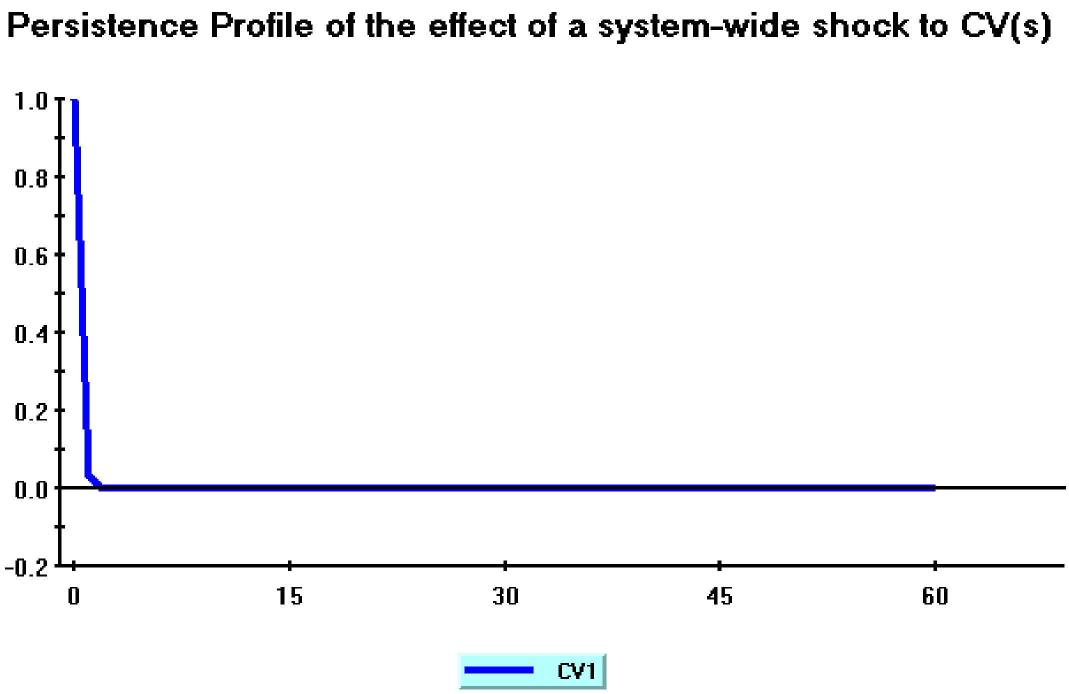

Figure 9: Persistence Profile

The persistence profile shows that the model would take approximately 2 months for the system to return to equilibrium after a system-wide shock.

CONCLUSIONS

This investigation aims to study the causality between the oil price and exchange rate to the US and Malaysian government bonds namely the US Treasury Bills (UST), the Government Investment Issues (GII) and Malaysian Government Security (MGS). Furthermore, this study also aims to study whether GII or MGS to be first affected in response to movement in the US market and the global oil price. From the results and findings in this investigation, we found that:

1. US Treasury yield rate, global oil price and the USD/MYR exchange rate are more influential to affect Malaysian Islamic and conventional bond yields;
2. The US Treasury rate is the most influential parameter to affect Malaysian Islamic and conventional bond yields; and

3. In Malaysian context, the GII is more influential than the MGS and hence more stable. However, this would require further study to verify this claim as we believe that the GII must be a function of the MGS. Thus, we expect MGS should influence GII.

LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The limitations in this study, amongst others, but not limited to are listed in the following points. We also make some suggestions deemed necessary for future research purposes:

1. Absence of interest rate. Interest rates are crucial parameters in determining the bond yields. Availability of interest rates will help explain the flow of money between Malaysia and the US by the institutional players and other market players in the bond markets.

2. Absence of liquidity premium. In this study, we used the yield rate of UST, GII and MGS. But, the spread between GII and MGS and the spread between MGS and UST would give more meaningful value to the research. It is more interesting to see the influence between the change in interest rate, oil price, exchange rate and the liquidity premium.

3. Small market size. The Malaysian Islamic bond i.e. the GII is too small when compared to the US Treasury. Hence, we suggest to use an index composed of Muslim world sukuk index.

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