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[Reviewed by Sumio Ishikawa, and approved by Hoe Ee Khor]

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Abstract

In this paper, vector error correction model and multivariate GARCH (triangular BEKK and dynamic conditional correlation) models are used to analyze the impact of changes in oil prices on Malaysia's real GDP, inflation, fiscal revenues, stock market and exchange rate. The results suggest that every USD1 increase in Brent oil prices is associated with an increase in real GDP of approximately MYR 646 million, an increase in CPI level of 0.03, and an increase in annual fiscal revenues of around MYR 339 million. A 1 percent increase in oil prices also results in a 0.04 percent increase in the stock market index and 0.03 percent appreciation of the ringgit tomorrow. Also, the multivariate GARCH model results suggest the existence of significant volatility persistence in, and inter-sector volatility spillovers between oil, stock and foreign exchange markets.

JEL classification: E32, C32, G11, G13, Q34, Q42

Keywords: Oil Price Shock, Vector Error Correction Model, Multivariate GARCH, Volatility

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Executive Summary

The impact of oil prices on the macroeconomy has long been a topic of interest to economic researchers. Overall, a significant amount of empirical research finds that oil price surges result in significant negative effects on oil importing economies. For oil exporting countries, the literature does not have a consensus on the impact of higher oil prices on the country's real sector. In this paper, we analyze the impact of oil prices on Malaysia's real economic activity, inflation, fiscal sector, and financial variables (such as stock prices and the ringgit).

We first present some stylized facts about oil prices, real GDP, inflation, fiscal revenues and financial variables. The data shows that higher oil price growth is generally associated with higher GDP growth, and three filter techniques (Hodrick-Prescott, Kalman, and extended Kalman) suggest that potential growth tend to be lower during periods of significantly lower oil prices. Oil price growth and inflation tend to be positively correlated, albeit the increase in the inflation comes with a lag of a few quarters after the growth in oil prices. Also, higher growth in oil prices tend to be associated with higher growth in fiscal revenues. During periods of high oil prices, petroleum-related revenues tend to be hefty and during period of low oil prices, petroleum-related revenues tend to fall. Finally, the daily prices of oil, the Kuala Lumpur Composite Index (KLCI), and the Malaysian ringgit (MYR) have a tendency to move together. Simple graphical and correlation analysis also suggest volatility clustering and volatility cross-correlations between oil, currency, and stock markets.

We then analyze more formally the relationship between oil prices, and Malaysia's output, inflation and fiscal revenues using a vector error correction model (VECM). Impulse response analysis suggest that a typical oil price shock of 13.4 percent increases the level of real GDP by 0.7 percent after one or two quarters, increases inflation by 0.2 percent after two quarters, and increases fiscal revenues by 3.5 percent after one year. A 1.0 percent increase in Brent oil prices is associated with 0.042 percent increase in real GDP, 0.014 percent increase in the consumer prices, 0.141 percent increase nominal fiscal revenues. Thus, every USD1 increase in Brent oil prices is associated with an increase in real GDP of approximately MYR646 million, an increase in CPI level of approximately 0.03, and an increase in annual fiscal revenues of around MYR 339 million.

Next, we analyze more formally the volatility relationship between oil prices and Malaysia's stock and foreign exchange market using two multivariate generalized autoregressive conditional heteroscedasticity (GARCH) models—the triangular Baba, Engle, Kraft, and Kroner (BEKK) model and the dynamic conditional correlation model (DCC). Our empirical results suggest that a 1 percent increase in oil price today will result in a 0.04 percent increase in the KLCI index and a 0.03 percent appreciation of the ringgit tomorrow. The results also support the conclusion of volatility persistence in the oil, stock, and the currency markets. The magnitude of the ARCH coefficients are much smaller than their GARCH counterparts, signifying that long-term persistence is more important in determining the assets' volatility than news about yesterday's volatility. The results also suggest the existence of inter-sector volatility spillovers between the oil, stock and foreign exchange markets. Both models also suggest significant asymmetric effects in the oil and stock markets, but not in the foreign exchange market, between positive and negative shocks. This implies that volatility is higher in the oil and stock markets, during periods of negative oil price shocks and KLCI downturns.

In summary, our VECM, triangular BEKK and DCC analyses suggest that oil prices have important effects on Malaysia's real sector, inflation, fiscal sector, stock market and exchange rate. The Malaysian authorities have managed well the effects of fluctuating oil prices on the Malaysian economy through economic and fiscal measures, including adopting a flexible exchange rate to help the economy absorb the effects of oil movements on the financial variables. Also, the Malaysian authorities have employed various measures to help counteract the negative effects of the fluctuations in oil prices. Going forward, Malaysia can increase its resilience to oil price movements by further diversifying its economy, its exports, and its fiscal revenue base.

1. Introduction

The impact of oil prices on the macroeconomy has long been a topic of interest to economic researchers. The impact of oil prices on the U.S. economy for example has long been a subject of several researches, considering that a significant number of U.S. recessions have been preceded by oil price increases (see, for example, Hamilton [1983, 2003]). Overall, a significant amount of empirical research finds that oil price surges result in significant negative effects on oil importing economies (see, for example, Mork [1989], Garratt and others [2003] and Jimenez-Rodriguez and Sanchez [2005]).

For oil exporting countries, the literature does not have a consensus on the impact of higher oil prices on the country's real sector. Some studies have found that higher oil prices have resulted in positive impact on real economic activity of some countries like Norway, but negative impact for others like UK (see Jimenez-Rodriguez and Sanchez [2005]). The negative impact may arise, for instance, from Dutch disease effects of the oil resource (Bjornland 1998).

In this paper, we analyze the impact of oil prices on Malaysia's real economic activity, inflation, fiscal sector, and financial variables (such as stock prices and the ringgit). Malaysia is a commodity exporting country and oil price changes have important effects on its economy. Mineral fuels accounted for 13.9 percent of Malaysia's exports in 2016, down from 15.8 percent in 2010. Petroleum-related revenues also accounted for almost 15.0 percent of the revenues of the government in 2016, down from more than 35.0 percent in 2010. Thus, understanding the impact of oil price increases and decreases on Malaysia's economic and financial variables is a matter of important interest. And from those empirical findings can flow the policy implications, including the policy measures the authorities can employ to help counteract the impact of oil price fluctuations on the economy and financial sector.

Our findings suggest that the effects of oil prices on Malaysia's GDP, inflation, fiscal revenue, stock market, and exchange rate are non-trivial. Our vector error correction model (VECM) estimates imply that the elasticities of real GDP, inflation, and fiscal revenues to oil price changes, are respectively, 0.042, 0.014, and 0.141. This implies that every 1 US dollar increase in Brent oil prices translates to increases in annual real GDP, consumer prices index (CPI) level, and fiscal revenues of around MYR 646 million, 0.03, and MYR 339 million. Meanwhile, our two multivariate GARCH models estimates that 1 percent increase in today's oil prices will result in a 0.04 percent increase in the stock market index and 0.03 percent appreciation in the ringgit tomorrow. In addition, both models document the significant volatility persistence in, as well as volatility spillover across, the oil, stock, and forex markets. Likewise, our estimation results suggest that volatility in those markets are higher during periods of downturns than during upswings.

This study is organized as follows. Section 2 discusses the possible channels of transmissions as well as presents some stylized facts about oil prices, real GDP, inflation, fiscal revenues and financial variables. Section 3 analyzes the relationship between oil price shocks, GDP, inflation and fiscal revenues more formally using a vector error correction model (VECM). Section 4 delves into the statistical analysis of volatility relationship between the volatilities of oil prices and the Malaysian stock market and foreign exchange market using two multivariate GARCH models. Section 5 summarizes the main findings of paper and suggest some possible policy implications.

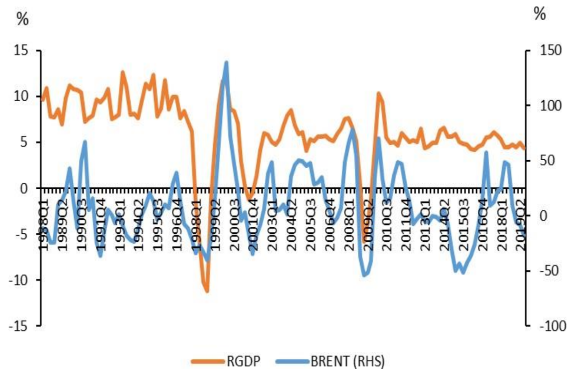
2. Transmission Channels and Stylized Facts

In addition to the direct impact on the oil producing sectors, an increase in oil prices can affect real GDP growth in oil-endowed economies in several channels. Production linkages can affect related sectors via forward (e.g. processing and further transformation) and backward (inputs suppliers for oil producers) linkages. Consumption linkages occur as household income and expenditures from oil-corporate sector increase. Fiscal linkages also occur, as resource rents accrue to the government and are invested in other sectors (Lebdioui 2019). The linkages can also occur via the external sector through the exports and the current account balance. In addition, macro-financial linkages can also be at work, as the surpluses in the oil-producing sector and the stronger fiscal position sometimes can create conditions for excess liquidity and deposit upturns, which may potentially encourage borrowing-financed investment (International Monetary Fund 2016).

In this section, we present some stylized facts about the relationship between oil prices, macroeconomic variables, and some financial variables.

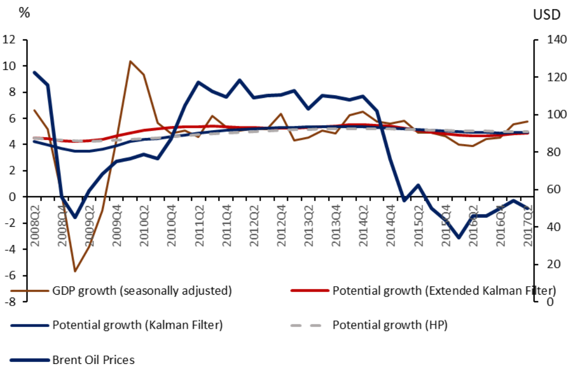
Figure 1 depicts the relationship between oil prices and Malaysia GDP growth. As apparent from the figure, higher oil price growth is generally associated with higher Malaysian GDP growth. During the period Q1 1988 to Q3 2019,[2] the correlation between the growth of Brent oil prices and Malaysia's real GDP growth is around 0.48. Figure 2 meanwhile suggests that lower oil prices are not only associated with lower Malaysian GDP growth but also maybe associated with lower potential growth. All three filters techniques (Hodrick-Prescott, Kalman, and extended Kalman) suggest that potential growth tend to be lower during periods of significantly lower oil prices.

Figure 1. Oil Prices and GDP Growth



Source: CEIC; Department of Statistics Malaysia; AMRO staff calculations

Figure 2. Oil Prices, GDP Growth and Potential Growth

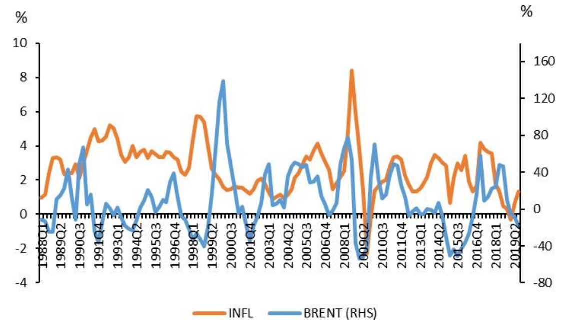


Source: AMRO staff calculations based on the model by Ozbek and Ozlale (2005)[3]

Figure 3 suggest that oil price growth and Malaysia inflation tend to be positively correlated, albeit the increase in the inflation comes with a lag of a few quarters after the growth in oil prices. This is also not surprising considering that, for one, oil prices directly affects transport prices. The latter, which constitutes 14.6 percent of the CPI basket, in turn accounts for a significant percentage point contribution in the headline inflation (see Figure 4).

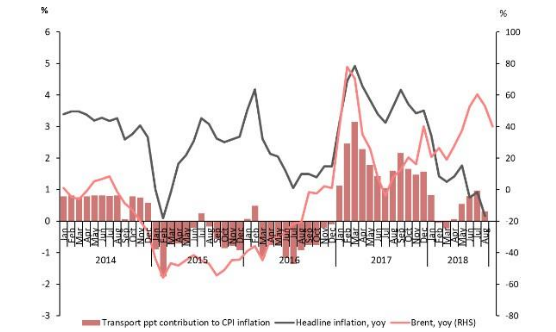
[2] The earlier quarterly GDP data in CEIC database goes back only to Q1 1987.
[3] The estimation was done using WinRATS Pro 10.

Figure 3. Oil Prices and Inflation



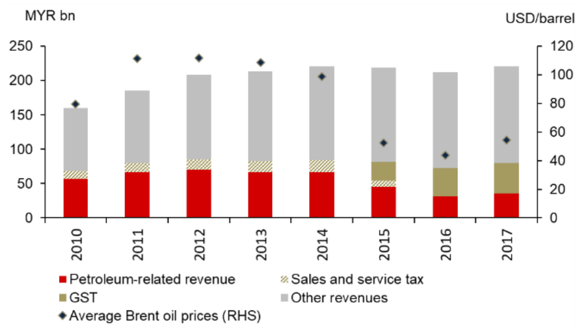
Source: CEIC

Figure 4. Oil Prices, Transport Inflation, and CPI



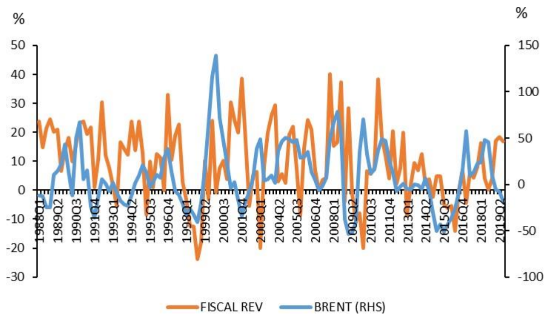
Source: CEIC; Department of Statistics, Malaysia

Figure 5. Oil Prices and Fiscal Revenues



Source: CEIC; Bank Negara Malaysia; Malaysia Ministry of Finance; AMRO staff calculations

Figure 6. Oil Price Growth and Fiscal Revenues Growth



Source: CEIC; Bank Negara Malaysia

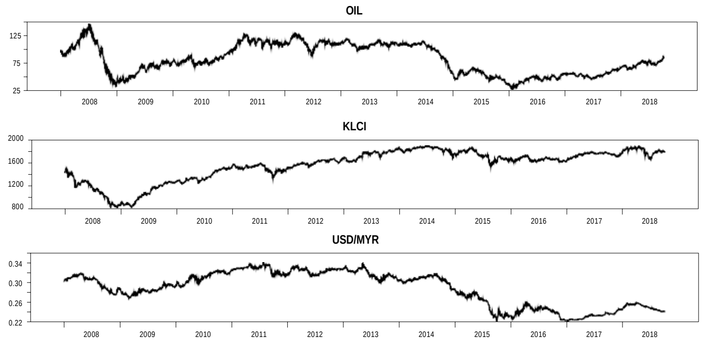
Figure 5 depicts that oil prices affect Malaysia's government fiscal revenue significantly. During periods high oil prices like in 2011 to 2013, petroleum-related revenues tend to be hefty and during period of low oil prices like in 2015 to 2017, petroleum-related revenues tend to fall significantly. Petroleum-related revenues in Malaysia comes from several sources. Petroleum-related companies pay a petroleum income tax (PIT), and the government receives royalties from petroleum companies as well as export duties on petroleum products. In addition, the state-owned firm Petronas also remit dividends to the government. Finally, the government also receives income from petroleum operations from Malaysia-Thailand Joint Authority (MTJA).[4] A change in oil prices can affect fiscal revenues from all these sources. Thus, for example, following the collapse in oil prices in late 2014, petroleum-related revenues fell from MYR66 billion in 2014 to MYR31 billion in 2016, or less than half the amount before the oil price collapse. On the flip-side, higher oil prices also results in a windfall of higher petroleum-related revenues. In addition, the non-petroleum related revenues also increase when higher oil prices positively impact real GDP. Thus, it is not surprising that, overall, higher growth in oil prices tend to be associated with higher growth in fiscal revenues (Figure 6), although the association comes with a few quarters of lag. The amount of Petronas dividends

[4] The Malaysia-Thailand Joint Authority is the entity that manages and controls the exploration and production of petroleum in the Malaysia-Thailand Joint Development Area (MTJDA), an area where the two countries have overlapping continental shelf claims. Malaysia and Thailand agreed to share the revenues and expenses from the petroleum activity in the MTJDA.

remittance to the government, for example, is generally negotiated based on the last year's oil prices.

Figure 7 shows that the daily prices of oil, the KLCI, and the MYR have a tendency to move together. Table 1 shows that the unconditional correlation between oil price growth and the rate of USD/MYR changes is positive, implying that increases in oil prices are associated with an appreciation of the ringgit. The unconditional correlation between changes in oil price and in the stock exchange index is also positive, and about as high as the correlation between the changes in exchange rate and oil prices. Meanwhile, the unconditional correlation between stock index growth and the rate of change of USD/MYR is also positive and higher than the unconditional correlation between the exchange rate and oil prices.

Figure 7. Oil Prices, KLCI Index and USD/MYR



Source: Haver Analytics

Table 1. Correlations Between Daily Growth Rates

	OIL	KLCI	MYR
OIL	1.00	0.12	0.11
KLCI	0.12	1.00	0.35
MYR	0.11	0.35	1.00

Source: AMRO staff calculations

Figure 8. Squared Daily Growth Rates: Oil, KLCI and USD/MYR

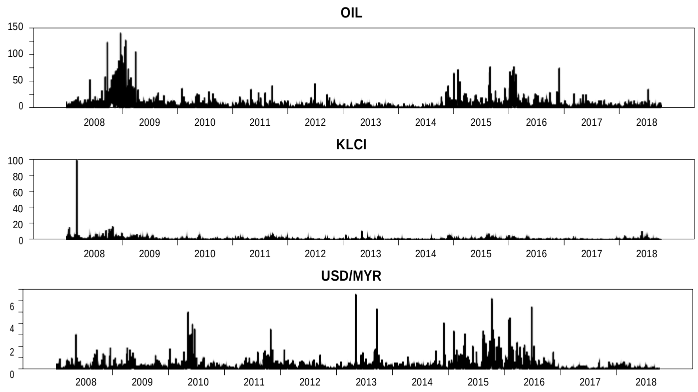


Fig 2. Squared Daily Returns

Source: Haver Analytics; AMRO staff calculations

Table 2. Correlations Between Squared Daily Growth Rates

	OIL	KLCI	MYR
OIL	1.00	0.09	0.06
KLCI	0.09	1.00	0.10
MYR	0.06	0.10	1.00

Source: AMRO staff calculations

There also appears to be evidence of volatility persistence and cross-correlation of volatility between oil price, stock market and the exchange rate. Figure 8 on the squared daily returns suggest volatility clustering in particular, around 2008-2009 and 2015-2016, periods when oil prices and GDP growth were on a downturn. Meanwhile, Table 2 shows the unconditional correlations on the squared returns of oil, KLCI and the USD/MYR rate. It suggests some volatility cross-correlations between oil, stock markets and exchange rate. Similar to the cross-correlations for the daily growth rate between the three markets (Table 1), the cross-correlation for *volatility* between the three markets is highest for KLCI and MYR, then oil and KLCI, and lowest for oil and MYR, although the values of the correlations are closer in magnitude (Table 2).

3. Impact of Oil Prices on Real GDP, Inflation, and Fiscal Revenues

In this section, we analyze more formally the relationship between oil prices, and Malaysia's output, inflation and fiscal revenues. Section 3.1 below explains the data sources and transformation, and statistical methodology to measure the impact of oil prices, while Section 3.2 presents our empirical findings.

3.1 Data Sources and Methodology

To measure the impact of oil prices on Malaysia's output, inflation, and fiscal revenue, we employed Vector Autoregression (VAR)/VECM estimations of oil prices, prices, real GDP, and fiscal revenues. We used quarterly series covering the period from Q3 1987 to Q3 2019. Average Brent oil prices, real GDP, consumer prices index and fiscal revenue data were from CEIC Data Company. The series were transformed to their natural logarithm and seasonality adjusted using X13 in Eviews. We tested the order of integration of these transformed variables using augmented Dickey-Fuller unit roots tests, and found all the series to be integrated of order 1. The Schwartz information criterion suggests a lag length of 1 for the VAR.

If system is cointegrated, running a VAR on the first difference of the variables would result in misspecification, as one would be ignoring the information from the long-run relationship among the cointegrated variable. However, if the system is not cointegrated, it would best to run a VAR on the first difference of the variables. Thus, to determine the VAR specification, we tested for cointegration using Johansen's (1988) methodology, and found evidence of cointegration among the variables. Thus, in sum, we decided to employ a vector error correction model with the following specifications:[5, 6]

$$\Delta lbrent_t = a_{10} + \alpha_b ECT_{t-1} + a_{11}\Delta lbrent_{t-1} + a_{12}\Delta lp_{t-1} + a_{13}\Delta lgdp_{t-1} + a_{14}\Delta lfiscal_{t-1} + \varepsilon_t^b$$
$$\Delta lp_t = a_{20} + \alpha_p ECT_{t-1} + a_{21}\Delta lbrent_{t-1} + a_{22}\Delta lp_{t-1} + a_{23}\Delta lgdp_{t-1} + a_{24}\Delta lfiscal_{t-1} + \varepsilon_t^p$$
$$\Delta lgdp_t = a_{30} + \alpha_g ECT_{t-1} + a_{31}\Delta lbrent_{t-1} + a_{32}\Delta lp_{t-1} + a_{33}\Delta lgdp_{t-1} + a_{34}\Delta lfiscal_{t-1} + \varepsilon_t^g$$
$$\Delta lfiscal_t = a_{40} + \alpha_f ECT_{t-1} + a_{41}\Delta lbrent_{t-1} + a_{42}\Delta lp_{t-1} + a_{43}\Delta lgdp_{t-1} + a_{44}\Delta lfiscal_{t-1} + \varepsilon_t^f,$$

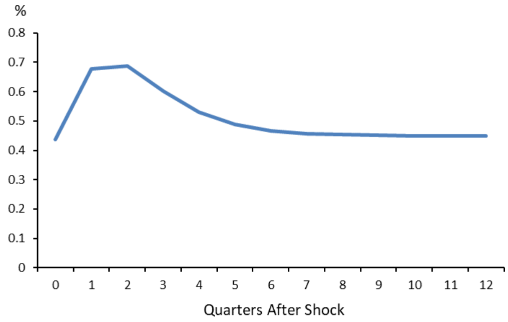
where *ECT* represents the error correction term associated with the cointegration relationship, and $lbrent_t$, lp_t, $lgdp_t$ and $lfiscal_t$ are the log of the seasonally-adjusted oil price, consumer price, real GDP and fiscal revenue, respectively.

[5] Johansen's max-eigenvalue test suggest 1 cointegrating equations while the trace test suggests a cointegration rank of two. Based on the interpretability of the results, we adopt the result that there is one cointegration equation.
[6] Our estimation results are reported in the Appendix. It indicates that fiscal revenues are significantly positively impacted by Brent oil prices and real GDP. The speed of adjustment parameter indicates that fiscal revenues are responsive to the previous period's deviation from the equilibrium relationship. Residual tests also fail to reject the null hypothesis of no serial correlation and the correlograms indicate that the residuals are white noise.

3.2 Empirical Findings

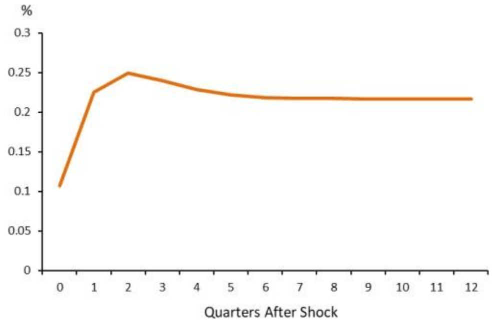
Impulse response analysis suggests that the impact of oil prices on Malaysia's real GDP, price, and fiscal revenues may be non-trivial. Figure 9 plots the response of real GDP to an oil price shock. A typical oil price shock's effect on real GDP peaks one or two quarters after the shock, increasing real GDP by around 0.7 percent above its base. The response of GDP to the oil price shock recedes after the second quarter. Figure 10 suggests that a typical oil price shock increases inflation by 0.1 percent from its base, on impact. The effect increases to around 0.25 after two quarters after which the effect on inflation recedes. Figure 11 also suggests that the impact of an oil price shock on Malaysia fiscal revenues may be quite substantial. The impact comes with a lag and the full effect is felt most after one year, when the oil price shock increases fiscal revenues by around 3.5 percent.

Figure 9. Response of Real GDP to Oil Price Shock



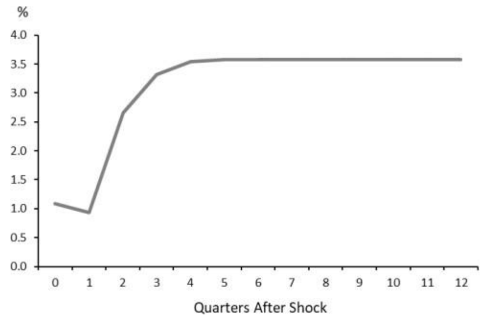
Note: Pesaran-Shin (1988) were used in calculating the generalized IRFs.
Source: AMRO staff calculations

Figure 10. Response of Inflation



Note: Pesaran-Shin (1988) were used in calculating the generalized IRFs.
Source: AMRO staff calculations

Figure 11. Response of Fiscal Revenues



Note: Pesaran-Shin (1988) were used in calculating the generalized IRFs.
Source: AMRO staff calculations

Table 3. One-Year Accumulated Elasticities of Real GDP, Inflation, and Fiscal Revenues With Respect to Oil Prices

Real GDP	Inflation	Fiscal Revenue
0.042	0.014	0.141

Source: AMRO staff calculations.

Table 3 also reports the one-year accumulated elasticities of real GDP, inflation, and fiscal revenues with respect to Brent oil prices. We calculated these as the total percent increases in real GDP, inflation, and fiscal revenues within one year, divided by the total percent increase in Brent oil within a year.[7] As Table 3 reports, a 1 percent increase in Brent oil prices is associated with a 0.042 percent increase in real GDP, a 0.014 percent increase in the CPI, and a 0.14 percent increase in fiscal revenues within a time horizon of one year from the shock.

Table 4 presents the impact of a USD1 increase in Brent oil prices on annual real GDP, inflation, and annual fiscal revenues of Malaysia. In the case of real GDP, we calculate this by multiplying the ratio of average annual real GDP to average Brent oil price during the 1987-2018 sample period, to the elasticity of real GDP in Table 3.[8] The cases of inflation and fiscal revenues are calculated analogously. As Table 4 reports, every USD1 increase in Brent oil prices is associated with an increase in real GDP of approximately MYR646 million, an increase in inflation of approximately 0.03, and an increase in annual fiscal revenues of around MYR 339 million.

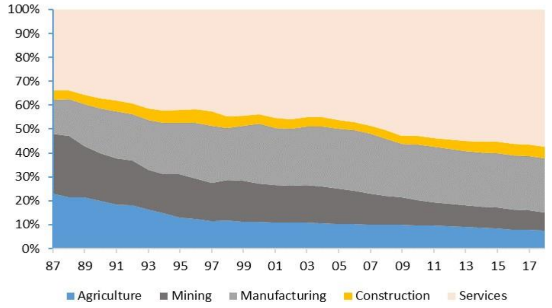
Table 4. Impact of USD1 Increase in Oil Prices on Annual Real GDP, Inflation, and Annual Fiscal Revenues

Impact On		
Real GDP (MYR mn 2015p)	Inflation	Fiscal Revenues (MYR mn)
645.887	0.027	338.650

Source: AMRO staff calculations

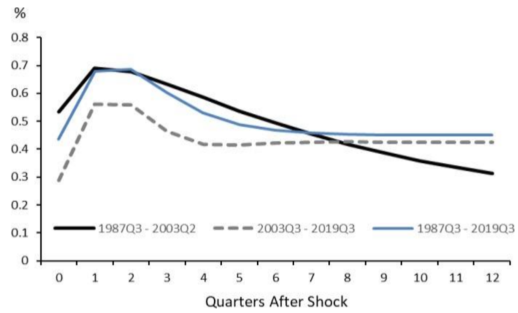
3.3 Sub-period Analysis

Figure 12. Sectoral Share of GDP



Source: Haver Analytics

Figure 13. Response of Real GDP to Oil Price Shock: Sub-period Analysis



Note: Pesaran-Shin (1988) were used in calculating the generalized IRFs.
Source: AMRO staff calculations

The Malaysian economy has undergone significant transformation from being heavily reliant on primary commodities in the 1980s to a substantially diversified economy today. Malaysia economy has diversified both vertically and horizontally.[9] Vertically, value addition has been expanded both upstream and downstream in the petroleum, palm oil and

[7] See Pereira (2000) for a similar methodology.
[8] See Pereira (2000) for a similar methodology.
[9] Vertical diversification refers to downstream and upstream diversification, such as higher value addition, while horizontal diversification refers to diversification towards new or unrelated sectors (Lebdioui 2019).

natural rubber industries. Petronas, for example, has made investments in refineries, petrol distribution, chemicals and fertilizers, and maritime transportation services. The rubber industry has been transformed from natural rubber exports to an integrated system of rubber-based manufacturing industries. The country has also evolved from being a crude palm oil producer to becoming a processed palm oil exporter. Horizontally, the electronics and electrical sector (E&E) sector was developed and became a major source of export revenue (Lebdioui 2019). More broadly, the share of manufacturing and services sectors in GDP increased significantly even as that of the mining and agriculture sectors decreased (Figure 12).

To analyze what effect Malaysia's economic diversification had on the impact of oil prices on the Malaysian economy, we conduct a sub-period analysis of our VECM model. We divided the available data sample into roughly two equal size, one corresponding to before and up to Q2 2003, and the other from Q3 2003 and after. The estimation results are reported in the Appendix.

Figure 13 suggests that oil price shock affected GDP less in the later period compared to the earlier period. The impulse response suggests that a typical oil price shock's effect on GDP during the earlier period peaks one or two quarters after the shock, increasing real GDP by around 0.7 percent above its base. In comparison, during the later period, the oil price shock's effect on GDP still peaks one or two quarters after the shock, but peaks only at 0.5 percent. Similarly, during the earlier period, a USD1 increase in oil price translate to an average increase of real GDP by MYR 902 million during the earlier period. The impact fell to only MYR 488 million in the later period (Table 5).

Table 5. Impact of USD1 Increase in Oil Prices on Annual Real GDP: Sub-period Analysis

Impact On Real GDP (MYR mn 2015p)	
1983Q3 - 2003Q2	2003Q3 - 2019Q3
901.797	487.957

Source: AMRO staff calculations

4. Impact of Oil Prices on Malaysia's Financial Variables

In this section, we analyze more formally the volatility relationship between oil prices and Malaysia's stock and foreign exchange market. We are interested in analyzing the relationship of the returns on these three assets, short-term and long-term volatility persistence in each of these assets, as well as the short-term and long-term volatility spillovers across these three sectors.

4.1 Data Sources and Methodology

To estimate the impact of oil prices on the KLCI and the USD/MYR as well as the relationships of the volatilities among the three variables, we employed two multivariate GARCH models—the triangular BEKK model and the dynamic conditional correlation model (DCC). We estimated a model of the following form:

$$y_{it} = m_{i0} + \sum_{j=1}^{3} m_{ij}\, y_{jt-1} + u_{it}, \quad u_{it}|I_{it-1} \sim N(0, h_{it}), \qquad i,j = 1,2,3$$

$$u_{it} = \nu_{it} h_{it}^{1/2}, \qquad \nu_{it} \sim N(0,1)$$

$$V_{it} = c_{ii} + \sum_{j=1}^{3} a_{ij} u_{jt-1}^2 + \sum_{j=1}^{3} b_{ij}\, h_{jt-1} + \sum_{j=1}^{3} d_{ij}\, v_{jt-1}^2,$$

where y_{it} is the growth rate of series *i*, computed as $100 * \ln(\frac{p_{it}}{p_{it-1}})$ where p_{it} is the series' daily value. Both *i* and *j* are from 1 to 3, where 1 refers to Brent oil price, 2 refers to KLCI index, and 3 refers to the USD/MYR rate. The first equation relates the growth of oil price, KLCI index, and exchange rate to its own lagged value and the lagged value of the other two variables.[10] The second equation relates the shocks u_{it} to the conditional variance V_{it} . The second equation specifies that the volatility of y_{it} is determined by the conditional variance, which is described in the third equation. The third equation represents the time series process of the volatility of the three variables. This specification conveniently allows for volatility persistence, volatility spillovers, and asymmetric effects. In this specification, a_{ij} governs the ARCH effects, b_{ij} governs the GARCH effects, and d_{ij} governs the indicator function for asymmetry. In this analysis, the ARCH effects capture the impact of today's news on the volatility of a certain variable such as oil price as well as the spillover of this to the volatilities of KLCI and USD/MYR. On the other hand, the GARCH effects measure the long-term volatility persistence as well as the long-term persistence's volatility spillovers.

The BEKK model is articulated in Baba and others (1990) and Engle and Kroner (1995), while the DCC model is from Engle (2002). The BEKK model uses straightforward recursions on each component of the conditional covariance matrix, thus: $H_t = CC' + A'\varepsilon_{t-1}\varepsilon_{t-1}{}' A + B'H_{t-1}B$. To avoid bad regions in the likelihood function, it imposes positive semi-definiteness on each term. Meanwhile, the DCC model decomposes the conditional covariance matrix into conditional variances and a correlation matrix instead of directly modeling it, thus: $H_t = D_t R_t D_t$, where $D_t = diag(\sqrt{h_{11t}}, \sqrt{h_{22t}}, \sqrt{h_{33t}},)$ and the correlation matrix R_t is assumed to be time-varying. In our estimation of the triangular BEKK model, we used the Cholesky ordering, (OIL, KLCI, USD/MYR), and we accounted for asymmetric effects, as introduced by Grier and others (2004). For both models, we employed the Berndt and others (1974) method for optimization. We used Haver Analytics data on daily last values of Brent prices, the KLCI Index and spot MYR from 1 January 2008 to 5 October 2018. All estimations were done using RATS Pro 10. Table 6 below summarizes the estimation results.

4.2 Empirical findings

Our estimates suggest that oil prices also have important effects on Malaysia's financial variables such as stock prices and the exchange rate.

A 1 percent increase in oil price will result in a 0.04 percent increase in the KLCI index and a 0.03 percent appreciation of the ringgit in the next period. The estimation results (Table 6) show that the estimated coefficients of oil prices in the KLCI equation (m_{21}) and the exchange rate equation (m_{31}) are both significant. Stated another way, both the triangular BEKK and the DCC models suggest that an increase in the oil price yesterday increases

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[10] Both the Schwartz and the Akaike information criterion suggest the VAR order of lag 1 adopted here is appropriate. Residual diagnostic tests reveal no evidence of serial correlation for both the standardized residuals and the squared of the standardized residuals.

today's the KLCI index and strengthens the Malaysian ringgit. Also, both models' estimates for the magnitude of the oil prices' impact are similar, at 0.04 and 0.03 for KLCI and USD/MYR, respectively.

Table 6. Multivariate GARCH Estimates

	Asymmetric Triangular BEKK			Asymmetric DCC		
Parameters	**Coeff**	**Signif**	**T stat**	**Coeff**	**Signif**	**T stat**
Mean						
m_{10}	-0.002	0.934	-0.083	-0.002	0.934	-0.082
m_{11}	-0.031	0.089	-1.700	-0.037	0.056	-1.914
m_{12}	-0.071	0.165	-1.387	-0.037	0.527	-0.632
m_{13}	0.047	0.553	0.592	0.028	0.731	0.344
m_{20}	0.007	0.507	0.663	0.009	0.388	0.863
m_{21}	0.042	0.000	8.008	0.045	8.363	0.000
m_{22}	0.086	0.000	4.416	0.079	0.000	3.737
m_{23}	0.025	0.293	1.053	0.022	0.342	0.951
m_{30}	-0.005	0.406	0.406	-0.004	0.527	-0.632
m_{31}	0.033	0.000	10.010	0.033	0.000	9.840
m_{32}	0.020	0.060	1.879	0.016	0.142	1.469
m_{33}	0.002	0.935	0.081	0.011	0.597	0.529
Variance						
c_{11}	0.120	0.000	7.589	0.023	0.000	4.172
c_{21}	-0.040	0.012	-2.504			
c_{22}	0.082	0.000	9.210	0.012	0.000	6.873
c_{31}	-0.020	0.050	-1.963			
c_{32}	0.011	0.160	0.160			
c_{33}	0.027	0.000	3.897	0.002	0.000	5.775
a_{11}	0.019	0.338	0.958	0.013	0.007	2.714
a_{12}				0.127	0.001	3.293
a_{13}				0.081	0.306	1.025
a_{21}	0.014	0.000	3.612	0.000	0.656	-0.445
a_{22}	0.169	0.000	9.492	0.061	0.000	6.211
a_{23}				-0.016	0.061	-1.876
a_{31}	0.014	0.000	6.791	0.001	0.000	6.549
a_{32}	-0.004	0.616	-0.501	0.003	0.097	1.661
a_{33}	0.275	0.000	23.257	0.104	0.000	9.824
b_{11}	0.982	0.000	573.190	0.952	0.000	175.133
b_{12}				-0.101	0.010	-2.588
b_{13}				-0.112	0.133	-1.504
b_{21}	0.003	0.003	2.979	0.002	0.033	2.133
b_{22}	0.947	0.000	212.516	0.849	0.000	67.386
b_{23}				0.007	0.515	0.651
b_{31}	0.002	0.022	2.284	-0.001	0.000	-5.454
b_{32}	-0.010	0.000	-4.304	-0.002	0.118	-1.561
b_{33}	0.956	0.000	271.454	0.889	0.000	107.255
d_{11}	0.252	0.000	19.866	0.058	0.000	7.045
d_{21}	-0.032	0.000	-5.477			
d_{22}	0.330	0.000	22.882	0.099	0.000	7.698
d_{31}	-0.009	0.043	-2.023			
d_{32}	0.069	0.000	6.309			
d_{33}	0.036	0.283	1.074	-0.004	0.769	-0.294
$dcc(a)$				0.005	0.013	2.478
$dcc(b)$				0.990	0.000	198.412

The estimation results from both multivariate GARCH models also support the conclusion of volatility persistence in the oil, stock, and currency markets. As reported in Table 6, both models suggest that the lag period's forecast variance (i.e. own GARCH effects), b_{ii} , is significant in explaining today's volatility for each of the three assets. This signifies long-term persistence in the volatility of oil, KLCI and MYR. Both models also suggest that oil exhibits the highest amount of long-term volatility persistence (as seen in b_{11} being 0.982), followed by MYR (b_{33} being 0.956) and then the KLCI (b_{22} being 0.947). The own ARCH effects, a_{ii}, are also statistically significant for all the three assets in the DCC model (a_{11}, a_{22}, a_{33}) although statistically significant only in the stock and forex markets in the BEKK model (a_{22}, a_{33}), which implies that the conditional variance of each of the assets react to yesterday's news about volatility. The magnitude of the a_{ii} coefficients are much smaller than their b_{ii} counterparts, signifying that long-term persistence is more important in determining the assets' volatility than news about yesterday's volatility.

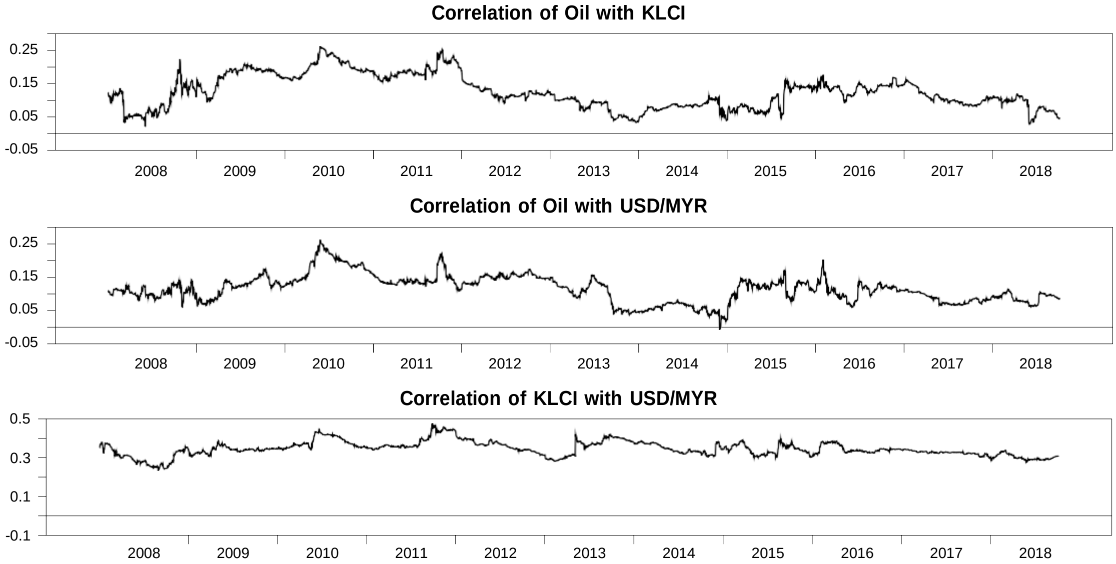
The empirical results for both models also suggest the existence of volatility spillovers between the oil, stock and foreign exchange markets. For both models, the results suggest statistically significant positive short-term persistence volatility spillovers (a_{ij}) from oil to MYR (a_{31}). The BEKK model finds statistically significant positive short-term persistence volatility spillover from oil to KLCI (a_{21} being 0.014 with t statistics of 3.612), but the DCC model reports a statistically insignificant coefficient (t statistics being -0.445) for such coefficient. For long-term persistence volatility spillover (b_{ij}), at 5% level of significance, both models report statistically significant positive spillovers from oil to KLCI (b_{21}), but the results are mixed for spillovers from oil to MYR (b_{31} being 0.002 for BEKK and -0.001 for DCC) (see Table 6).

Both models suggest significant asymmetric effects in the oil and stock markets, but not in the foreign exchange market. This implies that volatility is higher in the oil and stock markets, during periods of negative oil price shocks and KLCI downturns. However, asymmetric effects do not seem to be as prominent in the foreign exchange market. As Grier and others (2004) pointed out, the hypothesis that the covariance process is symmetric would require that all the d_{ij} coefficients be insignificant. However, the estimation results of both the triangular BEKK and the DCC model show strong asymmetric effects except in the case of d_{33} , *viz*, in the foreign exchange market (d_{11} and d_{22} are significant in both models). The magnitude of the asymmetric coefficients are higher for the BEKK than the DCC model. The BEKK model suggest that, *ceteris paribus*, oil prices are 25 percent more volatile during periods of negative oil price shocks, compared to periods of positive oil price shocks of the same magnitude, while the stock market is likewise 1/3 more volatile during downturns than upswings.

Figure 14 graphs the DCC model's dynamic conditional correlations, which can be interpreted as contemporaneous correlations of the three assets' returns. It suggests that the time-varying conditional correlations can differ quite a bit from the constant conditional correlations ($\rho_{21} = 0.10, \rho_{31} = 0.11, \rho_{32} = 0.33$),[11] particularly for correlation between oil and KLCI and between KLCI and USD/MYR, which suggests the importance of calculating conditional correlations dynamically. The figure also depicts a pattern of volatility clustering for the three conditional correlation series. Finally, these time-varying conditional correlations are mean-reverting, as suggested $dcc(a)$ and $dcc(b)$ coefficients summing to less than one (see Table 6).

[11] Derived from estimating constant correlation multivariate GARCH model (estimation results not shown to save space).

Figure 14. Asymmetric DCC Model: Time-Varying Conditional Correlations



Source: AMRO staff calculations

5. Summary of Findings and Policy Implications

In this paper, we analyzed and quantified the effects of oil prices on Malaysia's real GDP, inflation, fiscal revenues, stock markets, and exchange rate. Section 2 presented the stylized facts on the relationship between oil prices and Malaysia's economic and financial variables. In Section 3, we investigated more formally the relationship between oil prices and Malaysia's real GDP, inflation, and fiscal revenues, using a vector error correction model.[12] We found that the elasticities of real GDP, inflation, and fiscal revenues to oil prices are 0.042, 0.014, and 0.141, respectively. This translates to an increase in annual real GDP, inflation, and annual fiscal revenues of around MYR 646 million, 0.03, and MYR 339 million, respectively for every 1 US dollar increase in Brent oil prices. In Section 4, we quantified the impact of oil prices on Malaysia's stock market and exchange rate. We found that every 1 percent increase in oil prices translates to KLCI increasing by 0.04 percent and ringgit 0.03 appreciation. We also found significant volatility persistence in, and inter-sector volatility spillovers between, the oil, stock, and foreign exchange markets, as well as important asymmetric effects on volatility in these markets. All these imply that oil prices have important effects on Malaysia's real sector, inflation, fiscal sector, stock market and exchange rate.

The Malaysian authorities have managed well the effects of fluctuating oil prices on the Malaysian economy. Malaysia's economic and fiscal diversification hitherto have helped weaken the correlation between oil prices and the MYR in recent years, and the flexible exchange rate has also helped the economy absorb the effects of oil price movements on the financial variables. Also, the Malaysian authorities have employed various measures to help counteract the negative effects of the plunge in oil prices, for example, in late 2014 to 2016.

[12] As an area of future research, it will be interesting to investigate other aspects of this topic using other models. For example, the time variant causal relationship between oil prices and fiscal revenues may possibly be investigated using a bootstrap rolling window model. Nonlinear autoregressive lag models can also be potentially used to analyze the asymmetric impact oil prices on the Malaysian economy.

Alongside an accommodative monetary policy, the government has also employed income-supporting measures such as the Bantuan Rakyat 1 Malaysia (BR1M) cash aid to lower-income households, tax relief to low income individuals, and a reduction in Employees Provident Fund (EPF) contributions by employees, which have not only helped alleviate the plight of poor households, but also contributed to the country's economic resilience. These were important policy initiatives both to counter the cyclical effects of falling oil prices as well as to counter possible hysteresis effects, as factors of production (capital and labor) can lie idle. Also, the introduction of GST in April 2015 and further subsidy reforms through the implementation of a managed float for retail fuel prices in December 2014 helped mitigate the fall in revenue and reduced operating expenditure. The introduction of GST diversified Malaysia's revenue base and increased indirect tax collections, while the rationalization of fuel subsidies resulted in a fall in the total subsidies bill, and alongside the reduction in other expenditure items, resulted in a fall in operating expenditures. As a result of the government's proactive response to the fall in the price of oil, Malaysia was able to meet its deficit targets in 2015 and 2016, notwithstanding the challenging oil price environment. Overall, the government's reforms resulted in a diversification of the country's revenue base, reduced its dependence on oil-related revenues, and helped the federal government achieve its fiscal deficit targets.

Going forward, Malaysia can increase its resilience to oil price movements by further diversifying its economy, its exports and its revenue base. Export competitiveness and diversification can be increased further by linking SMEs to new markets, intensified export promotion, increased tourism receipts, and by taking full advantage of its existing and forthcoming international trade agreements such as the ASEAN Economic Community (AEC), the Regional Comprehensive Economic Partnership (RCEP), the E.U.-Malaysian FTA and other FTAs. Malaysia can also take advantage of the potential positive trade diversion and investment diversion opportunities engendered by the re-escalation of US-China trade tensions. For instance, the US and China can potentially import more substitute products on their respective tariff lists from Malaysia, and also some Chinese or U.S firms can potentially relocate to Malaysia as a way to bypass the tariffs. The potential winners are the domestic industries that export final products to the U.S. in competition with China, such as solar panel electronic integrated circuits and electrical machines. Thus, the government can for example facilitate or give incentives for Chinese producers to relocate to Malaysia and make Malaysia its production and export base to the U.S., to mitigate against the risk of a possible re-escalation of US-China trade tension.

Overall, economic diversification can be enhanced through policies that are conducive to private sector growth, such as industrial upgrading policies. [13] Thus, the country should be firm in its implementation of its Productivity Blueprint. A growth accounting exercise by AMRO staff suggests that a 1 ppt increase in productivity will boost Malaysia's potential growth by around 0.8 ppts. To enhance productivity, the Malaysian economy can be further restructured towards higher value-added production and more knowledge-based services. Such an economic transformation would require an increase in innovation among firms, as well as investment in education—especially vocational training—to increase the share of skilled labor in the workforce, in addition to addressing labor market rigidities and mismatches.

On the fiscal side, Malaysia had exerted efforts to diversify its revenue base. The country has lowered its dependency on petroleum-related sources of revenue to around 5% in 2019

[13] See International Monetary Fund (2016).

from 9.2% of GDP in 2009. The government has also made good progress in pursuing revenue-enhancing measures as well as fiscal reform initiatives aimed at advancing transparency, accountability, and fiscal discipline. One of these measures was the Special Voluntary Disclosure Program from November 2018 to September 2019, which aimed to encourage tax payers to voluntarily declare unreported incomes under reduced penalty rates. Other efforts to widen the revenue base in 2019 included the implementation of a departure levy and a service tax on imported services. In the budget 2020, the government also proposed to increase the tax rate for the top income earners to 30% from 28% previously. Tax enforcement measures were also pursued including assignment of tax identification numbers and the purchase of customs cargo scanners, and a higher minimum penalty for illegal gamblers. The government has also established a Tax Reform Committee which recommends measures to 1) enhance tax administration, 2) reduce tax leakages, 3) narrow the tax gap by taxing the underground economy, and 4) find new sources of revenue. Continued implementation of these efforts are expected to contribute to further fiscal revenue diversification.

References

Baba, Yoshi, Robert Engle, Dennis Kraft, and Kenneth Kroner. 1990. "Multivariate Simultaneous Generalized ARCH." Mimeo, UCSD.

Berndt, E.K., B.H. Hall, R.E. Hall and J.A. Hausman. 1974. "Estimation and Inference in Nonlinear Structural Models." *Annals of Economic and Social Measurement*, Vol. 3/4: 653-665.

Bjornland, Hilde Christiane. 1998. "The Economic Effects of North Sea Oil on the Manufacturing Sector." *Scottish Journal of Political Economy* 45(5): 553-585.

Engle, R.F. 1992. "Dynamic Conditional Correlation." *Journal of Business and Economic Statistics* 20: 339-350.

Engle, R.F. and KF Kroner. 1995. "Multivariate Simulataneous Generalized ARCH." *Econometric Theory* 11:12-150.

Garratt, Anthony, Kevin Lee, M Hashem Pesaran, and Yongchoel Shin. 2003. "A Long Run Macroeconomic Model of the UK." *Economic Journal* 113(487): 412-455.

Grier, Kevin, Olan Henry, Nills Olekalns, and Kalvinder Shields. 2004. "The Asymmetric Effects of Uncertainty on Inflation and Output Growth." *Journal of Applied Econometrics* 19: 551-565.

Hamilton, James D. 2000. "What is an Oil Shock?" *Journal of Econometrics* 113(2): 363-398.

Hamilton, James D. 1983. "Oil and the Macroeconomy since World War II." *Journal of Political Economy* 91(2): 228-248.

International Monetary Fund. 2016. "Economic Diversification in Oil-Exporting Arab Countries", https://www.imf.org/external/np/pp/eng/2016/042916.pdf.

Jimenez-Rodriguez, Rebeca and Marcelo Sanchez. 2005. "Oil Price Shocks and Real GDP Growth: Empirical Evidence for some OECD Countries." *Applied Economics* 37(2): 201-228.

Johansen, S. 1988. "Statistical Analysis of Cointegrating Vectors." *Journal of Economic Dynamics and Control* 12:231-254.

Lebdioui, Abdelkader Amir. 2019. *Economic Diversification and Development in Resource-dependent Economies: Lessons from Chile and Malaysia* (Doctoral thesis). https://doi.org/10.17863/CAM.46517.

Masih, Abul and Rumi Masih. 1997. "On the Temporal Causal Relationship Between Energy Consumption, Real Income, and Prices: Some New Evidence from Asian-Energy Dependent NICs Based on a Multivariate Cointegration/Vector Error-Correction Approach." *Journal of Policy Modeling* 19(4): 417-440.

Mork, Knut Anton. 1989. "Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamilton's Results." *Journal of Political Economy* 97(3): 740-744.

Ozbek, Levent and Umit Ozlale. 2005. "Employing the Extended Kalman Filter in Measuring the Output Gap." *Journal of Economics Dynamics and Control* 29(9): 1611-1622.

Pereira, Alfredo. 2000. "Is All Public Capital Created Equal?" *Review of Economics and Statistics* 82(3): 513-518.

Appendices

Vector Error Correction Estimates
Sample (adjusted): 1987Q3 2019Q3
Included observations: 129 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LFISCALSA(-1)	1.000000
LRGDPSA(-1)	-1.347432 (0.26801) [-5.02756]
LPSA(-1)	0.233579 (0.55759) [0.41891]
LBRENTSA(-1)	-0.236056 (0.02963) [-7.96712]
C	5.959090

Error Correction:	D(LFISCALSA)	D(LRGDPSA)	D(LPSA)	D(LBRENTSA)
CointEq1	-0.468488 (0.07843) [-5.97318]	0.025785 (0.01405) [1.83553]	0.004087 (0.00666) [0.61383]	0.265147 (0.14668) [1.80766]
D(LFISCALSA(-1))	-0.147163 (0.07885) [-1.86645]	-0.015544 (0.01412) [-1.10068]	0.001013 (0.00669) [0.15133]	-0.035538 (0.14746) [-0.24101]
D(LRGDPSA(-1))	1.078094 (0.50533) [2.13344]	0.429613 (0.09051) [4.74666]	0.007139 (0.04289) [0.16643]	1.272521 (0.94505) [1.34651]
D(LPSA(-1))	0.339961 (1.03708) [0.32780]	-0.270312 (0.18575) [-1.45525]	0.169314 (0.08803) [1.92336]	-8.200615 (1.93951) [-4.22819]
D(LBRENTSA(-1))	-0.130036 (0.05044) [-2.57789]	0.012613 (0.00903) [1.39603]	0.007941 (0.00428) [1.85458]	0.239622 (0.09434) [2.54010]
C	0.007491 (0.01188) [0.63071]	0.010120 (0.00213) [4.75735]	0.005190 (0.00101) [5.14814]	0.042407 (0.02221) [1.90930]
R-squared	0.354563	0.217652	0.071637	0.183751
Adj. R-squared	0.328326	0.185849	0.033899	0.150570
Sum sq. resids	0.630550	0.020228	0.004543	2.205336
S.E. equation	0.071599	0.012824	0.006077	0.133901
F-statistic	13.51370	6.843817	1.898262	5.537861
Log likelihood	160.1598	382.0105	478.3370	79.40306
Akaike AIC	-2.390075	-5.829620	-7.323054	-1.138032
Schwarz SC	-2.257060	-5.696605	-7.190039	-1.005017
Mean dependent	0.020790	0.014375	0.006491	0.009353
S.D. dependent	0.087363	0.014212	0.006183	0.145285

Determinant resid covariance (dof adj.)	4.58E-13
Determinant resid covariance	3.79E-13
Log likelihood	1112.639
Akaike information criterion	-16.81610
Schwarz criterion	-16.19537
Number of coefficients	28

Vector Error Correction Estimates
Sample (adjusted): 1987Q3 2003Q2
Included observations: 64 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LFISCALSA(-1)	1.000000
LRGDPSA(-1)	-0.314425
	(0.36323)
	[-0.86564]
LPSA(-1)	-2.356718
	(0.77779)
	[-3.03001]
LBRENTSA(-1)	-0.310850
	(0.09383)
	[-3.31287]
C	5.157131

Error Correction:	D(LFISCALSA)	D(LRGDPSA)	D(LPSA)	D(LBRENTSA)
CointEq1	-0.217495	0.015825	0.018040	0.016185
	(0.08356)	(0.01845)	(0.00457)	(0.16489)
	[-2.60275]	[0.85760]	[3.95034]	[0.09815]
D(LFISCALSA(-1))	-0.299086	-0.014381	-0.006665	0.122006
	(0.11902)	(0.02628)	(0.00650)	(0.23486)
	[-2.51286]	[-0.54718]	[-1.02467]	[0.51948]
D(LRGDPSA(-1))	2.406620	0.409694	-0.041810	1.315009
	(0.62449)	(0.13790)	(0.03413)	(1.23227)
	[3.85377]	[2.97098]	[-1.22512]	[1.06715]
D(LPSA(-1))	2.985749	-0.292059	0.083207	-2.523004
	(2.47799)	(0.54719)	(0.13542)	(4.88969)
	[1.20491]	[-0.53374]	[0.61443]	[-0.51598]
D(LBRENTSA(-1))	-0.083530	-0.001800	0.006212	0.011857
	(0.07824)	(0.01728)	(0.00428)	(0.15439)
	[-1.06763]	[-0.10416]	[1.45287]	[0.07680]
C	-0.029746	0.012126	0.007407	-0.001210
	(0.02549)	(0.00563)	(0.00139)	(0.05030)
	[-1.16684]	[2.15412]	[5.31653]	[-0.02405]
R-squared	0.339159	0.193487	0.308162	0.051401
Adj. R-squared	0.282190	0.123960	0.248521	-0.030375

Sum sq. resids	0.313110	0.015268	0.000935	1.219160
S.E. equation	0.073474	0.016225	0.004015	0.144983
F-statistic	5.953381	2.782909	5.166936	0.628558
Log likelihood	79.43067	176.0967	265.4674	35.93100
Akaike AIC	-2.294708	-5.315523	-8.108357	-0.935344
Schwarz SC	-2.092313	-5.113127	-7.905962	-0.732949
Mean dependent	0.023955	0.016418	0.007226	0.005077
S.D. dependent	0.086722	0.017334	0.004632	0.142830

Determinant resid covariance (dof adj.)	3.47E-13
Determinant resid covariance	2.34E-13
Log likelihood	567.3699
Akaike information criterion	-16.85531
Schwarz criterion	-15.91080
Number of coefficients	28

Vector Error Correction Estimates
Date: 12/20/19 Time: 22:14
Sample: 2003Q3 2019Q3
Included observations: 65
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LFISCALSA(-1)	1.000000
LRGDPSA(-1)	-0.140272 (0.39617) [-0.35407]
LPSA(-1)	-2.032907 (0.79022) [-2.57260]
LBRENTSA(-1)	-0.201202 (0.02749) [-7.31907]
C	1.345086

Error Correction:	D(LFISCALSA)	D(LRGDPSA)	D(LPSA)	D(LBRENTSA)
CointEq1	-0.827641 (0.13773) [-6.00906]	0.015997 (0.01657) [0.96558]	0.003396 (0.01421) [0.23903]	-0.084182 (0.23639) [-0.35612]
D(LFISCALSA(-1))	0.056685 (0.10931) [0.51859]	-0.012122 (0.01315) [-0.92197]	0.001968 (0.01128) [0.17454]	0.065027 (0.18760) [0.34662]
D(LRGDPSA(-1))	0.222340 (1.02507) [0.21690]	0.239802 (0.12330) [1.94481]	0.048464 (0.10575) [0.45827]	0.909687 (1.75931) [0.51707]
D(LPSA(-1))	-1.287950 (1.31631) [-0.97846]	-0.501049 (0.15834) [-3.16447]	-0.021012 (0.13580) [-0.15473]	-13.10043 (2.25916) [-5.79882]
D(LBRENTSA(-1))	-0.133709 (0.07101)	0.032268 (0.00854)	0.016988 (0.00733)	0.454544 (0.12187)

	[-1.88304]	[3.77790]	[2.31903]	[3.72980]
C	0.022531	0.012136	0.005058	0.070860
	(0.01678)	(0.00202)	(0.00173)	(0.02879)
	[1.34303]	[6.01383]	[2.92265]	[2.46104]
R-squared	0.441254	0.365496	0.140753	0.415954
Adj. R-squared	0.393903	0.311724	0.067936	0.366459
Sum sq. resids	0.280411	0.004057	0.002985	0.825986
S.E. equation	0.068940	0.008293	0.007112	0.118321
F-statistic	9.318725	6.797189	1.932958	8.403902
Log likelihood	84.76026	222.4217	232.4011	49.64985
Akaike AIC	-2.423393	-6.659129	-6.966189	-1.343072
Schwarz SC	-2.222680	-6.458416	-6.765476	-1.142360
Mean dependent	0.017674	0.012364	0.005768	0.013564
S.D. dependent	0.088552	0.009996	0.007367	0.148653

Determinant resid covariance (dof adj.)	1.58E-13
Determinant resid covariance	1.07E-13
Log likelihood	601.7235
Akaike information criterion	-17.65303
Schwarz criterion	-16.71637
Number of coefficients	28