Banafea, Waheed Abdulrahman; Ali, Abdelaziz Abdelmegid

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Large Oil Shocks and Economic Growth: Evidence from Saudi Arabia

Waheed Abdulrahman Banafea* , Abdelaziz Abdelmegid Ali

Department of Economics and Budget, Institute of Public Administration, P.O.Box 205 Riyadh 11141, Saudi Arabia.
*Email: banafeaw@yahoo.com

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ABSTRACT

This paper aims to analyze the impact of large oil shocks on economic growth in Saudi Arabia, using a standard VAR model and a Markov-switching heteroscedastic regime, by using a quarterly data from 1981Q1 to 2019Q4. The results indicated that there were three large negative oil shocks, 1986Q1, 2008Q4, and 2014Q4, but there was only one large positive shock in 1990Q3. The impulse response and variance decomposition analysis show that both large negative and positive oil shocks have positive impacts on economic growth in Saudi Arabia, although only large negative shocks are statistically significant. Furthermore, large oil shocks only have a significant positive impact on economic growth comparing with normal oil shocks.

Keywords: Large Oil Shocks, Asymmetric Effects, Economic Growth, VAR, Saudi Arabia
JEL Classifications: Q43, C5

1. INTRODUCTION

The impact of oil shocks on economic growth has continued to generate controversies among researchers and policymakers, whether in oil-exporting or oil-importing countries. Hubber introduced peak oil theory in 1956, showing that the production of oil follows a bell-shaped curve, which simultaneously affects the macroeconomic indicators of both these types of countries. On this basis, many economists have connected the global recessions of the 1970s and beyond with oil price shocks.

Darby (1982) and Hamilton (1983) were the first two economists to investigate the impact of oil shocks on the U.S. economy. They found a statistically significant correlation between an increase in the crude oil price and real GNP. In addition, Hamilton (2008) later suggested that 9 of the 10 recessions in the U.S. between 1945 and 2005 were preceded by large increases in oil prices. He had a general conviction that oil price shocks are directionally asymmetric, where large positive oil price shocks matter but negative ones do not.

Segal (2007) indicated that Hamilton's studies point out that oil shocks cause economic recessions if there is a significant increase in the price of crude oil. He noticed that, during the period of 1960-1972, the GDP of the U.S. averaged a growth rate of 4%, but it decreased to 2.4% during the period of 1973-1981. Between the two periods, the inflation and unemployment rates also increased by more than two-fold, from 3.1% to 6.7%, and Hamilton referred in his discussion to the more than doubling of oil prices since 1972. It was based on this evidence that Hamilton suggested a hypothesis that the U.S. economic recession at the time was due to increases in oil prices.

Burbridge and Harrison (1984) examined the effects of oil price increases using a vector autoregressive (VAR) model over the period from January 1961 to June 1982 for a selection of OECD countries. They found that increases in the oil price had a sizable negative impact on industrial production in the U.S. and the U.K., but that the responses in other countries were small. Mork (1989) examined the relationship between oil price changes and economic growth, also using a VAR model, and found that oil price changes have an asymmetric impact on economic activities. Hooker (1996) supported the earlier results of Hamilton (1983)—that the level of changes in the oil price has an impact on economic growth—and reported how economic growth had decreased by 0.6% when oil prices rose by 10% during the period of 1948-1972.

Guo and Kliesen (2005) analyzed the impact of oil price volatility on the U.S. economy, using daily oil futures prices over the period of 1984-2004. Their results, consisting of impulse response functions and variance decomposition, confirmed that a fair portion of the fluctuations in the unemployment rate and in investment could be explained by oil price volatility. In addition, they found that oil price volatility has a significant effect on U.S. macroeconomic indicators, and suggested that changes in oil prices are less significant than the uncertainty surrounding future prices due to other exogenous events, like significant terrorist attacks and military conflicts in the Middle East.

To account for the fact that economic activity responds asymmetrically to oil price shocks, Lardic and Mignon (2006) studied the relationship between oil prices and GDP in 12 European countries from 1970 to 2003 at quarterly intervals. They found evidence of asymmetric cointegration between oil prices and GDP in the majority of the countries considered. However, Blanchard and Gali (2007) reported that oil shocks have smaller impacts on the world economy now than they did in the past.

Important for our work, Gronwald (2008) introduced the concept of differentiating between large and normal positive oil shocks. The results of their impulse response and variance decomposition analysis indicated that only large positive oil shocks have had a negative impact on real GDP growth in the U.S. They then primarily attributed the remarkable impact of large oil price shocks on real GDP growth to at least three large oil price increases; specifically those that occurred in 1973-1974, 1979, and 1991.

Hesary et al. (2013) assessed the impact of oil price shocks on oil producing and consuming economies. For net oil exporter countries, they found that there are direct and indirect effects of positive oil shocks on the GDP in Iran and Russia, and that the net effect is always positive and larger than the direct effect. On the other hand, the results for net oil importer countries were divided into three groups. In Group A, the results were negative in the case of direct effects, and positive in the case of indirect effects. In Group B, both the direct and indirect effects were positive, while both were negative in Group C.

Moshiri (2015) investigated the asymmetric effects of oil shocks on the economic performance of nine major oil-exporting countries—including Saudi Arabia—using a GARCH method to estimate such shocks. The results of their decomposition analysis indicated that negative oil shocks explain a larger portion of the variance in GDP growth compared to positive shocks in most of these countries (e.g., 13% in Saudi Arabia). Also, their analysis of the impulse response function indicated that only negative oil shocks have a significant impact on GDP growth in Saudi Arabia, Algeria, Iran, and Kuwait.

Ftiti et al. (2016) examined the impact of oil price shocks on economic growth in four major OPEC countries (the UAE, Kuwait, Saudi Arabia, and Venezuela) over the period from September 3rd, 2000 to December 3rd, 2010 using a time-varying dynamic correlation. Their results indicated that oil price shocks have both medium- and short-term effects on economic growth.

Alrasasi and Banafea (2015) examined the impacts of different types of oil shocks—namely those of demand shocks, supply shocks, and aggregate demand shocks—on economic activity in Saudi Arabia using monthly data from February 1980 to February 2014. They followed the method of Kilian (2008) to identify oil supply and demand shocks. Their analysis of the impulse response function indicated that only oil supply shocks have a positive and statistically significant impact on economic growth. Moreover, Banafea and Alrasasi (2016) then utilized a structural vector autoregression (SVAR) model and the method of Mork (1989) to investigate the asymmetric impact of oil shocks on economic growth in Saudi Arabia using quarterly data from 1980Q1 to 2014Q4. The results of this impulse response function indicated that the impact of positive oil shocks on economic growth is relatively large (in terms of the duration of their significant effects) compared to negative oil shocks.

Sim and Sek (2019) also examined the effect of oil shocks on the global economy using threshold regression. Their study applied the data decomposition method of Kilian to distinguish oil shocks based on whether they had a demand versus a supply origin. These results showed that the impacts of oil shocks differ across sectors, implying different oil intensity. Hence, the global economy is oil-demand driven. Besides that, the impact of oil is relatively large in the energy sector when compared to non-energy sectors or the precious metals industry. Nevertheless, the impact of oil shocks is small when compared to non-oil shocks, such as exchange rate changes and global price inflation shocks. Consequently, these authors conclude that non-oil shocks are the main determinants of global economic fluctuations.

A more recent study by Abbritti et al. (2020) examined the impact of oil price shocks on the U.S. economy from January 1974 to August 2016. They suggested that oil price shocks have a large and significant impact on some U.S. macro variables, and that the magnitude of the effect depends on the level of the oil price before the occurrence of the shock.

Our motivation for analyzing the impact of oil shocks on economic growth in Saudi Arabia is that the work found in the literature did not differentiate between the impact of large and normal oil shocks on economic growth. This may overlook issues facing the oil-based economy of Saudi Arabia, which is likely more affected by large negative and positive oil shocks compared to normal negative and positive oil shocks. Moreover, what distinguishes our current paper from the previous work is that we differentiate between oil shocks based on their size—namely between large- and normal-sized oil shocks—as well as between positive and negative oil shocks.

The rest of this paper is organized as follows: section 2 presents our methodology and the resulting data; section 3 presents our empirical results and a discussion of them; and the final section presents our conclusions.

2. METHODOLOGY AND DATA

Carruth et al. (1998) had previously indicated that the breakdown of the relationship between variables could be related to larger models by comparing them to their functional form. Recently, Gronwald (2008) confirmed that a bivariate VAR model provides clearer findings about the impact of large oil shocks on GDP growth in the U.S. compared to higher-dimensional VAR models. Following the literature, this paper employs a traditional bivariate VAR model consisting of real gross domestic product (GDP) growth and oil price shocks in order to investigate the relationship between economic growth and such shocks. Therefore, impulse response analysis and variance decompositions are performed using the Cholesky decomposition, with real GDP growth placed first in the ordering followed by oil price shocks.

We used quarterly data from the period between 1981Q1 and 2019Q4, and obtained real GDP and real oil prices from the World Bank and International Monetary Fund (IMF) databases, respectively[1]. Both variables have been transformed into their first-log-differences. The maximum lags were chosen based on the Akaike information criterion (AIC).

2.1. Oil Price Shocks

Since we are interested in this paper in investigating asymmetric impacts of large oil price shocks on economic growth in Saudi Arabia, we have utilized a procedure from Gronwald (2008) that differentiates between large and normal shocks using a Markov-switching heteroscedasticity (MSH) method. This allows us to distinguish between oil shocks based on their magnitudes at different periods of time. Thus, the following model is estimated as:

$$ln\Delta o_t = \theta + \gamma_1 ln\Delta o_{t-1} + \gamma_2 ln\Delta o_{t-2} + \gamma_3 ln\Delta o_{t-3} + \gamma_4 ln\Delta o_{t-4} + \gamma_5 lno_{t-5} + \varepsilon_t \quad (1)$$

where Δ is the first difference operator, o_t is the real oil price, and ε_t is the error term equal to IID(0, σ^2 (S_t)). In this case, σ^2 is the variance and S_t is an unobservable regime variable, which are both controlled by the discrete time and state of the Markov process. The number of lags are based on the AIC, as mentioned earlier.

Although Gronwald's procedure focuses only on large and normal positive oil shocks, we extend the analysis by measuring large and normal negative oil shocks. It should be mentioned that Gronwald and others—such as Lee et al. (1995) and Hamilton (1996)—focused on positive oil shocks since their work concentrated on oil-importing countries such as the U.S. However, in this paper, we are studying the impacts of large oil shocks on economic growth in Saudi Arabia, which is considered one of the largest oil-exporting countries in the world. Another feature of the Saudi economy is that it is still lowly diversified, and still depends heavily on natural resources such as crude oil and gas (Banafea and Ibnrubbian, 2018). Consequently, large or even normal negative oil shocks may have a significant impact on economic growth in Saudi Arabia.

According to the MSH process, there are three regimes to consider:

- Regime 1 represents no volatility in oil prices.
- Regime 2 represents normal volatility in oil prices[2].

$$NORMAL^{+} = \begin{pmatrix} \Delta o_t if Prob\left(s_t = regime 1,2\right) \geq 0.5 \, and \, \Delta o_t > o \\ 0 \, otherwise \end{pmatrix}$$

where $Prob(s_t{=}regime1{,}2)$ is the estimated filtered probability for regimes 1 and 2, and $NORMAL^{+}$ are the normal oil price increases in these regimes as depicted in Figure 1.

$$NORMAL^{-} = \begin{pmatrix} \Delta o_t if Prob\left(s_t = regime 1,2\right) \geq 0.5 \;\, and \;\, \Delta o_t > o \\ 0 \, otherwise \end{pmatrix}$$

where $NORMAL^{-}$ are the normal oil price decreases in regimes 1 and 2 as depicted in Figure 2.

$$NORMAL^{*} = \begin{pmatrix} \Delta o_t if Prob\left(s_t = regime 1,2\right) \geq 0.5 \;\, and \\ \Delta o_t = NORMAL^{-} \; and \; NORMAL^{+} \\ 0 \, otherwise \end{pmatrix}$$

1 Due to the lack of quarterly data, real GDP was transformed from an annual to a quarterly frequency using Denton's method, and real oil prices were transformed from a monthly to a quarterly frequency by taking the end-of-period value. As per the literature, quarterly data is more suitable when studying the impact of oil shocks on macro-variables (Mork, 1989; Lee et al., 1995; Hamilton, 2003).

2 $NORMAL^{+}$, $NORMAL^{-}$, and $NORMAL^{*}$ are the changes in oil prices as natural logarithms corrected for large oil price shocks *($LARGE^{+}$, $LARGE^{-}$, $LARGE^{*}$)* in regime 3.

Figure 1: Normal oil price increases (*$NORMAL^{+}$*)

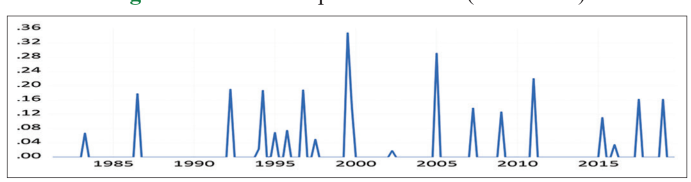


Figure 2: Normal oil price decreases (*$NORMAL^{-}$*)

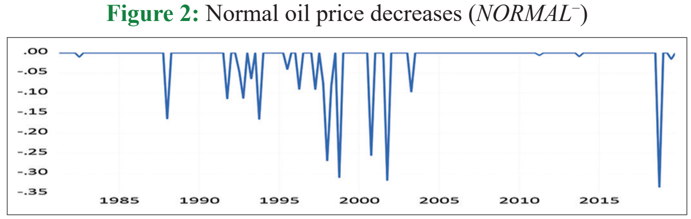
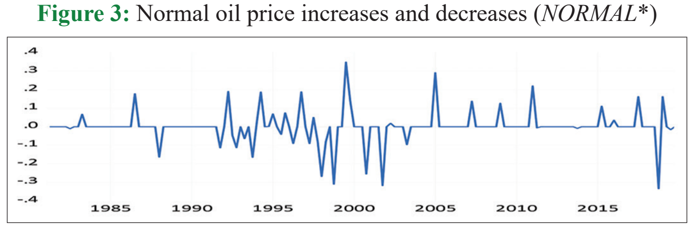


Figure 3: Normal oil price increases and decreases (*NORMAL**)



where *NORMAL** are the normal price increases and decreases in regimes 1 and 2 as depicted in Figure 3.

- Regime 3 represents high volatility in oil prices.

$$LARGE^{+} = \begin{pmatrix} \Delta o_t ifProb\left(s_t = regime3\right) \geq 0.5 \ and \ \Delta o_t > 0 \\ 0\, otherwise \end{pmatrix}$$

where $Prob(s_t{=}regime3)$ is the estimated filtered probability for regime 3, and $LARGE^{+}$ are the large positive oil price shocks in this regime as depicted in Figure 4.

$$LARGE^{-} = \begin{pmatrix} \Delta o_t ifProb\left(s_t = regime3\right) \geq 0.5 \, and \ \Delta o_t < 0 \\ 0\, otherwise \end{pmatrix}$$

Figure 4: Large positive oil shocks ($LARGE^{+}$)

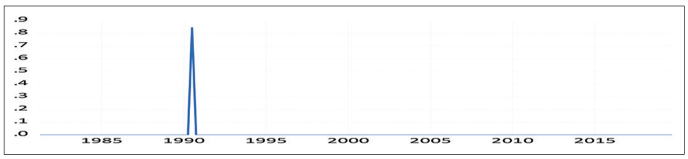


Figure 5: Large negative oil shocks **(**$LARGE^{-}$)

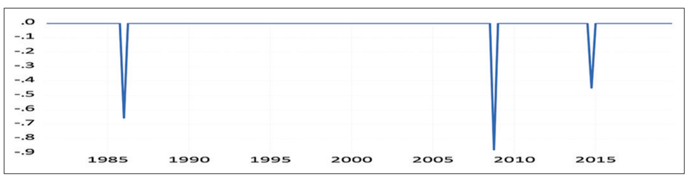


Figure 6: Large oil shocks (*LARGE**)

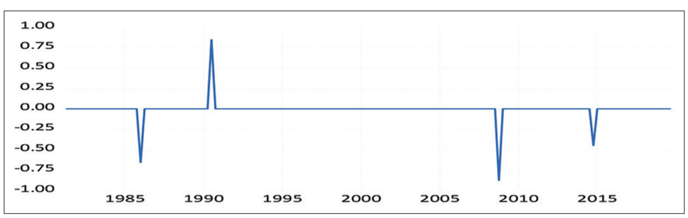


Figure 7: Positive oil shocks

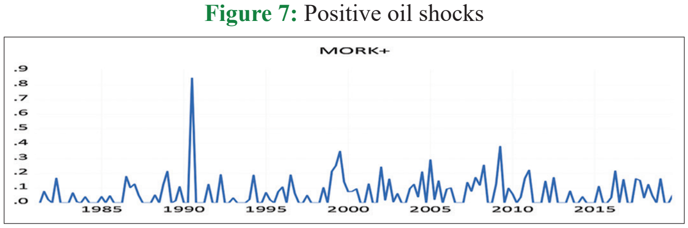
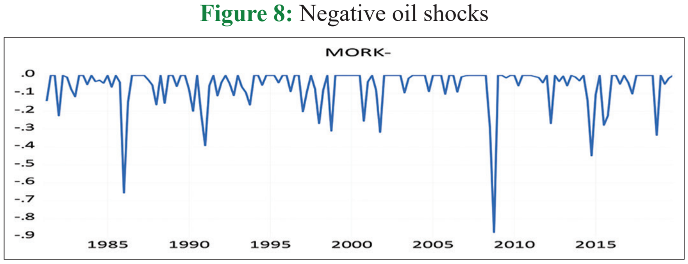


Figure 8: Negative oil shocks



where $LARGE^{-}$ are the large negative oil price shocks in regime 3 as depicted in Figure 5.

$$LARGE^{*} = \begin{pmatrix} \Delta o_t ifProb\left(s_t = regime3\right) \geq 0.5 \, and \\ \Delta o_t = LARGE^{+} and \ LARGE^{-} \\ 0\, otherwise \end{pmatrix}$$

where *LARGE** are the large positive and negative oil price shocks in regime 3 as depicted in Figure 6.

For a comparison, the asymmetric oil price shocks proposed by Mork (1989) can be introduced. There, Mork indicated that oil price decreases and increases do not have similar impacts on GDP. By studying the two as separate variables when it comes to U.S. GDP, they found that only oil price increases have a significant negative impact. This was later confirmed by Lee et al. (1995).

To see this, we can write Mork's oil price specification as follows (Figures 7 and 8):

$$MORK^{+}\begin{pmatrix} \Delta o_t if \, \Delta o_t > 0 \\ 0\, otherwise \end{pmatrix}$$

$$MORK^{-}\begin{pmatrix} \Delta o_t if \, \Delta o_t < 0 \\ 0\, otherwise \end{pmatrix}$$

where $MORK^{+}$ and $MORK^{-}$ indicate the positive and negative oil shocks proposed by Mork (1989), as depicted in Figures 7 and 8, respectively.

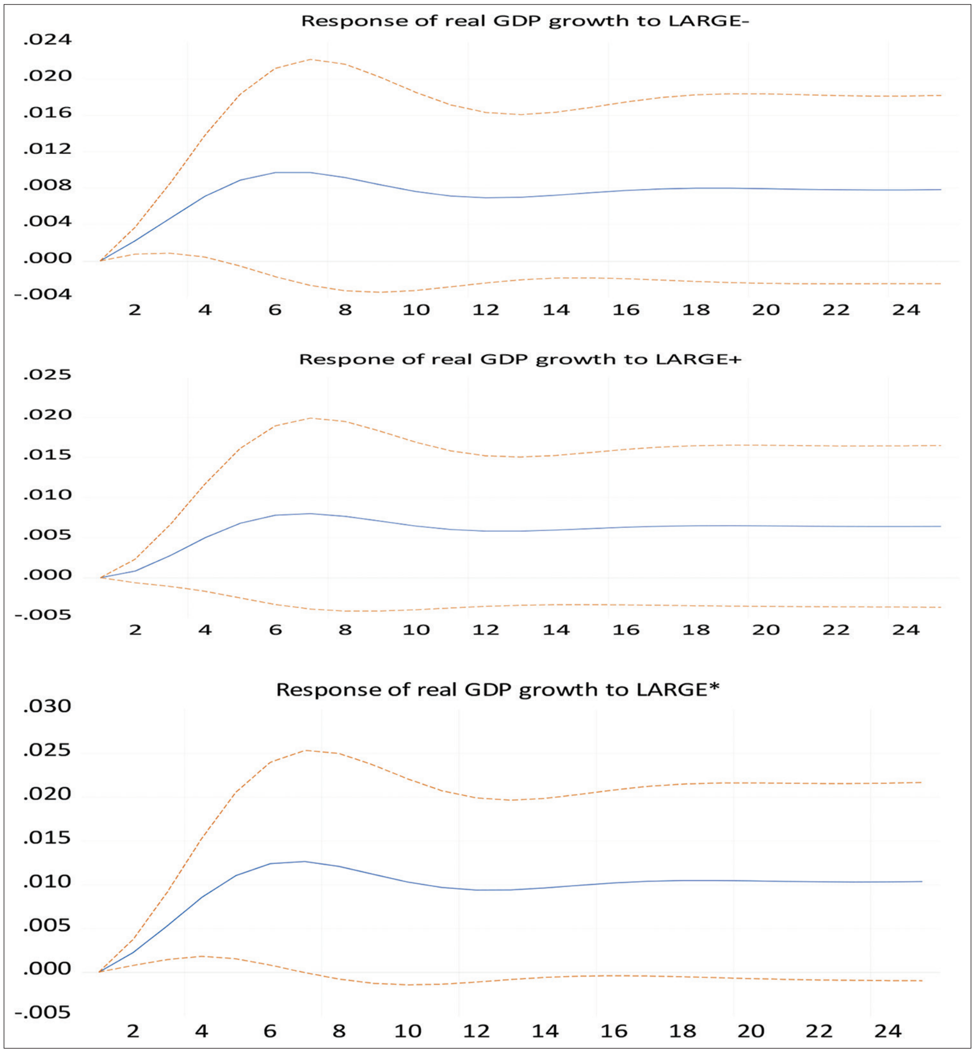
3. EMPIRICAL RESULTS AND DISCUSSION

The estimated filtered probability for regime 3 indicates that only one large positive oil price shock ($LARGE^{+}$) in 1990Q3 occurred during the sample period. In particular, the crude oil price jumped from $15.05 per barrel in 1990Q2 to $35.03 per barrel in 1990Q3, and this could be related to the invasion of Kuwait by Iraq. However, the sample period actually experienced multiple large negative oil price shocks ($LARGE^{-}$), namely those of 1986Q1, 2008Q4, and 2014Q4. In 1986, there was an oil supply shock that caused prices to sharply decrease from $26.68 in 1985Q4 to $13.85 in 1986Q1. In 2008, the sharp decrease from $99.06 in 2008Q3 to $41.25 in 2008Q4 was due to the financial crisis. Then, in mid-2014, oil supply shocks were in particular due to an increase in U.S. shale oil production and changes in OPEC policies, with prices declining over 2014 from $111.86 in 2014Q2 to $62.16 in 2014Q4.

3.1. Impulse Response Analysis

Figure 9 shows the response of real GDP growth to impulses in the form of large oil price shocks. Both $LARGE^{-}$and *LARGE** have statistically significant positive impacts on real GDP growth. However, the response of real GDP growth to *LARGE** shocks can be considered to be greater in terms of the duration of significant impacts when compared to $LARGE^{-}$ shocks. It is worth noting

Figure 9: Response of real GDP growth to *LARGE*⁻, *LARGE*⁺, and *LARGE** oil shocks



again here that the economy of Saudi Arabia depends heavily on oil, and the oil sector accounts for a large share of its GDP. As a result, most Saudi export earnings come from oil exports, and these dominate over any non-oil exports. For instance, oil exports in 2008 increased by about 37%, while non-oil exports increased by only about 16%.

As seen from our impulse response analysis, the Saudi economy gains from both $LARGE^-$ and $LARGE^*$ shocks, since both types have statistically significant positive impacts on real GDP growth. This result supports the hypothesis that large negative oil shocks may trigger the global demand of oil to increase, which increases oil exports and leads to a positive impact on Saudi GDP.

Oil importing countries on the other hand may receive an advantage from large negative oil shocks, as these can allow them to increase their oil reserves. For instance, U.S. oil reserves increased from 22,311 billion barrels in 2007 to 22,812 billion barrels in 2008, and from 33,403 billion barrels in 2013 to 36,520 billion barrels in 2014[3]. In fact, during the time when $LARGE^-$ shocks occurred, net exports from Saudi Arabia increased at a decreasing rate, whilst they increased at an increasing rate when $LARGE^+$ shocks occurred. In addition, during large negative oil shocks ($LARGE^-$), real GDP growth increased by 8.7% and by 1.1% (in 1986Q1 and 2014Q4, respectively), while it decreased in 2008Q4 by 0.61%.

In contrast, the impulse analysis indicates that a shock in $LARGE^+$ leads to a positive effect on real GDP, but one that is clearly insignificant. This result could be attributed to the reduced amount of oil price information obtained by the $LARGE^+$ dataset compared to $LARGE^-$ and $LARGE^*$. In fact, there is only one large positive oil price shock in the whole sample period, which occurred in 1990Q3.

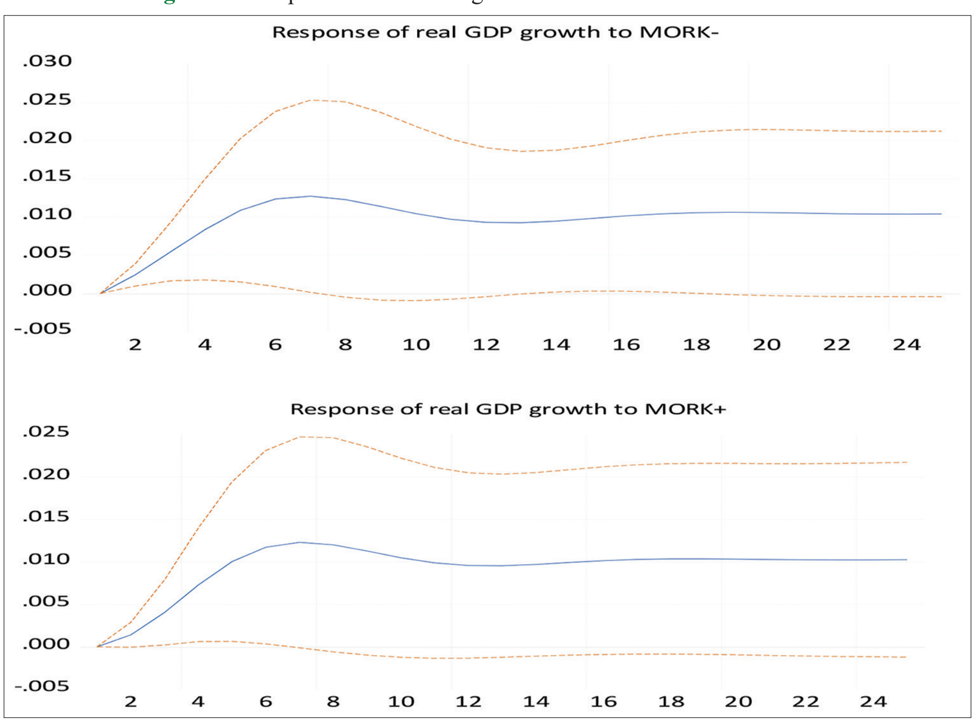
Figure 10 shows that the response of real GDP growth to $NORMAL^+$ shocks is relatively weak compared to $NORMAL^-$ and $NORMAL^*$. Moreover, all the normal oil prices ($NORMAL^+$, $NORMAL^-$, $NORMAL^*$) lead to positive but insignificant effects on real GDP growth. These results indicate that only large oil shocks ($LARGE^-$, $LARGE^*$) have a statistically significant positive impact on real GDP growth, which is consistent with the results obtained by Gronwald (2008).

Figure 11 shows that the responses of real GDP growth to both $MORK^+$ and $MORK^-$ shocks are positive and statistically

3 https://www.worldometers.info/oil/us-oil/#oil-reserves

Figure 10: Response of real GDP growth to *NORMAL*⁻, *NORMAL*⁺, and *NORMAL** oil shocks

Figure 11: Response of real GDP growth to *MORK*⁻and *MORK*⁺ shocks



significant. However, the impulse response shows that the response of real GDP growth to a shock in $MORK^{-}$ is stronger compared to in $MORK^{+}$ when it comes to the duration of significant impacts. By comparing the responses of real GDP growth to $LARGE^{+}$ and $MORK^{+}$ shocks, we found that real GDP growth responds positively to both, but $LARGE^{+}$ shocks only lead to insignificant impacts for all lags under consideration. This could be due to the reduced amount of oil price information contained in the $LARGE^{+}$ variable compared to in $MORK^{+}$. For instance, $LARGE^{+}$ contains only a single positive large oil shock (occurring in 1990Q3), while $MORK^{+}$ contains all positive shocks and does not differentiate between large and small shocks.

When it comes to the responses of real GDP growth to both $LARGE^{-}$ and $MORK^{-}$ shocks, we see that they are consistent with each other. However, the response of real GDP growth can be considered stronger for an impulse in a $MORK^{-}$ shock in terms of the duration of significant impacts. This could again be attributed to a reduced amount of oil price information in the $LARGE^{-}$ set compared to $MORK^{-}$, since $LARGE^{-}$ only contains three large negative oil shocks (those occurring in 1986Q1, 2008Q4, and 2014Q4).

The impulse response analysis provides interesting results regarding the response of real GDP growth in Saudi Arabia to various types of oil shocks. This analysis may contradict the traditional hypothesis, which states that oil exporting countries are negatively affected by negative oil shocks. In fact, Saudi Arabia gains from both negative and positive oil shocks through net exports. When there is a large negative oil shock, oil importing countries may be attracted by this shock and increase their demand for oil. As a result, Saudi Arabia's net exports will increase—albeit at a decreasing rate—since oil exports dominate non-oil exports and the oil sector accounts for a large portion of GDP. Moreover, when there is a large positive oil shock, government spending in Saudi Arabia may increase due to high oil revenues gained from such shocks, and this can positively affect GDP growth.

3.2. Variance Decomposition Analysis

Table 1 presents forecast error variance decompositions for four periods. Our analysis of the variance decomposition of real GDP growth confirms the results of the impulse responses. Both $LARGE^{-}$ and $LARGE^{*}$ explain a higher portion of the variance in real GDP growth when compared to $LARGE^{+}$. A shock in $LARGE^{-}$ can explain about a 4.5% fluctuation in real GDP growth, while a shock in $LARGE^{*}$ can explain about 7.25%. However, the portion of variance explained by a shock in $LARGE^{+}$ should be considered small, since it can only cause about a 2.72% variation in real GDP growth.

Shocks in $NORMAL^{-}$, $NORMAL^{+}$, and $NORMAL^{*}$ explain only a small portion of variance in real GDP (2.69%, 0.04%, and 1.54%, respectively). Moreover, shocks in $MORK^{-}$ and $MORK^{+}$ lead to a relatively larger portion of variance in real GDP compared to the other oil shocks. For instance, a shock in $MORK^{-}$ can account for about a 7.82% variation in real GDP growth, while this is only about 6.53% for $MORK^{+}$. This analysis of the variance decomposition of real GDP is consistent with the impulse response analysis, in which the strongest effect on real GDP growth was obtained from $LARGE^{*}$, $MORK^{-}$.

Table 1: Variance decomposition of real GDP growth

Period	GDP	$LARGE^{-}$
4	97.6516	2.3484
8	95.9109	4.0891
12	95.5246	4.4754
16	95.4996	4.5007
	GDP	$LARGE^{+}$
4	99.0246	0.9754
8	97.5962	2.4039
12	97.2969	2.7031
16	97.2734	2.7266
	GDP	$LARGE^{*}$
4	96.8078	3.1922
8	93.5940	6.4060
12	92.8251	7.1750
16	92.7404	7.2596
	GDP	$NORMAL^{-}$
4	98.9909	1.0091
8	97.8768	2.1232
12	97.4044	2.5956
16	97.3069	2.6931
	GDP	$NORMAL^{+}$
4	99.9933	0.0067
8	99.9687	0.0313
12	99.9581	0.0419
16	99.9572	0.0428
	GDP	$NORMAL^{*}$
4	99.3876	0.6124
8	98.7099	1.2900
12	98.4830	1.5170
16	98.4547	1.5428
	GDP	$MORK^{-}$
4	96.7309	3.2691
8	93.3241	6.6759
12	92.2790	7.7211
16	92.1777	7.8223
	GDP	$MORK^{+}$
4	97.9031	2.0970
8	94.5013	5.4987
12	93.6033	6.3967
16	93.4611	6.5389

4. CONCLUSION

The purpose of this paper has been to investigate empirically the impact of large oil shocks on real GDP growth in Saudi Arabia to large oil shocks using quarterly data from 1981Q1 to 2019Q4. We provided evidence that only $LARGE^{-}$ and $LARGE^{*}$ shocks have statistically significant positive impacts on real GDP growth. This result can be attributed to an increase in net exports during negative oil shocks. In fact, Saudi Arabia did indeed experience increases in net exports during negative oil shocks (although at a decreasing rate), which may be reflected as a positive response in real GDP growth.

The analysis of both impulse response and variance decomposition provided the insight that large negative oil shocks have a greater influence on economic growth in Saudi Arabia than large positive oil shocks. This should assist policymakers in Saudi Arabia in formulating their fiscal policy in such a way as to capture the benefits of large negative oil shocks in order to increase economic growth.

This paper can also be considered as the basis for future research into the effects of oil shocks on the economies of oil exporting countries, since it takes into consideration the impacts on economic growth of both (1) large oil shocks with no differentiation between negative and positive shocks, and (2) large negative and positive shocks as separated variables. This is in contrast with most of the previously published work, which has so far only focused on oil importing countries and large positive oil shocks.

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