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The Effects of Asymmetric Oil Price Shocks on Saudi Arabian Macroeconomic Variables

Abdulaziz Hamad Algaeed, Ph.D.
Department of Economics. Imam Mohamed bin Saud Islamic University.
P.O.Box 87752, Riyadh 11652, Saudi Arabia

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Abstract
This paper focuses on analyzing the impact of oil price shocks (OILP) over some macroeconomic variables, non-oil GDP (NOIL), government expenditure (GOEX), and the capital formation (KFORM), in the Saudi economy covering the period of 1985-2015. Both symmetric and asymmetric oil price shocks are considered, using unrestricted VAR methodology. The empirical findings support long-run relationships among the macroeconomic variables. A linear oil price shocks indicate a positive influence on the macroeconomic variables. The effect ranged between 21-30 percent. On the other hand, non-linear positive oil price shock counted for about 3.8-6 percent, whereas a non-linear negative oil shocks affected the macro variables by 33-40 percent. Moreover, the symmetric oil price shocks are consistent with pairwise Granger causality test where the direction of causality is running from the oil price changes to non-oil GDP, government expenditure, and capital formation. Furthermore, asymmetric negative shocks have stronger and long lasting effects in comparison with asymmetric positive oil price shocks or with the symmetric oil price shocks. Saudi Arabia experienced years of surpluses, and now running deficits. The volatility of oil prices in the international market and thereby revenues compels the government to do more to stabilize revenues through diversification of production base.
Keywords: Oil Prices, Saudi Arabia, Co-integration Analysis, Economic Growth, Impulse Response.

1.Introduction

Oil as energy, plays a major role in the global economy. Despite the ups and downs in its prices, still under considerable attention especially its future earnings and prices. Although efforts put forward to find alternative substitutes, it remains the main factor stimulating the world economic growth. Much of the literature after 1973/74 oil shock was directed towards the impact of such a shock on the oil importing countries, little has been focused on the effects of the oil shocks on the oil exporting countries. These countries are characterized by a limited home production base. Hence, there is a close relationship between the overall fiscal and balance of payments developments with the government oil revenues are the main sources for foreign exchange (Morgan, 1979). Furthermore, an increase in domestic income due to accumulation of revenues, will be reflected on the increase in imports. The unbalance between revenues and expenditures motivated researchers to assert the need that expenditures to be covered by permanent revenues (Tanzi, 1986 and Mansfield, 1979). This suggests a stabilizing fiscal policy should be countercyclical running surpluses in good export years and deficits in the bad export years. However, price of a barrel has risen from \$26 in 2002 to \$107 in 2012. Since that, the price of a barrel declined drastically reaching a minimum of about \$19 in the middle of march 2016. The price climbing trip is settled at a swinging price between \$48-\$50 nowadays.

The oil producing countries has been cynically characterized as, with oil sufficient to create problems, but not enough to solve them (Gelb and Auty, 1986). The fluctuations in oil prices deemed to be beneficial for some countries, whereas considered a curse for others. Some scholars assert the positive relationship between the oil price hike and inflation (Lacheheb and Siraj, 2016). Different consequences may rise depending on the economic structure of each country. Thus, understanding the empirical relationship between oil price and other relevant variables is an important as monetary authority keeps theses variables under control (Lacheheb and Siraj, 2016). The theory has been concentrated on the impact of oil fluctuations and forwarded its search for the positive correlation between oil prices and inflation, amongst them Lacheheb and Siraj, (2016); Tatom (1981), Khan and Hampton (1983); and others. The effect of oil price increase or decrease to inflation rate is warranted. Firms resort to cut down on production to avoid the rise in oil prices. On the other hand, the production cost falls as a result of price reduction which may not reflected on the price of goods and services.

Several studies directed their emphasis on the argument that, if economic growth is not affected by oil price shocks, then policies that countering price changes are not necessary (Sharri, *et al*. 2013). Thus, these studies did not concentrate on specific sector of the economy for policy formulation.

Over a long period of time, oil price fluctuated sharply. The sharp decline in oil price in 2009 affected the total earnings of the oil producing counties. However, sharp increases in the price of oil are considered major contributors to the business cycles (Thankgod and Maxwell, 2013). Skepticism of the role of oil in causing recession after the price shocks has led scholars to distinguish between an oil price shocks and a monetary policy shocks, especially in early 70s, 80s, and the 90s, where the price of oil has driven up. Furthermore, restrictive monetary policy is needed to counter rising inflationary pressure, while efforts to offset real economic effects, that put pressure to accommodate appropriate policy. Therefore, monetary policy could influence oil price which in turn influences the growth of the economy. The fact is that, oil prices are driven by demand which harden the distinguish between monetary policy response to oil shock and the rise in inflation.

On the other hand, it is easy to detect the historical path of oil price fluctuations. In 1973, the OPEC oil embargo on some of western countries led to a rise in the price of the crude to about 260 percent, taking world economy into a step of recession. Moreover, in 1978, the Iranian revolution which caused a significant price hike from \$13 to about \$35 per barrel, and continued to rise during the 80s during the Iranian Iraqi hostile. In 1997, Asian financial crisis caused a drop in the price of the oil to about \$12 in 1998. Furthermore, in 2008 the oil price climbed till it reached \$115, and during this time the world hit by another crisis that is, world financial crisis which caused the price of the crude oil to drop as fast as ever before to \$44 per a barrel. However, in 2012 the prices recovered and reached \$112 a barrel, and then external factors influenced the price of oil causing it to go down, such as weak economic growth worldwide. The decline of the price got worse in 2014 due to the shale oil and stronger dollar. Boheman and Maxen (2015), summarized several factors influencing the oil price fluctuations. First the overall world production and its relationship with the oil market forces, that's supply and demand. Secondly, the production of OPEC affects the world supply where OPEC is responsible for 43 percent of the world's supply in the year 2014. Thirdly, in addition, the global economic growth has a direct impact on the demand of oil and in turn on the price. Nevertheless, there are some factors indirectly affect the world oil market, such as dollar exchange rate fluctuations and the geopolitical turbulences.

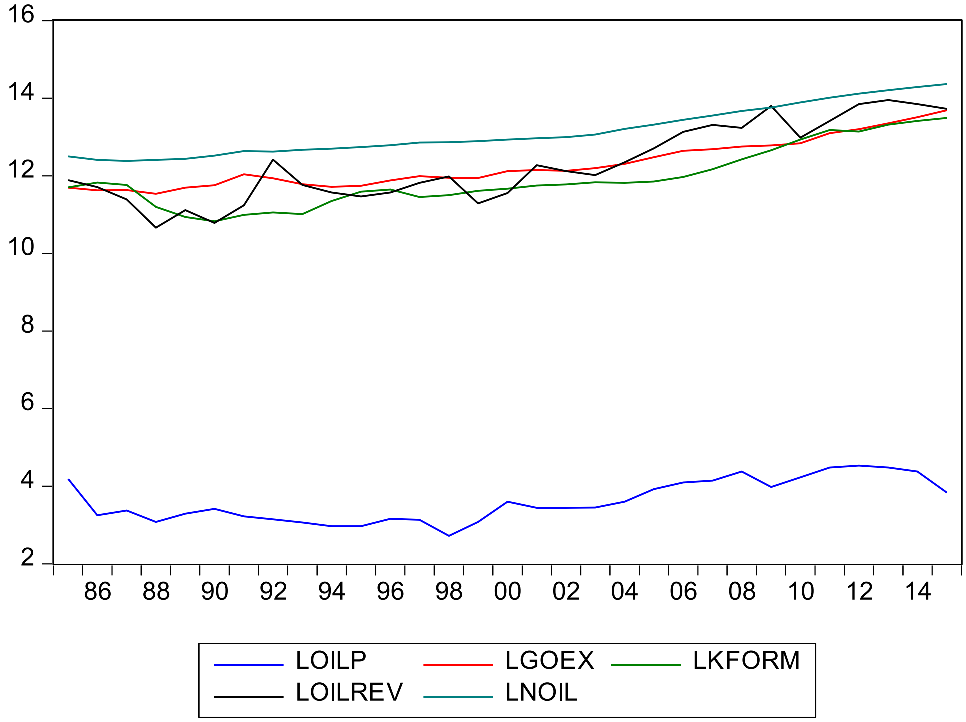

Figure 1. Real oil price (OPEC basket), real capital formation, real non-oil GDP, Real government expenditure, and real oil revenue in log.

The above figure 1, explains well the oil revenues and their dominance in the Saudi economy. The main point here is that, the fluctuations in the oil prices reflected upon the oil revenues and hence on the rest of macroeconomic variables.

The scope of this paper is different than other studies done on Saudi Arabia in two folds. First, the methodology, where the concentration is on the effects of oil price shocks namely, symmetric and asymmetric shocks. Secondly, the use of non-oil GDP variable rather than total GDP. In the literature GDP is defined to include the production of crude oil which is definitely influenced by oil prices fluctuations. The price of oil is determined outside the country and there is a need to see the effects of domestic policies on the non-oil traded and service sectors. Hence, non-oil reflects the power of the diversification of the local economy.

Although this paper does not consider the data from 1970s, it employed 1980's data. However, the use of data regarding fluctuations of oil prices in the 1980s is warranted. According to Gounder and Bartleet (2007), numerous researchers suggest that, the factor of cost share of the oil is low to cause a reduction in the US output growth after 1973/74 oil price shock. It could be attributed to the co-incidence due to the end of pegged exchange rate, which caused a major reduction in the US money supply. Thus, choosing the data covering 1985-2015 tends to be applicable and accepted.

This paper is sought to investigate and test empirically, using the unrestricted VAR approach, the effects of symmetric and asymmetric oil prices shocks on some of macroeconomic variables, real government expenditure, real non-oil GDP growth, and real capital formation (investment). The aim is to identify the channels through which the oil price shocks transmitted into the economy, and conclude whether the economic growth, government expenditure, and capital formation are sensitive to asymmetric oil price shocks in a major member of OPEC. The choice of non-oil GDP variable is warranted as I mentioned earlier. However, the decision to use government expenditure is to reflect the role of government in affecting the economic growth. Capital formation is the key player for investment activities.

The organization of this paper is as follows. Section 1 an introduction. Section 2 reviews the theoretical and empirical literature. Section 3 develops the theoretical model, estimation and discussion of the results, and section 4 presents a summary of the results and their implications.

2. The Review of Literature and Empirical Studies

Oil price variations and their implications on the macro level of the economy, has encouraged scholars everywhere to indulge in studying the detrimental effects of oil price fluctuations on the economy as whole. However, different models employed to examine the positive and negative impacts of an oil price shock over a certain economy.

Hamilton, (1983), explained in his distinguished article, that the average growth rate of the US GDP for the period of 1960-1972 is 4 percent. However, this growth rate is declined to about 2.4 percent due to the rise in the oil price in the 1973/74, whereas inflation rate has risen from 3.1 percent to about 6.7 percent. In addition, unemployment rate reached the highest of 6.7 percent. All of this happened during the first oil price shock. Utilizing Granger causality model involving six variables, he concluded that the increase in price of oil caused the US recession.

Rodriguez, and Sanchez (2004), analyzed the consequences of oil price shocks on industrialized countries' activities. They employed VAR methodology based on linear and non-linear approaches. The non-linear model contains three approaches. Asymmetric, scaled and net oil price shocks. They found evidence of a symmetric effect of oil price shock on the real GDP. The rise in oil prices had a significant impact on the growth of GDP. They found also a negative impact on all activities except in Japan. Thus, oil shocks affected negatively GDP growth in England and positively the Norwegian economy.

Gounder and Baetleet (2007), aimed of their work to test the effects of world price of crude oil on New Zealand economic growth over the period of 1989-2006. Several hypotheses related to the relation between oil price and growth are examined using VAR approach. They considered three oil price measures. The models that used are linear oil price and two non-linear oil price transformations to examine different effects. The WALD and Likelihood ratio tests of Granger causality are employed. They concluded that linear price change, the asymmetric price change, and the net price variables were significant. The asymmetric price decrease was not significant.

Olusegun, (2008), investigated the effect of oil shocks over macroeconomic variables in the Nigerian economy. The period covered is from 1970-2005. He used VAR approach and forecast error variance decomposition in estimating seven variables. Nevertheless, results of the oil price shock do not have a substantial effect on the supply of money, level of price and the governmental expenditure. However, the variability in price level is best explained by money supply shock and output.

Sharri, et al. (2012), tested empirically the effects of oil price shocks on inflation in Malaysia over the period of 2005-2011, using monthly data. VAR and VECM and Granger causality models were applied. They concluded that oil price shock affects inflation. The exchange rate does not Granger cause to inflation nor to exchange rate. They recommended that government should control oil price to avoid inflation.

Arora, et al. (2013), studied the consequences of endogenous oil price shocks with quantities during business cycles and the crude oil dynamics. They showed that a model with endogenous crude oil is better to explain business cycles than with exogenous price of oil or oil quantities. Also, a model that employs real oil price as exogenous can't comprehend the interaction between price of oil and macroeconomic variables to oil price shocks. Thus, responses of oil shocks depend largely upon how oil constructed.

Hafiz, et al. (2013), aimed to test for the effects of oil price shocks on economic sectors in Malaysia. Data are not stationary in all levels, but stationary in the first difference. The co-integration model was applied. The results indicated that one co-integration equation exists suggesting the long-term effects of oil prices on agriculture, construction, manufacturing, and transportation sectors. At last, Granger causality test was performed. Their findings implied that in Malaysia, oil price shocks can affect agriculture sector, contrary to the result founded by Alper and Torul (2000).

Taghizadeh, *et al.* (2013), examined the effects of oil price shocks on oil producing and consuming countries. They used simultaneous equation for different countries with trade partnership relations. They found that oil producing countries, Iran and Russia, are positively affected with oil price shocks. Also, they benefit through trade partners too. However, for oil consuming countries, the results are diverse. For example, Japan, Switzerland, and Turkey, they benefit from oil price shocks directly and indirectly.

Thankgod, and Maxwell (2013), used structural co-integrated VAR model for Nigeria for the period 1970-2010. This study concentrated on the direct impact of oil price shocks on the macro economy, and the reaction of monetary variables to an extended shock. Their findings showed that there exist long-run relationships involving oil price, CPI, rate of treasury bill, exchange rate, the rate of interest, and the supply of money in Nigeria. Unexpected oil price shock causes inflation and decline in exchange rate.

Olukorede (2014), extends the literature on the consequences of oil price shocks using the United States, Norway, and South African data from 1980-2010. SVAR and panel VAR are employed. He found that the USA and Norway stick to non-linear oil price shocks specifications. These specifications are not plausible for emerging net oil importing countries. However, the SVAR restrictions limit the shocks effects. Panel VAR methodology is easy to accommodate all oil price shocks specifications. He concluded that there is evidence of unsatisfactory effects during negative oil price shocks.

Alley, I. et al. (2014), applied the general methods of moment (GMM) in examining the consequences of oil price shocks in Nigeria for the period of 1981 to 2012. The main findings are that, oil price shocks insignificantly hinder economic growth. However, oil price is significantly improved it. The positive and significant impact of oil price on economic growth confirms that the rise in oil price is beneficial to oil-exporting countries like Nigeria. Nevertheless, Shocks create uncertainty and affect the effectiveness of fiscal policy.

Boheman, and Maxen (2015), analyzed the effects of oil price shocks on economic growth in oil exporting countries versus non-oil exporting countries. They used data from 1980-2008, for eleven OPEC countries and eight non-OPEC countries. The VAR is being used to investigate the response of each group's combined economic growth to oil price shocks. They concluded that a 1 percent increase in the change of oil price, will increase the GDP growth rate the following year with 0.145 percent for OPEC countries and 0.141 percent for non-OPEC countries.

Kose, and Baimaganbetov, (2015), assessed empirically the asymmetric impacts of real oil price shocks on the macro variables, the industrial production, exchange rate, and inflation in Kazakhstan for the monthly period of 2000-2013, using SVAR model. The main findings showed that the negative oil price shocks had a major effect on the performance of Kazakhstan economy.

Lacheheb, and Siraj (2016), examined the relationship between oil price changes and inflation in Algeria for the period 1970-2014. They intended to capture asymmetric relationship between oil price and inflation by using nonlinear ARDL. Their findings revealed the existence of nonlinear effect of oil price on inflation rate. Whereas, a significant relationship between oil price reduction and inflation was absent.

Kamel, et al. (2016), investigated the impact of oil prices on macroeconomic fundamentals as well as monetary policy and stock market for eight oil-exporting and non-oil exporting countries in the middle east and north African countries, Saudi Arabia, Egypt, Kuwait, Iran, Morocco, Algeria, Tunisia, and Turkey. Using quarterly data from 1994Q4-2015Q2 with a panel ARDL. They concluded that there is short run dynamic cross section relationship between growth rate and consumer price index, oil prices, money market rate and market capitalization. In the long run, the dependent variables such as CPI and stock market exhibited a co-integration relationship with oil prices.

Brini, et al. (2016), attempted to analyze the effects of oil price shocks on inflation and exchange rate in six of the importing MENA countries, from the period of January 2000- July 2015. They employed structural VAR model. The impulse response function indicated that the long-run relationship between oil price and exchange rate is significant. However, the impact of oil price on inflation is negligible. The variance decomposition results do not support the existence of such effect in Iran and Algeria.

Algahtani, (2016), attempted to analyze the effects of oil price shocks on the Saudi economic activity covering the period from 1970-2015. The period has chosen to reflect the years of ups and downs of the oil prices. VAR and VECM were applied. To test for short and long-run relationships between the variables. He deduced that there exists positive long-run correlation between oil price and GDP.

Nwogwugwu, et al. (2016), aimed at investigating the symmetric and asymmetric effects of oil price shocks on macro variables in Nigeria. The exponential EGARCH model was used to estimate the changes of oil price, while the VAR was used to predict the dynamic structural relationships between oil price fluctuations and macroeconomic variables. Their findings suggest that volatility in all macro models selected except interest rate which takes long time to diminish. The symmetry of oil shocks significantly influences exchange rate, output, unemployment rate, and government spending. The asymmetric positive and negative oil price shocks influence exchange rate.

3. The Model, Estimation, and Discussions

Following the standard literature, the asymmetric price specification which proposed by Mork (1989) in Ebele, and Iorember, (2015), Kose, and Baimaganbetov, (2015) discusses the positive and the negative oil price shocks. In accordance, the asymmetric oil price shock is specified as follows:

$$OP_t^+ = \begin{cases} OPt, & if\ OPt > 0 \\ 0 & otherwise \end{cases} \quad (1a)$$

$$OP_t^- = \begin{cases} OPt, & if\ OPt < 0 \\ 0 & otherwise \end{cases} \quad (1b)$$

Where: OP_t is the percentage change in real oil price.

Due to the volatility of price of oil over a long time of stability, Lee, *et al.* (1995), in Kose, and Baimaganbetov (2015) proposed AR (4) generalized AR conditional heteroscedasticity, GARCH (1,1) to capture the effect of price of oil, such that:

$$OP_t = \delta_0 + \delta_1 OP_{t-1} + \delta_1 OP_{t-2} + \delta_1 OP_{t-3} + \delta_1 OP_{t-4} + e_t \quad (2)$$

e_t / I_{t-1} □ N $(0, h_t)$

$h_t = \lambda_0 + \lambda_1 e^2_{t-1} + \lambda_2 h_{t-1}$

$SOPI_t = \max\left(0, \hat{e}t / \sqrt{\hat{h}t}\right)$

$SOPD_t = \min\left(0, \hat{e}t / \sqrt{\hat{h}t}\right)$

Where: SOPI represents the scaled oil price increase, and SOPD is scaled price decrease.

Furthermore, Hamilton (1996) in Olukorede (2014), suggested net price increase, NOPI. This measurement defined as a value of oil price in quarter t, p_t, that exceeds the highest value over the last four quarters. So, an increase in oil price may be a result of price correction to earlier levels, which may not affect the economy as a whole. NOPI is constructed as:

$NOPI_t = (0, \max(OP_t - (OP_{t-1}, OP_{t-2}, OP_{t-3}, OP_{t-4}))$

Looking at recent studies on the dynamics of oil price shocks, one note that vector auto regression methodology (VAR) is overwhelmed. The usage of VAR has an advantage, because it does not require arbitrary restrictions of the structured models, which is inappropriate (Gounder and Baetleet, 2007). Moreover, all variables in VAR are considered endogenous. In a multivariate model, a change in a variable will influence its own lags, in addition to the other variables. So, the lag length is of importance, and will be determined later through the criterion known in the literature. The ordering of the variables is vital to the model. In this study, the positive, negative, and symmetric changes of oil prices placed first. The rationale behind this is that, a potential impulse of the variable to the system affects the variables in the right direction, Boheman and Maxen (2015). The asymmetric oil price will be the most potential striking factor where it's impact will be transmitted to other variables. Hence, asymmetric oil price change is ordered first, then after that the rest of the variables. As in the literature, the VAR system can be written as:

$$y_t = c + = \sum_{i=1}^{p} \Phi iyi - t + \mathcal{E}t \quad (3)$$

Where:

Yt: (nx1) endogenous variables.

C: $(c_1, \ldots, c_n)$ is (nx1) intercept vector of VAR.

Φ_i: is the i^{th} (6x6) matrix of (nx1) vector of autoregressive for i= 1, 2, …, p.

$\mathcal{E}_t$: is (6x1) generalization of white noise.

Since this paper uses six endogenous variables in the system, oil price shocks (symmetric and asymmetric), real non-oil GDP, real capital formation, and real government expenditure. The unrestricted VAR model is written as:

$$\begin{bmatrix} Oilp+ \\ Oilp- \\ Oilp \\ Noil \\ GOEX \\ kform \end{bmatrix} \begin{bmatrix} c1 \\ c2 \\ c3 \\ c4 \\ c5 \\ c6 \end{bmatrix} + \Phi(1) \begin{bmatrix} Oip+t-1 \\ Oilp-t-1 \\ Oilp\ t-1 \\ Noilt-1 \\ Goext-1 \\ Kformt-1 \end{bmatrix} \begin{bmatrix} \mathcal{E}1t \\ \mathcal{E}2t \\ \mathcal{E}3t \\ \mathcal{E}4t \\ \mathcal{E}5t \\ \mathcal{E}6t \end{bmatrix} \quad (4)$$

Where: Φ (1) is the lag polynomial operators, the error vectors are assumed to have zero mean, contemporaneously correlated, but not auto correlated. By introducing the moving average, the goal is to capture the system's response to the oil price shock. Hence, the presence of the moving average is to enable us to get the forecast error variance decomposition and impulse response function.

$$y_t = \mu + \sum_{i=0}^{\infty} \psi i\ \mathcal{E}t - i \quad (5a)$$

With ψ_0 is the identity matrix and μ is mean of process:

$$\mu = (I_p - \sum_{i=0}^{\infty} A)^{-1} c \quad (5b)$$

Finally, in order to analyze the effects of oil price shocks on some of the macroeconomic variables in the Saudi economy, three levels of unrestricted VAR are tested. The VAR models are prepared in the estimated following orders:
Symmetric oil price shock, includes (OILP, NOIL, GOEX, KFORM).
Asymmetric oil price shock includes ($OILP^+$, NOIL, GOEX, KFORM), and ($OILP^-$, NOIL, GOEX, KFORM).

3.1 The Unit Root Test

One of the characteristics of the time series is stationarity. Dickey-Fuller test (DF) adds lags of the first difference. However, three regression models incorporate intercept and trend, intercept, and none are used in this paper to test for unit root. Two extensively used unit root test, namely Augmented Dickey Fuller (ADF) and Phillips-Peron (PP) tests are employed to examine the stationarity of the time series. In the literature, ADF test is performed using the following equation:

$$\Delta Y_t = \psi + \Phi T + \gamma \Delta Yt - 1 + \zeta i \sum_{i=1}^{n} \Delta Yt - i + et \quad (6)$$

where, ψ is a constant, Φ is the coefficient of time trend T, γ and ζ are the parameters where, $\gamma = \rho - 1$, ΔY is the first difference of Y series, n is the number of lagged first differenced term, and e_t is the error term. The Phillips and Perron test is performed using the following equation:

$$\Delta Y_t = \varphi + \pi T + \delta \, \Delta Y_{t-1} + e_t \quad (7)$$

where, φ is a constant, π is the coefficient of time trend T, δ is the parameter and e_t is the error term. To achieve this task, Augmented Dickey-Fuller (1987), (ADF), and Phillips and Perron (PP) (1990) tests are applied. Results for these tests are similar and close to each other, and thus, reported in table 1. Both tests showed that variables are stationary at the difference in the ADF and PP tests. Some of the variables, such as non-oil GDP, in addition to some others, are not stationary at level I(0). Moreover, all variables are stationary at difference I(1) and significant at 1 and 5 percent level. However, to obtain short and long-run analyses, it is of interest to have all relevant variables in the same order, I(1). The results obtained of the tests are in table 1, and meet this condition.

Table 1**.** Augmented Dickey-Fuller and Phillips-Perron tests.

	Augmented-Dickey Fuller (ADF)						Phillips Prron(PP)					
	LEVEL			1st DIFFERENCE			LEVEL			1st DIFFERENCE		
series	Intercept	T&I	None	Intercept	T&I	None	Inter.	T&I	None	Intercept	T&I	None
$OILP^+$	**4.34***	**4.23****	**3.14***	**6.00***	**5.97***	**6.13***	**4.23***	**4.08***	**3.15***	**12.58***	**12.80***	**13.02***
$OILP^-$	**8.01***	**7.37***	**6.45***	**10.16***	**10.37***	**10.44***	**9.19***	**8.05***	**6.26***	**13.54***	**15.51***	**13.98***
OILP	**1.67**	**3.98****	**0.46**	**6.49***	**6.08***	**6.58***	**1.74**	**3.96****	**0.45**	**6.76***	**6.26***	**6.72***
NOIL	**1.99**	**0.72**	**1.45**	**2.12**	**4.88***	**1.67*****	**4.09***	**5.29***	**0.16**	**26.99***	**27.12***	**19.65***
GOEX	**2.07**	**5.42***	**1.47**	**4.16***	**5.24***	**9.26***	**4.25***	**5.42***	**0.12**	**27.62***	**29.19***	**19.83***
KFORM	**3.53****	**4.61***	**0.10**	**8.72***	**8.59***	**8.87***	**3.61****	**4.59***	**0.03**	**15.49***	**19.67***	**14.45***

Note: (*), (**), and (***) are statistically significant at 1, 5, and 10 percent. T&I trend and intercept.

3.2 Johansen Co-integration Test Result

Having the order of integration of time series is set, the following step is to test for the long-run equilibrium relationships among the variables. The importance of long-run equilibrium and stationarity is to eliminate the presence of spurious regression. It is worthwhile to note that Johansen's co-integration test requires to choose the lag length. In order to find out the lag length, unrestricted VAR models under consideration are applied, and the lag length is determined by the appropriate methodology. From table 2a, trace statistic test confirms the existence of 3 co-integrated equations at the 5 percent level. The null hypothesis for the trace test is that, there is no co-integration between real oil price shocks OILP, non-oil GDP, NOIL, government expenditure GOEX, and real capital formation (KFORM). So, the null hypothesis of None is rejected, indicating that there is at most three co-integrated equations. Furthermore, Max-eigen test indicates 2 co-integration equations. The null hypothesis of max-eigen test is rejected, which implies that there is at most 2 co-integration between (OILP), non-oil GDP, GOEX, and KFORM. Similarly, table 2b and 2c reveal the existence of at most 1 co-integration test by trace and max-eigen tests, rejecting the null hypotheses that there is at most 1 co-integration between OILPI, oil price increase and oil price decrease OILPD, NOIL, GOEX, and KFORM.
The goal is to depict the long-run association between the macro variables and the oil price shocks. Co-integration equations are normalized on the oil price variable and the rest of the variables. Among different sets of models include symmetric and asymmetric oil price shocks, I have chosen the following equations that fit well, (standard error in parentheses):

$$\boldsymbol{NOIL} = -1.738 \;\; -0.567\, OILPD \;\; -0.414\, GOEX \;\; -0.504\, KFORM \quad (8)$$

$$\underset{(0.141)}{} \quad \underset{(0.142)}{} \quad \underset{(0.062)}{} \quad \underset{(0.051)}{}$$

$$\boldsymbol{GOEX} = \underset{(0.535)}{3.844} + \underset{(0.379)}{0.125}\,OILPI \;\underset{(0.197)}{-20320}\,NOIL \;+\underset{(0.168)}{1.1381}\,KFORM \tag{9}$$

$$\boldsymbol{KFORM} = \underset{(0.378)}{3.377} + \underset{(0.329)}{0.109}\,OILPI + \underset{(0.440)}{0.879}\,GOEX - \underset{(0.426)}{2.039}\,NOIL \tag{10}$$

Given the co-integration results (equations 8-10), the long-run relationships between the oil price shock and the macro variables exist. With non-oil GDP as a dependent variable, the long-run relationship indicates that asymmetric oil price shock by 10 percent causes a decline in non-oil GDP by 6 percent. Furthermore, a rise in oil price by 10 percent leads to a rise in government expenditure by 13 percent. Similarly, a rise in oil price by 10 percent will cause a rise in capital formation by 11 percent. This conclusion is warranted as long as the government receives the rent and in turn distributes it.

Table 2a. Johansen Co-integration test result.
Trace test indicates 3 co-integration, and Max test 2 co-integration equations

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Statistics	Hypothesized No. of CE(s)	Max-Eigen Statistic	0.05 Critical Statistic
None*	111.139	47.856	None*	71.109	27.584
At most 1*	40.020	29.797	At most1*	23.927	21.132
At most 2*	16.103	15.495	At most2	14.055	14.264
At most 3	2.047	3.842	At most3	2.0476	3.841

*denotes rejection of the hypothesis at the 0.05 level. **Mackinnon-Haug-Michelis (1999) p- values.

Table 2b. Johansen Co-integration test result.
Trace test indicates 1 co-integration, and Max test 1 co-integration equations

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Statistics	Hypothesized No. of CE(s)	Max-Eigen Statistic	0.05 Critical Statistic
None*	79.733	47.856	None*	50.148	27.584
At most 1	29.585	29.797	At most1	18.871	21.132
At most 2	10.715	15.495	At most2	9.303	14.264
At most 3	1.412	3.841	At most3	1.412	3.841

*denotes rejection of the hypothesis at the 0.05 level. **Mackinnon-Haug-Michelis (1999) p- values.

Table 2c. Johansen Co-integration test results
Trace test indicates 1 co-integration, and Max test 1 co-integration equations

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Statistics	Hypothesized No. of CE(s)	Max-Eigen Statistic	0.05 Critical Statistic
None*	108.281	47.856	None*	78.533	27.584
At most 1	29.748	29.797	At most1	16.465	21.132
At most 2	13.283	15.495	At most2	12.497	14.264
At most 3	0.787	3.841	At most3	0.787	3.841

*denotes rejection of the hypothesis at the 0.05 level. **Mackinnon-Haug-Michelis (1999) p- values.

VECM analysis is performed, but not reported. The error correction term (ECT) is (-3.146) and significant at 10 percent level. This indicates that the adjustment process to equilibrium is at a speed of 314 percent a year. We estimate the error correction model to be able to determine the dynamic behavior of the real oil price shocks with non-oil GDP, real government expenditure, and real capital formation. The error correction term, however, shows the speed of adjustment towards equilibrium. Furthermore, Since the coefficient is negative and significant at 10 percent level, we assure the existence of long-run stable relation between real oil price, real government expenditure, real capital formation and the real non-oil GDP. This suggests that the system corrects its previous period's disequilibrium at the speed alluded to.

3.3 The Granger Causality Test Result

To demonstrate the causality link between oil price shocks and the macroeconomic variables, Granger pairwise causality test is implemented. It is worthwhile to mention that unrestricted VAR optimal lag length is applied. To determine the lag length, FPT, AIC, SC, and HQ criterion is implemented. According to this criterion lag of 4 periods is advised. According to the lag criterion, the causality test is run with four lags. The merit of Granger causality test is that, this approach evaluates whether past information on one variable helps in prediction of other variables' outcomes (Nwogwugwu, et al. 2016).

Table 3. Pairwise Granger Causality Tests with 4 lags Symmetric oil price shock

Null Hypothesis	Obs.	F-Statistic	Prob.
LNOIL does not Granger Cause LOILP	27	1.68386	0.1975
LOILP does not Granger Cause LNOIL		3.41402	0.0303
LGOEX does not Granger Cause LOILP	27	1.75447	0.1821
LOILP does not Granger Cause LGOEX		3.69872	0.0229
LKFORM does not Granger Cause LOILP	27	1.32754	0.2978
LOILP does not Granger Cause LKFORM		3.15273	0.0396
LGOEX does not Granger Cause LNOIL	27	1.05497	0.4070
LNOIL does not Granger Cause LGOEX		0.91928	0.4742
LKFORM does not Granger Cause LNOIL	27	0.70610	0.5981
LNOIL does not Granger Cause LKFORM		1.15685	0.3624
LKFORM does not Granger Cause LGOEX	27	1.06482	0.4025
LGOEX does not Granger Cause LKFORM		1.82036	0.1689

Table 4. Pairwise Granger Causality Tests with 4 lags Asymmetric oil price shock

Null Hypothesis:	Obs	F-Statistic	Prob.
OILPD does not Granger Cause OILPI	26	2.53465	0.0783
OILPI does not Granger Cause OILPD		0.39520	0.8093
LNOIL does not Granger Cause OILPI	26	0.11304	0.9762
OILPI does not Granger Cause LNOIL		0.99654	0.4363
LGOEX does not Granger Cause OILPI	26	0.14294	0.9637
OILPI does not Granger Cause LGOEX		1.11087	0.3836
LKFORM does not Granger Cause OILPI	26	0.08433	0.9861
OILPI does not Granger Cause LKFORM		0.85752	0.5089
LNOIL does not Granger Cause OILPD	26	3.57926	0.0271
OILPD does not Granger Cause LNOIL		2.25463	0.1059
LGOEX does not Granger Cause OILPD	26	3.28280	0.0363
OILPD does not Granger Cause LGOEX		2.13697	0.1205
LKFORM does not Granger Cause OILPD	26	3.42640	0.0315
OILPD does not Granger Cause LKFORM		2.49490	0.0817
LGOEX does not Granger Cause LNOIL	27	1.05497	0.4070
LNOIL does not Granger Cause LGOEX		0.91928	0.4742
LKFORM does not Granger Cause LNOIL	27	0.70610	0.5981
LNOIL does not Granger Cause LKFORM		1.15685	0.3624
LKFORM does not Granger Cause LGOEX	27	1.06482	0.4025
LGOEX does not Granger Cause LKFORM		1.82036	0.1689

Table 3, shows the null hypothesis of symmetric oil price shock, does not Granger cause non-oil GDP, government expenditure, and capital formation is rejected at the 5 percent level. Hence, oil price shock Granger cause non-oil GDP, government expenditure and capital formation. On the other hand, table 4 shows that the null hypothesis of asymmetric oil price shocks, does not Granger cause non-oil GDP, real capital formation, and government expenditure is accepted at 5 percent level. Thus, asymmetric oil price shock does not affect the macroeconomic variables alluded to. To sum, positive and negative price shocks has no causal relationships with NOIL, KFORM, and GOEX.

3.4 The Impulse Response Function

Impulse response functions are used to capture the response of some of macroeconomics volatility due to symmetric or asymmetric shocks of oil price. It shows dynamic properties of the model, which means the responses of dependent variables to unit shock of independent variables. However, it traces the effects of a one standard deviation shock in a certain variable on the current and future values of the rest of macro variables. Figure 1, shows the IRFs of each variable in the study to a one standard deviation shock in the oil price. Government expenditure, non-oil GDP, and capital formation respond slowly but still positive till the third year, about 1988. After that the oil price shocks started gradually affect the variables positively till the 9th year. After that the shock affects the variables negatively. It reflects the change in the price of oil in the oil world market. The figure showed conformity among the variables. They rise together and decline together reflecting the dominance of the oil sector over the Saudi economy. Asymmetric oil price shocks depicted in figure 2. This figure shows the IRFs of GOEX, NOIL, and KFORM to a one standard deviation shock to a positive and negative fluctuation in the oil price. Due to the increase in the oil prices, the government expenditure started to decline till the 2nd year. After that, the government expenditure became negative and continued until the 5th year when it became positive and vanished quickly. This analysis applies to the non-oil GDP and the capital formation. Looking at the negative oil price shocks (from the point of view of oil producer), a one standard

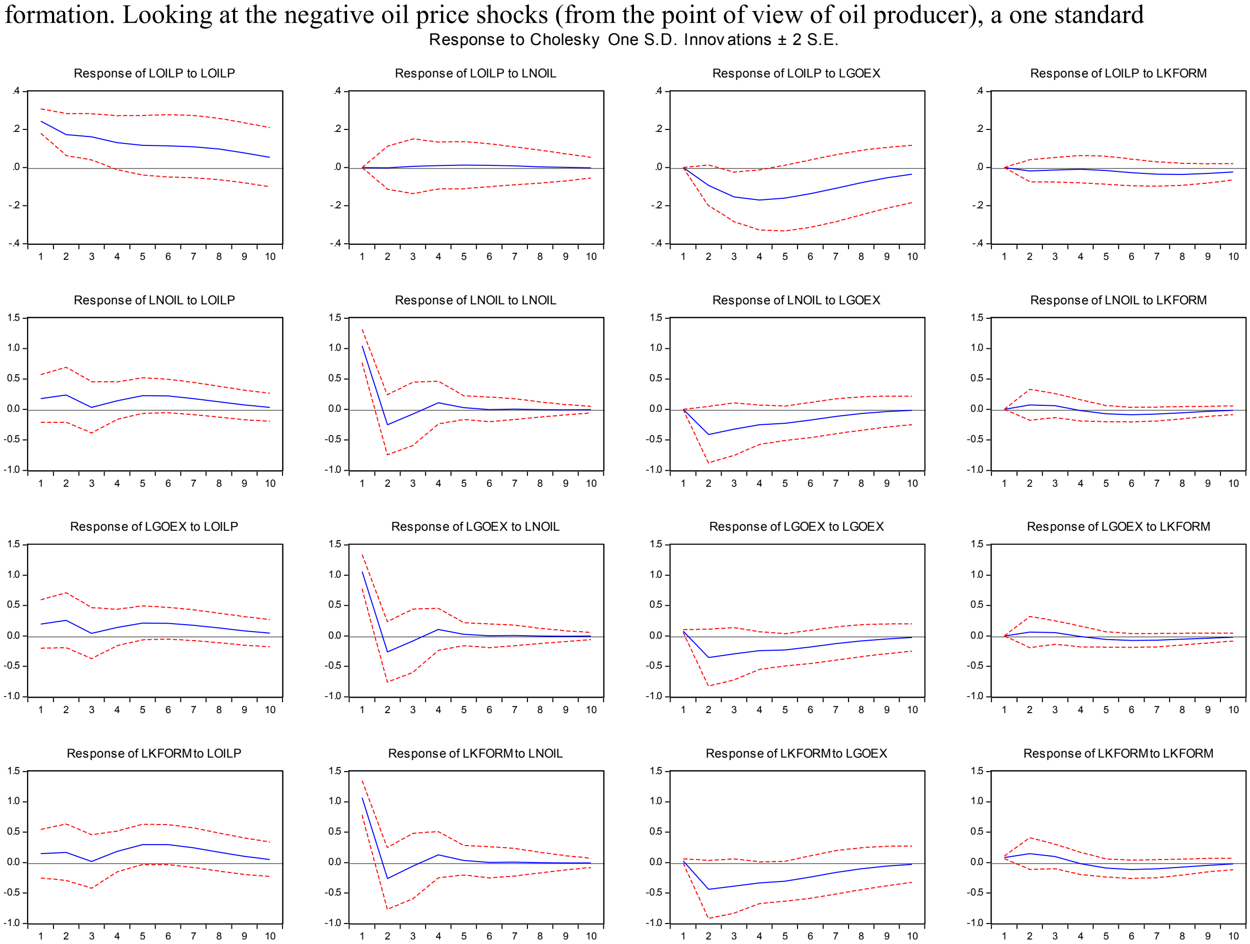

Figure 1. Responses of GOEX, NOIL, and KFORM to symmetric real oil shocks.

deviation shock to negative oil price causes the non-oil GDP to decline negatively (-35) percent 3rd year, and continue to become negative until the 7th year and after that disappeared. Similarly, government expenditure negatively affected sharply by the fall in oil prices internationally. However, capital formation declined due to the dependence of this variable on the government's capital formation. It is notable that theses variables are rely heavily upon the oil rent.

Table 5. Result of Variance decomposition analysis (symmetric oil price shock)

Variance decomposition for LOILP (Percentage points)				
Period	LOILP	LNOIL	LGOEX	LKFORM
1	24.3641	0.00000	0.00000	0.00000
3	16.1291	0.6450	-15.4654	-1.2591
5	11.6706	1.2555	-16.1065	-1.4860
7	10.9694	0.8479	-10.8853	-3.4658
9	7.7037	0.0982	-5.4525	-3.0919
Variance decomposition for LNOIL (Percentage points)				
1	17.8982	104.4553	0.0000	0.0000
3	3.2520	-7.3082	-32.5721	6.1110
5	22.7415	2.7824	-22.9734	-7.1568
7	17.9356	0.3581	-11.3869	-7.6890
9	7.2425	-0.5498	-3.6678	-3.1928
Variance decomposition for LGOEX (Percentage points)				
1	19.4651	105.9445	8.0871	0.0000
3	4.4890	-8.0314	-29.5968	5.6188
5	21.3007	2.6788	-22.9734	-5.8393
7	17.5886	0.6441	-12.5188	-7.1231
9	8.2900	-0.4082	-4.7548	-3.5396
Variance decomposition for LKFORM (Percentage points)				
1	14.5984	106.8494	2.6486	8.3968
3	1.7358	-5.8070	-38.8437	9.7597
5	29.6840	3.6634	-30.8184	-8.9418
7	24.3745	0.5519	-16.2389	-10.1511
9	10.4435	-0.6304	-5.7076	-4.5034
Cholesky Ordering LOILP LNOIL LGOEX LKFORM				

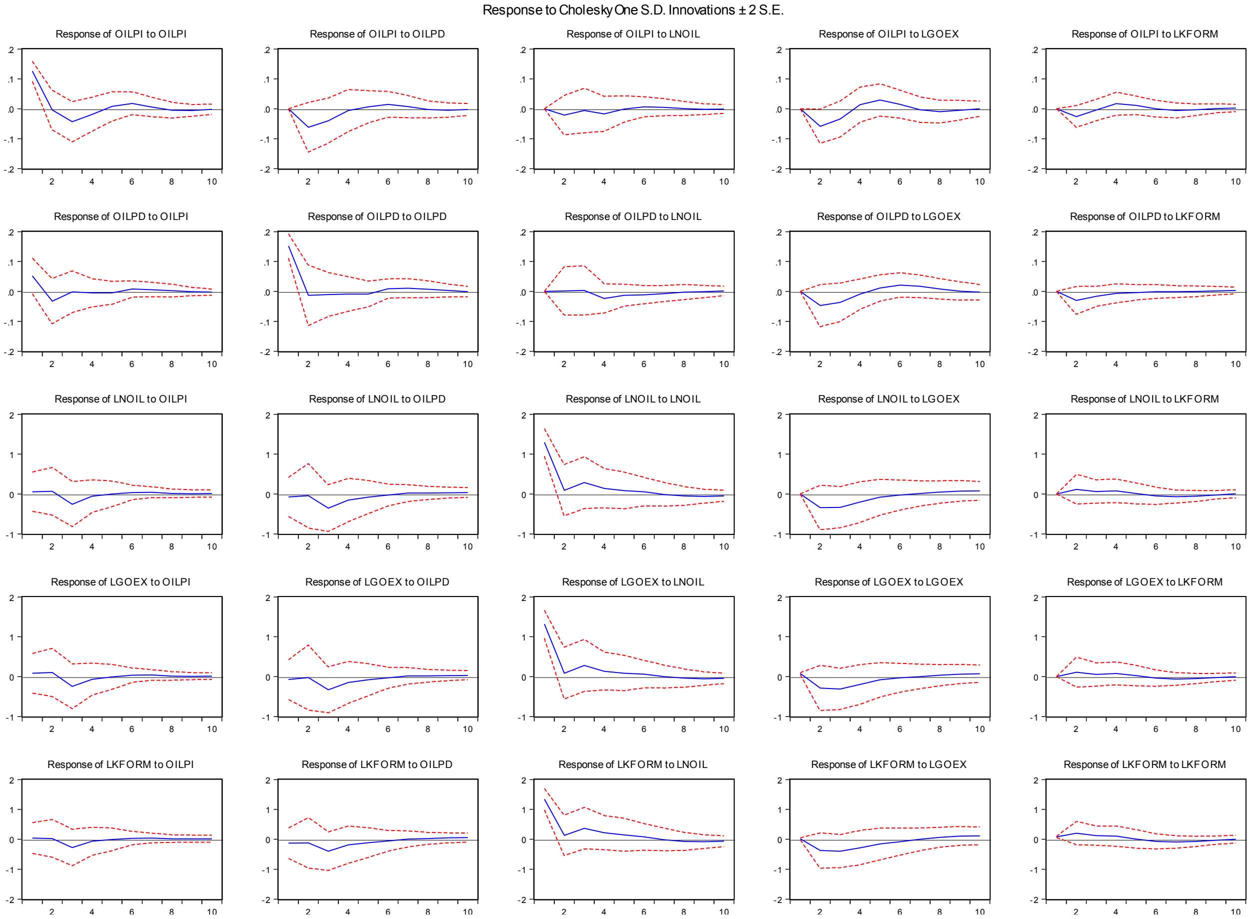

Figure 2. Responses of GOEX, NOIL, and KFORM to asymmetric real oil price shock

Table 6. Result of Variance decomposition analysis (Asymmetric oil price shock)

	Variance decomposition for OILPI (Percentage points)				
Period	OILPI	OILPD	LNOIL	LGOEX	LKFORM
1	12.6029	0.0000	0.00000	0.00000	0.00000
3	-4.3525	-3.9894	-0.5826	-3.4203	-0.4151
5	0.7884	0.6379	-0.0810	2.9416	1.1369
7	0.5681	0.7036	0.4877	-0.3555	-0.5759
9	-0.5734	-0.4503	-0.1534	-0.5152	0.1146
	Variance decomposition for OILPD (Percentage points)				
1	5.2117	15.2273	0.0000	0.0000	0.0000
3	-0.1376	-1.0544	0.3492	-3.6428	-1.6505
5	-0.4872	-0.8982	-1.3047	1.1349	1.1349
7	0.6059	1.0378	-0.6952	1.7023	1.7023
9	-0.0791	0.2977	-0.0718	0.1123	0.1940
	Variance decomposition for LNOIL (Percentage points)				
1	5.6789	-7.3105	129.5555	0.0000	0.0000
3	-25.5152	-35.5514	28.3916	-33.5976	5.8379
5	0.0358	-7.9143	8.5823	-8.1485	1.1440
7	4.0116	2.0643	-1.0863	1.2668	-6.8142
9	0.7841	3.1447	-5.9554	7.3824	-2.2767
Variance decomposition for LGOEX (Percentage points)					
1	8.2433	-7.6514	131.6694	7.7421	0.0000
3	-24.2908	-33.2553	28.0164	-30.9692	5.1065
5	-0.8359	-7.9381	8.6833	-8.1582	2.2737
7	3.8719	1.4994	0.0210	0.1338	-6.1619
9	0.6199	2.5628	-5.3579	6.2323	-2.4743
Variance decomposition for LKFORM (Percentage points)					
1	3.8670	-13.2581	134.4548	1.6802	7.8812
3	-27.9071	-40.1353	36.8698	-39.5362	12.959
5	-0.4576	-11.3239	14.4417	-15.8080	0.6055
7	3.9941	0.6211	-1.3879	-0.3136	-9.2147
9	1.7584	4.5556	-8.3964	10.9261	-3.4934
Cholesky Ordering OILPI OILPD LNOIL LGOEX LKFORM					

4. Conclusion and Policy Implications

The Saudi Arabian economy, as a major producer of crude oil, is vulnerable to the oil price volatility. Far from scattered studies on the oil linear price shocks on Saudi economy, this paper has examined thoroughly the effects of oil price shocks on macroeconomic variables covering the period of 1985-2015. The symmetric and asymmetric effects of oil price shocks on non-oil GDP, government expenditure, and capital formation are empirically tested using unrestricted VAR model. The Johansen co-integration tests showed an existence of long-run relationships involving oil price, non-oil GDP, government expenditure, and capital formation. However, in the short-run, the findings showed that GOEX, NOIL, and KFORM respond positively with symmetric oil price shock, table 5. The effects ranged between 21-30 percent. On the other hand, the results showed that GOEX, NOIL, and KFORM respond positively to one standard deviation of asymmetric positive oil price shocks. The positive effects ranged between 3.8-6 percent, table 6. By the same token, GOEX, NOIL, and KFORM respond negatively to one standard deviation of asymmetric negative oil price shocks. The negative effects ranged between 33-40 percent. In assessing the oil price effects, the variance decomposition of VAR revealed that asymmetric oil price shocks contribution in forecast error variation in GOEX, NOIL, and KFORM is between 33-40 percent. These findings are consistent with the results obtained from equations 8-10. From equation 8, a negative oil price shocks (say 10 percent) causes a decrease in NOIL by 6 percent. From equation 9, a positive oil price shock (say 10 percent) leads to a rise in government expenditure, GOEX, by 13 percent. Similarly, from equation 10, a positive oil price shock (say 10 percent) causes an increase in capital formation, KFORM, by 11 percent. However, asymmetric negative shocks have stronger and lasting effects in the long-run in comparison with asymmetric positive oil price shocks or with the symmetric oil price shocks. Since the symmetric oil price shock affects strongly the non-oil GDP, GOEX, and capital formation, one should keep in mind the asymmetric negative oil shock which causes a halt in investment undertaken during the years of positive oil booms. The role of government is to strengthen the macroeconomic structure to help mitigating the negative effects via implementing policies that help to maintain growth. This paper's findings are in line with the findings of Ebele, and Iorember (2015) concerning the positive impact of oil price shocks.

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