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Assessing the Macroeconomic Implications of Oil Price Fluctuations in Saudi Arabia: An SVAR-based Study

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Abstract: *This study aims to analyse the impact of oil price fluctuations on the major macroeconomic indicators of the Saudi Arabian economy, including gross domestic product, total revenue, inflation, money supply, and real exchange rate. This study utilises Structural Vector Auto-Regression (SVAR) analysis to investigate the influence of oil price shocks on macroeconomic indicators. This research validates the previous findings indicating an increase in oil prices positively impacts GDP and total revenue. This study provides evidence that inflation exhibits minimal responsiveness to fluctuations in oil prices. Regarding the variable of interest, namely the Real Effective Exchange Rate (REER) and money supply, it was observed that these variables had a substantial effect on the shock in oil prices. The results have important policy implications, providing an understanding of how Saudi Arabia's macroeconomic factors respond to changes in oil prices, and highlighting the importance of strengthening and expanding the financial sector per the diversification objectives of Vision 2030.*

Keywords: Money Supply; Oil Price Shock; Saudi Arabia; SVAR

JEL Classification: Q310

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Introduction

Oil is regarded as a significant factor in explaining the course of economic activities in countries worldwide (Heo et al., 2010). The importance of crude oil is evident in its substantial influence on the macroeconomic indicators of any nation, regardless of whether it is a producer or importer of oil. The adverse impact of the oil-price shock has bolstered the economic growth of nations that import oil, while simultaneously mitigating inflationary pressures. Decreased oil prices can enhance the trade balances of nations that import oil by reducing their expenses on oil imports, so allowing them to allocate more funds toward other imports and exports. Lower oil prices can decrease production and shipping costs for commodities, leading to reduced expenses for corporations and perhaps lower prices for consumers. Oil-producing nations heavily depend on oil revenue, hence their response to a decline in oil prices is essentially the contrary. The decrease in crude oil prices results in reduced revenue for oil-producing nations since they receive a smaller amount of money from the sale of oil. Moreover, a decrease in crude oil prices has a direct impact on the income of countries that produce oil, as they receive less revenue from oil sales. Furthermore, countries that produce oil may be compelled to decrease their budgets, resulting in a decrease in public spending, unemployment, and a deceleration of economic expansion. While there have been multiple indications of a correlation between oil price shocks and macroeconomic activities, the precise nature of this relationship remains unresolved. Considering what was said previously, two distinct components of literature have become apparent. According to early researchers like Hamilton (1983), there was a significant increase in oil prices in the United States from the end of World War II until 1973. Cunado and Gracia (2003) provide a similar background, indicating that the impact of oil price shocks on economic growth in a group of European economies has been substantial. The investigations encompass publications by Davis (1987), Hooker (1996), Mork (1989), Mork et al. (1994), Lee et al. (1995), Davis and Haltiwanger (2001), and Cunado and Gracia (2005). This study is important as it provides a more nuanced understanding of the processes that actually take place in one leading oil-exporting country: Saudi Arabia. The study looks at the 36 years from1984 to 2019 and thus reflects long-term trends in relationships that are important for public policy. All of this is extremely useful insight in the context of Vision 2030, Saudi Arabia's grand plan to diversify its economy and wean itself off oil revenue. Furthermore, the addition of under-researched variables like money supply and REER in combination with SVAR methodology show a wider perspective for economic scenario.

It is imperative to understand the macroeconomic implications of oil price shocks in order to frame prudent policies that are resilient even in presence of external shocks. This paper is part of the scarce literature in this context, so it provides important policy conclusions and builds a basis for forthcoming research based on updated data driven analysis responding to new economic issues. The results highlight

that economic diversification, strong monetary policies and long-term strategic planning are all key pre-requisites to achieve stability and sustainability for the Saudi Arabian economy.

This backdrop has provided the basis for establishing the main goal of this study, which is to analyse the influence of oil price fluctuations on macroeconomic indicators in Saudi Arabia. Saudi Arabia's economy is heavily reliant on the global oil sector, and the government has always depended on oil earnings to finance its macroeconomic policies. The economic pressures experienced by the Saudi Arabian economy are a direct consequence of the decrease in global oil prices in recent years. In response to this challenge, the government has implemented various macroeconomic policies to alleviate the impacts of declining oil prices. Saudi Arabia possesses approximately 16 to 17 percent of the world's total reserves and has established itself as a prominent exporter of crude oil. It also holds a significant role within the Organisation of the Petroleum Exporting Countries (OPEC), alongside countries such as the UAE, Iraq, Iran, Venezuela, Kuwait, Algeria, Angola, Congo, Equatorial Guinea, Gabon, Libya, and Nigeria. Oil accounts for about 85 percent of Saudi Arabia's total export earnings, making up more than 40 percent of its GDP. According to a report by the IMF in 2019, Saudi Arabia's significant reliance on something is a barrier to achieving long-term economic development. The capital-intensive nature of the oil industry poses a challenge for young Saudis entering the profession every year[2].

During the study, particular attention will be given to the influence on the Real Effective Exchange Rate (REER) and Money Supply (MS). In addition, various additional factors such as Total Revenue (TR), Gross Domestic Product (GDP), and Inflation (Inf.) are taken into account. Moreover, in contrast to prior studies, the current approach and methodology used are also unique in terms of setting or enforcing structural limitations. This study is important because it adds to the limited existing knowledge on the impact of oil price shocks on the economic activity of oil-exporting countries.

In order to enhance the comprehensiveness of this study, Saudi Arabia, the leading nation in terms of oil exports, has been selected. The main significance of the current study resides in its clarity and understandability. The current study examines the influence of oil shocks on six variables, rather than focusing on only two or three macroeconomic factors. This comprehensive approach also encompasses the often overlooked aspect in the literature, which is the incorporation of money supply returns into the analysis. An empirical addition to the paper is the inclusion of both money supply (MS) and real effective exchange rate (REER) in one location. Certain empirical inquiries require responses with current data. Some inquiries include: How does the money supply respond to an oil shock? Does the reaction exhibit any alterations when the model incorporates the real effective exchange rate? Among several macroeconomic factors, which variable has the highest shock-absorbing capacity, and which variable has a dissipating impact?

The current research paper is organised to provide an introduction to the subject that will be examined in the study. The subsequent section presents a summary of the existing body of literature. The following section, namely section III, includes data sources for all the variables under consideration, as well as the technique used. In addition, Section IV of the study conducts an empirical analysis and presents observations derived from the Impulse Response Function (IRF) and Vector Data Analysis (VDA). The final section provides a concise overview of the primary discoveries and evaluates the proposed policy recommendations.

Review of Literature

There have been numerous studies conducted in the area of Economics to examine the impact of oil price shocks on the economic activity of nations worldwide. The studies conducted emphasise the impact of varying oil prices on important economic variables such as interest rate, GDP, inflation, etc. After the oil price shock of the 1970s, there was a rapid increase in studies focused on understanding the fluctuations in oil prices, specifically the occurrence of oil price shocks. The oil price shocks of the 1970s were a momentous event that had a profound impact on the global economy. J. Hamilton was a pioneer or one of the initial individuals to actively engage in the competition with his work. J. Hamilton's work has been influential for researchers studying the impact of oil price shocks on different economic activities. (Hamilton, 1983) noted that there exists a fundamental inverse correlation between economic activity and oil price shocks. Hamilton advocated for the use of the Vector Autoregressive (VAR) method in his research. He found that the shocks in oil prices led to a recession in the United States (US) after the war. The aforementioned studies have provided ample opportunities to investigate and comprehend the repercussions of oil price shocks on different economic factors, both individually and collectively. These factors include GDP, inflation rate, financial markets, exchange rate, monetary policy, fiscal policy, industrial output, trade, and balance of trade.

Effect of oil price shock on GDP (output)

The study conducted by Farzanegan and Markwardt (2009) examined the diverse repercussions and influence of oil price changes on the Iranian economy. He found that there is a positive correlation between oil prices and both Iranian industrial production and government spending. Almulali et al. (2010) utilised the vector error correction model to evaluate the impact of oil prices on Qatar's GDP. VECM stands for Vector Error Correction Model. It was shown that Qatar's GDP experiences a notable positive impact, albeit this comes with the drawback of increased inflation.

Berument et al. (2010) found that an increase in oil prices has a significant and positive impact on the economic outputs of several Middle Eastern nations, including Algeria, Kuwait, Libya, Oman, Qatar, Syria, Iran, Iraq, and the United Arab Emirates. Conversely, fluctuations in oil prices do not exhibit a statistically significant impact on output in Bahrain, Israel, Egypt, Djibouti, Tunisia, Jordan, and Morocco. When analysing the repercussions of oil shocks, it is discovered that lower output growth is associated with oil supply shocks. Oil shocks may be broken down into two aspects, namely oil demand, and supply, and this analysis helps to understand the effects on nations that rely on oil production. Nevertheless, it is clear that oil demand shocks do not have any impact on the output.

(Rasasi and Banafea, 2015) The authors noted that both comprehensive demand shocks and discrete oil demand shocks had a positive impact on industrial production (IP). The cointegration results suggest a durable and robust positive correlation between oil prices and GDP. Additionally, oil revenue plays a significant role in the overall Saudi GDP and serves as the main driver of economic activity. Al-Mawali et al. (2016) examined the impact of the oil sector on the Oman economy during the past thirty years and predicted the significant macroeconomic factors that affect the economy. Through the evaluation of simulations of different models, it has been noted that the oil industry has a substantial positive effect on Oman's GDP, while also extending its influence to other sectors of the economy that are not related to oil. Abdulrahman (2021) During the research period, it was found that both oil and non-oil exports had a positive impact on the economic performance of Saudi Arabia.

Impact of oil price shock on Inflation

Only a limited number of studies have exclusively focused on the extent to which changes in oil prices affect inflation. Hooker (2002) sought to evaluate the validity of the Phillips curve model by analysing quarterly data from 1962: Q2 to 2000: Q1. The researcher's findings indicate a major deviation from the traditional relationship between inflation and unemployment in the United States. Additionally, the impact of oil prices on inflation has been negligible since 1980. A Phillips framework analysis utilising data from the G5 nations yielded similar findings, as demonstrated by Chinn and Leblanc (2004). It revealed that the recent increases in oil prices had little effect on inflation in the United States, Japan, and Europe.

Simultaneously, Noord and André (2007) present compelling evidence that the impact of energy prices on core inflation is quite small compared to the 1970s. However, as emphasised by Kilian (2009), there is a correlation between the cause of the increase and the effects of rising oil prices on US GDP and Consumer Price Index (CPI) inflation. Using a single-equation Phillips curve model to measure the extent of oil price pass-through can be misleading since it assumes that a change in oil price directly represents the shock.

Ali Ahmed and I. K. M. Wadud (2011) found that when the Consumer Price Index decreases, it may be due to an increase in uncertainty about oil prices. This uncertainty can cause people, households, and other sectors of the economy to postpone buying expensive items, which in turn leads to a decrease in demand. (Sek and Lim, 2016) The Blanchard-Quah identification can be applied to focus the inquiry on ten oil-importing and exporting nations each. The data used for this analysis spans from January 1973 to January 2015. Their research demonstrates the presence of interactions between different variables and highlights that shocks in oil supply have a more significant impact on explaining CPI inflation compared to shocks in oil demand. Although an oil supply shock can effectively account for inflation in countries that import oil, oil demand has minimal explanatory power. A separate study discovered that fluctuations in oil prices have a noteworthy influence on the consumer price index (CPI) inflation rate of a country that exports oil. Specifically, the inflation rate exhibits an unfavourable response to a positive shock in oil prices, Alekhina and Yoshino (2018). A single unit shock to oil prices can account for as much as 4% of the fluctuations in the inflation rate, as shown by the variance decomposition methodology. Mukhtarov et al. (2019) state that the cointegration technique can be used to clarify a lasting connection between variables. In addition, their analysis utilising a vector error correction model (VECM) revealed a significant and positive influence of both oil prices and exchange rates on long-term inflation. This implies that a 1% increase in oil prices and exchange rates leads to a respective 0.58% and 1.81% increase in inflation. Moreover, inflation was detected in both situations of high and low oil prices, and the exchange rate serves as a conduit through which oil prices affect inflation. The study conducted by Wen et al. (2021) reveals that there is a distinct variation in the influence of oil price shocks and the corresponding inflation reaction across different countries. Specifically, the impact of oil price shocks on inflation in the United States is found to be the most significant among the G7 nations. Moreover, the fluctuating effect of the oil price shock on inflation throughout time. Supply shocks exert a disproportionately significant impact prior to the financial crisis, but their significance diminishes over the course of the crisis. Contrary to popular opinion, demand shocks exert a significantly stronger influence during this time period. Furthermore, these effects have experienced a substantial rise in the latter part of 2014. (Hijazine & Al-Assaf, 2022) The study investigated the influence of oil prices on both overall and underlying inflation in Jordan from the first quarter of 2002 to the fourth quarter of 2019. The study determined that short-term headline inflation is positively influenced by oil prices through the use of the Johansen cointegration test and vector error correction model. Although fluctuations in oil prices do not affect the underlying inflation rate, a one-way causal relationship has been shown between oil prices and overall inflation. Ultimately, although GDP growth, interest rates, and import prices affect both inflation indices, it seems that oil prices do not have a significant positive impact on either headline or core inflation.

Oil price variation's impact on the exchange rate

(Aleisa & Dibooglu, 2002) found that the response of the Real Exchange Rate is mostly influenced by changes in real oil output rather than by fluctuations in real oil prices. In their investigation of the impact of real oil prices on the real exchange rate of three oil countries, Habib and Kalamova (2007) found that fluctuations in real oil prices did not cause any significant alteration in the exchange rate of Saudi Arabia. The absence of a precise correlation between the actual exchange rate and real oil prices can be attributed to Saudi Arabia's practice of oil revenue sterilisation, along with its price subsidy plan and the existence of a flexible labour market. Furthermore, the assessment conducted by Mirza et al. (2013) about the cost and benefit analysis of Saudi Arabia's stable currency rate revealed that it has facilitated economic stabilisation and effectively controlled inflation by pegging it to the US dollar. They observed that the monetary intervention by Saudi Arabia's monetary agency was ineffective in controlling inflation due to the steady exchange rate with the US dollar. In addition, the monetary authorities of OPEC member countries should consider the impact of oil price shocks when developing their exchange rate policies. According to Altarturi et al. (2016), nations whose currencies are connected to the US dollar tend to respond to oil price fluctuations with a delay. In a study conducted by Kilian (2016), it was shown that the impact of the fracking boom in the United States on Saudi Arabia may be measured and evaluated. The study suggests that if there had been no fracking boom, the loss in Saudi Arabia's foreign exchange reserves between 2014 and 2015 would have been reduced by 27%. Saudi Arabia was compelled to utilise its financial reserves as a result of a decrease in revenue caused by the reduction in oil prices, which was triggered by the fracking boom. According to Alkhareif (2017), the exchange rate system in which the Saudi Arabian currency is tied to the US dollar has been beneficial for the country. The author's cross-sectional study demonstrates that Saudi Arabia's macroeconomic position exhibits greater stability compared to other countries with similar economic structures but varying exchange rate regimes. Razek & McQuinn (2021) conducted contemporary research to evaluate the international competitiveness of Saudi Arabia's currency rate, taking into consideration the risks linked with the oil markets. The study found that the risks associated with the oil market, geopolitical factors, and global demand are important factors that explain the fluctuation in the real effective exchange rate (REER). The research has confirmed that linking the Saudi Riyal to the US dollar has resulted in numerous advantages for the Saudi economy. This has been achieved by implementing significant internal economic reforms and taking advantage of a robust oil market.

Previous studies primarily focused on the impact of oil price shocks on a limited number of macroeconomic variables, a gap that we aim to fill in this study. Supposedly, the literature does not take a comprehensive approach when addressing the impact of the oil shock on Saudi Arabia (or other oil-exporting countries). There has been no

previous research that has studied the impact of oil price shocks on a comprehensive and wide-ranging set of factors in the Saudi Arabian economy. In addition, this study includes important factors such as money supply in the model, which has not been thoroughly examined in relation to the impact of oil prices on macroeconomic variables in oil-exporting economies. Most existing research primarily focuses on GDP, CPI, and exchange rates. Therefore, this study is crucial in the current global context and aims to address this knowledge gap.

Data Used and Methodology

Source of Data and Variables

The data sources include of the Saudi Arabian Ministry of Finance (SAMoF), General Authority for Statistics (GaStat), Saudi Arabian Monetary Authority (SAMA), and the International Monetary Fund (IMF). These sources cover the time period from 1984 to 2019. The variables and their sources[2] are described in Table 1 below.

Table 1: Variable description and Data Source

Variable	Description	Source
Oil Prices	Crude prices per barrel are the average of Brent, Dubai and WTI in nominal US Dollar terms	IMF
Total Revenue	Oil and Non-Oil Revenue	SAMoF
Output	Gross Domestic Product At Current Prices	GaStat
Price Inflation	CPI- consumer prices Index (annual per cent)	IMF
Monetary Supply	M3 = demand deposits with the banking sector + 'Other Deposits with the Bank + Saving deposits + Other Quasi Deposits	SAMA
Exchange Rate	Real effective exchange rate (2010=100)	IMF

Note: Oil Prices (OP), Total Revenue (TR), Output (GDP), Price Inflation (Inf.), Monetary Supply (MS), Exchange Rate (ER).

Source: The Author.

Unit Root Testing

Various specifications have been tested, including both with and without an intercept/trend, depending on the characteristics of the series. The null hypothesis of unit root is rejected with a significance level of 10%. The abbreviations "S" and "NS" represent the terms "stationary" and "non-stationary," respectively. The first differenced form reveals that log(OP), log(Inf.), log(TR), log(ER), log(GDP), and log(MS) exhibit to be stationary.

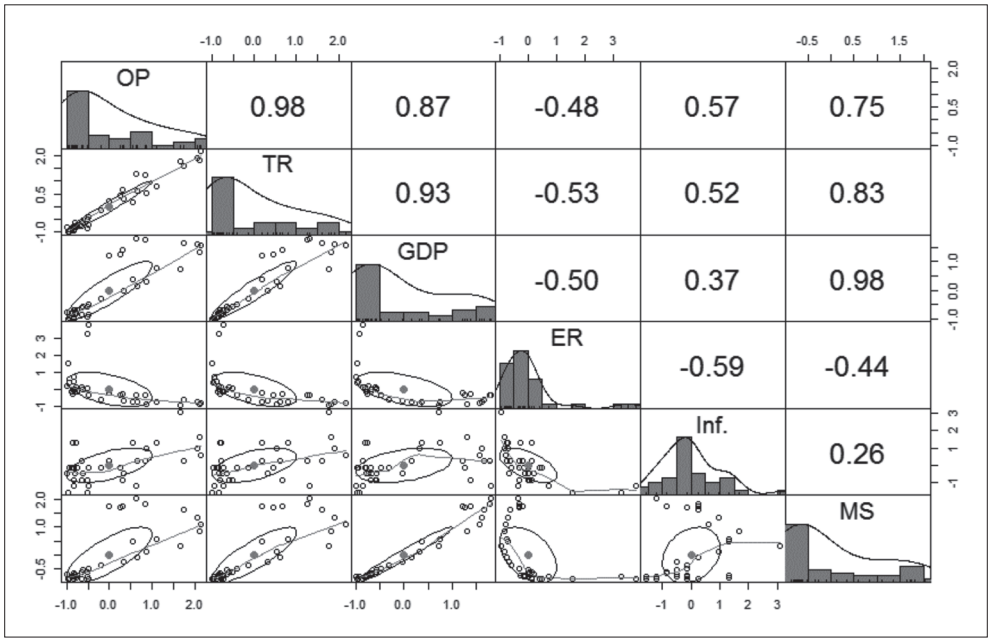
Table 2: Augmented Dicky Fuller Test & Elliot, Rothenberg and Stock Test

Variable	Level/Difference	ADF# Test	ERS## Test
Log(OP)	Level	NS	NS
	Differenced	S	S
Log(Inf.)	Level	NS	NS
	Differenced	S	S
Log(TR)	Level	NS	NS
	Differenced	S	S
Log(GDP)	Level	NS	NS
	Differenced	S	S
Log(MS)	Level	NS	NS
	Differenced	S	S
Log(ER)	Level	S	NS
	Differenced	S	S

Note: ADF: Augmented Dicky Fuller Test for testing Stationarity; ERS: Elliot, Rothenberg & Stock Test for Stationarity.

Source: Author

Figure 1: Pairwise-Correlation Coefficient and Histogram



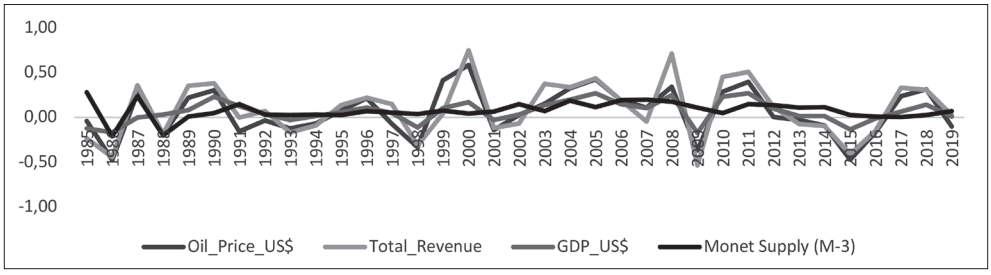
Source: Authors' calculation based on IMF, SAMoF, GaStat, and SAMA databases

Note: IMF: International Monetary Fund, SAMoF: Saudi Arabia Monetary Fund, GaStat: General Authority for Statistics (Saudi Arabia), SAMA: Saudi Arabian Monetary Authority

The correlation analysis depicted in Figure 1 indicates a strong positive link between oil prices (OP) and total revenue (TR), with a correlation coefficient of 0.98. Similarly, the correlation coefficient between oil prices and GDP is significantly strong and positive, measuring 0.87. The oil price has a negative correlation with the Real Effective Exchange Rate (REER) of -0.48, indicating an inverse relationship. On the other hand, the relationship between the oil price and inflation is positive, but not very significant, with a value of 0.57. Nevertheless, there exists a positive and robust correlation (0.75) between the price of oil and the money supply.

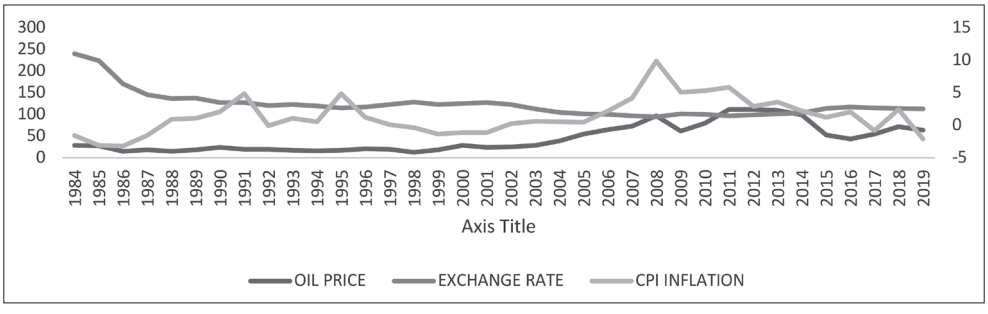
Figure 2 illustrates the correlation between oil prices, GDP, total revenue, and money supply from 1984 to 2019. Oil price fluctuations exert a significant impact on macroeconomic indicators. This is quite typical of a nation whose main revenue comes from exporting oil. This graph depicts the correlation between GDP, total revenue, and money supply with the variations in actual oil prices from 1984. It is evident that the previous variables are correlated with the trend of the latter. It is interesting to note that oil prices have a similar effect on the exchange rate, but they cause it to move in the opposite way. In addition, regardless of the level of oil prices, Saudi Arabia is largely dependent on imports. Consequently, the import values of trade partners may increase the inflation rate, as seen in Figure 3.

Figure 2: Trends in GDP, Total Revenue, Money Supply and Oil Price (1985-2019)



Source: Authors' calculation based on IMF, SAMoF, GaStat, SAMA databases

Figure 3: Trends in Oil Price, Exchange Rate, and CPI Inflation (1985-2019)



Source: Authors' calculation based on IMF, SAMoF, GaStat, and SAMA databases.

Methodology

The vector autoregressive (VAR) model is a fairly generic way for multivariate time series. The reason for this is that the multivariate time series includes endogenous variables that are regressed on both the lag of other variables and the lag of itself, resulting in a multi-equation model. The primary limitation of the generic VAR model is its failure to account for the simultaneous links among the variables. Instead, it primarily emphasises the establishment of relationships between variables with a time delay. Understanding the implications of a shock in real time is essential for analysing the impulsive response of these models. The limitation is resolved by the use of the structural vector autoregressive (SVAR) model, which establishes or models the concurrent relationship between the variables[1].

SVAR, on the other hand, cannot be estimated directly. This is a theoretical construct that cannot be observed. We need to deal with the reduced version of VAR, and we will require matrix A to get there. Based on economic theory and understanding, Matrix A sets constraints on the concurrent connection among the structural model's endogenous variables. Let us start with the simple VAR equation

$$X_t = B_0 + B_1 X_{t-1} + B_2 X_{t-2} + \ldots B_p X_{t-q} + u_t \quad (1)$$

Where X_t is an n × 1 vector including the following variables (Oil Prices(OP), Output(GDP), Total Revenue(TR), Inflation(Inf), Money Supply(MS), Real Effective Exchange Rate (ER). Oil prices are assumed to be exogenous variables. The optimal number of lags in the above equation is signified by q. Now introducing matrix, **A,** i.e., the matrix containing restrictions on the contemporaneous relationship among the endogenous variables on the left side of the equation (1) above.

$$AX_t = B_0 + B_1 X_{t-1} + B_2 X_{t-2} + \ldots B_p X_{t-q} + u_t \quad (2)$$

Taking A^{-1} on both sides of the equation (2), we get the reduced form

$$A^{-1} AX_t = A^{-1} B_0 + A^{-1} B_1 X_{t-1} + A^{-1} B_2 X_{t-2} + \ldots A^{-1} B_p X_{t-q} + A^{-1} u_t \quad (3)$$

Since $A^{-1} A = \mathrm{I}$, where I stands for identity matrix, equation 3 above reduced to

$$X_t = G_0 + G_1 X_{t-1} + G_2 X_{t-2} + \ldots G_p X_{t-q} + e_t \quad (4)$$

Where $G_0 = A^{-1} B_0$, $G_1 = A^{-1} B_1$, $G_2 = A^{-1} B_2$, $G_p = A^{-1} B_p$ and finally $e_t = A^{-1} u_t$

It can be seen that the forecast error of the reduced form SVAR, i.e., the forecast error **e** is a linear combination of the structural shocks **u.** One of the key benefits of SVAR is that it isolates solely exogenous shocks and obtains the response of endogenous variables after these shocks have damaged the economy. The task at hand is to identify solely exogenous shocks. To trace the dynamic effects exclusively on external

shocks, they must first be identified. It is this uncovering of the structural model that is called identifications. According to Sims (1986), identification is the interpretation of previously observed differences to anticipate future activity outcomes. Before we go any further and impose limitations under matrix A, let's do some fundamental analysis to understand the distribution of the variables given above and calculate the pairwise correlation coefficient between them. This aids in determining the strength of the correlation between the variables. Since the variables are in different units, it would be inappropriate to draw a comparison and calculate the correlation coefficient among them directly. Thus, it is important to scale down the variables by calculating the z value and then calculating the pairwise correlation coefficient[2].

Coming to the SVAR restriction settings, Our SVAR system consists of six variables. Variable oil price is an exogenous variable, and the impact of its shock is evaluated on the rest of the other variables. Structural parameters are retrieved by estimating reduced form VAR with the set of short-run constraints on contemporaneous coefficients shown below.

Where, $e_{OP}, e_{TR}, e_{GDP}, e_{ER}, e_{inf.}$ & e_{MS} are structural shock representing oil prices, total revenue, output, i.e. GDP, real effective exchange rate, inflation, and money supply, respectively while $u_{OP}, u_{TR}, u_{GDP}, u_{ER}, u_{inf.}$ & u_{MS} are reduced-form residuals. Global forces determine oil prices; it is not explained by any domestic macroeconomic variable.

$$\begin{bmatrix} e_{OP} \\ e_{TR} \\ e_{GDP} \\ e_{ER} \\ e_{inf.} \\ e_{MS} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a^{21} & 1 & 0 & a^{24} & 0 & 0 \\ a^{31} & a^{32} & 1 & 0 & 0 & 0 \\ a^{41} & a^{42} & a^{43} & 1 & 0 & a^{46} \\ a^{51} & 0 & a^{53} & 0 & 1 & 0 \\ a^{61} & a^{62} & a^{63} & a^{64} & a^{65} & 1 \end{bmatrix} \begin{bmatrix} u_{OP} \\ u_{TR} \\ u_{GDP} \\ u_{ER} \\ u_{inf.} \\ u_{MS} \end{bmatrix}$$

Total revenue has a contemporaneous relationship with the oil price and exchange rate, and it is determined by the oil price and real effective exchange rate in equation II as per the matrix above. GDP is described in equation three by the oil price and total revenue. In equation four, all variables except inflation explain the real effective exchange rate. Aside from its own lag, inflation is also affected by the oil price and GDP in equation five, and all factors in equation six determine the money supply. We set fifteen constraints on the system, forcing it to do nothing more than identify. To assess the impact of the oil price shock on other variables, impulse response analysis and variance decomposition analysis were performed using the estimated structural model.

Empirical Findings

Impulse Response Analysis

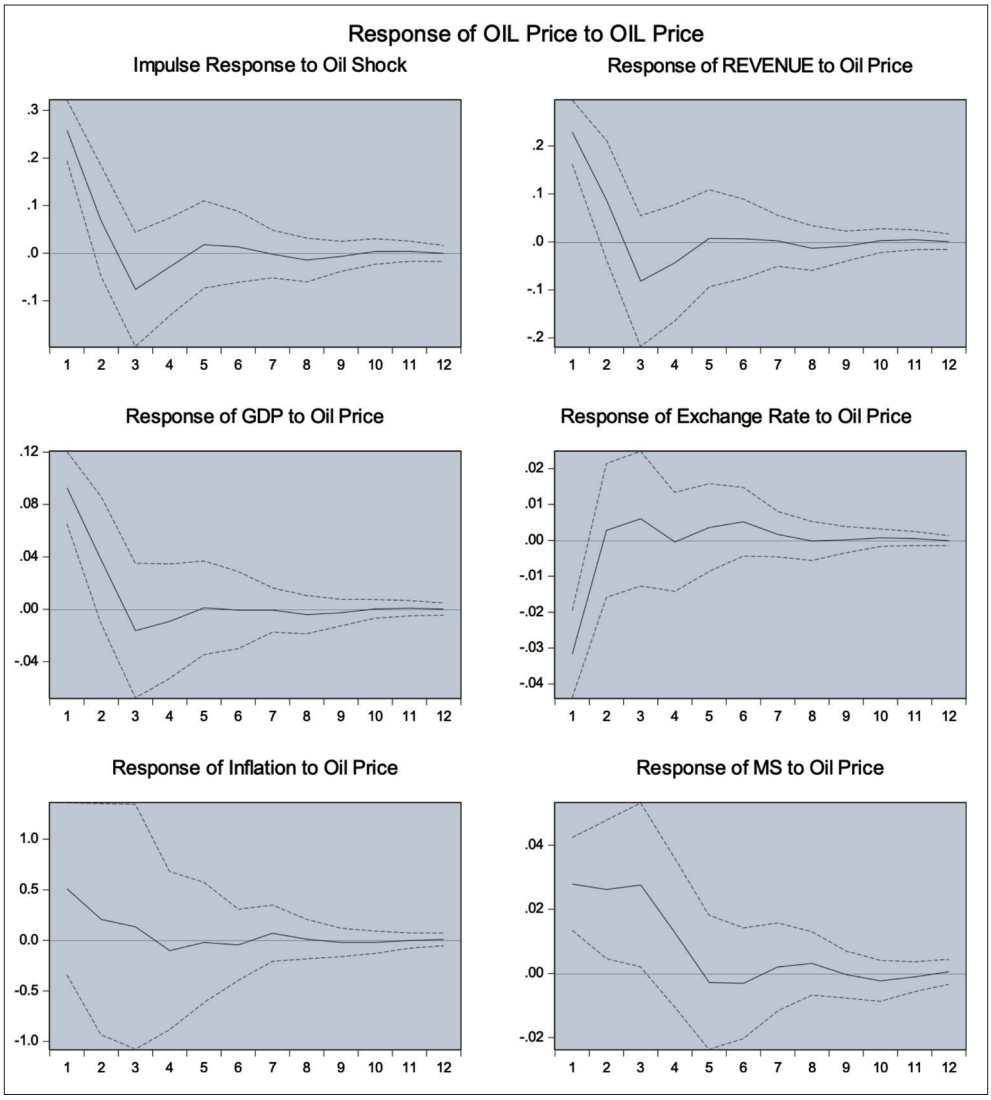
Figure 5 illustrates the response of Saudi Arabia's economic factors to a one-standard-error shock in global oil prices; dotted lines depict the standard-error confidence bands around each response. The bars demonstrate the accuracy of the impulse response function (IRF) by faithfully reflecting the response pattern over the entire period. Oil price shocks hinder production in the oil-producing sectors due to a decrease in profits and a rise in the marginal production cost[3].

We found that a decline in oil prices had a significant effect on production. As the price of oil decreases, the level of production starts to decline. The initial stage of the oil shock impacts the GDP and swiftly reduces it, eventually reaching a severe nadir in the third period. A plausible explanation is that the petroleum industry contributes approximately 42 percent to the Gross Domestic Product (GDP). Nevertheless, there is a rebound from the third interval, but the overall pattern continues to be negative until the fifth interval. Following the sixth stage, there is a gradual increase after the first decline. The data indicates a consistent pattern until period 10, at which point it gradually converges, suggesting that the impact of shock-1 diminishes after period 10.

Likewise, a decrease in revenue occurs in response to an oil price shock as a result of reduced export earnings. The revenue had an immediate decline as a result of adverse oil price shocks, demonstrating its rapid responsiveness to such shocks until period three. Due to the fact that around 80 percent of Saudi Arabia's government income comes from oil revenue, a decrease in oil prices will result in a decline in government income. However, after period 3, the influence of the adverse oil price shock on income rapidly diminishes, and the shock gradually dissipates by period 9.

Fluctuations in oil prices have a direct impact on inflation in Saudi Arabia, as the country heavily relies on oil production and revenue for its economic stability. Following the oil price shock, there was an early decrease in inflation, although the decline was not significant. The decline persisted during the fourth quarter and remained in negative territory until the sixth. After the seventh period, the value had a consistent and positive increase, with little fluctuations. In general, the adverse oil price shock has minimal impact on inflation. The IRF's finding can be explained economically by the fact that the oil price shock reduces inflation by decreasing aggregate demand.

Figure 5: Impulse Response Functions



Source: Author

Further, Figure 5 demonstrates the effect of the oil shock on the real effective exchange rate (REER). REER exhibits a quick response to oil price shocks starting from period one. This response is followed by a positive trend from period three, reaching its highest point in period seven, and then gradually declining. Although the Saudi economy is linked to the US dollar, the Saudi Real Effective Exchange Rate (REER) decreases in order to discourage the outflow of cash. The Saudi kingdom's

economic stability is directly impacted by any decline in oil prices. Investors perceive this as a detrimental occurrence, as the withdrawal of capital has the potential to trigger a crisis in the balance of payments.

MS operates under a regime of fixed exchange rates and complete substitutability of capital. This is to maintain a stable exchange rate for smooth export earnings and to avoid arbitrage. MS experienced a slow decline until period three as a result of a decrease in oil prices, followed by a continued downward trend from period three to period five. Therefore, the influence of shock-1 steadily decreases after period 12, indicating that the variability has reached a stable state by period 12.

Variance Decomposition Analysis

Variance decomposition analysis (VDA) is used to calculate the percentage variation in forecast error caused by other endogenous shocks. Table 3 displays the breakdown of the variance of variables in the VAR system throughout the specified time period.

Table 3: Variance Decomposition Analysis (VDA)

VDA of REVENUE							
Period	**S.E.**	**Oil**	**Revenue**	**GDP**	**ER**	**Inflation**	**MS**
1	0.251	83.073	0.025	11.996	1.519	0.384	3.003
2	0.324	57.202	0.697	14.100	3.967	0.479	23.555
3	0.347	55.476	1.355	12.828	5.061	3.350	21.929
4	0.361	52.553	1.473	14.239	4.724	6.733	20.279
5	0.363	52.039	1.548	14.145	4.961	7.031	20.276
6	0.364	51.693	1.541	14.246	5.250	6.994	20.277
7	0.365	51.644	1.553	14.286	5.273	6.987	20.256
8	0.365	51.695	1.553	14.270	5.271	6.979	20.233
9	0.365	51.694	1.553	14.288	5.267	6.977	20.221
10	0.365	51.691	1.558	14.287	5.269	6.977	20.219
11	0.365	51.689	1.557	14.296	5.269	6.976	20.212
12	0.365	51.687	1.558	14.297	5.271	6.976	20.212
VDA of GDP							
Period	**S.E.**	**Oil**	**Revenue**	**GDP**	**ER**	**Inflation**	**MS**
1	0.103	81.268	0.028	13.275	1.680	0.425	3.323
2	0.125	63.858	0.624	11.664	5.894	0.298	17.661
3	0.130	61.244	0.758	11.759	6.639	2.870	16.730
4	0.133	58.527	0.785	12.642	6.611	5.525	15.909
5	0.134	58.148	0.837	12.572	6.603	5.893	15.946
6	0.134	57.937	0.835	12.565	6.730	5.915	16.017
7	0.134	57.901	0.835	12.591	6.755	5.911	16.008
8	0.134	57.926	0.836	12.575	6.752	5.905	16.006
9	0.134	57.924	0.838	12.577	6.749	5.906	16.005
10	0.134	57.922	0.839	12.577	6.750	5.906	16.005
11	0.134	57.918	0.839	12.582	6.752	5.906	16.003
12	0.134	57.917	0.840	12.582	6.752	5.906	16.003

VDA of Exchange Rate							
Period	**S.E.**	**Oil**	**Revenue**	**GDP**	**ER**	**Inflation**	**MS**
1	0.042	58.484	40.243	0.903	0.114	0.029	0.226
2	0.046	47.378	43.422	2.250	1.254	1.645	4.051
3	0.047	47.114	41.936	2.166	2.206	2.536	4.042
4	0.048	46.557	41.600	2.167	2.294	3.388	3.994
5	0.048	46.659	41.204	2.164	2.567	3.434	3.972
6	0.048	47.156	40.636	2.215	2.538	3.404	4.052
7	0.048	47.153	40.582	2.212	2.553	3.423	4.076
8	0.048	47.096	40.532	2.285	2.570	3.419	4.098
9	0.048	47.059	40.500	2.315	2.607	3.416	4.103
10	0.048	47.068	40.489	2.315	2.607	3.415	4.107
11	0.048	47.070	40.483	2.318	2.606	3.415	4.107
12	0.048	47.069	40.483	2.318	2.608	3.415	4.107
VDA of Inflation							
Period	**S.E.**	**Oil**	**Revenue**	**GDP**	**ER**	**Inflation**	**MS**
1	2.472	4.258	0.006	2.753	0.349	91.945	0.689
2	2.875	3.672	2.419	6.945	1.353	84.690	0.922
3	3.029	3.503	2.206	6.600	2.937	83.622	1.132
4	3.081	3.495	2.133	6.491	2.903	83.882	1.096
5	3.094	3.471	2.117	6.453	2.903	83.809	1.246
6	3.098	3.483	2.111	6.483	2.898	83.711	1.313
7	3.100	3.531	2.119	6.486	2.895	83.626	1.344
8	3.100	3.532	2.125	6.495	2.894	83.609	1.344
9	3.100	3.536	2.125	6.496	2.902	83.597	1.345
10	3.100	3.539	2.125	6.497	2.906	83.588	1.345
11	3.100	3.539	2.126	6.497	2.906	83.587	1.345
12	3.100	3.540	2.126	6.498	2.906	83.585	1.345
VDA of MS							
Period	**S.E.**	**Oil**	**Revenue**	**GDP**	**ER**	**Inflation**	**MS**
1	0.046	36.751	4.525	0.994	55.896	0.208	1.626
2	0.057	44.330	11.252	0.638	36.316	2.545	4.919
3	0.069	47.271	8.956	1.275	30.881	1.996	9.621
4	0.071	47.873	8.802	1.205	29.531	2.341	10.249
5	0.072	46.595	8.848	2.935	29.317	2.271	10.034
6	0.072	46.129	8.930	3.528	29.059	2.242	10.112
7	0.072	46.120	8.916	3.522	29.108	2.238	10.095
8	0.072	46.102	8.886	3.646	29.079	2.228	10.059
9	0.072	46.073	8.910	3.658	29.066	2.239	10.054
10	0.072	46.111	8.898	3.677	29.032	2.239	10.044
11	0.072	46.108	8.894	3.690	29.029	2.239	10.040
12	0.072	46.107	8.897	3.693	29.026	2.239	10.039
Factorisation: Structural							

Note: SE refers to Standard Error

Source: Author

The variance decomposition analysis quantifies the extent to which each variable contributes to the variation of the other variables. For instance, based on the

autoregressive model, the oil shock has a significant influence on GDP, ranging from around 81.26 percent in the initial period to 57.91 percent in the twelfth period. This is accurate considering the Saudi economy's dependence on oil. Whether an oil price shock arises from external factors or production manipulation is inconsequential. Regardless, the volatility in oil prices will have an impact on both GDP and revenue. When considering inflation, it is evident that changes in oil prices did not significantly account for the fluctuations in inflation in Saudi Arabia. The percentage of inflation variance attributed to changes in oil prices was 4.25 percent in period 1, 3.67 percent in period 2, and 3.54 percent in period 12.

Now let's discuss the variables of interest, namely the Real Effective Exchange Rate (REER) and the Money Supply (MS). It is important to note that the Saudi Riyal is fixed to the US dollar at a higher value to prevent speculation against the Riyal. However, the real effective exchange rate (REER) of the currency exhibits a significant level of sensitivity to changes in oil prices. The correlation between oil prices and REER decreased from 58.48 percent in period 1 to 47.06 percent in period 12. Another significant factor in determining the fluctuation in Real Effective Exchange Rate (REER) is revenue. In period 1, revenue accounted for 40.24 percent of the variation, while in period 12, it accounted for 40.48 percent. Regarding the Real Effective Exchange Rate (REER), it has experienced a decline in value over a period of time. The oil shock accounted for approximately 36 percent of the overall variance in the money supply during the initial period. However, it achieved a percentage of 46.10 in the 12th quarter. Nevertheless, a greater level of variance was elucidated by REER. During the first period, the Real Effective Exchange Rate (REER) accounted for 55.89 percent of the variability in the Money Supply (MS), but this decreased to 29.02 percent by the twelfth period.

The analysis reveals that oil price shocks significantly affect the GDP and total revenue of Saudi Arabia, which is in good agreement with its huge dependence on exports of crude. In particular, a one-standard-error shock in global oil prices leads to GDP falling which bottoming out around the third period and eventually recovering by the tenth period. It also highlights the urgency in Saudi Vision 2030 to diversify country's economy thus buffering it from such risks (Saudi Vision 2030,2016). Given that around 80% of government income comes from oil revenues, total revenue similarly exhibits a dramatic fall in reaction to unfavourable shocks to the price of oil. This quick reaction to changes in oil prices emphasises the dangers of an economy dependent on oil and the need for a more diverse source of income (IMF, 2019). It's interesting to note that inflation shows little reaction to fluctuations in the price of oil, staying negative until the sixth quarter before stabilising. This suggests that domestic inflation is more influenced by aggregate demand factors and global economic conditions rather than direct oil price changes (Kilian, 2009).

This study finds that oil price shocks also play a major role in affecting the Real Effective Exchange Rate (REER) and money supplyM3. REER is fast to respond by moving up as soon as oil prices fall with 7 periods being the peak before a decline,

implying stable (not falling) Oil price necessary for maintenance of SAR's value. This dynamic is further complicated by the fixed exchange rate regime of Riyal to US dollar, and its interconnected relationship with oil price corresponding directly through fluctuation in foreign reserves, monetary stability (SAMA, 2020). Money supply also shows a downward trend in response to oil price shocks, reflecting the interconnectedness of oil revenues with the overall liquidity in the economy. The decline in oil prices reduces export earnings, which in turn impacts the money supply, highlighting the need for robust monetary policies to manage such fluctuations (Alkhareif et al., 2017). These results, taken together, underscore the need for building robust economic structures and diversifying revenue streams to lessen exposure to fluctuations in oil prices; thus enabling long-term growth. Ideally, future policies should concentrate on diversifying the non-oil sectors and strengthening the resiliency of financial sector with time consistent to that envisaged for broader SDGs in economic resilience.

Conclusion

The study applied the SVAR model to analyse the correlation between oil price shocks and five additional economic variables: total revenue, GDP, inflation, REER, and Money Supply. Based on the findings, both GDP and Total Revenue exhibited significant responsiveness to fluctuations in oil prices. The volatility of oil prices accounted for a significant amount of variation in each of these parameters. The finding aligns with Saudi Arabia's substantial reliance on the oil industry in relation to its GDP and exports, which constitute a substantial portion of its total revenues. Conversely, the oil price shock had minimal impact on inflation. Regarding the variables of interest, namely REER and Money Supply, it was found that both of these variables exhibited significant reactions to the oil price shock. The Saudi Riyal is fixed to the US dollar, and the monetary base in Saudi Arabia is defined by the government's fiscal policies, the private sector's balance of payments, and the net credit extended by commercial banks to the private sector. Therefore, the inflow of funds into the system is predominantly influenced by the export revenues of the oil business, which directly and principally benefit the government. The fixed exchange rate mechanism has been shown to be highly efficient for Saudi Arabia (Abdulrahman, 2011). Amidst the decline in the value of the dollar, the stability of this fixed exchange rate has been questioned, resulting in Saudi exports being more affordable and imports becoming more costly. This has put pressure on the country's foreign currency reserves. Oil price shocks have been observed to cause an increase in the Saudi Real Effective Exchange Rate (REER), leading to appreciation and a decrease in trade competitiveness for Saudi Arabia. Nevertheless, the Saudi government was fortunate to benefit from the surging oil prices, which helped alleviate the pressure on their foreign reserves. An important concern arises from the responsiveness of REER and MS to oil price

shocks. Should Saudi Arabia contemplate granting its monetary authorities greater jurisdiction? In order to regulate monetary factors, it is necessary to take into account counter-cyclical monetary policies. The effectiveness of countercyclical fiscal policy in mitigating the impact of dropping global oil prices is limited. A parallel incident took place during the Covid-19 epidemic. The decline in oil prices has a substantial impact on the financial situation in Saudi Arabia. Saudi Arabia should prioritise the growth and consolidation of the financial industry in order to diversify its economic activities in line with the goals of Vision 2030. Suppose the Saudi government aims to enhance the involvement of the private sector. Under these circumstances, it is necessary to grant greater autonomy to its monetary policy. This is due to the positive correlation between the expansion of private sector participation and the increase in foreign exchange earnings. Consequently, the government's share will diminish. This will directly impact the government's budget goals, requiring the participation of a proactive and autonomous monetary authority. To address fluctuations in foreign prices and ensure macroeconomic stability, it is imperative to grant greater authority to the Saudi monetary agency in the context of Saudi Arabia.

Declarations

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Conflicts of interest/Competing interests

There is no conflict of interest/Competing interests

Availability of data and material

The data supporting the findings of this study are publicly available on the websites of the IMF, SAMA, GaStat, and SAMoF.

Code Availability

Not applicable; however, analysis can be provided upon request.

Authors' Contributions

Dr. Syed Mohd Shahzeb conceived the research idea, designed the methodology, conducted the empirical analysis using the SVAR model, and served as the corresponding author. Himanshu Khushwaha contributed primarily to the literature review and supported the refinement of the manuscript. Both authors reviewed and approved the final version of the paper.

Appendix A

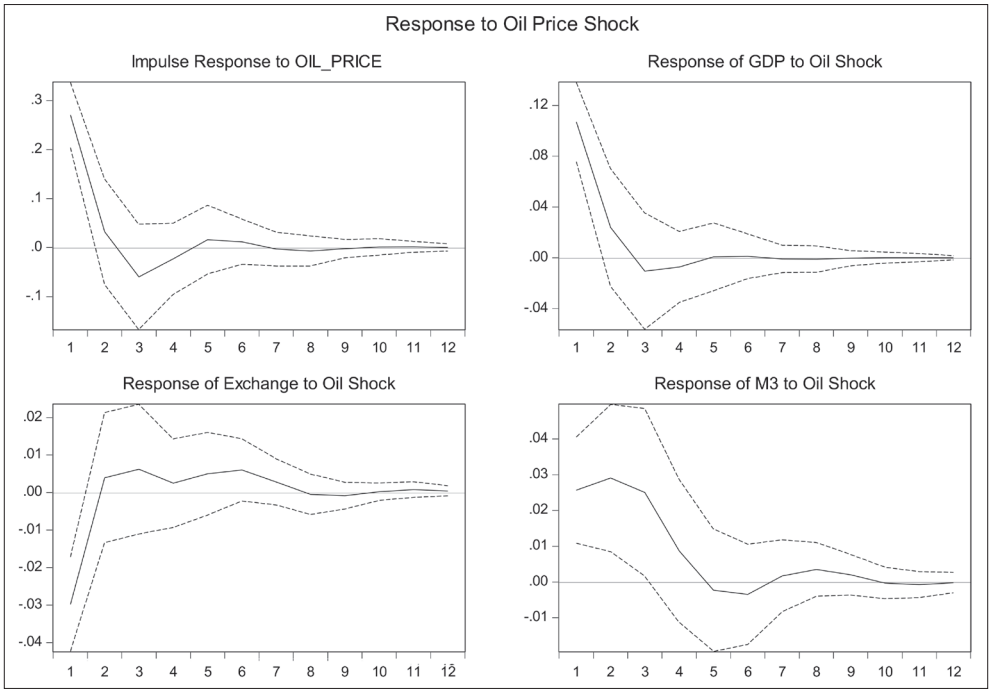
Robustness of the Results

Table A-4: Descriptive statistics of key macroeconomic variables

Indicator	OIL PRICE	REVENUE	DGP	EXCHANGE	CPI	M-3
Mean	0.023	0.047	0.054	-0.022	-0.015	0.069
Median	0.023	0.069	0.059	-0.018	0.125	0.066
Maximum	0.461	0.560	0.240	0.088	5.702	0.247
Minimum	-0.647	-0.770	-0.192	-0.269	-4.938	-0.237
Std. Dev.	0.274	0.311	0.116	0.065	2.411	0.097
Skewness	-0.751	-0.647	-0.392	-1.654	-0.137	-1.298
Kurtosis	3.105	3.097	2.625	7.450	3.176	6.089
Jarque-Bera	3.308	2.455	1.104	44.847	0.155	23.741
Probability	0.191	0.293	0.576	0.000	0.925	0.000
Sum	0.802	1.641	1.907	-0.760	-0.534	2.409
Sum Sq. Dev.	2.559	3.299	0.455	0.145	197.697	0.323
Observations	35	35	35	35	35	35

Source: Author

Figure A-5: Estimated values of impulse response function



Source: Author

Table A-5: Variance Decomposition of GDP

Variance Decomposition of GDP					
Period	**S.E.**	**Oil Price**	**GDP**	**REER**	**M-3**
1	0.117	83.067	16.933	0.000	0.000
2	0.120	83.342	16.335	0.232	0.091
3	0.121	82.685	16.793	0.291	0.231
4	0.121	82.482	16.924	0.339	0.255
5	0.121	82.459	16.926	0.355	0.260
6	0.121	82.443	16.941	0.356	0.261
7	0.121	82.436	16.941	0.356	0.266
8	0.122	82.437	16.940	0.357	0.267
9	0.122	82.437	16.940	0.357	0.267
10	0.122	82.436	16.940	0.357	0.267
11	0.122	82.436	16.940	0.357	0.267
12	0.122	82.436	16.940	0.357	0.267
Variance Decomposition of REER					
Period	**S.E.**	**Oil Price**	**GDP**	**REER**	**M-3**
1	0.042	50.615	0.000	49.385	0.000
2	0.045	44.469	0.079	55.338	0.114
3	0.046	45.092	0.260	53.993	0.655
4	0.046	44.435	1.274	53.301	0.990
5	0.047	44.404	2.238	51.965	1.392
6	0.047	45.294	2.217	51.117	1.372
7	0.047	45.415	2.220	50.988	1.377
8	0.047	45.391	2.219	51.001	1.389
9	0.047	45.387	2.255	50.962	1.397
10	0.047	45.376	2.267	50.955	1.401
11	0.047	45.390	2.267	50.941	1.402
12	0.047	45.394	2.267	50.936	1.403
Variance Decomposition of M3					
Period	**S.E.**	**Oil Price**	**GDP**	**REER**	**M-3**
1	0.046	30.555	1.098	14.676	53.671
2	0.058	44.686	3.217	17.732	34.365
3	0.064	51.743	3.121	16.030	29.105
4	0.066	51.148	3.202	16.173	29.477
5	0.066	50.519	3.281	17.047	29.153
6	0.066	50.523	3.494	16.982	29.001
7	0.066	50.321	3.664	16.912	29.103
8	0.067	50.432	3.653	16.899	29.017
9	0.067	50.463	3.653	16.900	28.984
10	0.067	50.451	3.654	16.902	28.993
11	0.067	50.451	3.657	16.902	28.989
12	0.067	50.450	3.659	16.904	28.988
Factorization: Structural					

Source: Author

NOTES

[1] https://www.r-econometrics.com/timeseries/svarintro/
[2] https://statisticsbyjim.com/basics/correlations/
[3] https://www.britannica.com/place/Saudi-Arabia/Economy

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