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Article

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Symmetric oil price shocks and government expenditure-real exchange rate nexus: ARDL and SVAR models for an oil-based economy, 1970–2018

Abdulaziz Hamad Algaeed^{1*}

Abstract: Historically, oil has been the main source of earnings in the Saudi Arabian economy. Different from other symmetric oil price shock studies, the aim of this paper is to test the impacts of symmetric oil price shocks on government expenditure-real exchange rate nexus and ultimately, to check the conformity of symmetric oil price shock findings to those prevailing in literature. To achieve this endeavor, autoregressive distributed lag (ARDL) and structural vector autoregressive (SVAR) have been employed for the period of 1970 to 2018. The goal of carrying out ARDL and SVAR together is to consolidate and strengthen the consistency of the results obtained from both approaches. Our models' findings support the short-run appreciation of the real exchange rate as a reaction to symmetric oil price shocks and to real government expenditure. The latter finding, though is consistent with Dutch disease predictions. However, in the long-run symmetric oil price shocks negate the real exchange rate. The directional map of causality is as follows: symmetric oil price shocks impact the total earnings of the Saudi government and hence, government spending. Thereafter, the composition of expenditure causes an

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PUBLIC INTEREST STATEMENT

The aim of this paper has been to test empirically the impacts of symmetric oil price shocks and real government expenditure on real exchange rate in an oil-based economy. The findings of this research revealed the existence of a positive impact of symmetric oil price shocks on the real exchange rate, while exists negative impacts in the long run. Furthermore, real government expenditure shocks have impacted the real exchange rate positively. The findings are consistent with Dutch disease literature. This study employed ARDL and SVAR approaches for the sake of confirming and conformity of the findings. As a major oil-producing country, Saudi policy-makers are susceptible to fluctuations of oil prices because the slump in government earnings will hinder the aggregated efforts of maintaining stable economic prosperity and employment. Thus, knowing sources of economic disruption helps in planning future expenditure on local sectors such as education, health, and capital formation.

appreciation of the real exchange rate. Policymakers should consider oil price fluctuations as a source of disturbance to government earnings. Solutions could be carried out by benefiting from other countries' experience.

Subjects: Macroeconomics; Financial economics; Econometrics

Keywords: Government expenditure; ARDL; oil price; exchange rate; symmetric; SVAR

Jel Classifications: C22; C13; E10; G15; F31

1. Introduction

Oil earnings play a major role in the solidity of the Saudi economy nowadays. One of the prominent characteristics of the Saudi Arabian economy is its heavy reliance on oil export earnings and a high degree of openness, making it sensitive to external shocks. Thus, a vulnerable issue for Saudi policymakers is the reality of fluctuating oil prices in global markets. However, government expenditures' impact on exchange rate is a long story with an open end. Undoubtedly, government expenditure looked at as a savior in critical cases, such as in the recent global financial crisis, which is not that far behind. Just as important, in a resource-dependent country, oil price shocks can significantly influence government revenue and expenditure where growth in government revenue tends to accelerate the expansion of non-oil sectors. Furthermore, government expenditure may also induce inflation, leading to appreciation of the local currency (the real effective exchange rate). In this case, competitiveness in traded sectors would be at risk (Khadan, 2016).

The linkage between oil prices and exchange rates is thoroughly discussed in the literature. In this relationship, one channel of transmission is the terms of trade. Trade was related to the nominal exchange rate but did not have a direct impact on it (Raji et al., 2018). Beckmann et al. (2017) identified some theoretical channels between oil prices and exchange rates. Terms of trade are focused on real exchange rates, wealth, and portfolios, assumed that effects flow from the nominal exchange rates to the oil prices. However, the channel of expectations allows a bidirectional causality between oil prices and exchange rates. Accordingly, government expenditure shocks affect output and private consumption jointly with real appreciation of exchange rate (De Castro & Fernández, 2013). Moreover, using rational expectations, unexpected and expected government spending shocks tend to appreciate the German real and nominal exchange rates for the period 1975: 2–1989: 4 (Koray & Chan, 1991). After pioneering work to identify the relationship between variations in oil prices and exchange rates, the next wave of studies focused on discerning the specific influence of oil prices on exchange rate variability (Muhammad et al., 2012). In like manner, the role of political and legal institutions is addressed in the literature. The co-variations between oil prices and real exchange rates depend on the institutional differences for oil-producing countries (Rickne, 2009; Moshiri, 2015).

After the collapse of fixed exchange rates in 1971, Saudi Arabia pegged its currency (the Riyal) to the US dollar. However, in 1975, the Saudi government pegged the Riyal to the Special Drawing Right (SDR) until May 1981, when it reverted to the US dollar. Although the nominal exchange rate is not altered, it changes from time to time to reflect changes in the inflation rate.

The primary objective of this study is to widen the scope of analysis thereby testing empirically the impacts of symmetric oil price shocks and government expenditure on the real exchange rate. In this paper, it is proposed (hypothesized) that symmetric oil price shocks and government expenditures affect the real exchange rate positively (appreciation) in the short run and symmetric oil price shocks negatively in the long run. The current study contributes to the literature by shedding light on the impacts of symmetric oil price shocks and real government expenditure on the real exchange rate in an open oil-based economy covering the period of 1970–2018. The uniqueness of this study stems from the fact that it incorporates ARDL and SVAR models to strengthen and consolidate findings. However, the handful of related studies have concentrated

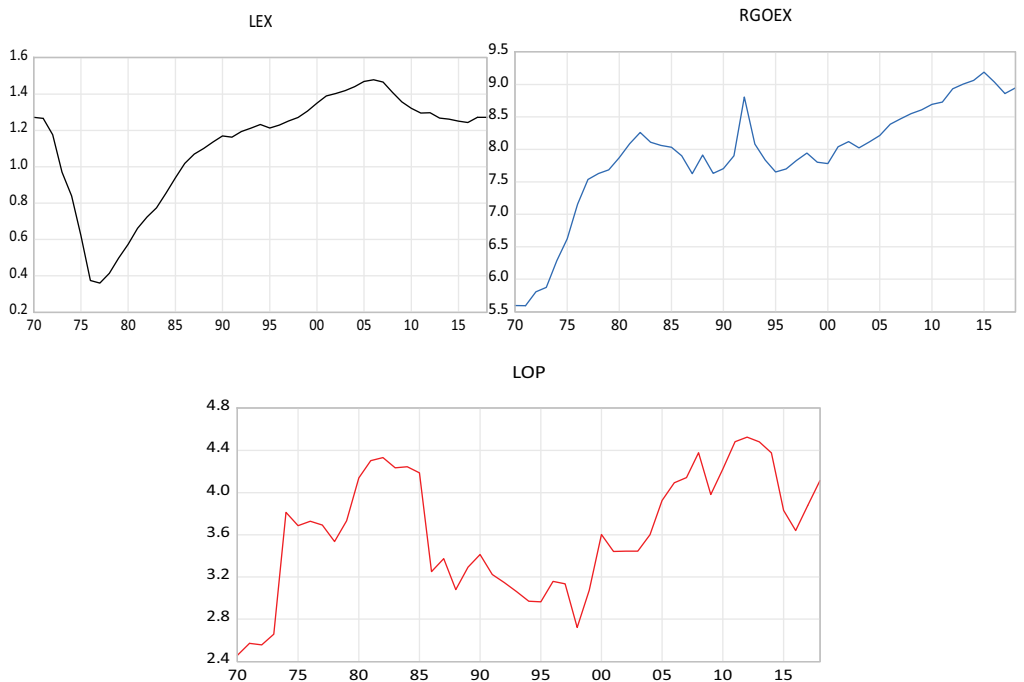
on the association between oil price, oil revenue, government expenditure, and economic growth; see, for example, Al Rasasi and Banafea (2016); and Al Rasasi et al. (2018).

Furthermore, in economic literature, the impact of oil price shocks and government expenditure have tended to appreciate the real exchange rates in oil-producing countries. Thus, the outcomes of this research will be valuable for policymakers, researchers, and others who are interested in understanding the impacts of oil price fluctuations and government expenditure on real exchange rates in the context of a major oil-producing country. Because of Saudi government’s earnings are dominated by windfalls, policymakers can arrange for suitable ways and means to encounter the impacts of oil price shocks and maintain stable real exchange rate. Thus, stable real exchange rate will be reflected on the value of imports and hence, inflation. Inflation surreptitiously affects the value of saving (investment) and causes the redistribution of income and assets. On the other hand, taking precautionary measures against oil price fluctuations will mitigate the slump in government earnings to keep aggregated efforts of maintaining stable economic prosperity and employment. The expected research findings are as follows, symmetric oil price shocks and government expenditure will influence the real exchange rate positively in the short run. However, in the long run, only symmetric oil price shocks influence the real exchange rate negatively. Furthermore, the causality test asserts that symmetric oil price shocks will exert pressure on government expenditure which, in turn, will cause the real exchange rate to appreciate.

Afterward, Figure 1 reflects the direction of real government expenditure, real exchange rate, and symmetric oil prices. It is interesting to note the presence of positive directional movements of the real exchange rate and symmetric oil price with real government expenditure. Besides, the negative directional movements of the real exchange rate with symmetric oil prices.

The remainder of this paper is structured as follows. Section 2 reviews theoretical and empirical oil price shock literature. Section 3 develops ARDL and SVAR models. Section 4 presents the estimation of ARDL and SVAR models, their interpretations, and the discussion of the empirical findings. Section 5 presents the conclusion and some policy suggestions based on the research outcomes.

Figure 1. Log real exchange rate, real government expenditure, and real OPEC basket oil price.



2. Review of related and empirical literature

The potency of fiscal policy in stabilizing the economy has been well documented in the literature. Under flexible exchange rates, an increase in government expenditure will lead to an increase in interest rate and hence, an appreciation of the exchange rate. On the contrary, Karras (2011) points out that, under fixed exchange rates, preventing appreciation of exchange rates requires expansionary monetary policy to further the expansion of government expenditure. He asserts that fiscal policy is more potent under fixed exchange rates than under flexible ones. Using rational expectations, Koray and Chan (1991) found that anticipated and unanticipated government spending caused the real and nominal exchange rates to appreciate. Rickne (2009) illuminated the role of well-developed political and legal institutions in the relationship between oil prices and real exchange rates in oil-exporting countries and found that co-variation between oil prices and real exchange rates was conditional on political and legal institutions. In another interesting study, Adedokun (2018) tested the impacts of oil shocks (prices and revenues) on the dynamic relations between government revenue and expenditure and their impacts on macroeconomic variables. He concluded that oil shocks did not predict variations in government expenditure in the short run but did predict oil revenue in the short and long run. Alternatively, exchange rates tend to respond asymmetrically to shocks in the crude oil market. For instance, Khadan (2016) found that energy shocks had a positive and immediate effect on growth, but this growth was not sustained. Thus, the negative energy revenue shocks had a greater adverse impact on government expenditure. This finding is attributed to the reduction in capital expenditure. Besides, Cakrani et al. (2013) revealed a positive relationship between government spending and the overvaluation of real exchange rates in Albania. It has been argued that a country as an oil exporter (importer) may experience exchange rate appreciation (depreciation) because of an oil price increase (Tasar, 2018; Raji et al., 2018). However, when USD depreciates, oil prices will go up due to higher demand.

Other studies have explored the effects of government expenditure shocks on exchange rates in various contexts and country settings. According to De Castro and Fernández (2013), government expenditure shocks affected output and private consumption jointly. Further, appreciation of Spanish exchange rate resulted from the persistence of the nominal exchange rate and higher relative prices. Miyamoto et al. (2016) used panel data from 125 developing and developed countries and concluded that increasing government expenditure (military spending) caused the real exchange rate to depreciate and consumption to fall in underdeveloped countries, while in developed economies, it was the other way around. Nwosa (2017) found a positive and significant relationship between fiscal policy and the exchange rate in Nigeria.

There have also been studies to probe the impacts of oil price changes and exchange rates in the context of oil-producing countries. Koh (2017) used data for 40 oil-producing countries from 1973 to 2010 and found that countries with fixed exchange rates are experiencing adverse effects from oil price changes and tended to encounter a small and delayed depreciation. Meanwhile, under flexible exchange rates, depreciation was immense. Accordingly, Narayan et al. (2008) examined the relationship between oil price and the Fijian dollar-USD exchange rate using data from 2000 to 2006. They employed GARCH and EGARCH models and found that an increase in oil prices led to an appreciation of the exchange rate. Further, Al-mulali and Sab (2011) discovered that the UAE dirham-USD exchange rate was not an appropriate measure and oil price increases engender liquidity which in turn causes inflation. Moreover, Muhammad et al. (2012) examined the link between oil prices and exchange rate in Nigeria using daily data. Applying generalized autoregressive conditional heteroscedasticity (GARCH) and the exponential (EGARCH) techniques, they confirmed the depreciation of the Nigerian naira-US dollar exchange rate.

In a similar vein, Brahmaire et al. (2014) examined the dynamic short-run and long-run relationships between US-imported oil prices and exchange rates using monthly data from January 1996 to December 2009. They found that in the short run a unidirectional causality runs

from exchange rate to oil prices. Moreover, in the long run, causality runs from oil prices to the exchange rate. Nonetheless, Osuji (2015) examined the impact of oil price changes on the USD-Naira exchange rate using daily data from January 2008 to December 2014. He discovered that the relative oil price significantly affected the exchange rate. Moreover, the evidence indicated the existence of unidirectional causality running from oil prices to exchange rate.

Along the same lines, Babatunde (2015) examined the impact of oil price changes on the exchange rate in Nigeria. He found that an increase/decrease in oil price resulted in a depreciation/appreciation of the exchange rate. In the same manner, Atems et al. (2015) pointed out that oil supply shocks had no effects on exchange rates, while global aggregated demand and oil-specific demand tended to result in exchange rate appreciation. Furthermore, Hashimova (2017) showed that the fall in oil prices caused the depreciation of Azerbaijan's currency. In contrast, Baghestani and Toledo (2019) confirmed that oil price movements predict the direction in the real exchange rate up to 3 months for Canada, Mexico, and the US. Furthermore, in linking 65 major currencies, Wen and Wang (2020) indicated that the US dollar and the Euro are the major transmitters of volatility. Therefore, volatilities are sensitive to international economic fundamentals. As a result, oil exports, among other related variables, cause volatility transmission across world markets.

Further elaborating on this topic, Garcia et al. (2018) found that increases/decreases in spot oil prices caused appreciation/depreciation in the peso/USD exchange rate. However, future prices had no effect on the exchange rate. Accordingly, Raji et al. (2018) indicated a unidirectional effect from oil price to the foreign exchange rate, and an increase in oil price led to an appreciation in the Nigerian naira-USD exchange rate. On the other hand, Samhi and Mohamed (2018) concluded that variations in the Algerian dinar against the US dollar tended to depreciate the dinar. Mohammed et al. (2019) examined the relationship between oil prices and the Nigerian naira-USD exchange rate using daily data and found that an increase in oil prices led to an increase in the naira-USD exchange rate. By the same token, Nusair and Olson (2019) tested the impacts of oil price shocks on exchange rates in seven Asian countries Indonesia; Japan; Korea; Malaysia; Philippines; Korea, and Thailand. They found a symmetric effect on exchange rate depends on each country's currency status. With the preceding analyses in mind, Olayungbo (2019) examined the relative Granger causal impacts of oil price on exchange in Nigeria and did not find a Granger causal relationship between oil price and exchange rate. Equally, Yiew et al. (2019) confirmed the existence of asymmetric cointegration between oil prices and exchange rates. Contrary to previous findings, Kaushik et al. (2014) suggested that oil price changes did not affect the real exchange rate in India. Conversely, Tasar (2018) asserted that causality is running from oil price shocks to the exchange rate in Romania.

Empirical studies that dealt with the Saudi case are numbered. Aleisa and Dibooğlu (2002) examined sources of real exchange rate volatility in Saudi Arabia using monthly data from January 1980 until February 2000. They segregated changes into real and nominal and discovered that real shocks significantly affected real exchange movements. Additionally, they found that oil production shocks were responsible for the real exchange rate variations. Furthermore, Abdel-Latif et al. (2018) examined the impacts of oil price shocks on government health and education expenditure in Saudi Arabia. They found a non-linear relationship between oil price shocks and government expenditure. Moreover, long-run negative oil price shocks affected government expenditures, especially in the health sector, while long-run positive oil price shocks provided economic benefits. Therefore, it did not lead to increased expenditures on health. Accordingly, Nouria et al. (2018) examined the influence of oil price movements on the exchange rates in some of the MENA countries (Egypt, Jordan, Morocco, Qatar, Saudi Arabia, Tunisia, and the UAE). They concluded that an increase in oil prices caused an appreciation of exchange rates in Saudi Arabia and Tunisia. However, the drop in oil prices depreciated the exchange rates only in Saudi Arabia. Furthermore, a rise in oil prices led to exchange rate fluctuations in Tunisia and Saudi Arabia.

All in all, there is no consensus amongst economists that oil price shocks and government expenditure impact real exchange rates positively. However, Narayan et al. (2008), Nouria et al. (2018), Garcia et al. (2018), Mohammed et al. (2019), Tasar (2018), and Baghestani and Toledo (2019) found that oil price shocks affect real exchange rates positively (appreciation). On the other hand, government expenditure tends to appreciate real exchange rates, Nwosa (2017) and Cakrani et al. (2013) concluded that rise in government expenditure appreciates exchange rates. Though, in this paper, symmetric oil price shocks tend to appreciate the real exchange rate in short run and negatively in long run. Additionally, real government expenditure appreciates the real exchange rate in the short and long run.

Having reviewed literature, this paper contributes to the existing literature by adding evidence of thorough and deep analysis of the impact of symmetric oil price shocks and real government expenditure on the real exchange rate for a major oil-producing country. The impacts of symmetric oil price shocks and government expenditure on the real exchange rate are susceptible and vital for policymakers. It assists them in identifying sources of disturbance to government revenues and help overcome the government's budget imbalance. Afterward, addressing the conformity of our economic findings to researchers' outcomes is an addition.

3. Research methodology

3.1. The ARDL model

Following Adedokun (2018) as a starting theoretical foundation, an eclectic model has been developed and adopted to test the impacts of symmetric oil price shocks and real government expenditure on the real exchange rate. The model is constructed as a log-linear ad hoc model specified to include the following variables:

$$LEX_t = \beta_0 + \beta_{1t}LOP + \beta_{2t}RGOEX + U_t \quad (1)$$

where LEX_t is the real bilateral Riyal-USD exchange rate, calculated according to the following formula: $LEX_t = \log(\text{Riyal} * \text{US CPI} / \text{Saudi CPI})$. LOP_t is the OPEC basket real oil price; $RGOEX_t$ is the real government expenditure and U_t is an error term. According to Dutch disease literature, an increase in oil price would cause a positive impact on the real exchange rate. However, a rise in government expenditure would also cause an appreciation of the exchange rate. The latter is called the spending effect.

The autoregressive distributed lag (ARDL) was first introduced and applied by Pesaran and Shin (1999) with the characteristic that not all variables are required to be stationary at I (0) or I (1). One major advantage of this test is that it is based on a single ARDL equation rather than on a VAR as in the Johansen approach. As a result, the number of estimated parameters is reduced. In contrast, unlike Johansen's model, several restrictions can be easily imposed on each separate variable. The ARDL test does not require pre-testing for the order of integration (Khalil and Dombrecht 2011). Furthermore, this approach collapses in the case of an integrated stochastic trend. Thus, the ARDL (p, q) model can be specified as the unrestricted error correction version as follows:

$$\Delta LEX = \Gamma_0 + \sum_{i=1}^n \Gamma_{1i} \Delta LEX_{t-i} + \sum_{i=0}^n \Gamma_{2i} \Delta LOP_{t-i} + \sum_{i=0}^n \Gamma_{3i} \Delta RGOEX_{t-i} + \alpha_1 LEX_{t-1} + \alpha_2 LOP_{t-1} + \alpha_3 RGOEX_{t-1} + e_{1t} \quad (2)$$

where Γ_{ti} with $t = 1, 2,$ and 3 represents short-run dynamic coefficients. The ARDL model includes the log real bilateral exchange rate, the real log government expenditure, and the log real OPEC oil price basket. Similarly, α_1 to α_3 represent the long-run relationships, while Γ_1 to Γ_3 represent the short-run dynamics of the model. As has been noted, because of the existence of long-run

relationships among the variables LEX_t , $RGOEX_t$, and LOP_t , bound testing is performed, which depends on an F-test to examine the possibility of co-integration (long-run relationships) among the variables. If the F-value is higher than the upper bound, we reject H_0 and conclude that there are co-integrated variables, such that:

$$H_0: \alpha_1 = \alpha_2 = \alpha_3 = 0$$

By the same token, if the F-value is less than the lower bound, H_0 is accepted, and the variables are not co-integrated. So, in the case of no long-run relationships among the variables:

$$H_1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq 0$$

The error correction model of ARDL is shown in equation (3). The speed of adjustment is represented by δ_1 . Eventually, the short-run correction model relationships presented in this analysis are specified as follows:

$$\Delta LEX_t = \Gamma_0 + \sum_{i=1}^n \Gamma_{1i} \Delta LEX_{t-i} + \sum_{i=0}^n \Gamma_{2i} \Delta LOP_{t-i} + \sum_{i=0}^n \Gamma_{3i} \Delta RGOEX_{t-i} + \delta_1 ECM_{t-1} + u_{1t} \quad (3)$$

Testing for ECM is desirable because it reveals the speed of adjustment and the way the variables converge toward long-run equilibrium. If the expected ECM_{t-1} with δ_1 is negative and significant, the variations between the dependent and independent variables are easily corrected to stable long-run relationships. The negative percentage of disequilibrium of the past year will return to long-run equilibrium in the following year. Hence, the explanatory variables will converge to long-run equilibrium at a certain speed, given by the magnitude of δ_1 .

3.2. Structural vector autoregression (SVAR)

Vector autoregressive (VAR) plays a pivotal role in describing the dynamic behavior of economic and financial determinants of time series. Consequently, VAR forecasts are flexible because they are built on the prospect of the future path of a variable. In addition, VAR is used for structural deduction and policy-making analysis. Following the economic literature (e.g., Su et al. 2016) that addresses the impacts of oil price structural shocks on the government-exchange rate nexus, a reduced form VAR model can be specified as follows:

$$Y_t = \beta + \sum_{i=1}^p A_i y_{t-i} + e_t \quad (4)$$

where y_t is the 3-vector of endogenous variables that includes the percentage change in LOP_t , $RGOEX_t$, and LEX_t . β is the 3-vector of intercept coefficients to be estimated. e_t is a 3-vector of innovations, which may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all the right-hand side variables. It is assumed further that e_t is related to fundamental oil price shocks Π_t according to $e_t = A_0^{-1} \Pi_t$. Equation (4) can be rewritten as the VAR oil price shocks structural model as follows:

$$A_0 y_t = A_0 \beta + \sum_{i=1}^p A_0 A_i y_{t-i} + \varepsilon_t \quad (5)$$

Given the vector autoregressive model (VAR), the impulse response function (IRF) measures the reaction of one variable to a shock coming from another variable. The advantage of using VAR in the case of exchange rates, real government expenditure, and symmetric oil prices is that the variables are dynamic and can be evaluated without referring to causality (Beckmann et al., 2017). On the other hand, structural vector autoregressive (SVAR) can easily and precisely distinguish between different shocks.

$$\begin{pmatrix} \Delta(LOP) \\ \Delta(RGOEX) \\ \Delta(LEX) \end{pmatrix} = \begin{pmatrix} a_{11}(H) & 0 & 0 \\ a_{21}(H) & a_{22}(H) & 0 \\ a_{31}(H) & a_{32}(H) & a_{33}(H) \end{pmatrix} \begin{pmatrix} \varepsilon_t LOP \\ \varepsilon_t RGOEX \\ \varepsilon_t LEX \end{pmatrix}$$

where a_{ij} are matrices in lag operator H , such that $H^K x_t = x_{t-K}$; a_{ij} is estimated coefficient j , $a_{ij} = \sum_k a_{ij} H^k$ is the sum of the moving average coefficients for $K = 1, 2, \dots, \rho$, where ρ is the degree of polynomial $a_{ij}(H)$. It is the optimal lag operator of the VAR. \square_t^{LOP} , \square_t^{RGOEX} , and \square_t^{LEX} are structural shocks. Utilizing Cholesky decomposition in an identified structural VAR, it could be implemented according to the above structure. The long-run restrictions that are imposed are as follows:

- (1) Government expenditure and the exchange rate do respond to symmetric oil price shocks contemporaneously. Thus, $a_{12} = a_{13} = 0$. Studies have mentioned that oil price causes an appreciation or depreciation of the exchange rates in oil-based economies (see, e.g., Narayan et al., 2008; Hashimova, 2017; and Noura et al. 2018). On the other hand, government expenditure will respond positively to symmetric oil price changes.
- (2) Oil price does not respond to government expenditure nor to exchange rate shocks.
- (3) Exchange rate responds to symmetric oil price shocks and government expenditure shocks contemporaneously. Hence, $a_{23} = a_{13} = 0$, which is consistent with Dutch disease theory (Corden, 1984).

4. Results and discussion

4.1. Descriptive statistics

Before indulging into analysis of results, descriptive statistics are presented. It is useful to explore the meaningfulness of the impacts of symmetric oil price shocks on government expenditure-real exchange rate nexus thereby different statistical measurements of the variables. Table 1 reports the summary statistics of the variables of this study.

From Table 1, the average value of government expenditure is (32,399.70) in millions of Saudi Riyals (local currency). For example, in 2015, government expenditure reached the peak with a value of 1,140,603 million reflecting an increase of 190 times the government expenditure value in 1970. After 2015, the value fluctuated enormously to reflect the unstable movements in

Table 1. Results of descriptive statistics of government expenditure (GOEX), oil prices (OP), and real exchange rate (EX) for the period of 1970–2018

Components	Oil price (OP)	Real exchange rate (EX)	Government expenditure (GOEX)
Mean	43.33429	3.174893	323,997.5
Median	38.13000	3.431237	221,272.0
Maximum	92.40000	4.391062	1,140,603
Minimum	11.67000	1.433129	6028.000
Std. Dev.	22.98370	0.830504	295,726.8
Skewness	0.530388	-0.685432	1.342782
Kurtosis	2.128458	2.454947	3.716943
Jarque-Bera	3.848197	4.443379	15.77445
Probability	0.146007	0.108426	0.000376
Sum	2123.380	155.5698	15,875,877
Sum Sq. Dev.	25,356.03	33.10740	4.20E+12
Observations	49	49	49

the world oil market. Similarly, the average oil price is 43.33 USD with the maximum of 92.4 USD in 2014. Though the minimum oil price is 11.67 USD in 1970. Between 1970 and 2018 the oil market experienced ups and downs due to political instability. Furthermore, the average real exchange rate is 3.17 (Saudi riyal per US dollar) with a maximum of 4.39 in 2006 and a minimum of 1.43 in 1977. Equally important, the standard deviation of the variables $GOEX_t$, OP_t , and EX_t is 295,012.6, 22.98, and 0.831, respectively. This means that the most volatile is $GOEX_t$ (295,727), while the least volatile is EX_t with (0.831). The variables $GOEX_t$ and OP_t are positively skewed while EX_t is negatively skewed. The higher positive skewness could be attributed to higher incremental values of the variable. On the other hand, the steepness measure is with the coefficient of 3.72 for $GOEX_t$, 2.45 for OP_t , and 2.13 for EX_t . Finally, J-B suggests the probability of less than 5% for the variable $GOEX_t$ and normally distributed. However, OP_t and EX_t may not normally distribute with probability greater than 5%. Data used in this paper are sourced from the Saudi Arabian Monetary Agency (SAMA), yearly statistics 2019, and International financial statistics (IFS).

4.2. The unit root test

Kaushik et al. (2014) explain the importance of using stationary data, where the use of non-stationary data can yield spurious outcomes. An augmented Dicky–Fuller test is performed in this form:

$$\Delta X_t = \alpha + \rho_t + \Delta X_{t-1} \sum_{i=0}^n \delta_i + \Delta Y_{t-1} + \varepsilon_t \tag{6}$$

where X_t is the variable under consideration, Δ is the first difference operator, t is a time trend, and ε_t is a stationary random error term. If the null hypothesis $\delta = 0$ is not rejected, the variable series contains a unit root and is non-stationary. The optimal lag length in equation (6) is identified by ensuring that the error term is a white noise error term. In addition to the augmented Dicky–Fuller test, a Phillips-Perron test is also conducted to ensure the stationarity of the series. The Phillips-Perron test uses non-parametric correction to deal with any correlation in error terms.

The aim of this test is to check whether a linear combination of integrated variables becomes stationary over a long-run period. If this happens, then there is co-integration among variables. Unit root tests, ADF, and PP are applied. Levels and first differences are included for each test. Table 2 shows that for the ADF test, none of the variables LOP_t , $RGOEX_t$, and LEX_t are stationary at the level. The reason is that the values of the test statistics for the variables are less than the critical values of the ADF statistics (Jibir & Aluthge, 2019). Results indicate that the null hypothesis of non-stationarity cannot be rejected at all levels. Nevertheless, all variables become stationary at the first difference and the ADF test statistics' values are greater than the critical values at 1%, 5%, and 10% level of significance. Thus, the results indicate that LOP_t , $RGOEX_t$, and LEX_t are stationary at the first difference and cannot be rejected. To repeat, the stationary properties of the variables according to ADF and PP tests confirm that all the variables are not integrated of order zero I (0). However, all variables (LOP_t , $RGOEX_t$, and LEX_t) are integrated of the order one I (1). This suggests a random walk trend. At the integrated level of one, all variables are significant, ranging between 1% and 5% level of significance.

Table 2. Augmented-Dickey Fuller and Phillips-Perron tests

	Augmented-Dickey Fuller		Phillips- Perron	
	Level	1 st Difference	Level	1 st Difference
LEX_t	-2.352	-2.401**	-1.4966	-2.600***
$RGOEX_t$	-2.579	-6.375*	-2.638	-6.383*
LOP_t	-2.396	-6.603*	-2.428	-6.597*

*, **, and *** are statistically significant at 1%, 5% and 10% level, respectively.

Lag	Log L	LR	FPE	AIC	SC	HQ
0	-69.02724	NA	0.004930	3.3201211	3.321655	3.246111
1	72.38961	257.6929	1.37e-05	-2.683983	-2.202206	-2.504381
2	95.51657	39.05886*	7.37e-06*	-3.311847*	-2.468738*	-2.997545*
3	99.77479	6.623909	9.24e-06	-3.101102	-1.896660	-2.652098

* significant at 5 percent level

In addition, applying the PP test allowed for results in line with ADF test. The outcomes of the ADF and PP tests confirm that the variables are of order I (1), which paves the way to introduce and apply the ARDL approach.

Considering the foregoing analysis, the strength of Akaike information criterion over other criteria is based on the following fact, 20 different ARDL models are performed. The lower value of AIC is selected, that is (2, 4, 0) which gives the lowest values of AIC. Moreover, Figure 2 illustrates the strength of the selected model criteria.

4.3. The ARDL regression model

The autoregressive distributed lag (ARDL) approach is particularly useful in analyzing economic scenarios in small data samples. In these instances, a change in one variable will bring about changes in another variable, and changes in variables may not be immediate but will be distributed over time. Likewise, ARDL is built on several assumptions that there is no autocorrelation; there is no heteroscedasticity in the data (variance and mean are constant), and the data must be stationary. Therefore, ARDL is useful for determining long-run relationships among variables.

The estimation results are presented in Table 4. Symmetric oil price shocks are statistically insignificant at the 5% level. Ten percent increase in the symmetric oil price shocks leads to 0.11% appreciation of the real exchange rate, while 10% increase in the symmetric oil price shocks lagged one year causes a 0.53% depreciation in the exchange rate and is statistically significant at 5% level. However, the coefficient of depreciation of the real exchange rate is consistent with the findings of Muhammad et al. (2012) and Smahi and Mohamed (2018). On the contrary, 10% increase in symmetric oil price shocks lagged three years causes 0.64% appreciation of the exchange rate which is in line with predictions of Dutch disease theory. Furthermore, it is statistically significant at 5% level. Also, the results from Table 4 point out that 10% increase in real

Figure 2. The strength of model selection criteria.

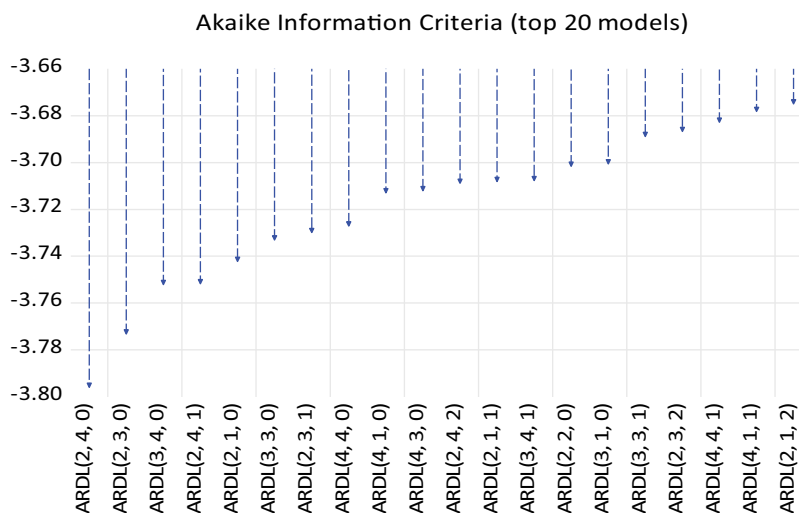


Table 4. The ARDL regression with dependent variable LEX

Variable	Coefficient	St. Error	t-Statistic	Probability
LEX (-1)	1.618584	0.086101	18.79872	0.0000
LEX (-2)	-0.697427	0.081406	-8.567229	0.0000
LOP	0.011082	0.017768	0.623679	0.5368
LOP (-1)	-0.053306	0.023479	-2.270347	0.0293
LOP (-2)	-0.023472	0.023590	-0.994999	0.3264
LOP (-3)	0.063710	0.023748	2.682709	0.0110
LOP (-4)	-0.029507	0.018648	-1.582378	0.1223
RGOEEX	0.038861	0.016459	2.361034	0.0238
C	-0.106811	0.080200	-1.331820	0.1913
R^2	0.991196			
Adjusted R^2	0.989239			
F-Statistics	506.6182			
D-W	2.026369			

government expenditure induces 0.40% appreciation of the exchange rate. This finding is statistically significant at the 5% level and consistent with Dutch disease literature (spending effect). As expected earlier, the ARDL coefficients of independent variables reflected the right signs. To be specific, a priori expectations of positive impacts of symmetric oil price shocks and real government expenditure on the real exchange rate are conspicuous.

On the other hand, the adjusted R-square of 0.99 suggests that 99% of variations in the dependent variables is well explained by the independent variables. The probability of the F-test is statistically significant indicating that the regressors jointly and significantly influence the regression. The D-W statistic is 2.02, suggesting the absence of the first-order autocorrelation.

To sum, symmetric oil price shocks and real government expenditure had the expected signs. However, the impact of symmetric oil price shocks on the real exchange rate is somewhat low. This suggests that, according to the causality test, LOP_t does Granger cause $RGOEEX_t$, and in turn, $RGOEEX_t$ does Granger cause LEX_t . Thus, based on earlier results, the significant effect of the symmetric oil price shocks on the real exchange rate is not spontaneous but materializes after 3 years.

To consolidate earlier findings, fully modified ordinary least square (FMOLS) is introduced. FMOLS is a non-parametric approach that works on correcting autocorrelations between independent variables and the error term. Besides, it corrects heteroscedasticity. Accordingly, the results obtained from the fully modified ordinary least square (FOLS) test are presented in Table 5. The findings are consistent with the results obtained from ARDL. A 10% change in symmetric oil price shocks causes 3.5% depreciation of the real exchange rate. Symmetric oil price shock coefficient is statistically significant at 5%. Furthermore, 10% increase in real government expenditure, $RGOEEX_t$, would cause a 3.0% appreciation of the real exchange rate. Thus, $RGOEEX_t$ is statistically significant at the 5% level. It is important to note that FMOLS confirms long-run co-integration coefficients.

4.4. The ARDL short-run, long-run, and bounds testing

Based on Table 6, short-run values of the coefficients are not statistically significant, except the symmetric oil price shocks lagged 2 years. However, the negative sign indicates a depreciation of the real exchange rate. The error correction model has a negative sign and is significant at the 1% level. This points out the existence of long-run relationships among the variables LEX_t , $RGOEEX_t$, and LOP_t . The speed of adjustment of short-run variables to the long-run equilibrium for the error correction model, ECM_{-1} , is a bit low and is 8%. This finding indicates that the last period's

Table 5. FMOLS estimates with dependent variable LEX

Variable	Coefficient	St. Error	t-Statistic	Probability
LOP	-0.348834	0.150043	-2.324902	0.0246
RGOEX	0.299605	0.100510	2.980855	0.0046
C	0.029535	0.638415	0.046263	0.9633
R^2	0.255738			
Adjusted R^2	0.222660			
Long-run variance	0.201289			

Table 6. The ARDL error correction dependent variable LEX

Variable	Coefficient	St. Error	t-Statistic	Probability
D (LEX (-1))	0.697427	0.075502	9.237219	0.0000*
D (LOP)	0.011082	0.015953	0.694650	0.4917
D (LOP (-1))	-0.0110731	0.016438	-0.652815	0.5180
D (LOP (-2))	-0.034203	0.016224	-2.108134	0.0420*
D (LOP (-3))	0.029507	0.017074	1.728181	0.0925
Co-int Eq (-1)	-0.078843	0.019999	-3.942355	0.0004*
R^2	0.801188			
Adjusted R^2	0.775700			
Log likelihood	94.38760			
D-W	2.026369			

* significant at 5 percent level

Table 7. Long-run estimates with dependent variable LEX

Variable	Coefficient	St. Error	t-Statistics	Probability
LOP	-0.399450	0.192951	-2.070212	0.0457*
RGOEX	0.492885	0.152540	3.231186	0.0026*
C	-1.354734	0.940573	-1.440328	0.1584

* significant at 5 percent level

disequilibrium is corrected at a speed of 8% annually, and though suggesting a convergence of our model's variables to long-run equilibrium at a speed of 8% a year. The low speed of adjustment is justified on the grounds that the volatility of oil prices affects the total government oil earnings, and in turn, affects the internal and external demand of goods and services which will impact the exchange rate. Equally important, in examining the long-run results, Table 7, one notices that symmetric oil price shocks cause 40% of the depreciation of the real exchange rate, and real government expenditure accounts for 50% of the appreciation of the real exchange rate. Both LOP_t and $RGOEX_t$ coefficients are statistically significant at the 5%

Table 8. Serial correlation LM test

Breusch-Godfrey Serial Correlation LM Test: Null hypothesis: No serial correlation at up to 2 lags			
F-statistics	1.597533	Prob. F (2,23)	0.2172
Obs.* R^2	3.865511	Prob. Chi-square (2)	0.1447

Table 9. F-bBounds test				
Test statistics	Value	Significant	I (0)	I (1)
Asymptotic: n = 100				
F-statistics	3.586653	10%	2.63	3.35
K	2	5%	3.10	3.87
		1%	4.13	5

Table 10. Heteroskedasticity test			
Breusch-Pagan-Godfrey heteroskedasticity test: null hypothesis: homoskedasticity			
F-statistics	7.309587	Prob. F (8,36)	0.0000
Obs.*R ²	27.85291	Prob. Chi-square (8)	0.0005
Scaled explained SS	21.96295	Prob. Chi-square (8)	0.0050

level. Therefore, appreciation caused by government expenditure tends to influence domestic prices, which in turn impacts terms of trade.

To ensure the consistency of the model, several statistical tests have been performed. The model passed the serial correlation test. From Table 8, Breusch-Godfrey serial correlation LM test with probability value of (0.2172) indicates the rejection of the null hypothesis of the presence of serial correlation. Subsequently, for the bound testing, Table 9 shows that the F-statistic value is about 3.58%, which is greater than the upper bound at the 10% level. This suggests the rejection of the null hypothesis that there exists no co-integration among all variables. For the normality test, Table 10 shows that there is no heteroscedasticity.

Furthermore, to check the stability of the model, the CUSUM and CUSUMQ tests are implemented. It was determined that the long-run coefficients and short-run dynamics of the ARDL estimates are stable. Thus, Figure 3 shows the stability of the model.

4.5. Variance decomposition

The relative importance of shocks is usually determined through variance decomposition. In fact, variance decomposition reveals the effects of one variable on the remaining variables of the structural vector autoregression (SVAR). Table 11 shows the percentage of forecast error variance for each shock. About 31% of the variations in symmetric oil price shocks LOP_t explained by its own shocks in the first year. As time passes, it diminishes to about 11% by the end of the tenth year. Just as important, the response of symmetric oil price shocks to real government expenditure $RGOEX_t$ and to the real exchange rate (LEX_t) is almost negligible after the period of the tenth year. Similarly, the response of

Figure 3. Stability test of the model.

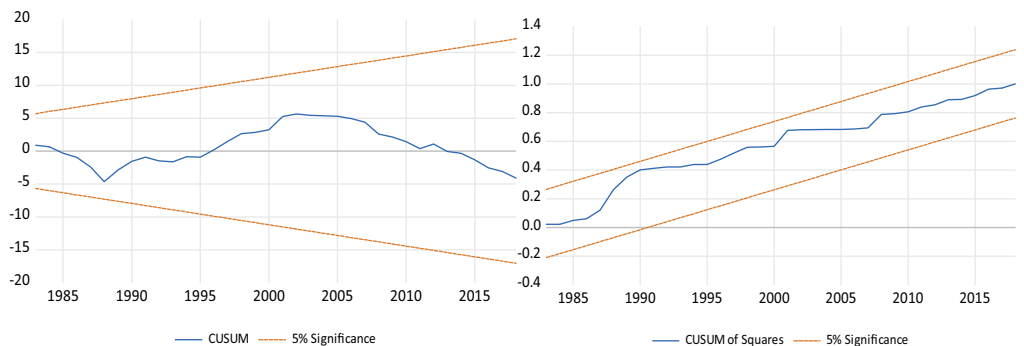


Table 11. Variance decomposition

Response of LOP to:			Response of RGOEX to:			Response of LEX to:			
Period	LOP	RGOEX	LEX	LOP	RGOEX	LEX	LOP	RGOEX	LEX
1	0.3087	0.0000	0.0000	0.0457	0.3095	0.0000	0.0416	0.2786	0.2892
2	0.3087	0.0000	0.0000	0.3344	0.3095	0.0000	0.3961	0.5882	0.2892
3	0.2576	0.0048	0.0064	0.4384	0.2960	0.0343	0.6694	0.6281	0.2292
4	0.2129	0.0165	0.0127	0.4668	0.3240	0.0749	0.6908	0.5951	0.2099
5	0.1825	0.0283	0.0166	0.5072	0.3668	0.1050	0.6396	0.5972	0.2193
6	0.1599	0.0372	0.0187	0.5477	0.4049	0.1260	0.6253	0.6284	0.2317
7	0.1413	0.0441	0.0203	0.5754	0.4374	0.1430	0.6463	0.6637	0.2403
8	0.1259	0.0499	0.0217	0.5929	0.4681	0.1583	0.6771	0.6954	0.2481
9	0.1139	0.0553	0.0230	0.6068	0.4991	0.1723	0.7079	0.7266	0.2574
10	0.1052	0.0603	0.0242	0.6210	0.5304	0.1852	0.7398	0.7598	0.2683

Cholesky Ordering: LOP, RGOEX, and LEX

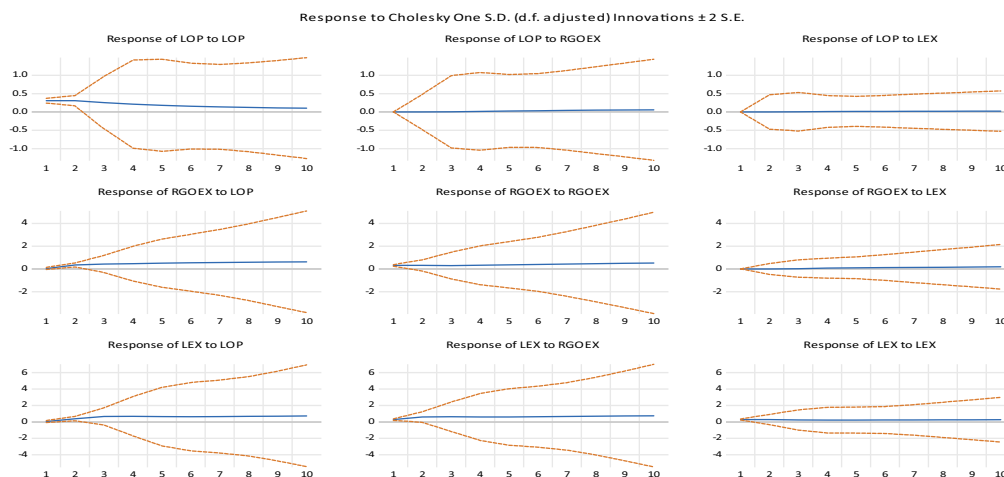
RGOEX_t to symmetric oil price shocks has risen from 5% to about 62% after the tenth year. In contrast, the response of RGOEX_t to LEX_t is about 19% by the end of the tenth year. It is interesting to note that the response of LEX_t to symmetric oil price shocks increased from 4% in the first year to a striking magnitude of 74% after the time span. The positive influence of the symmetric oil price shocks on LEX_t reveals an appreciation of the real exchange rate LEX_t. However, 29% of the contribution to variations in LEX_t is attributed to its own shocks in the first year. After that, it started to diminish till the end of the period.

All in all, it is easy to observe that between 74% and 76% of variations in the real exchange rate, LEX_t, is explained by the symmetric oil price shocks, LOP_t, and the real government expenditure, RGOEX_t, respectively. These conclusions strongly support the ARDL and FMOLS findings.

4.6. Impulse response function

Figure 4 reports the impulse response of innovations of symmetric oil price shocks, real government expenditure, and real exchange rate over a ten-year horizon. One standard deviation of oil price shocks to LEX_t is positive and continues to be positive in the long run; one standard deviation of real government expenditure to the real exchange rate LEX_t is positively significant and continues to be significant in the long run; one standard deviation of the real exchange rate LEX_t to LEX_t is positive (22%–29%) and

Figure 4. Responses of RGOEX_t, LEX_t to symmetric oil price shocks LOP_t.



continues to be positive in the long run; and finally, one standard deviation of symmetric oil price shocks to government expenditure is positively significant and continues to be so in the long run. Consequently, one standard deviation of symmetric oil price shocks, LOP_t , and real government expenditure shocks, $RGOEX_t$, to the real exchange rate, LEX_t , are positive and long-run lasting.

4.7. The discussion

Having specified the baseline model, which relied on the work of Adedokun (2018), supporting data are sourced from Saudi Arabian monetary agency (SAMA) yearly statistics and from international financial statistics (IFS). An ad hoc model has been formulated to test the impacts of symmetric oil price shocks and government expenditure on the real exchange rate. The real exchange rate is regressed against real government expenditure and symmetric oil price. All variables are transformed into log-linear form.

To perform this analysis, an autoregressive distributed lag and structural autoregressive models are tested to see how much real exchange rate is impacted by the symmetric oil price shocks and the real government expenditure. Prior to executing these tests, the unit root test is launched. At the integrated level of one, all variables are statistically significant at 1% and 5% level, respectively. On the other hand, the ARDL model test shows that 10% increase in symmetric oil price shocks leads to an appreciation of the real exchange rate by 0.11%. However, a rise in real government expenditure by 10% would cause an appreciation of the real exchange rate by 0.40%. Of equal importance, in the long run, and other things equal, 10% increase in symmetric oil price shocks would lead to a 3.5% to 4% depreciation of real exchange. Nevertheless, 10% rise in real government expenditure would cause between 3% to 5% appreciation of the real exchange rate in the long run.

Furthermore, the analysis of SVAR tends to confirm the findings stemmed from the ARDL model test. It is worthwhile to note that between 74% and 76% of variations in the real exchange rate, LEX_t , are explained by the symmetric oil price shocks, LOP_t , and the real government expenditure, $RGOEX_t$, respectively. Our results are consistent with researchers' findings in economic literature where positive oil price shocks tend to appreciate/depreciate the real exchange rates (Tasar, 2018;; Raji et al., 2018). Besides, the impulse response function, IRF confirms that one standard deviation of symmetric oil price shocks, LOP_t , and real government expenditure shocks, $RGOEX_t$, to the real exchange rate, LEX_t , is significantly positive and long-run lasting.

In addition, the speed of convergence from short-run to long-run equilibrium is 8% and warranted on the basis that the impacts of symmetric oil price shocks on the real exchange rate via the effects of government expenditure take time. Furthermore, statistical robustness tests revealed the stability of the model and no serial correlations.

At last, the results obtained in this research are in line with the findings of Muhammed et al. (2012); Brini et al. (2016), Nouria et al. (2018), Raji et al. (2018), Garcia et al. (2018), Tasar (2018), Mohammed et al. (2019), and Babatunde (2015), and others.

5. Conclusion and policy recommendations

The impact of symmetric oil price shocks on exchange rates is not yet a settled issue among economists. In economic literature, studies have concluded both appreciation and depreciation of real exchange rates due to symmetric and a symmetric oil price shocks. Different from other symmetric oil price shock studies, this work analyzed and estimated the effects of symmetric oil price shocks and real government expenditure on the real exchange rate for the period of 1970 until 2018. Eclectic ARDL and SVAR models were developed and tested. Additional FMOLS test is carried out to widen and strengthen the quality of research outcomes. The ADF and PP tests showed stationary time series at the first difference. Furthermore, error correction and bounds test revealed a clear and concise long-run relationships among the variables LOP_t , $RGOEX_t$, and LEX_t .

The major hypothesis of this study was that symmetric oil price shocks and real government expenditure affect the real exchange rate positively and therefore, found to be inclined to Dutch disease theory. The ECM_{t-1} is statistically negative at a 1% level, and the error correction model reveals (0.08%) yearly speed of adjustment from the short run to the long-run equilibrium. This is somewhat low, indicating that the adjustment process from the short run to the long run takes a considerable time. The justification for low adjustment process is that, according to the causality test, the symmetric oil price shocks affect the government's oil income and then, expenditure. Hence, the expenditure's impacts will be transmitted into the real exchange rate. On the contrary, the coefficient of symmetric oil price shocks lagged 3 years revealed a negative and statistically significant impact on the real exchange rate (depreciation).

The results obtained from ARDL, SVAR, and FMOLS are in line with those in the economic literature, that is the oil price shocks appreciate/depreciate the real exchange rates. By the same token, government expenditure appreciates/depreciates the real exchange rates. The IRFs indicate that the response of the real exchange rate to symmetric oil price shocks and government expenditure shocks causes obvious stable appreciation of the real exchange rate over time. It is worthwhile to note too, that between 74% to 76% of the variations in the real exchange rate, LEX_t is brought about by the symmetric oil price shocks and the real government expenditure $RGOEX_t$, respectively.

The outcomes are pivotal for policymakers, local and foreign investors, and researchers. According to Brahmasrene et al. (2014), policymakers and investors could benefit from these findings on the basis that imported US oil price fluctuations tend to follow exchange rate variations in the short run, while currency fluctuations follow oil price fluctuations in the long run. As a result, oil prices play a role in modeling the exchange rates (Babatunde, 2015). Accordingly, moving to flexible exchange rates and establishing oil funds could serve as fiscal buffers (Koh, 2017) to reduce and soften the hard impacts of oil price fluctuations. Saudi Vision 2030 motivated substantial efforts to accelerate the steps toward increasing sources of government income to maintain stable economic growth. The stable real exchange rate will be reflected on the value of imports and hence, inflation. Furthermore, taking precautionary measures against oil price fluctuations will mitigate the slump in government earnings and assist in the aggregated efforts of maintaining stable economic prosperity and employment. Designing a detailed roadmap within a designated time framework is necessary to help local and global economies avoid the pitfalls of oil price variations.

This research is limited to the Saudi Arabian economy and carried out despite some limitations. Lack of historical quarterly data for the 70s and early 80s. However, further development of this research is possible by testing the impacts of asymmetric oil price shocks on real exchange rates. Further extension is possible by applying Hodrick–Prescott filtering approach to test for the effects of oil price and government expenditure volatility on the real exchange rates. Furthermore, it is worthwhile to include Gulf Cooperation Countries (GCC): Oman, United Arab Emirates, Qatar, Kuwait, and Bahrain. These economies share the same economic, cultural, and structural environments.

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