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The Impacts of Non-linear Oil Price Shocks on Saudi Saving-investment Behavior: An Empirical Investigation

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ABSTRACT

The purpose of this paper is to analyze theoretically and empirically the effects of a non-linear oil price shocks (OIL^{shock}) on Saudi investment-saving behavior for the period of 1985-2015, using structural vector autoregressive approach. The OIL^{shock} is calculated as SOPI, employing GARCH(1,1). Johansen's testing procedure result asserts the existence of stable long-run relationship between private saving investment (PI), OIL^{shock}, government expenditure (GOEX) and per-capita income (PERCAPITA). The findings confirm that the OIL^{shock} affect positively (+) PI. The sign is as expected and significant. Moreover, capital investment takes time to absorb the shock. Nonetheless, PERCAPITA as a proxy for aggregate demand had the right sign and statistically significant. GOEX had the positive sign reflecting the crowd-in effects. Although, Emmanuel et al. (2014), found negative impacts of OIL^{shock} on PI, our results should differ in sign because this analysis is forwarded towards an oil-exporting country.

Keywords: Investment, Saudi Arabia, A Nonlinear Oil Price Shocks, Structural Vector Autoregressive
JEL Classifications: C51; E22; Q43

1. INTRODUCTION

In economic literature, investment is the purchase of physical goods in hope of more consumption of goods and services tomorrow. Based on the theory, achieving economic development without capital accumulation is like building a palace from sands. Higher level of investment and income can be reached through the expansion of existing capital stock or through adding more new capital stock to the existing. Investment in infrastructures both additional capacity and maintenance is still need to be addressed empirically as a source of eliminating poverty and helping achieving targeted economic development and prosperity. Saving and subsequently investment plays a major role in determining output either in goods or services everywhere in the globe. After World War II, hardware development occupied large size of theory and the minds of development scholars. They believe that infrastructures' projects are crucial for economic development and growth. However, during 1980s and the 1990s came in favor of private sector financing solutions for infrastructures or sometimes private partnership with government. A more balanced view has emerged in favor of the role of public sector in the 1990s. There are several reasons behind this summarized in the DFID working paper, 24 (2007. p. 16-18). First, base structures are important for economic development and growth. So, that poverty is reduced directly through access to services and improves the standard of living. Secondly, the main funds for infrastructure come from government. However, the 2006 estimates for the public sectors share in financing the infrastructures in less developed countries are 70%. Private sectors are 20%, and foreign aid is 10%. Thirdly, public sector investment in infrastructure is insufficient and sometimes inefficient and is not enough to offer services to the needy people. Fourth, foreign aid is not sufficient to finance infrastructures as it supposed to be. Fifth, the share of private sectors might help in yielding good management. In the literature, studies reveal strong relationship between income and investment (Emmanuel et al., 2014). Furthermore, investment is positively correlated with income and an increase in investment yields higher level of income. There are two major reasons for dealing with investment (Romer, 2012). First, firms' investment demand (demand side) and households' saving (supply side) determine the output produced in society. Secondly, investment decisions usually characterized with volatility, thus, the investment demand may explain the fluctuations in the short-run. There are several factors that affect investment behavior, economic growth, exchange rate, inflation, export, interest rate, and other macroeconomic variables (Emmanuel et al., 2014). In addition to the factors alluded to, some scholars refer to uncertainty and its relation with investment as a determinant of dynamic investment. Some others combine risk and investment as a factor that influences investment behavior (Effiong, 2014). Nevertheless, researchers worked hard to empirically capture the effects of an oil price shock (OIL^{shock}) over macroeconomic variables such as gross domestic product, inflation rates, and exchange rate variations Mork (1989); Guo and Kleisen (2005); Kliesen (2008); Alley et al. (2014); Brini et al. (2016); and Kose and Baimaganbetov (2015) and Ebele and Iorember (2015). Needless to say, a handful studies paid a thorough attention to the impact of OIL^{shock} on saving-investment.

Looking at the Saudi data, with the emphasis on investment and its relation with other variables, one can easily notice the influence of oil revenues on macroeconomic variables. The growth rate of private investment has grown at different levels. For example, investment grew from 11.4% of gross domestic product (GDP) in 1990 to about 19% of GDP in 2001 and continued to about 28 percent in 2014. However, the relationship between investment and saving has fluctuated due to variations in oil prices and earnings. The gross domestic saving was about 27% of the gross domestic product in 1973. The value as a percentage of GDP has fallen to about 24% of GDP in 1983. It stared to climb up to 53% in 2007. Furthermore, the value of domestic savings declined to about 26% in 2009. Now, it is stable to some extent and close to 25% in 2014 (Figure 1). On the other hand, the divergence between investment and saving indicates that there exist some saved resources that are not channeled into the stream of investments in the country.

This paper attempts to address the importance of saving-investment decisions especially in an emerging oil-based economy, and to explain the role of OIL^{shock} on the saving-investment decisions. It is clear that any OIL^{shock} (from the point of view of an oil-exporting country), will influence the earnings of oil and thereby the saving-investment directions. This study differs from other studies in the following. First, structural vector autoregressive (SVAR) methodology is applied to test the relationship between private investment (PI), OIL^{shock}, government expenditure (GOEX), and per-capita income (PERCAPITA), where the concentration is on the effects of a non-linear OIL^{shock}. Secondly, this analysis is directed towards the PI decisions, where the task is to see how an OIL^{shock} is transmitted into saving-investment decisions and causes variations in the investment. Thirdly, although, financial development plays a major role in saving-investment decisions, Mckinnon's hypothesis indicated inconclusive evidence in the Saudi economy case (Algaeed, 2016).

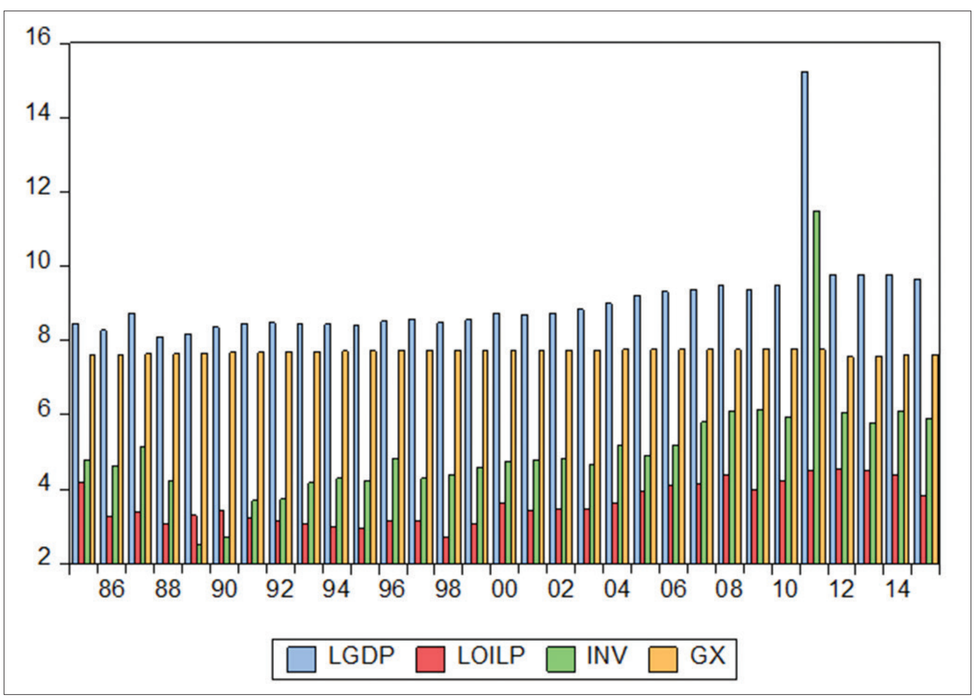
The main purpose of this paper is to analyze and investigate empirically the relationship between PI, OIL^{shock}, GOEX, and PERCAPITA, using SVAR. It is of interest to determine the long-run economic stability among the variables alluded to. The stability relationship between the variables is on the front, because the variations in investment will affect the growth rate of real GDP and hence employment in the economy.

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

2. REVIEW OF LITERATURE AND EMPIRICAL STUDIES

The theory of investment behavior based on the neo-classical theory is started with Jorgenson, where he called it a theory of optimal accumulation (Eisner and Nadiri, 1968). Thus, the

Figure 1: Growth rate of real private investment, real gross domestic product and oil prices (in log)



demand for capital stock is a function of output produced and some other variables such as relative price of output and capital. Investment could be divided into two main parts, replacement of depreciations of capital stock and distributed lag adjustment of capital. Saving-investment decisions are strongly influenced by three sectors: Households, firms, and the government. The main determinants of investment demand are firms. Considering this, labor force growth is an important factor for investment demand. Thus, low labor force growth and high capital/labor ratio might cause dearth in investment opportunities (Desroches and Francis, 2007. p. 7-9). Based on the analysis of Eklund (2013), Keynesian approach to investment is that, investment will be considered until no other investments of which marginal efficiency of capital exceeds interest rate. Furthermore, the difference in views between Keynes and Fisher lies in risk and uncertainty and how people form expectations. In addition, Keynes does not consider investment as a variable influenced by optimal capital stock. In sum, the Keynesian spirit of investment had influence on the classical and neoclassical approaches through the net present value.

The augmented model proposed by Hamilton (2003), who pioneered the work based on the effects stemming from OIL^{shock}, led to follow his steps by economists. Kliesen (2008) showed that an increase in crude oil price either to \$100 or \$150 per barrel will result in a modest slowdown in real gross domestic product growth rates. However, a rise in crude spot oil to \$150 per barrel will cause inflation rate to go up to 4% in the year 2009. Thus, inflation rate is above the expectation rate. The gross domestic product will be affected through uncertainty of future oil prices. Hence, uncertainty will negatively influence investment decisions. Lower growth rate of real GDP will be affected through costly resource reallocations (Kliesen, 2008).

Ferrucci and Miralles (2007), discuss the variations pattern of saving across economies in relation with assets valuations, current account balances, and investment. They looked at the empirical evidence behind these trends. Moreover, they used reduced-form model which relates private saving with different macroeconomic variables. Estimates are achieved through a dynamic model which accounts for cross-sectional heterogeneity. Their findings suggest that saving rates in emerging economies are higher than cross-country estimates based on fundamentals, especially in Asia. Demographic factors and financial catching up have been key players of observed changes in investment. Furthermore, progress in financial deepening in less developed countries may cause redistribution of international saving flows.

Sengonul and Degirmen (2009), explore the determinants of net private saving within the framework of the effects of OIL^{shock} on private savings and investment gap before and after the 2001 Turkish financial crisis. The inclusion of the oil price variable is warranted. This inclusion is to explain the effects of oil prices on current account deficit. This happens through saving and investment gap. Autoregressive distributed lag ARDL and ECM tests are applied using data for the period of 1990: Q1 - 2007: Q3. The evidence shows that effectiveness of interest rate for deposits, GDP growth, and oil prices exerted strong influence on net private savings in the short and long-run.

Eklund (2013), discusses investment theories and their implications. He empirically started with profit maximization problem of the firms, neoclassical theories, the accelerator, and Tobin's q theories using dynamic optimization. He showed the differences between theories based on assumptions and their conclusions. He also reviewed thoroughly the empirical applications especially Tobin's q.

Al-Khouri and Dhade (2014), investigate the relationships between oil price changes, savings, legal and institutional development and economic growth for Gulf Cooperation Council (GCC), countries. The GCC consists of six countries: Saudi Arabia, Bahrain, Qatar, Oman, United Arab Emirates and Kuwait. In their analysis, they used annual data covering the period of 1980-2011. They implemented fixed effect and random effect model techniques. Then they employed Arellano-Bond/Blundell-Bond estimator to reduce endogeneity problem. Their findings revealed a non-linear and concave relationship between savings and economic growth. That means, at low level of economic growth, increased saving rates lead to higher economic growth. Also, with increase in oil surpluses, high level of saving lead to lower level of economic growth. This might happen due to low absorption capacity. In addition, oil price changes explain the variability in economic growth, other things being equal. Economic globalization affects economic growth negatively.

Emmanuel et al. (2014), examined the impacts of OIL^{shock} on the Ghanaian domestic investment for the period of 1984-2012. They applied dynamic ordinary least squares (OLS) approach to estimate the effects of OIL^{shock} on domestic investment in Ghana. Their findings showed that there exist long-run relationships between domestic PI and OIL^{shock}, exchange rate, inflation, income and credit for the private sector. There are negative impacts of OIL^{shock} on investment. They suggested cushioning the economy against future OIL^{shock} through providing domestic credit to private investors to compensate them to pursue their investments goals.

Diksha and Goodness (2015), examines the effects of the variability of oil prices on savings in South Africa using quarterly data for the period of 1960-2014. The paper employed GARCH-in-mean VAR model. The aim is to test for the positive and negative OIL^{shock} on savings. The findings prove that oil price uncertainty, which is measured as the conditional standard deviation of one-step-ahead forecast error of the change in oil price, is negatively affect the savings. The responses of investment-savings due to a positive and a negative shock are symmetric in both direction and magnitude.

3. THE THEORETICAL MODEL, ESTIMATION, AND DISCUSSIONS

Before going into constructing the investment macro models, it is important to review the theoretical and empirical models. Later, the testable Saudi investment macro model will be established. In this analysis, I follow Eklund (2013). Keynes and Fisher introduced the present discounted value of a future sum. Investment is taken if the net present value is equal to zero such that:

$$\text{NPV} = -C_0 + \int_o^\infty C(t)e^{(g-r)^t}\,dt \quad (1)$$

Where, g represents growth rate, r is opportunity cost of capital (discount rate). When r = 1, then NPV = 0. Hence, return on investment is Keynes' marginal efficiency of capital, and Fisher's internal rate of return.

In the classical theory, maximizing profit yields an optimal capital stock. Based on this, Cobb-Douglas production function is written with output as:

$$Y_t = f(K_t, L_t) = AK^{\alpha} L^{1-\alpha} \quad (2)$$

Where, Y_t is the output, K_t is capital, and L_t is labor. The profit function can be written as:

$$\Pi_t = P_t Y_t - s_t I_t W_t L_t \quad (3)$$

Π_t denotes profit, P_t is price of output, s_t is the price of capital, and W_t is the wage rate. Under the assumption of profit maximizing firm, the current value of a firm is:

$$V_0 = \max E_{\psi 0}\int_0^\infty \Pi t\, e^{-rt}\, dt = E_{\psi 0}\int_0^\infty [P_t Y_t - s_t I_t - W_t L_t] e^{-rt} d_t \quad (4)$$

Subject to: $dK/d_t = I_t - \beta K_t = \dot{K}_t \;\; K(0)$ is given.

E is an expectations operator, given the information set δ. The maximization of V_0 is:

$$L = V_0 + \int_0^\infty \Phi_t \left[(I_t - \beta K_t) - \dot{K}_t\right] e^{-rt} d_t \quad (5)$$

With rearrangements:

$$L = \int_0^\infty \left[P_t Y_t - s_t I_t - W_t L_t + \Phi_t\,(It - \beta K_t) - \Phi_t\,\dot{K}_t\right] e^{-rt} d_t \quad (6)$$

From equation (6), the current Hamiltonian is:

$$H = pf(K,L) - sI - wL + \Phi(I - \beta K) \quad (7)$$

Where Φ is the costate variable, and represents the shadow price of capital. To obtain first order condition, Hamiltonian's differentiation yields:

$$\frac{\partial H}{\partial I} = -s + \Phi = 0 \quad (7a)$$

This implies that opportunity cost of capital is equal to the shadow price. However, in order to obtain equality between marginal revenue of labor and wage rate, the first order condition yields:

$$\frac{\partial H}{\partial L} = p\, f_L' - w = 0 \quad (7b)$$

In equilibrium, net investment ought to be zero, and gross investment equal to the depreciation of capital, thus:

$$\frac{\partial H}{\partial \Phi} = \frac{\partial K}{\partial I} = I - \Phi K = 0 \quad (8)$$

And hence,

$$\frac{\partial H}{\partial K} = p\, f_K' - \Phi\beta = 0 \quad (8a)$$

Since y is the control variable, and given $\dot{y} = \frac{\partial H}{\partial K}$ such that $y = \Phi\, e^{-rt}$ at time t, yields:

$$-\frac{\partial H}{\partial K} = \frac{d}{d_t}\left[e^{-rt}\Phi(t)\right] = \frac{\partial \Phi}{\partial t} - r\Phi \quad (8b)$$

Rewriting equation (8a), yields:

$$-p\, f_K' + \Phi\beta = \frac{\partial \Phi}{\partial t} - r\Phi \quad (8c)$$

Equation (7a) tells us that s = Φ, which means that: $\partial s/\partial t = \partial \Phi/\partial t$, Thus:

$$\frac{\partial H}{\partial K} = p\, f_K' + s\beta = \frac{\partial s}{\partial t} - rs \quad (9)$$

From equation (9), it is easy to get the marginal rate of return on capital as:

$$p f_K' = s\left[\beta + r - (\partial s/\partial t)/s\right] \quad (9a)$$

Jorgenson's user cost can be written as:

$$C = s\left[\beta + r - (\partial s/\partial t)/s\right] \quad (10)$$

The above equation (10) implies that: $C = p\, f_K'$ It is easy to derive the optimal capital stock using Cobb-Douglas production function.

The accelerator model has been built on the relationship between desired capital stock and output. This model is criticized because the cost of capital and profitability are not of great importance. This situation has weakened the model and made it better used to explain investment patterns. Furthermore, Tobin's q (Tobin, 1969), emphasized the relation between market value of a firm and the replacement cost used by investors to determine investment choice. It says that if the value of a firm exceeds acquiring the firm, which includes machinery and equipment, it is the right choice. On the other hand, Mckinnon (1973) and Shaw (1973), pointed out that investment in developing nations is hindered by financial repressed sector, which will affect interest rate and thereby investment and hence, economic growth. Test results are an inconclusive in some countries (Algaeed, 2017). In economic theory, crowding out of public investment affects private investment negatively. This adverse impact does not appear in the accelerator as it happened in the developed nations. It accrues in developing nations through long-run efficiency of infrastructures and then investment (Emmanuel et al., 2014. p. 5-6).

Based on Emmanuel et al. (2014), an eclectic model is adopted where the specification of this model is set to suit the Saudi Arabian available variables:

$$PI_t = \Psi_0 + \Psi_1\, Oil^{shock} + \Psi_2\, GOEX_t + \Psi_3\, PERCAPITA_t + \varepsilon_t \quad (11)$$

$\Psi_1 > 0,\ \Psi_2 > 0,\ \Psi_3 > 0$

ΔPI_t: Is real log private investment

$GOEX_t$: Is log real government expenditure

$PERCAPITA_t$: Is real log per-capita income in Saudi Riyals

OIL^{shock}: Is an oil price shock calculated using GARCH(1,1), and,

ε_t: Is an error term.

Here, all variables in real log form. OIL^{shock} captures the variations in real oil prices obtained by general autoregressive conditional heteroskedasticity, GARCH(1,1). GOEX represents the important role of the Saudi Government in receiving the income and spending it. The inclusion of this variable, as a proxy for government investment is warranted. The purpose is to see whether government investment is complement to PI or not. If the government investment estimate is negative, then there exists crowding out effect. However, if the government investment estimate is positive, then crowding in effect exists. PERCAPITA represents the aggregate demand for the economy. A rise in income will generate an increase in aggregate demand for the economy. The role of financial development plays a major role in promoting investment and economic growth. The liquidity constraint variable is omitted from equation due to the inconclusive case regarding the Mckinnon's complementarity hypothesis in Saudi Arabia (Algaeed, 2016). Nonetheless, the lack of historical interest rate data compels me to neglect it. The data used here is collected from Saudi Arabian Monetary Authority, various issues. The real oil price implemented here is OPEC basket price. The data covers the period of 1985-2015. Table 1 shows estimates of robust least squares (RLS). The impact of OIL^{shock} on PI is positive as expected (from point of view of an oil exporting country), and significant at 5 percent level. A positive OIL^{shock} affects PI positively and vice versa. The sign of GOEX is positive indicating the presence of crowd-in effect. However the sign is not significant. Moreover, the elasticity of income is 1 and significant at 1 percent level. Nonetheless, The RLS model is not serially correlated. Figure 2 represents the OLS stability model. The model is free of serial correlation too (OLS estimates are not reported here).

3.1. The Non-linear OIL^{shock}

In the standard literature, the non-linear price specification which proposed by Mork (1989) discusses the positive and the negative OIL^{shock}. In accordance, the non-linear OIL^{shock} is specified as follows:

$$OP_t^+ = \begin{cases} OPt, & \text{if } OPt > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$OP_t^- = \begin{cases} OPt, & \text{if } OPt < 0 \\ 0 & \text{otherwise} \end{cases}$$

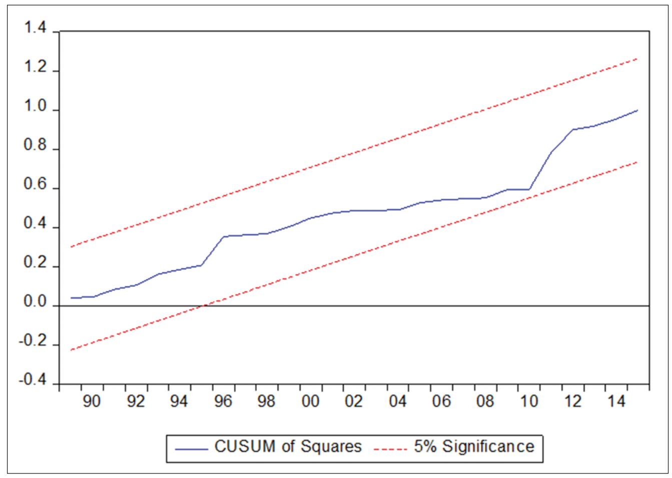
Where OP_t is the percentage change in real oil price. Because of the volatility of oil prices over a long period of time of stability, Lee et al. (1995) in Alom (2011), specified the non-linear OIL^{shock} as scaled or oil shock in a GARCH(1,1) to capture the effect of oil price, such that:

Table 1: Robust least squares estimates of private investment as a dependent variable

Dependent variable: Private investment			
Variables	**Coefficient**	**z-statistic**	**Probability**
C	−5.495390	−0.563843	0.5729
OIL^{shock}	21.93005	3.754923	0.0002
GOEX	0.854217	0.668606	0.5037
PERCAPITA	1.008432	13.22367	0.0000

R^2=0.58; R^2w=0.95; R^2n=310.51. GOEX: Government expenditure, OIL^{shock}: Oil price shock, PERCAPITA: Per-capita income

Figure 2: CUSUM of squares stability test



$$OP_t = \varphi_0 + \sum_{i=1}^{k} \varphi_i OP_{t-1} + e_t \quad \text{(Mean equation)}$$

$$e_t = e_t + \sqrt{h_t}, e_t \sim N(0,1)$$

$$h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1} \quad \text{(Variance equation)}$$

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

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

Where, SOPI represents the scaled oil price increase, and SOPD is scaled oil price decrease. Furthermore, Hamilton (1996) in Kose and Baimaganbetov (2015), suggested net price increase, NOPI. This measurement defined as a value of oil price in quarter t, p_t, exceeds the highest value over the last four quarters. So, an increase in oil price may be a result of price correction to earlier levels, which may not affect the economy as a whole. NOPI is constructed as:

$$NOPI_t=(0, \max (OP_t–(OP_{t-1}, OP_{t-2}, OP_{t-3}, OP_{t-4})) \quad (12)$$

Since this paper uses four endogenous variables in the system, OIL^{shock} (non-linear), real PI, real PERCAPITA, and real GOEX. The SVAR will be employed in the next analysis (Table 2).

3.2. Unit Root Test

Using OLS on non-stationary variables causes a misleading result of the variables estimates. In order to make precise estimates, checking for stationarity is of importance for forecasting and the processes to choose into our models. Variables that increase over time are non-stationary. In addition, series that are not increase over time, but carry effects of innovations do not vanish as time passes (Mahadera and Robinson, 2004). Thus standard errors with non-stationary variables are biased and causal relationships between variables are not reliable and yield a spurious regression. According to Mahadera and Robinson (2004), to achieve stationarity, one could subtract a trend or taking one or more difference. Furthermore, performing unit root tests is the goal to attain stationary variables, and avoid spurious regressions.

$$\Delta X_t=(\alpha-1)X_{t-1}+\varepsilon_t \quad (13a)$$

Equation (13), represents Dicky-Fuller test. If $\alpha>1$, or $\alpha=1$, this implies that X_t is non-stationary. Augmented Dicky-Fuller (ADF) test is developed to cure the presence of serial correlations in the Dicky-Fuller residuals. The idea is to add lagged dependent variables to eliminate residuals of serial correlations. To determine the unit roots, three regression models are used in the literature incorporate intercept, intercept and trend, and none. ADF and Phillips-Peron (PP) tests are employed to examine the stationarity of the time series. ADF test is implemented using the following equation:

$$y_t = \phi_0 = \sum_{j=1}^{k} \phi_j Y_{t-j}+\varepsilon_t \quad (13b)$$

$\varepsilon t \sim iidN(0,\sigma^2)$

Δy is the first difference of Y series, n is the number of lagged first differenced term, and ε_t is the error term. The PP test is performed using the following equation:

$$\Delta y_t = \psi_0 + \sum_{j=1}^{k} \Psi_j \Delta y_{t-j} + \Psi_k y_t - k+\varepsilon_t \quad (13c)$$

$\varepsilon t \sim iidN(0,\sigma^2)$

Where, $\psi_0=\phi_0$ is a constant, $\psi_j = \sum_{j}^{k} \phi j-1$, j=1,…, k. If $\psi_j=0$, then null hypothesis is accepted (presence of unit root). However, when $\psi_j<0$, that means there is no presence of unit root. To go on in the analysis, ADF, and PP tests are applied. Results for these tests are similar and close to each other, and thus, reported in Table 3. Both tests showed that variables are stationary at the difference in the ADF and PP tests. Some of the variables, such as private investment and the OIL^{shock} variables, are not stationary at level I(0). Moreover, all variables are stationary at difference I(1) and significant at 1% and 5% level.

Table 2: AR(1)-GACH(1,1) model results

Variable	Coefficient	z-statistic	Probability
Mean equation			
Constant	1.0000	2.77E-07	1.0000
ΔOP_{t-1}	1.0000	2.68E-07	1.0000
Variance equation			
Constant	1.46E-28	0.205078	0.7947
e^2_{t-1}	0.150000	0.162432	0.8710
h_{t-1}	0.600000	0.428236	0.6685

3.3. Johansen Co-integration Test Result

Based on Hjalmarsson and Osterholm (2007), Johansen's methodology starts with VAR (p) as:

$$y_t=\varphi+A_1Y_{t-1}+\ldots+A_pY_{t-p}+\varepsilon_t \quad (14)$$

Where, y_t is a n × 1 vector of variables that are integrated of order one. ε_t is a n × 1 vector of innovations. The VAR model can be written as follows:

$$\Delta y_t = \varphi + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \quad (14a)$$

Where,

$$\Pi = \sum_{i=1}^{p} A_i - I, \text{ and } \Gamma_i = -\sum_{j=i+1}^{p} A_j \quad (14b)$$

If coefficients matrix Π has reduced rank r<n, then there exist n × r matrices α and δ each with rank r such that: $\Pi = \alpha\delta'$ and $\delta' y_t$ is stationary. Moreover, the reduced rank of the Π matrix is the trace test and the maximum eigenvalue test as:

$$J_{Trace} = -T\sum_{i=r+1}^{n} ln(1-\hat{\lambda}_i)$$

$$J_{max} = -T\, ln(1-\hat{\lambda}_{r+1})$$

T is the sample size and I is the i^{th} largest correlation. Johansen's co-integration test requires deciding the lag length which can be calculated through unrestricted VAR models. The analysis here used 4 lags depending on unrestricted VAR lag order, LR, FPE, AIC, and HQ. From Table 4, trace statistic test confirms the existence of 3 co-integrated equations at the 5% level. The null hypotheses for the trace and max tests are that, there are no co-integrations between real OIL^{shock}, OIL^{shock}, real GOEX, $PERCAPITA_t$, and private investment expenditure PI_t. The null hypotheses are rejected. Thus, there exist long-run relationships among the variables alluded to.

Table 3: Augmented-Dickey Fuller and Phillips-Perron tests

Series	Augmented-Dickey Fuller						Phillips-Perron					
	Level			1st difference			Level			1st difference		
	Intercept	T&I	None	Intercept	T&I	None	Intercept	T&I	None	Intercept	T&I	None
PI	3.92*	4.61*	0.239	8.39*	8.15*	8.44*	3.29**	4.56*	9.27*	12.44*	12.48*	11.69*
GOEX	2.92	5.41*	1.47	4.16*	5.24*	9.26*	4.25*	5.42*	0.12	27.62*	29.19*	19.83*
OIL^{shock}	1.85	3.75**	0.65	4.94*	4.89*	5.01*	1.83	3.75**	0.49	7.18*	7.16*	7.08*
PERCAPITA	1.39	2.25	1.28	4.19*	5.45*	8.99*	4.51*	5.24*	0.43	25.85*	25.15*	24.26*

*,**and *** are statistically significant at 1%, 5% and 10% level respectively. T&I: Trend and intercept. GOEX: Government expenditure, OIL^{shock}: Oil price shock, PERCAPITA: Per-capita income, PI: Private investment

Table 4: Johansen co-integration test

H_0	H_A	Eigenvalues	λ_{Trace}	95%	H_0	H_A	λ_{Max}	95%
With OILshock (lags=4)								
r=0	r=1	0.9928	193.276*	47.8561	r=0	r=1	128.297*	27.584
r=1	r=2	0.7548	64.9793*	29.7971	r=1	r=2	36.5488*	21.132
r=2	r=3	0.6216	28.4305*	15.4947	r=2	r=3	25.2695*	14.265
r≤3	r=4	0.1145	3.16096	3.8415	r≤3	r=4	3.16096	3.841

r indicates the number of co-integrating vector. Critical values are from Mackinnon et al. (1991) P values. *indicates significance of the test statistic at 5% level. OIL^{shock}: Oil price shock

3.4. Causality Tests

The purpose of this test is to investigate whether one time series or more can definitely forecast another through multiple regression procedures. In the literature, the standard Granger causality test in bivariate environment can be assessed by regress each variable on itself lagged values and other variables. This can be specified as followed:

$$Y_t = \delta_0 + \sum\nolimits_{i=j}^{J} \delta_j Y_t - j + \sum\nolimits_{k=1}^{K} \gamma_k X_t - k + e_t \quad (15)$$

To examine null hypothesis, F test or similar tests be applied. The problem of the insufficiency of lags yield auto-correlated errors and hence misleading test statistics. Nevertheless, many lags weaken the power of the test. The reverse model can be estimated as:

$$Y_t = \delta_0 + \sum\nolimits_{i=j}^{J} \delta_j X_t - j + \sum\nolimits_{k=1}^{K} \gamma_k Y_t - k + e_t \quad (16)$$

The power of Granger causality test lies in fully specified models. If not specified, spurious relationships may exist. If the coefficient $\delta_j X_t$ are jointly significant and δ is significant too, then the null hypothesis that ΔX does not Granger cause ΔY is rejected. Tables 5 and 6 reveal the causality tests. VAR and vector error correction model (VECM) causality tests showed that causality is running from OIL^{shock}, and PERCAPITA to GOEX then to investment. On the other hand, pairwise causality test indicates clearly the acceptance of the null hypotheses that shock does not Granger cause GOEX and investment expenditures. There exist bidirectional causality between PERCAPITA and GOEX.

Table 5: VEC and VAR Granger causality/block exogeneity Wald tests

Excluded	Chi-square	df	Probability
Dependent variable D(shock)			
D(GOEX)	12.79668	2	0.0017
D(PERCAPITA)	13.79197	2	0.0010
D(PI)	4.418103	2	0.1098
Dependent variable D(GOEX)			
D(Shock)	1.504751	2	0.4712
D(PERCAPITA)	7.350352	2	0.0253
D(PI)	2.849767	2	0.2405
Dependent variable D(PERCAPITA)			
D(Shock)	1.387590	2	0.4997
D(GOEX)	3.601000	2	0.1652
D(PI)	0.400347	2	0.8186
Dependent variable D(PI)			
D(Shock)	2.841747	2	0.2415
D(GOEX)	5.447234	2	0.0656
D(PERCAPITA)	5.061306	2	0.0796
VAR Granger causality/block exogeneity Wald tests			
Dependent variable oil shock			
GOEX	2.363933	2	0.3067
PERCAPITA	1.063586	2	0.5876
PI	0.308038	2	0.8573
Dependent variable GOEX			
OIL^{shock}	32.38954	2	0.0000
PERCAPITA	358.0861	2	0.0000
PI	4.015245	2	0.1343
Dependent variable PERCAPITA			
OIL^{shock}	1.224899	2	0.5420
GOEX	0.677243	2	0.7128
PI	1.623818	2	0.4440
Dependent variable PI			
OIL^{shock}	3.177086	2	0.2042
GOEX	1.621136	2	0.4446
PERCAPITA	1.626097	2	0.4435

GOEX: Government expenditure, OIL^{shock}: Oil price shock, PERCAPITA: Per-capita income, VEC: Vector error correction, VAR: Vector autoregressive, PI: Private investment

3.5. The Impulse Response Function

The interaction between the systems which contain variables may not explained well by Granger-causality procedure. In the real world, one likes to know the response of one variable to an impulse in another variable in a system contains a set of variables. If one variable reacts to an impulse in another variable, this will yield the latter causal for the former (Rossi, 2004).

IRF employs the estimates of VAR models. Ronayne (2011), shows that the formulation of the IRF is as follows:

$$\text{IRF}(t, h, d_i) = \left[y_t + h | u_{t+j} = \begin{cases} d_i & \text{if } j = 0 \\ 0 & \text{if} \in (1, h \end{cases} ; \Omega_t \right] - E\left[y_t + h | u_{t+j} = 0 \ \forall j \in (0,h); \Omega_t \right] \quad (17)$$

Furthermore, IRF measures the reaction of the system of set of variables at t+h, for h= 0,…, H to a shock of a vector d_i. Ω_t is the set of information at time t which consists of lagged dependent variable vectors up to the lag order p. "In our 4-dimentional structural analysis, the shocks d_i, I = 1,…,4, that is correspond to OIL^{shock}, GOEX, PERCAPITA, and PI. The i^{th} structural shock d_i, corresponds to the i^{th} column of $\hat{A}^{-1}$ where each row corresponds to the response e.g. $\hat{A}^{-1}_{1,3}$ would be the response of p_t to Per-capita shock at time t" (Ronayne, 2011. p. 15).

Based on Musibau et al. (2013), SVAR will be implemented. The merit of using unrestricted VAR is that, it is superior in forecasting variance relative to a restricted VAR or VECM, especially in the short-run. However, the superiority holds when "the restrictions are true and performances of unrestricted VAR and VEMC for orthogonalized impulse response analysis over short-run are nearly identical" (Musibau,et al., 2013. p. 402).

Table 6: Pairwise Granger causality tests, lags 4

Null hypothesis	Observations	F-statistic	Probability
GOEX does not Granger cause shock	27	0.92521	0.4711
Shock does not Granger cause GOEX		0.68997	0.6084
PERCAPITA does not Granger cause shock	27	0.41687	0.7943
Shock does not Granger cause PERCAPITA		1.66196	0.2025
PI does no Granger on shock	27	0.41390	0.7964
Shock does no Granger on PI		0.94854	0.4590
PERCAPITA does not Granger on GOEX	27	464.942	7.E-18
GOEX does not Granger on PERCAPITA		2.97962	0.0474
PI does not Granger on GOEX	27	55.1081	7.E-10
GOEX does not Granger on PI		2.26012	0.1029
PI does not Granger on PERCAPITA	27	1.06255	0.4035
PERCAPITA does not Granger on PI		1.09287	0.3898

PERCAPITA: Per-capita income, GOEX: Government expenditure, PI: Private investment

To see the economic impacts of the OIL^{shock}, OIL^{shock}, PI_t, $GOEX_t$, and $PERCAPITA_t$, SVAR approach will be implemented. Following the standard literature, Pecican (2010), set the simultaneous equations systems as follows:

$$B.Y_t+CX_t=U_t \quad (17a)$$

Where, B is a matrix of endogenous variables. C is a matrix of predetermined variables. Y and U are column vectors of endogenous, predetermined and disturbance variables. The lag models with autoregressive process of order p can be written as:

$$Y_t = \Phi + \sum_{i=1}^{p} \delta_i y_t\text{-}i + u_t \quad (17b)$$

Where,
y is an economic variable.
Φ is an intercept parameter.
δ_i are autoregressive parameters.
u_t error term, that is uncorrelated random with zero mean and constant variance.

Considering a variable y_1 at time t, is described by an autoregressive process of the order 1, such that:

$$Y_{1t}=\varphi_0+\varphi_1 y_{1t-1}+\mathcal{E}_t \quad (17c)$$

Supposing a mutual relationship between y_{1t} and y_{2t}, and given that all variables in the VAR(p)-process are integrated of order one, I (1). A VAR(p)-process can be written a VAR (1)-process, such that:

$$Y_{1t}=\varphi_{10}+\varphi_{11} y_{1,t-1}+\varphi_{12} y_{2t}+\mathcal{E}_{1t} \quad (17d)$$

Similarly for y_2:

$$Y_{2t}=\varphi_{20}+\varphi_{21} y_{1t}+\varphi_{22} y_{2,t-1}+\mathcal{E}_t \quad (17e)$$

Y_{1t}, Y_{2t} describes the form of simultaneous equations model, such that:

$$Y_{1t}=\delta_{10}+\gamma_{11} y_{1,t-1}+\gamma_{12} y_{2,t-1}+u_{1t} \quad (18)$$

$$Y_{2t}=\delta_{20}+\gamma_{21} y_{1,t-1}+\gamma_{22} y_{2,t-1}+u_{2t} \quad (18a)$$

That is:

$$Y_t=A+BY_{t-1}+U_t \quad (18b)$$

Where,

A: Column vector of intercept parameters. B is a matrix of lagged endogenous variables parameters, and U is a vector of noise terms. Equations (18) and (18a) are the explanatory variables in the reduced form is a vector autoregressive model of order 1, VAR(1). The extension of more than two endogenous variables including p-lags is that:

$$Y_t=A+B_1 Y_{t-1}+B_2 Y_{t-2}+\ldots+B_p Y_{t-p}+U_t \quad (19)$$

The SVAR explains the effects of one standard deviation shock in the error term over the model's endogenous variables. The model applied here will have four variables with 4-dimentional column vector.

Where, $y_t = (OIL^{shock}, GOEX_t, PERCAPITA_t, PI_t)$ is a 4 × 1 vector of endogenous variables. A is a 4 × 1 vector of constant terms. B_i is a 4 × 4 autoregressive coefficient matrices. U_t is a 4 × 1 vector of serially mutual uncorrelated shocks.

The restrictions imposed and the contemporaneous structural parameter of the following order:

$$\begin{bmatrix} \text{Oil shock} \\ \text{GOEX} \\ \text{PERCAPITA} \\ \text{PI} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ a21 & 1 & 0 & 0 \\ a31 & a32 & 1 & 0 \\ a41 & a42 & a43 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \quad (20)$$

The structure of the error decomposition of Equation (20) is built on the restrictions which exert that the OIL^{shock} is exogenously determined, and do not respond to other shocks. The aim of usage of VAR, impulse response functions and variance decomposition functions is to test the interactions and consolidate the causal relationships. However, the impulse response function from a VAR is a guide for us to whether the effects are short lived or permanent. It shows dynamic properties of the model, which means the responses of dependent variables to unit shock of independent variables. However, it traces the effects of a one standard deviation shock in a certain variable on the current and future values of the rest of macro variables. Figure 4, shows the IRFs of each variable in the study to a one standard deviation shock in the oil price. The negative shock affected the GOEX and this variable responded

Table 7: Impulse response to Cholesky (d.f. adjusted) one S. D. innovations

Period	Oil^{shock}	GOEX	PERCAPITA	PI
Variance decomposition for OIL^{shock}				
1	0.008516	0.000000	0.000000	0.000000
3	0.004184	0.002615	−0.000245	0.000586
5	0.003510	0.001830	−0.002057	0.001396
7	0.002710	0.001295	−0.002667	0.000961
9	0.001793	0.000864	−0.002650	0.000432
Variance decomposition for PI				
1	0.160796	0.520358	1.043052	0.385326
3	0.326375	0.156535	−0267771	0.351304
5	0.280648	0.113046	−0.279768	0.174303
7	0.188713	0.084004	−0.301903	0.063024
9	0.098438	0.047266	−0.247365	0.003282
Variance decomposition for GOEX				
1	−000589	0.003942	0.000000	0.0000000
3	−0.003086	0.001738	−0.028714	0.004769
5	−0.006327	−0.004443	−0.013257	−0.005766
7	−0.009643	−0.004474	−0.003850	−0.007582
9	−0.009949	−0.004536	0.003123	−0.00636265
Variance decomposition for PERCAPITA				
1	0.186002	0.279793	1.112284	0.000000
3	0.156495	0.132360	−0.167969	0.160657
5	0.153258	0.063215	−0.120776	0.105708
7	0.109726	0.047013	−0.151925	0.036840
9	0.061604	0.030169	−0.130404	0.008627

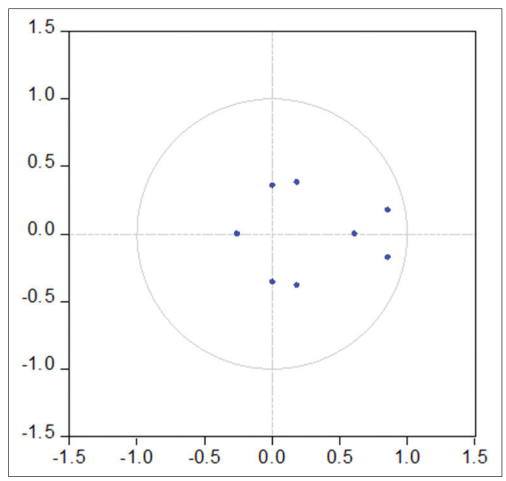
Cholesky Ordering OIL^{shock}, PI, GOEX, and PERCAPITA. GOEX: Government expenditure, OIL^{shock}: Oil price shock, PERCAPITA: Per-capita income, PI: Private investment

negatively from the 1st year. It continued performing negatively for the rest of time span, ten years. Similarly, PERCAPITA responded negatively, and gradually declines for the rest of the time span. The PI, experienced slight increase till the 3rd year. After that started to decline due to the decline in oil revenues despite the government's efforts to compensate the decline in PI. The crowd-in effect finding supports that. The IRFs is consistent with the causality tests where the effects run from OIL^{shock} to the GOEX. Looking at the negative OIL^{shock} (from the point of view of an oil producer), a one standard deviation shock to negative oil price causes GOEX to decline on average negatively by 9%, and continue to become negative over the time span. On the other hand, PI declined, on average by 20% due to the decline in oil revenues which caused by the fall in oil prices in world oil market. It's worthwhile to note, that the fall in oil earnings accompanied by a fall in GOEX and hence, investment. Also, it is important to note that, ECT is negative and significant at 5% level and is about 74%. The error correcting term, explains the speed at which the system adjust to equilibrium at the rate of 74% annually. The result is warranted and shows the immense effects of the OIL^{shock} on the Saudi economy. Thus, decline in earnings, drop in GOEX and PERCAPITA, and in turn PI. The SVAR model is stable (stationary), because all roots modulus are less than one in value, and lie inside the circle (Figures 3 and 4). However, if VAR is not stable (not stationary), then impulse response standard error does not exist (Table 7).

4. CONCLUSION AND POLICY RECOMMENDATIONS

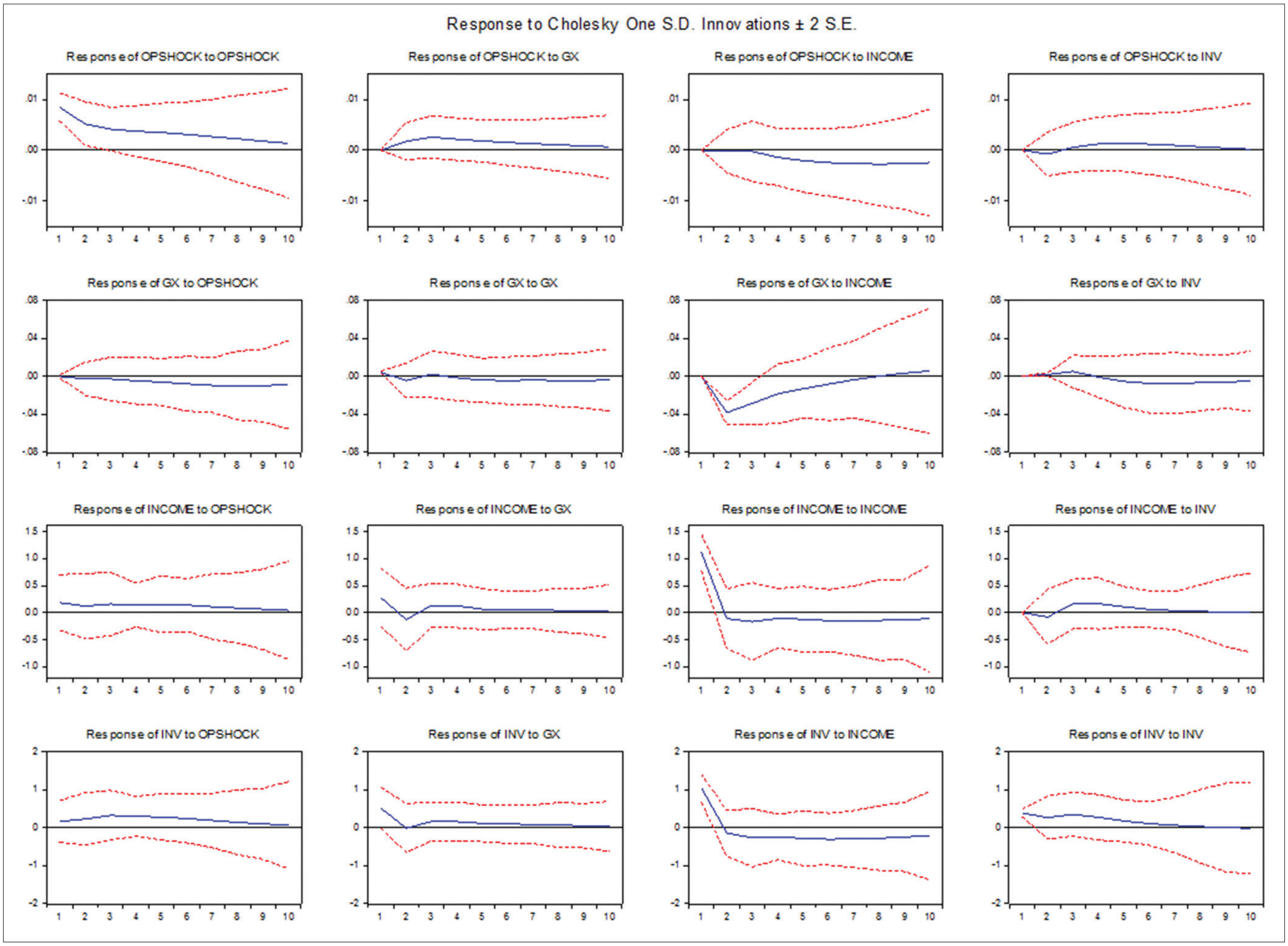
Given the volatility of the oil prices in the last few years, and the heavy reliance of the Saudi Arabian budget on oil earnings, it is worthwhile to analyze the impacts of such changes over the saving-investment behavior. Concentrating on the non-linear

Figure 3: Inverse roots of AR characteristic polynomial



OIL^{shock}, predicted from GARCH(1,1), this paper has examined thoroughly the impacts of such a shock on PI for the period of 1985-2015. The income elasticity as a proxy of the aggregate demand, and the crowd out effects has been empirically tested. The non-linear OIL^{shock} has been investigated using SVAR model. The Johansen co-integration tests showed an existence of long-run relationships among the variables, a non-linear OIL^{shock}, GOEX, PERCAPITA, and PI. However, in the short-run, the findings showed that OIL^{shock}, GOEX, and PERCAPITA have positively influenced PI. Furthermore, the results indicated that PI responded positively to one standard deviation of a nonlinear positive OIL^{shock}. The positive effect is about (20) percent. Based on the results obtained from equation 11, a positive OIL^{shock} (say 1 percent) causes an increase in PI by 21%. From the same equation, an increase in GOEX (say 1 percent) leads to a rise in PI by 0.85%. Similarly, from the same equation, 11, a 10%

Figure 4: Responses of government expenditure, per-capita income, and private investment to non-linear real oil price shock



increase in PERCAPITA causes an increase in PI, by 10%. The finding here is consistent with the findings in the literature. Facing the sharp decline in oil revenues which will definitely affects the macroeconomic variables; the Saudi authority has to think urgently in diversifying the resources of income. Nonetheless, the role of government is to strengthen the macroeconomic structure to mitigate the negative effects via implementing policies that encourage citizens to save more and ease uncertainty which usually causes delay in investment. The findings of this paper are in line with those obtained by Emmanuel et al. (2014) regarding the impacts of a nonlinear OIL^{shock}.

REFERENCES

Algaeed, A. (2016), The effects of asymmetric oil price shocks on Saudi Arabian macroeconomic variables. Journal of Economics and Sustainable Development, 7(20), 102-114.

Algaeed, A. (2017), The effects of asymmetric oil price shock on the Saudi consumption: An empirical investigation. International Journal of Energy Economics and Policy, 7(1),99-107.

Algaeed, A. (2016), Financial development and the Saudi Arabian economy: Re-examining Mckinnon's hypothesis. International Journal of Economics, Commerce, and Management, IV(10), 86-102.

Alley, I., Asekomeh, A., Mobolaji, H., Adeniran, Y. (2014), Oil price shocks and Nigerian growth. European Scientific Journal, 10(19), 375-391.

Al-Khouri, R., Dhade, A. (2014), The role of savings in reducing the effects of oil price volatility for sustainable economic growth in oil based economies: The case of GCC countries. International Journal of Economics and Finance, 6(4), 172-148.

Alom, F. (2011), Economic Effects of Oil and Food Price Shocks in Asia and Pacific Countries: An Application of SVAR Model. Paper Presented at the 2011 NZARES Conference, August, 25-26; 2011.

Brini, R., Jemmali, H., Farroukh, A. (2016), Macroeconomic Impact of Oil Price Shocks on Inflation and Real Exchange Rate: Evidence from Selected MENA Countries. 15th International Conference Middle East Economic Association (MENA 2016).

Desroches, B., Francis, M. (2007), Global Savings, Investment, and World Real Interest Rates. Bank of Canada Review. Winter 2006-2007.

Diksha, D., Goodness, A. (2015), Oil price uncertainty and savings in South Africa. OPEC Energy Review, 39, 285-297.

Ebele, E., Iorember, P. (2015), Modeling output effect of oil price shocks in Nigeria. European Journal of Globalization and Development Research, 11(2), 668-678.

Effiong, E.L. (2014), Oil price shocks and Nigeria's stock market: What have we learned from crude oil market shocks? OPEC Energy Review, 38(1), 36-58.

Eklund, J. (2013), Theories of Investment: A Theoretical Review with

Empirical Application. Swedish Entrepreneurship Forum Working Paper, 2013. p22.

Eisner, R., Nadiri, M. (1968), Investment behavior and neo-classical theory. The Review of Economics and Statistics, 50(3), 369-382.

Emmanuel, A., Barnor, C., Quaidoo, C. (2014), Oil Price Shocks and Domestic Price Investment inGhana. MPRA; 2014.

Ferrucci, G., Miralles, C. (2007), Saving Behavior and Global Imbalances: The Role of Emerging Market Economies. European Central Bank Working Series, No. 842, December, 2007.

Guo, H., Kliesen, K. (2005), Oil price volatility and U.S. Macroeconomic activity. Federal Reserve Bank of St. Louis Review, 87(6), 669-683.

Hjalmarsson, E., Osterholm, P. (2007). Testing for Co-Integration Using the Johansen Methodology Where Variables are Near-Integrated. IMF Working Paper; WP/07/141.

Hamilton, J. (2003), What is an oil shocks? Journal of Econometrics, 113(2), 363-398.

Hamilton, J. (1996), This is what happened to the oil macro-economy relationship. Journal of Monetary Economics, 38, 215-220.

Kliesen, K. (2008), Oil and the U.S. Macroeconomy: An update and a simple forecasting exercise. Federal Reserve Bank of St. Louis Review, 90(5), 505-516.

Lee, K., Ni, S., Ratti, R. (1995), Oil shocks and the macro economy: The role of price variability. Energy Journal, 16, 39-56.

Kose, N., Baimaganbetov, S. (2015), The asymmetric impact of oil price shocks on Kazakhstan energy macroeconomic dynamics: A structural vector autoregression approach. International Journal of Economics and Policy, 5(4), 1058-1064.

Mahadera, L., Robinson, P. (2004), Unit rot testing to help model building. Center for Central Banking Studies. London: Bank of England.

Mckinnon, R. (1973), Money and Capital in Economic Development. Washington, DC: Brookings Institution.

Mork, K. (1989), Oil and macroeconomy when prices go up and down: An extension of Hamilton's results. Journal of Political Economy, 97(3), 740-744.

Musibau, A., Adenikinju, O. (2013), Oil price shocks and stock market behavior in Nigeria. Journal of Economics Studies, 40(2), 180-202.

Pecican, F. (2010), Forecasting based on open VAR model. Romanian Journal of Economic Forecasting, 1, 59-69.

Romer, D. (2012), Advanced Macroeconomics. 4th ed. New York: McGraw-Hill Irwin.

Ronayne, D. (2011), Which Impulse Response Function? Warwick Economic Research Papers, No. 971. The University of Warwick.

Rossi, E. (2004), Impulse Response Functions. Lecture Notes, Economics 10. Pavia, Italy: Universita di Pavia.

Sengonul, A., Degirmen, S. (2009), Different Effects of Oil Prices on Private Saving Gap Before and After the 2001 Turkish Financial Crisis. 12th International Conference on Finance and Banking Structural; 2009.

Shaw, E. (1973), Financial Deepening in Economic Development. New York: Oxford University Press.

Tobin, J. (1969), A general equilibrium approach to monetary theory. Journal of Money, Credit and Banking, 1(1), 15-29.

Department for International Development (DFID), (2007). Literature review on private sector infrastructure investment. (2007), WSP international management consulting evaluation team, Working Paper 24, October; 2007.