Oil price shocks and economic growth in Nigeria: are thresholds important?

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Abstract

The impact of oil price shocks on the economy has occupied the attention of researchers for almost four decades. Majority of studies support the existence of a negative association, while some recent evidences seem to have popularised the view that outcomes are the artefacts of misspecified functional forms. This study, although similar in spirit to this popular opinion, is, however, distinct in a number of ways. Firstly, unlike most Nigeria-specific studies, this paper explores alternative measures of oil price shocks, which have been developed and used in the literature with a view to ascertaining the extent to which conclusions about the oil price-growth association depend on the definition of shocks adopted. More importantly, this, to the best of our knowledge, is a pioneer attempt at introducing threshold effects into the linkage between oil price shocks and output growth in Nigeria. The relatively recent regime-dependent multivariate threshold autoregressive model, together with the characteristic impulse response functions and forecast error variance decomposition, is adopted in this study. Using quarterly data spanning 1985–2008, a non-linear model of oil price shocks and economic growth is estimated.

Our main results indicate that oil price shocks do not account for a significant proportion of observed movements in macroeconomic aggregates. This pattern persists despite the introduction of threshold effects. This implied the enclave nature of Nigeria's oil sector with weak linkages. Therefore, the need to spend oil revenue productively is imperative if favourable effect on real output growth is envisaged.

1. Introduction

The provision of plausible explanations for the relationship between oil price movements and macroeconomic performance has occupied the attention of economists over the last four decades. This interest stems in part from the observed linkage between oil price realisations and episodes of recession.[1] The bulk of pioneering studies on oil price–macroeconomy interactions was targeted at establishing causal links, owing to the fact that

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the oil price episode was viewed as a permanent increase with the attendant effects on recessions in oil-dependent economies (Rasche and Tatom, 1977; Dagut, 1978; Darby, 1982; Lilien, 1982; Hamilton, 1983; Burbidge and Harrison, 1984; Nasseh and Elyasiani, 1984; Gisser and Goodwin, 1986; Loungani, 1986). The success of these efforts with regard to establishing causation was minimal, although their empirical evidences demonstrated that unanticipated rises in the price of oil have a negative impact on output growth. Subsequent oil price episodes[2] have resulted in the evolution of the perception of these price changes, and thus, a number of alternative explanations have been preferred for the influence of oil price increases on real activity. Firstly, output declines less as agents typically delay decisions with regard to consumption and investment due to the expected temporary nature of the oil price increase. Secondly, the novel episodes of oil price declines experienced around the mid-1980s diverted thinking towards the existence of asymmetries in this relationship (Mork, 1989; Bernanke *et al*., 1997; Hooker, 1999; Balke *et al*., 2002; Mehrara, 2008). Finally, recent attempts have focused on exploiting the possibility of non-linearities[3] and critical thresholds in the oil price–macroeconomy nexus. Huang *et al*. (2005) investigated the role of threshold effects by taking into account differences in speed of adjustment to oil price shocks across countries. These differentials with respect to tolerance are opined to be partly driven by country specificities in terms of energy efficiency, energy dependence and level of economic sophistication.

However, the preponderance of extant studies has examined this linkage for the net oil-importing industrial economies especially the United States and Organisation for Economic Cooperation and Development (OECD) countries. The role of oil price shocks in the booms and busts experienced by net oil-exporting developing countries has not been sufficiently covered in the literature. Specifically, studies are rare, as far as we know, in Nigeria, which have taken explicit account of potential non-linearities in the oil price–macroeconomy relationship. Also, most of the studies that look at threshold effects typically have a cross-sectional orientation. Hence, the present study further attempts to determine the impact of such effects in an oil-dependent economy, such as Nigeria. Against this background, therefore, this study seeks plausible answers to the following questions: (i) What is the impact of oil price shocks on output growth in the Nigerian economy?; (ii) Are there potential non-linear linkages in this relationship?; and (iii) What influence do critical thresholds have on the extent to which oil price fluctuations drive real output movements?

The broad aim of this paper, thus, is to offer an empirical analysis of the impact of oil price shocks on the Nigerian economy. It thereby adds to the scant literature on the effects of oil price changes on output in oil-exporting developing countries.[4] We pursue this goal by using an augmented vector autoregressive (VAR) model, considering its advantage in terms of the simultaneous modelling of equilibrium growth trends, as well as the dynamic response of the Nigerian macroeconomy to oil price variations.

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Following this introductory section, we focus on cross-cutting review of the oil price–macroeconomy literature in Section 2. A description of the data and econometric technique used is attempted in Section 3. Section 4 is preoccupied with the presentation and interpretation of estimation results, while the conclusions and plausible implications of our findings are presented in Section 5.

2. Oil and macroeconomy: a literature survey

This section is devoted to an extensive, albeit far from exhaustive, review of both the theoretical and empirical literature on the relationship between oil prices and the macroeconomy. The review of theoretical issues,[5] which is considered first, covers a number of channels of influence such as real balance, income transfer (from oil importers to oil exporters), endogenous monetary policy response and sectoral shifts. The subsequent bit then delves into the empirical review of the effects of oil price shocks on the macroeconomy. Theoretically, the real balance channel posits that oil price increases lead to higher inflation, with a given money supply, which lowers the amount of real balances. The lower real balances then produce recessions via the familiar monetary channel-increased interest rates leading to depressed investment spending, reduced aggregate demand and a concomitant fall in output [see Pierce and Enzler (1974) and Hall and Taylor (1991)]. Under the income transfer explanation, oil price increases lead to a transfer of income from net oil-importing economies to oil-exporting countries. This result in a reduction in consumption expenditure in the oil-importing countries as the purchasing power of consumers has been eroded by the oil price increase. This income redistribution leads to lower aggregate demand. Some researchers have opined that endogenous monetary policy responses are crucial. Hence, real output declines, which usually characterise oil price increases, are viewed as the result of counter-inflationary responses of monetary policy (Darby, 1982; Bohi, 1991). The argument is essentially that the oil price increases do not entirely account for the observed recessions; however, it is the reaction of monetary policy that either triggers or reinforces the output declines. Finally, the sectoral shift hypothesis posits that changes in oil prices perform better in explaining observed variations in output growth (Loungani, 1986). Within this backdrop, oil price shocks lead to a temporary upsurge in aggregate unemployment as workers in adversely impacted sectors may opt for suffering frictional unemployment pending improvement in conditions in their sector rather than outright movement into positively affected sectors of the economy (Hamilton, 1988).

The earlier attempts in the empirical literature were on investigating the economy's aggregate response to an unanticipated and permanent shock to oil prices (Rasche and Tatom, 1977, 1981; Bruno and Sachs, 1982, 1985; Eastwood, 1992). Seminal article of Hamilton (1983) shifted the macroeconomic analysis of shocks to oil prices to the supply

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side, employing the concept of Granger causality in testing the direction of effects of such shocks within a business cycle framework. Conventional wisdom posits symmetry in the response of the macroeconomy to both increases and decreases in oil prices. The failure of the oil price collapse of 1986 to result in economic boom for most countries served as a basis for growing scepticism on the attribution of recessions or their deepening in the past to positive shocks to oil prices (Mork, 1989). The efforts to address this issue have led to the investigation of the different mechanisms via which oil price shocks affect the macroeconomy. Mork *et al*. (1994), using data spanning 1967:3–1992:4 for seven OECD countries, found that all the countries, except Norway, experienced negative association between oil price increases and gross domestic product (GDP) growth. The bivariate regression estimated included GDP and current and lagged oil prices, while the multivariate model included other variables, such as the inflation rate, the short-term interest rate, the unemployment rate and the growth rate of industrial production. Jimenez-Rodriguez and Sanchez (2005), in an empirical investigation of the effects of oil price shocks on real economic activity using a multivariate VAR for a sample of seven OECD countries, revealed that oil price increases have a larger impact on the growth of GDP when compared with declines in oil prices. These oil price increases affect economic activity in an oil-importing country negatively (and significantly), while the effect for oil exporters was found to be ambiguous. Cavallo and Wu (2006) used a VAR model of three variables, namely output, inflation and oil prices, to estimate the effects of oil price shocks on output and prices for the US economy. The study found that following an oil price shock, output declined and prices increased. Lardic and Mignon (2008) investigated the existence of a long-run relationship between oil prices and GDP in 12 European countries using quarterly data from 1970:1 to 2003:4. To account for possible asymmetry in the linkage between oil price shocks and economic activity, they employ both the standard cointegration and a variant-asymmetric cointegration. From the results, only asymmetric cointegration exists between oil prices and GDP in most of the countries considered. This suggests that rising oil prices appear to retard economic growth by more than declining prices stimulate it.

Although emphasis with respect to research has been on net oil-importing industrial economies, a few recent studies have focused on the effects of oil price changes on the macroeconomy in developing countries. Raguindin and Reyes (2005) examined the effects of oil price shocks on the Philippine economy. Their impulse response functions (IRFs) for a linear specification of oil prices revealed that oil price shocks lead to prolonged declines in real GDP. In the non-linear VAR, however, oil price decreases play a greater role in fluctuations of model variables than oil price increases. They used data covering the period 1981–2003. Chang and Wong (2003), using quarterly data from 1978:1 to 2000:3, within a vector error correction model, on oil prices, GDP, consumer price index (cpi) and unemployment rate, found a marginal impact of oil price shocks on

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the Singapore economy. Both impulse response and variance decomposition (VD) analysis provide reasonable basis for their conclusion that the adverse effect of oil prices on GDP, inflation and unemployment rates in Singapore was minimal. They, however, conclude that this impact, although small, should not be interpreted as negligible. Specifically for Nigeria, Ayadi *et al*. (2000) examined the effects of oil production shocks on a net oil-exporting country, Nigeria. Using a standard VAR, which includes oil production, output, the real exchange rate and inflation over the 1975–1992 period, the impact responses show that a positive oil production shock was followed by rise in output, reduction in inflation and a depreciation of the domestic currency. With the same methodology and set of variables (except that oil price replaces its level of production), Ayadi (2005) found negligible responses of output, inflation and the real exchange rate following an oil price shock. Olomola and Adejumo (2006) examined the effects of oil price shocks on output, inflation, real exchange rate and money supply in Nigeria within a VAR framework. They found no substantial role for oil price shocks in explaining movements in output and inflation. Only the long-run money supply and the real exchange rate are significantly affected following a shock to oil prices. In a similar vein, there is a burgeoning literature on the non-linear impacts of oil price shocks on economic activity. However, because of the differences in the degree of economic development, the energy dependence and the efficiency of energy use in each country, the level of economic tolerance and speed of economic response to a positive oil price change and its shock are expected to be different. Huang *et al*. (2005) employed the multivariate threshold autoregressive (MVTAR) model of Tsay (1998) to find the threshold value of an oil price change and its shock in each country. They arrived at a number of interesting conclusions. Firstly, the most appropriate threshold value appears to vary according to an economy's degree of dependence on imported oil and its attitude towards adopting energy-saving technology. Secondly, an oil price shock has a limited impact on the economy if the change is below the critical threshold levels for a given economy. Thirdly, if the change is above the threshold levels, it appears that the change in the oil price explains the macroeconomic variables better than the shock caused by the oil price. Finally, an oil price change above the threshold level explains the variation in GDP growth better than the real interest rate.

More country-specific studies and superior statistical techniques are needed to test the relationship between oil price changes and macroeconomic performance.

3. Data description and methodology

3.1. Data description

The study determines the impact of oil price shocks on GDP, government revenue, monetary indicators, government consumption and inflation in Nigeria. Following Bohi (1991), fiscal and monetary indicators are included in the analysis. The availability of

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sufficiently long time series on the aforementioned variables served as an additional criterion for selection. Quarterly data spanning 1985Q1–2008Q4, a total of 96 observations, were employed.[6] All variables, except inflation, are transformed logarithmically and also expressed in their real values by deflating with the base year 1990 cpi. The most challenging feature identifiable from the oil–macroeconomy literature is the measure of oil price shocks to be used for analysis. We thus construct alternative measures of the oil price variable via a number of non-linear transformations, which capture key aspects of the departure of the oil price–output interaction from the standard linear view (Hooker 1996, 1999; Keane and Prasad, 1996). The reason for the statistical transformation of oil prices is to identify explicitly the component of the oil price that can be treated as purely exogenous to conditions in both specific countries and the global macroeconomy (Hamilton, 2003). The implication of this is that non-linear variants of the oil price changes filter out many of the endogenous drivers of oil price shocks.

Misspecification of the functional form is a major, but probably not the only, candidate for explaining the breakdown observed in the relationship between oil price fluctuations and output growth with the inclusion of more recent data (Mork, 1994). Therefore, researchers have directed efforts at exploring various oil price transformations with a view to re-establishing the oil price–output linkage especially in the post-1986 era, which was characterised by substantial oil price decreases and higher volatility than earlier episodes as such price movements were unprecedented (Mork, 1989; Lee *et al.*, 1995; Hamilton, 1996).

The traditional, also linear, measure of oil price shocks in the literature as popularised by Hamilton (1983) is the quarterly changes in real oil prices, which is constructed as the first log differences of the oil price variable, viz.,

$$\Delta o_t = \ln o_t - \ln o_{t-1}, \tag{1}$$

where o_t is the real oil price in period t and ln represents the logarithm of the same variable.

Evidence of non-linearity between GDP growth and oil price changes from the literature informed further investigation, with the general consensus being that positive oil price changes affect the macroeconomy by lowering real output growth, while the effect of oil price decreases on economic activity may at best be minimal. This asymmetry, as a phenomenon, has been well documented in the literature [see Mork (1989), and Jimenez-Rodriguez and the references therein). Mork (1989) concluded that oil price decreases are insignificant using a non-linear specification in which only positive changes are considered as follows:

$$\Delta o_t^{+} = \begin{cases} \Delta o_t & \text{if} \quad \Delta o_t > 0 \\ 0 & \end{cases}, \tag{2}$$

while intuitively for oil price declines,

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$$\Delta o_t^- = \begin{cases} \Delta o_t & \text{if} \quad \Delta o_t < 0 \\ 0 \end{cases}. \tag{3}$$

In this instance, oil price rises and declines are given separate treatment. He argued that there was little experience with declining oil prices prior to 1980 with the subsequently observed large oil price decreases eroding both the magnitude and statistical significance of the estimated effect of oil on the macroeconomy.

Hamilton (1996) proposed a net oil price increase (NOPI) measure on the basis that not all oil price increases impact on the behaviour of rational agents. Furthermore, Hamilton argued that a measure of how oil increase alters the spending decisions of households and firms would be a comparison with the current oil price to its historical path. Such reluctance to respond to small oil price changes could be a result of high costs of monitoring energy expenditures and frictions with regard to adjusting consumption. Hence, the amount by which the log real oil price in quarter *t* exceeds its maximum over the previous year (i.e. last four quarters) is used, while oil price increases less than this benchmark are assumed to have no effect. This transformed oil price variable is

$$\text{NOPI4} = \max\left[0, (\ln o_t) - \ln\left(\max\left(o_{t-1,} o_{t-2,} o_{t-3,} o_{t-4,}\right)\right)\right]. \tag{4}$$

To capture sluggish adjustment mechanisms because of rigidities specific to particular economic settings, Hamilton (1996) proposed a variant of the above measure, which covers the amount by which the log of oil prices in quarter *t* exceeds the maximum over the previous 12 quarters (3 years) as

$$\text{NOPI12} = \max\left[0, (\ln o_t) - \ln\left(\max\left(o_{t-1,\dots,} o_{t-12,}\right)\right)\right]. \tag{5}$$

With the above variables, it is possible to examine the causal relationship between 'important' oil price increases and macroeconomic indicators.

The macroeconomic environment also matters for an objective assessment of the impact of oil price shocks. Lee *et al*. (1995) showed that oil price increases in the aftermath of long periods of price stability have more dramatic implications than those changes that merely correct for large price declines in the immediate, recent past periods. Thus, it is not only the 'importance' of an oil price increase, as in Hamilton's suggestion, that matters but also the volatility of the oil price series. Lee *et al*.'s scaled oil price increase (SOPI) is calculated based on a generalised autoregressive conditional heteroscedasticity (GARCH) (1, 1) model as follows:

$$o_t = \alpha + \sum_{i=1}^{k} \beta_i o_{t-i} + \varepsilon_t; \; \varepsilon_t / I_t \rightarrow N(0, h_t), \tag{6}$$

$$h_t = \gamma_0 + \gamma_1 \varepsilon_{t-i}^2 + \gamma_2 h_{t-i}, \tag{7}$$

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$$\mathrm{SOPI} = \max\left(0, \varepsilon_t / \sqrt{h_t}\right). \tag{8}$$

A significant relationship between this conditional variance adjusted oil price shock variable and economic activity implies that an oil price increase will likely lead to a downturn in output growth where volatility is low, with an increase of similar scale resulting in minimal effect under a highly volatile oil price regime (Cunado and Perez de Gracia, 2005; Zhang, 2008). We adopt two key non-linear transformations, NOPI4 and SOPI, together with the linear measure in what follows. **Figure 1** provides a visual representation of the variables employed in our subsequent analysis.

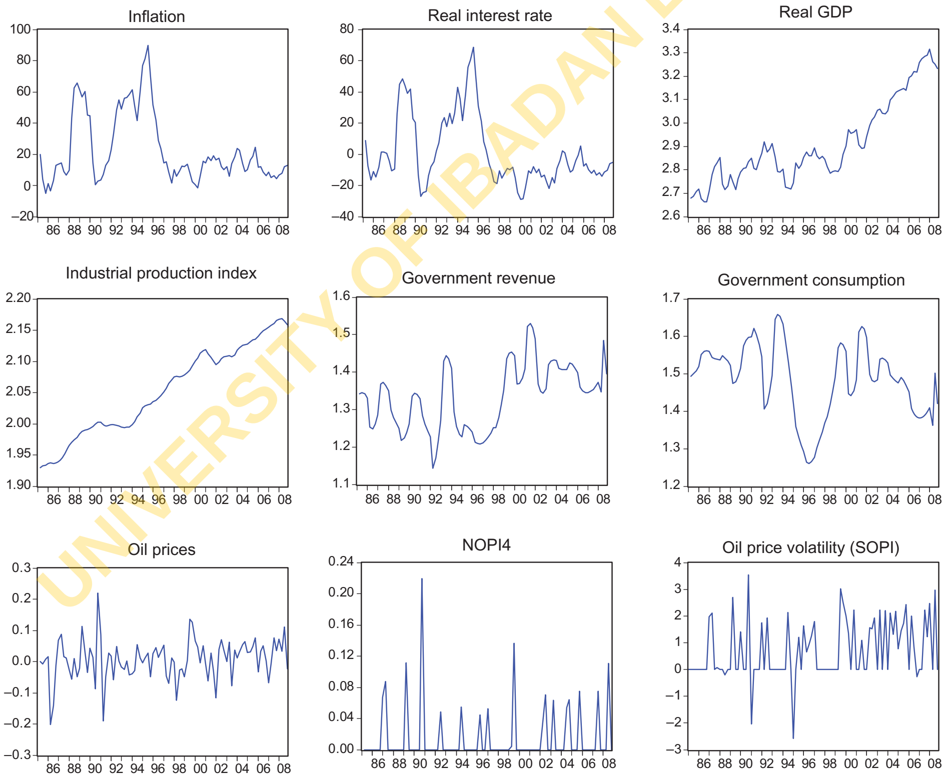

Figure 1 Variable plots 1985–2008. Note: All variables and their units of measurement are as detailed in Appendix 1. GDP, gross domestic product; NOPI4, net oil price increase; SOPI, scaled oil price increase.

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3.2. Econometric methodology

The analysis begins with ascertaining the order of integration of the variables. The procedure adopted in this study involves the use of the Phillips–Perron (PP) (Phillips and Perron, 1988) and Kwatkowski–Phillips–Schmidt–Shin (KPSS) (Kwatkowski *et al.*, 1992) tests. The null hypothesis of the PP test is non-stationarity; thus, failure with respect to rejection implies unit root in the series. On the contrary, stationarity is assumed under the null in the KPSS test. Following these unit root tests, the Johansen (1988) maximum likelihood approach to cointegration is employed to examine the presence of any long-run association among the variables. To account for the sensitivity of results using this approach to cointegration to the choice of lag length, the Schwarz information criterion is used. Also, in order to understand the dynamics of responses, both the IRFs and VD are used in a VAR framework. While the IRFs track the responsiveness of the regressands in the VAR to shocks to each of the other variables, the VDs provide information on the proportion of the movements in the dependent variables accounted for by their own shocks vis-à-vis the shocks to other factors.

The magnitude of the impact of oil price fluctuations or its volatility on an economy depends in part on the degree of reliance on oil imports and/or exports (Huang *et al.*, 2005). Hence, oil price shocks may have moderate effects on economic activities until some critical threshold is reached. To capture this notion, a formal MVTAR model *à la* Huang (2008) is adopted, viz.,

$$y_t = \left(\sum_{j=1}^{4} \alpha_{1j} d_{ij} + \sum_{i=1}^{p} \phi_{i,1} y_{t-i}\right)\left(1 - I\left[q_{t-d} > c\right]\right) + \left(\sum_{j=1}^{4} \alpha_{2j} d_{ij} + \sum_{i=1}^{p} \phi_{i,2} y_{t-i}\right) I\left[q_{t-d} > c\right] + \varepsilon_t, \quad (9)$$

where y_t is [real gross domestic product (RGDP), government revenue (REV), inflation (INF) and oil price (OILP)].[7] $d_{tj} = 1$ if observation t is characterised by quarter j and restricted to zero otherwise. z_{t-1} represents the I(1) variables cointegrating vector or an error correction term, while q_{t-d} denotes the threshold variable with delay period (d) and threshold level (c). ε_t is a stochastic term assumed to be distributed as N(0,1) and I[.] is an index function which equals 1 if the expression in bracket holds and zero otherwise.

4. Empirical results and analysis of findings

4.1. Time series properties

Stationarity tests performed on all the variables are presented in **Table 1**. Both the PP and KPSS tests indicate that INF, real interest rate (RIR), RGDP, industrial production (INDP), REV and government consumption expenditure (GCONS) are all integrated of order one, that is, I(1), while the oil shock measures (OILP, NOPI4 and SOPI) are I(0). Interestingly, however, both the linear (OILP) and volatility adjusted (SOPI) measures of oil price shocks appear to be integrated of order one as shown by the KPSS testing procedure. As

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Table 1 Unit root tests

	PP				KPSS				
	Level		First difference		Level		First difference		
Variable	Drift	Drift + trend	Drift	Drift + trend	Drift	Drift + trend	Drift	Drift + trend	Decision
INF	−2.462	−2.610	−6.817***	−6.796***	0.452*	0.185**	0.044	0.037	I(1)
RIR	−2.585	−2.741	−7.091***	−7.053***	0.527**	0.137*	0.035	0.036	I(1)
RGDP	−0.566	−2.171	−7.946***	−7.914***	2.005***	0.429***	0.074	0.040	I(1)
INDP	−0.873	−2.126	−4.109***	−4.119***	2.427***	0.113*	0.078	0.055	I(1)
REV	−2.905	−3.482*	−7.383***	−7.339***	0.919***	0.151**	0.032	0.026	I(1)
GCONS	−2.659	−2.847	−7.327***	−7.288***	0.355*	0.122*	0.036	0.035	I(1)
OILP	−7.899***	−8.161***	NA	NA	0.376*	0.031	0.024	0.022	I(0)
NOPI4	−10.372***	−10.316***	NA	NA	0.061	0.053	0.027	0.021	I(0)
SOPI	−9.682***	−10.571***	NA	NA	0.813***	0.051	0.030	0.023	I(0)

Notes: PP—Phillips and Perron (1988) unit root test with the Ho: variables are I(1); KPSS—Kwiatkowski *et al*. (1992) unit root test with Ho: variables are I(0); ***, ** and * indicate significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively, while, NA implies not applicable.

INF, inflation; RIR, real interest rate; INDP, industrial production; REV, government revenue; GCONS, government consumption expenditure; OILP, oil price; NOPI4, net oil price increase; SOPI, scaled oil price increase.

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the inclusion of a trend term in the auxiliary regression completely reverses this outcome, the conclusion is that both series are stationary levels and differencing them would be inappropriate (Hamilton, 1994; Iwayemi and Fowowe, 2009).

The need for the conventional cointegration tests is obviated as the variables are integrated in different orders. Hence, the impact analysis is performed within a VAR framework, with all non-stationary variables entering the unrestricted model in their differenced forms (Farzanegan and Markwardt, 2009).

4.2. One-regime VAR analysis

This begins with the unit root testing approaches presented in Table 1. It also involves the use of IRFs and forecast error VD to assess the response of macroeconomic variables to a unit shock to oil prices and the proportion of the variations in the variables attributable to oil price shocks, respectively. The analysis that follows is hence preoccupied with these issues together with the standard sensitivity checks typical in most VAR-based enquiries.

IRFs

The responses of the key macroeconomic variables to different oil price shocks are displayed in Figs 2–5. These impulse responses, displayed in the last column of each figure, trace the effect of a one-time shock to a measure of oil price shocks on the contemporaneous and future values of each of the other endogenous variables.

In **Fig. 2**, the response of macroeconomic variables to shocks to the benchmark linear oil price indicator is shown. Output responds positively throughout the 10 quarters following the change in oil prices. However, the significance of the response dies out after about four periods. Inflation initially drops in a seemingly precipitous manner during the first three quarters; however, this decline becomes completely muted 10 quarters later.

The response of government revenue to a shock to oil prices is insignificant in all periods after the one-time shock. Thus, output, inflation and government receipts respond differentially to shocks to the linear oil price variable.[8]

The observed breakdown in the oil price–macroeconomy relationship especially after the oil price collapse of the mid-1980s led to efforts at exploring plausible explanations for this phenomenon. Hamilton (1996), along this line, posited that novel[9] oil price changes are likely to have more impact on economic activities than those that are simply corrections of past oil price changes. He therefore suggested a net oil price shock measure (NOPI4), which only accounts for all prices that are greater than the prices recorded for the preceeding four quarters.

We construct and employ this oil shock measure and display the impulse responses in **Fig. 3**. Here, the response of output to a one unit shock to NOPI4 is minimal. Specifically, there is a marginal rise in output up to about four quarters before tapering off occurs in latter periods. Inflation shows no significant response to important oil shocks over the

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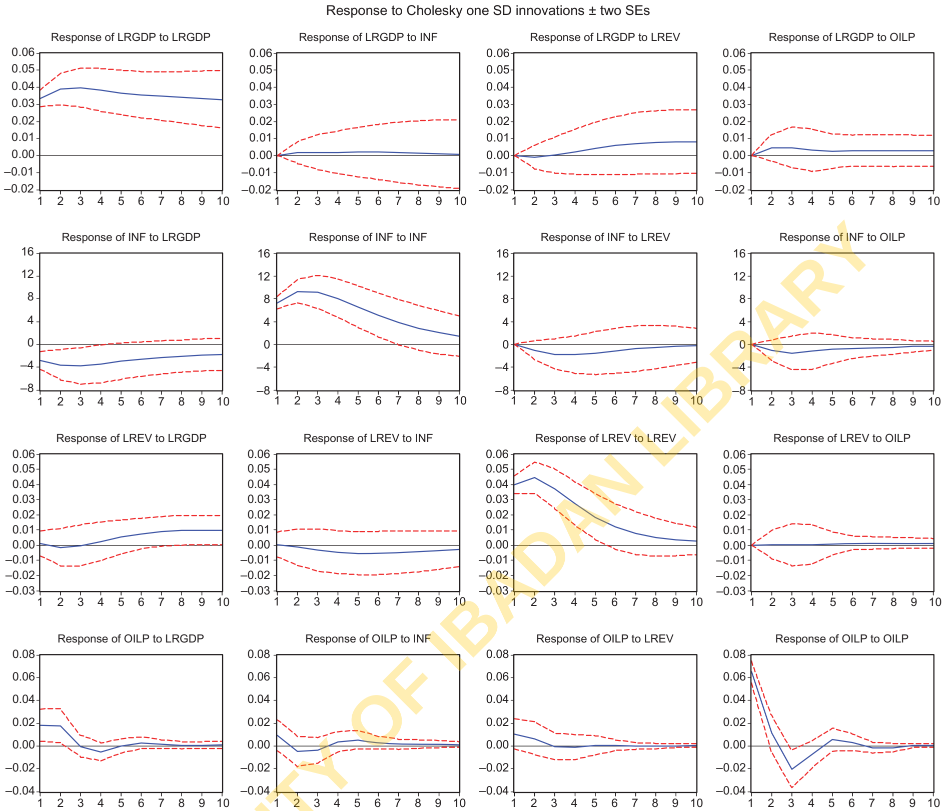

Figure 2 Impulse response functions of shocks to benchmark measure (OILP). INF, inflation; LREV, government revenue (log); LRGDP, real gross domestic product (log); OILP, oil price; SD, standard deviation; SE, standard error.

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previous four quarters. Nevertheless, the response of government revenue to oil price shocks (NOPI4) appears to be significant for most of the periods following a one-off shock to oil prices. This sharply contrasts with the results obtained with the linear measure. As unimportant oil prices are assigned a value of 0 in constructing the NOPI4, it is plausible that only substantial price changes which are more likely to affect oil revenue receipts are included. Hence, the marked difference in the results was returned by both models in our VAR framework.

Following Lee *et al*. (1995), we also construct a volatility adjusted measure of oil price shocks. This SOPI is obtained from a GARCH (1,1) model of oil price change. The intuition behind this is simply that oil price movements are likely to be more important in an environment characterised by historically stable prices, whereas the impact of oil shocks may be

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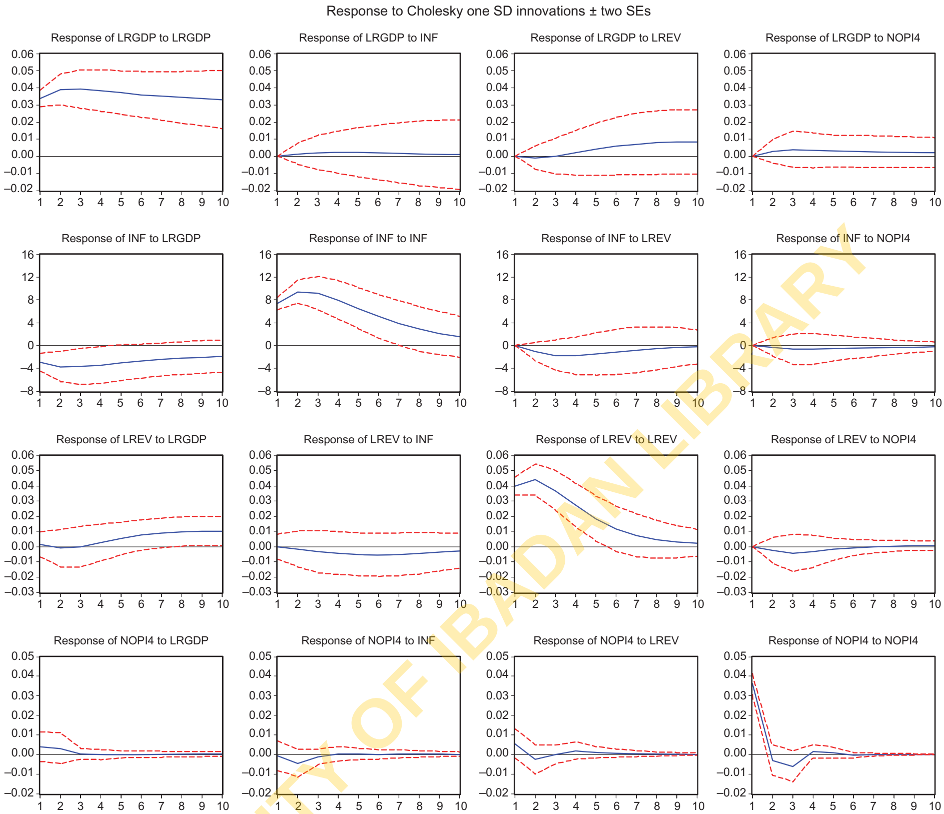

Figure 3 Impulse response functions of shocks to NOPI4. INF, inflation; LREV, government revenue (log); LRGDP, real gross domestic product (log); NOPI4, net oil price increase; SD, standard deviation; SE, standard error.

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muted, where prices are known to be volatile. **Figure 4** displays the impulse responses of the macroeconomic variables to shocks to the SOPI measure. In this case, output shows no response to shocks to SOPI. This implies that the volatility of oil prices is not an important factor influencing real output variations in Nigeria. Also, inflation did not respond to shocks to oil prices in all the 10 periods after the occurrence of such a shock. However, government revenue first increases around the two quarters before the effect dies out.

To ascertain the robustness of our results, we use an alternative measure of output—the industrial production index—to test the sensitivity of responses to the measure of output adopted. The summary of this exercise is displayed in **Fig. 5**.

It is interesting to note the difference observed with the use of the industrial production index. While output response was positive in the case of the linear benchmark (Fig. 2), the

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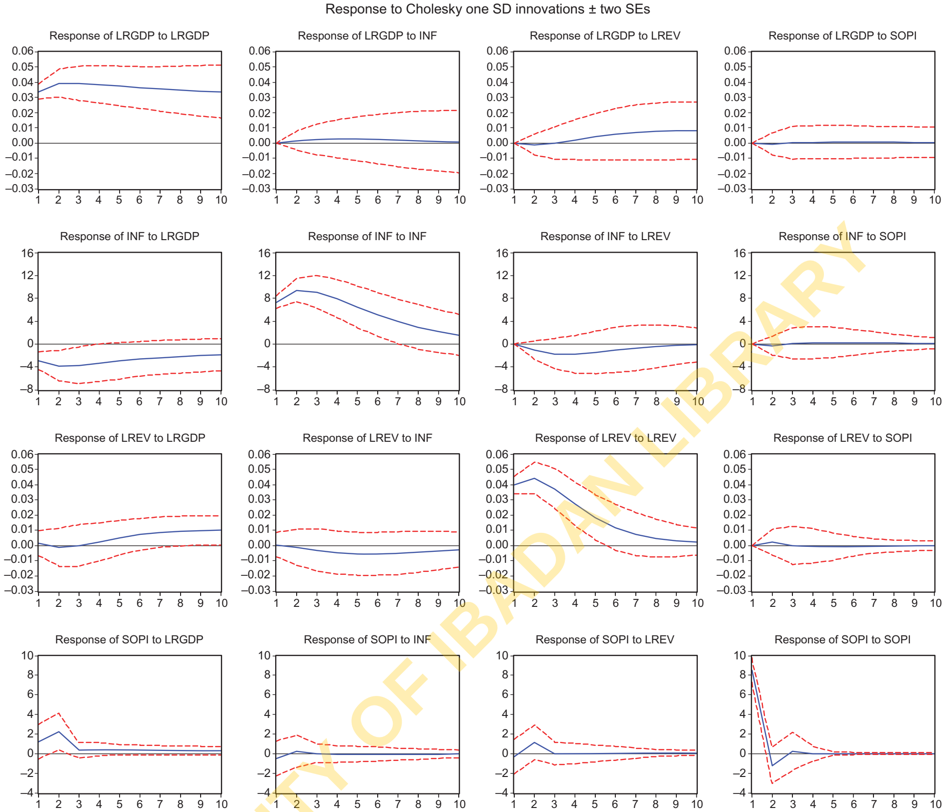

Figure 4 Impulse response functions of shocks to SOPI. INF, inflation; LREV, government revenue (log); LRGDP, real gross domestic product (log); SD, standard deviation; SE, standard error; SOPI, scaled oil price increase.

converse is true when the industrial production index is the output measure adopted. It is plausible that oil price changes result in the transfer of income from oil importers to oil exporters. For instance, an oil price increase implies that an input into production has become relatively scarce in oil-importing economies, hence the negative output response displayed in Fig. 5. This result agrees to a large extent with the arguments extensively developed by Abeysinghe (2001).

VD

The VD typically shows the proportion of the forecast error variance of a variable which can be attributed to its own shocks and the innovations of the other variables. The general

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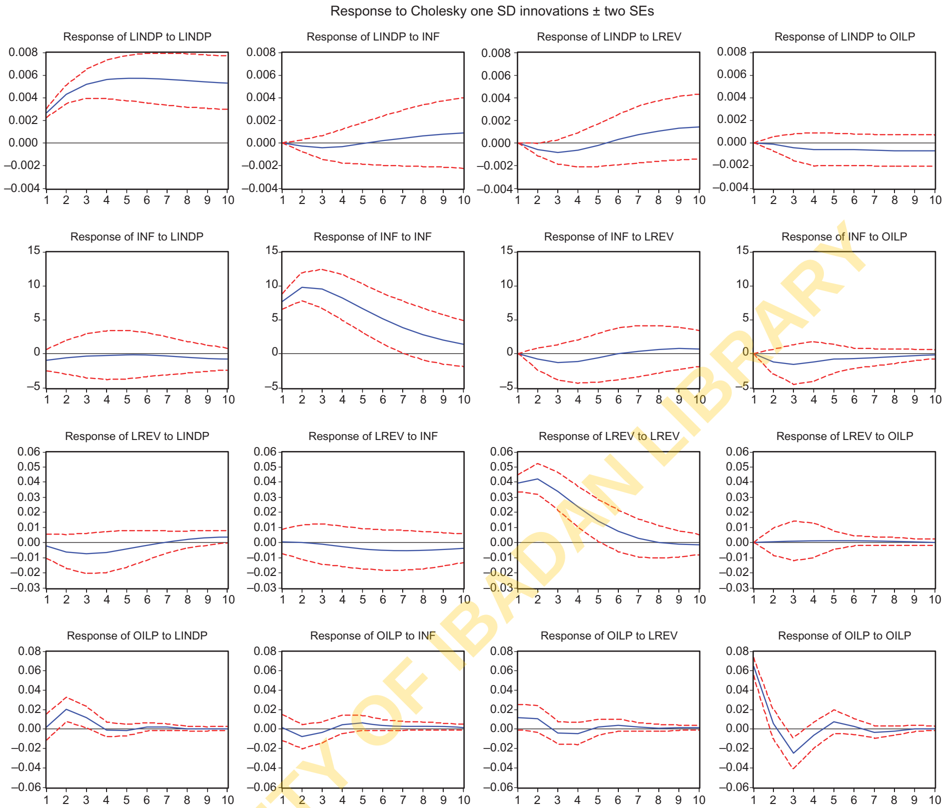

Figure 5 Impulse response functions of shocks to OILP (using industrial production index). INF, inflation; LREV, government revenue (log); LINDP, industrial production (log); OILP, oil price; SD, standard deviation; SE, standard error.

picture that emerges from a deeper look at **Tables 2–5** appears to be that oil price shocks only account for a small proportion of the forecast error variance of output, government revenue and inflation.

Table 2 presents the forecast error VD when the linear measure of oil shocks is used. It is easily seen that oil price shocks had 0 per cent initial impact on output, while there was a slight increase to about 0.77 per cent in the fifth period before an eventual marginal decline to 0.71 per cent at the end of the 10th period. Another striking finding from this table is that oil price shocks contribute less than 1 per cent to the variations in the other macroeconomic variables except for the fifth- and 10th-period inflation of 1.44 per cent and 1.47 per cent in that order. It is also interesting to note that the results from the use of alternative oil shock measures, that is, NOPI4 and SOPI, are quantitatively indistinguishable from the

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Table 2 Variance decomposition using linear oil shock measure (OILP)

Dependent variable	Period	Standard error	Output (real GDP)	Inflation	Government revenue	Oil
Output (real GDP)	1	0.0335	100	0.0000	0.0000	0.0000
	5	0.0842	98.7283	0.1787	0.3182	0.7748
	10	0.1157	96.9228	0.178	2.1926	0.7066
Inflation	1	7.8579	12.8816	87.1194	0.0000	0.0000
	5	20.0953	13.95	82.1574	2.4535	1.4394
	10	22.0548	16.3977	79.6157	2.5164	1.4702
Government revenue	1	0.0399	0.0926	0.0022	99.9052	0.0000
	5	0.0782	0.6139	1.0589	98.3089	0.0182
	10	0.0829	6.6924	2.2438	90.9395	0.1242
Oil	1	0.0689	7.0196	1.8054	2.3477	88.8273
	5	0.0764	11.5558	2.8615	2.6233	82.9594
	10	0.0767	11.6436	3.1032	2.6123	82.6409

GDP, gross domestic product; OILP, oil price.

Table 3 Variance decomposition using NOPI4

Dependent variable	Period	Standard error	Output (real GDP)	Inflation	Government revenue	NOPI4
Output (real GDP)	1	0.0336	100.0000	0.0000	0.0000	0.0000
	5	0.0843	98.8473	0.2239	0.3044	0.6244
	10	0.1157	96.9402	0.2119	2.2933	0.5546
Inflation	1	7.9091	13.4424	86.5576	0.0000	0.0000
	5	20.0009	14.2899	82.9567	2.4499	0.3034
	10	22.0352	17.2140	79.8894	2.5248	0.3719
Government revenue	1	0.0398	0.1433	0.0005	99.8562	0.0000
	5	0.0781	0.6219	0.9857	97.7763	0.6159
	10	0.0829	7.0481	2.2535	90.1240	0.5745
NOPI4	1	0.0367	1.1088	0.0352	2.2669	96.5891
	5	0.0379	1.6056	1.6067	2.9115	93.8762
	10	0.0379	1.6105	1.6099	2.9317	93.8478

GDP, gross domestic product; NOPI4, net oil price increase.

results in Table 2.[10] Also, irrespective of the oil shock measure adopted, the proportion of the variances in the forecast errors of inflation and government revenue explained by oil shocks remains at best infinitesimal. There is, however, as seen from Table 5, a relatively more pronounced impact on macroeconomic variables. For example, oil price shocks

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Table 4 Variance decomposition using SOPI

Dependent variable	Period	Standard error	Output (real GDP)	Inflation	Government revenue	SOPI
Output (real GDP)	1	0.0337	100.0000	0.0000	0.0000	0.0000
	5	0.0844	99.3751	0.2999	0.3080	0.0168
	10	0.1161	97.5594	0.2722	2.1488	0.0196
Inflation	1	7.9018	13.9402	86.0598	0.0000	0.0000
	5	19.9342	14.4613	83.0260	2.4632	0.0494
	10	21.9635	17.1583	80.3162	2.4539	0.0716
Government revenue	1	0.0397	0.1221	0.0169	99.8609	0.0000
	5	0.0781	0.5575	1.0370	98.3122	0.0932
	10	0.0827	6.5543	2.2677	91.0817	0.0964
SOPI	1	8.6261	1.9493	0.3345	0.1191	97.5970
	5	9.0921	8.2279	0.3752	1.7119	89.6850
	10	9.1228	8.8039	0.3974	1.7167	89.0819

GDP, gross domestic product; SOPI, scaled oil price increase.

Table 5 Variance decomposition using linear measure (OILP) and industrial production index

Dependent variable	Period	Standard error	Output (industrial production)	Inflation	Government revenue	Oil
Output (industrial production)	1	0.0027	100.0000	0.0000	0.0000	0.0000
	5	0.0109	97.8019	0.2617	1.2348	0.7016
	10	0.0168	95.6276	0.8375	2.4955	1.0396
Inflation	1	7.7763	1.4209	98.5791	0.0000	0.0000
	5	19.2799	0.3659	96.9808	1.0690	1.5843
	10	20.7777	0.6717	96.4182	1.3201	1.5899
Government revenue	1	0.0393	0.3839	0.0203	99.5957	0.0000
	5	0.0736	2.9352	0.4712	96.4999	0.0937
	10	0.0750	3.3560	2.5062	93.9942	0.1436
Oil	1	0.0655	0.0853	0.0505	3.4244	96.4399
	5	0.0766	9.3733	2.3542	5.0498	83.2227
	10	0.0773	9.3568	2.9706	5.3630	82.3095

OILP, oil price.

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account for more than 1 per cent of the variance of output and about 1.6 per cent of the variance of inflation after about 10 periods.

4.3. Two-regime VAR analysis

With this effect, oil price shocks affect macroeconomic performance, depending, to some extent, on economy's degree of oil dependence. There have been significant changes in the responses of both oil-importing and -exporting countries since the major energy crisis of the early 1970s. These coping strategies range from fuel substitution in the former countries to efforts at diversification in the latter. To capture the impact of such an effect, we use the oil price variable as the threshold variable and then split the sample into two regimes. Regime 1 contains all observations less than or equal to a critical threshold value, while those greater than this value are the components of Regime 2.[11] We now turn to the impulse responses of macroeconomic variables to a unit shock to oil prices in our constructed Regimes 1 and 2 in what follows.

IRFs (Regimes 1 and 2)

Figures 6 and 7 display the IRFs of macroeconomic variables to oil shocks. The output effects appear to be insignificant as seen from **Fig. 6**. There is, however, a period of marginal increase in output in response to oil shocks, which is also not significant over the range from the third to the sixth periods. Inflation, in similar fashion, declined between second and seventh periods, although this reduction was found to be insignificant as well. Therefore, the output and price effects of oil shocks in Regime 1 seem to be inconsequential. Government revenue, in contrast, shows a significant fall around the third period. However, the statistical importance of this decline is not clear.

A deeper look at **Fig. 7**, which shows the IRFs for Regime 2, reveals that responses of output, inflation and government revenue to a one-time shock to oil prices are similar to those obtained in Regime 1. Hence, it appears as though the response of the Nigerian macroeconomy to shocks to oil prices is independent of the critical threshold level as there seems to be no obvious distinction between the impulse responses across regimes. This, arguably,[12] makes a case for the unimportance of thresholds in the oil price–macroeconomy relationship in Nigeria. This conclusion is not different from those of earlier studies[13] like Ayadi *et al*. (2000), Ayadi (2005) and Olomola and Adejumo (2006), who found oil price shocks to have minimal impacts on the Nigerian economy.

VD for Regime 1

The last column of **Table 6** shows the respective proportions of the forecast error variance of macroeconomic variables attributable to oil price shocks. The overall picture that emerges is one in which oil price fluctuations explain far less than 1 per cent of the variations in output and the other variables.

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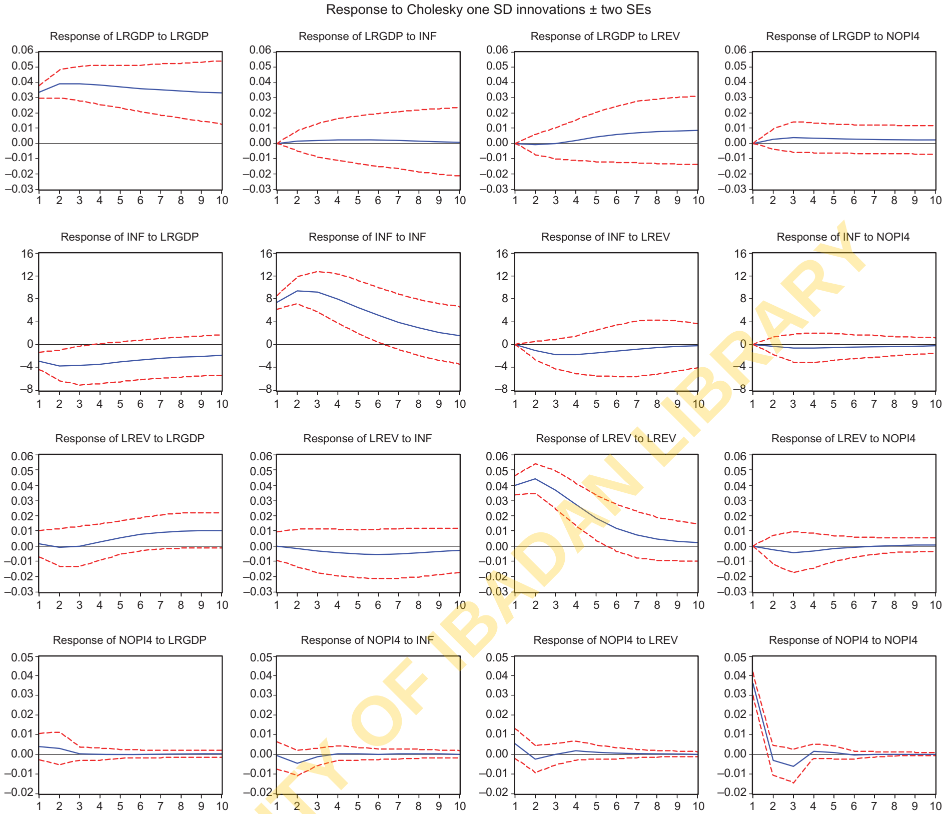

Figure 6 Impulse response functions of shocks to NOPI4 in Regime 1. INF, inflation; LREV, government revenue (log); LRGDP, real gross domestic product (log); NOPI4, net oil price increase; SD, standard deviation; SE, standard error.

The results for Regime 2, not presented here for the sake of brevity, seem to suggest a similar conclusion as in no case was the effect of oil shocks greater than 0.7123 (the response of output after about 10 periods). In sum, the VD results reinforce the conclusion from the previous IRFs that oil price shocks appear not to have appreciable effect on the macroeconomy in Nigeria.

5. Conclusions and policy implications

This paper empirically investigated the effects of oil price shocks on macroeconomic variables, with particular emphasis on real output, in Nigeria. The preponderance of evidences

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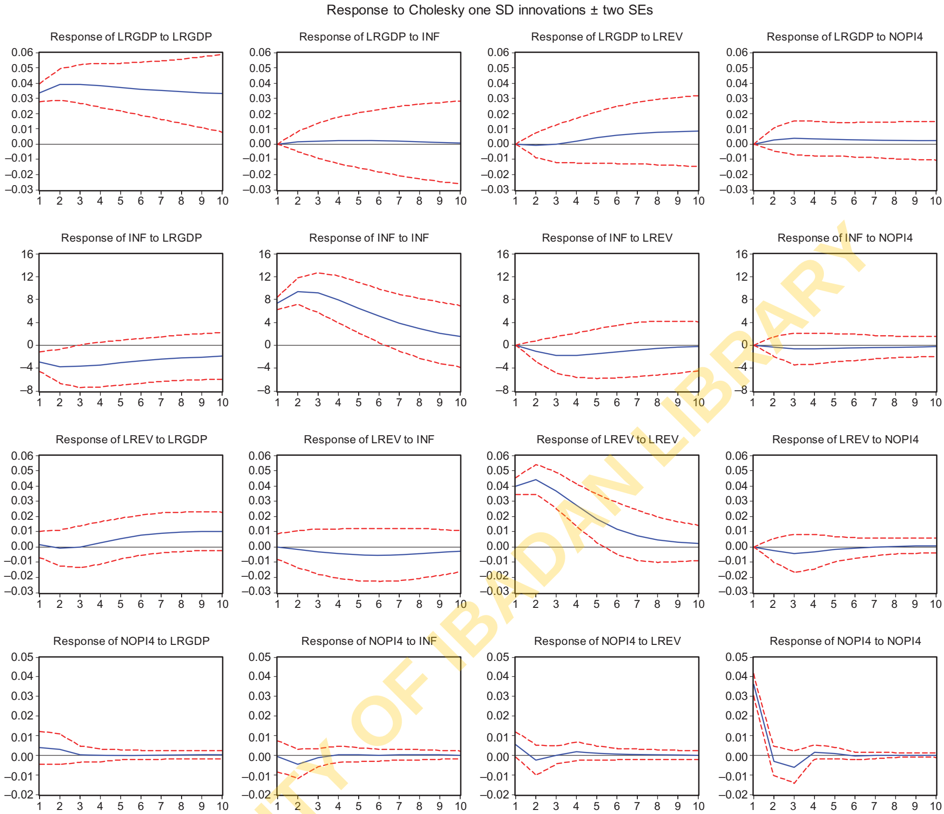

Figure 7 Impulse response functions of shocks to NOPI4 in Regime 2. INF, inflation; LREV, government revenue (log); LRGDP, real gross domestic product (log); NOPI4, net oil price increase; SD, standard deviation; SE, standard error.

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in the literature deals with this issue as it concerns net oil-importing economies. Although a number of studies focus on oil exporters, this study follows a different course by explicitly taking account of not only potential non-linearities but also the plausible role of thresholds in influencing the oil price–macroeconomy linkage. Broadly speaking, our findings show that the impact of oil price shocks on most of the macroeconomic variables in Nigeria is at best minimal. Specifically, the results of the IRFs and VD analysis to a large extent confirmed that oil price shocks are only able to explain a small proportion of the forecast error variance of these macroeconomic aggregates. Oil price shocks, as revealed by VD, accounted for less than 1 per cent of the variations in output, inflation and government revenue. The most striking finding, however, was that this pattern persists even when

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Table 6 Variance decomposition using NOPI4 in Regime 1

Dependent variable	Period	Standard error	Output	Inflation	Government revenue	NOPI4
Output	1	0.0336	100.0000	0.0000	0.0000	0.0000
	5	0.0843	98.8473	0.2239	0.3044	0.6244
	10	0.1157	96.9402	0.2119	2.2933	0.55546
Inflation	1	7.9091	13.4424	86.5576	0.0000	0.0000
	5	20.0009	14.2899	82.9567	2.4498	0.3034
	10	22.0352	17.2140	79.8894	2.5248	0.3719
Government revenue	1	0.0398	0.1433	0.0005	99.8562	0.0000
	5	0.0781	0.6219	0.9856	97.7763	0.6159
	10	0.0829	7.0481	2.2535	90.1240	0.5745
NOPI4	1	0.0367	1.1088	0.0352	2.2669	96.5891
	5	0.0379	1.6056	1.6067	2.9114	93.8762
	10	0.0379	1.6105	1.6099	2.9317	93.8479

NOPI4, net oil price increase.

critical thresholds are included in the estimation procedure. Hence, we find evidence of a muted effect of oil price shocks on the Nigerian economy. Although a policy of diversification is usually recommended for economies, which depend solely on oil revenue, the applicability of such an option appears unclear from what we have found in the case in Nigeria.

Notes

1. Hamilton (1983), in his seminal paper, pointed to this association on the premise that all but one of the post-war recessions in the United States were an aftermath of oil price increases. See Mork (1994) for a detailed discussion of developments in the literature on this subject, especially after the first major oil shock in 1973.
2. The other significant oil price surges and the associated events are as follows: 1978–1979 and the Iranian Revolution; 1990–1991 and the Persian Gulf War; 2003–2006 and the civil unrest in Venezuela. However, it is pertinent to note that a substantial part of the latter price shock has been attributed to heightened demand especially from fast growing economies such as China and India.
3. For excellent treatments on the impact of non-linearities on the oil price-macroeconomy linkage, see Mork (1989), Lee *et al*. (1995), Hamilton (1996), Jones *et al.* (2004), Jimenez-Rodriguez and Sanchez (2005) and the references they contain.
4. Although Lorde *et al*. (2009) embarked on a similar exercise, they did not investigate the role of threshold effects in the oil price–macroeconomy relationship for Trinidad and Tobago.

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Also, the oil shock measure reflecting volatility was adopted. This study, however, employs not only the volatility measure but also other non-linear measures with a view to ascertaining robustness of the results obtained.

5. For a detailed exposition on some other theoretical linkages between oil prices and the macroeconomy, the interested reader should see the underlisted: (i) potential output channel (Berndt and Wood, 1979; Fischer, 1985; Tatom, 1988; Rotemberg and Woodford, 1996; Finn, 2000); (ii) Dutch disease channel (Corden and Neary, 1982; Corden, 1984; Wijnbergen, 1984; Matsen and Torvik, 2005); and (iii) uncertainty and irreversible investment channel (Bernanke, 1983; Pindyck, 1991).
6. All data were obtained from the new Central Bank of Nigeria quarterly macroeconomic time series database available at the Centre for Econometric and Allied Research.
7. This oil price variable includes the linear benchmark (OILP) and the two other non-linear transformations (NOPI4 and SOPI), which are used, in turn, for the VAR analysis.
8. For the sake of robustness, we change the ordering of the variables in the unrestricted VAR. The results using three alternative orderings, available upon request, show that the responses of the variables to a shock to the linear oil price measure are similar to what was obtained here.
9. Novelty in this instance is defined in terms of oil price realisations that substantially exceed historically observed to the values. The history will, however, depend on how much of past price information the analyst decides to take on board.
10. Although the output effects in Tables 3 and 4 are less than 1 per cent, the magnitude is higher when the NOPI4 measure is used. In the fifth period, for instance, oil shocks accounted for 0.624 and 0.017 in the model with NOPI4 and SOPI, respectively.
11. It is noteworthy that a threshold value of 0.0034 is chosen as the critical point beyond which oil shocks become important. Sample splitting using this benchmark left us with 42 observations in Regime 1 and 54 observations in Regime 2. Also, the number of observation in each regime was similar when real output and other oil price measures were chosen as threshold variable. For the interested reader, these additional results are available upon request.
12. Arguable in the sense that the choice of both threshold variable and the critical threshold value, in this study, is somewhat arbitrary. The NOPI4 measure of oil price shocks was used as threshold variable, while a critical value of 0.0034 was adopted. Hence, Regime 1 comprised values less than or equal to 0.0034 and in Regime 2, those observations are greater than 0.0034.
13. The point of departure, however, of the present study is that thresholds were not explicitly considered in these studies.

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Appendix 1: Data description

This paper deployed quarterly data over the period spanning the first quarter of 1985 to the fourth quarter of 2008. All data were obtained from the Central Bank of Nigeria database. The descriptions of the actual variables, as well as their units of measurement (in parenthesis), are as follows: the real GDP is a measure of output (in million naira), the government revenue is total receipts of government from all sources (in million naira), inflation is the change in the consumer price index (in per cent), real interest rate is domestic lending rate less inflation influence (in per cent) and industrial production index is measured as a proxy for economic activity in the OECD. Also, government consumption refers to total government final expenditure (in million naira), while oil price and the other two measures of oil price shocks—NOPI4 and SOPI—are computed using the price of Nigeria's Bonny Light crude benchmark (in US dollars per barrel).

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