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ABSTRACT

Given its economic structure, high energy intensity and simultaneity as an oil importing and exporting economy, Nigeria stands out as a special case to study the oil-price-macroeconomy relation. This paper studies the linear and asymmetric impacts of oil price shocks on the Nigerian economy between1970Q1and 2008Q4. Using the vector error correction mechanism and the Granger causality test, we investigate the long-run and short-run impacts of oil price shocks on the supply-side of the economy, wealth transfer effect, inflation effect and real balance effect. Overall, the results from the linear model show that oil price shocks are not a major determinant of macroeconomic activity in Nigeria, and macroeconomic activities in Nigeria do not Granger cause world oil prices. Further, the results from our non-linear specification reveals that the impact of world oil price shocks on the Nigerian economy are asymmetric. Hence, the common practise of national development planning premised on forecasts of international oil prices should be de-emphasized in Nigeria.

Keywords: Oil price shocks; linear and asymmetric effects; transmission channels; Nigerian economy.

1. Introduction

Given the primary role that energy plays in driving modern economies, stability of oil prices has become a crucial factor with spatial and temporal implications for the development of the Nigerian economy. Over the past four decades, the global economy has witnessed frequent oil price distortions which have enormously influenced and changed the global perceptions of the oil price-macroeconomy (henceforth OPM) relation. Nigeria stands out as a special case to study the OPM relation because of its peculiar economic structure, high energy intensity, energy mix and dependence on international energy markets. Also, Nigeria is simultaneously an oil exporter and importer and oil price forecasts provide the framework for macroeconomic planning[2] and appraisal. Thus distortions (shocks) to oil prices are likely to pass through

[2] Oil price forecasts is the index used by government agencies for capital and recurrent budgeting.

directly or indirectly to every facet of the Nigerian economy both at the micro and macro levels.

Recognizing the significance of oil prices to the Nigerian economy, several authors have investigated the oil price-macroeconomy relationship in Nigeria (see for e.g., Ayadi, 2005; Akpan, 2009; Aliyu, 2009; Chuku et al., forthcoming; Olomola and Adejumo, 2006) and this relationship continues to dominate and inspire the minds of policy makers and academicians. Despite the plethora of studies on the OPM relation, the literature is yet to provide conclusive evidence as to how oil price shocks affect the macroeconomy of any country and Nigerian in particular, given the idiosyncrasies inherent in the Nigerian economy.

This paper is a modest contribution to the literature and evidence on the OPM relation for an oil exporting (and importing) developing economy. The paper is different from previous efforts at decoupling the OPM relation in three different ways. First, we clearly differentiate between linear and asymmetric impacts of oil price shocks on the Nigerian economy, a demarcation that is not considered in the previous literature for Nigeria. Second, we differentiate between short-run and long-run impacts; and thirdly, we use a higher data frequency mode, with a longer time frame. That is, quarterly data from 1970Q1 to 2008Q4.

We empirically examine the OPM relation by modelling the variables as a cointegrated system in a vector error correction model (VECM). Our objective is to examine the supply-side effect, wealth transfer effect, inflation effect and real balance effect of oil price shocks on the Nigerian economy. Overall, our results show that oil price shocks are not a key determinant of macroeconomic activity in Nigeria; hence the common practise of planning and projecting macroeconomic activity in Nigerian using the international prices of crude oil should be de-emphasized.

The rest of the paper is organized as follows. Section 2 explores the theoretical linkages and the mechanisms of transmission from oil prices to the macroeconomy. The section also examines the role of asymmetry in the responses of macroeconomic variables to oil price shocks. In Section 3, we present the empirical framework and methodology for the analysis. Section 4 discusses the results with informed synthesis, while we conclude in Section 5.

2. Oil Price shocks and the Macroeconomy

2.1. The literature

The oil price shocks of 1973/74 motivated much research on the oil price-macroeconomy nexus. These studies have arrived at different conclusions over time, and results are still metamorphosing. Earlier works (see for e.g., Darby, 1982; Hamilton, 1983; Burbidge and Harrison, 1984) obtained statistically significant empirical evidence of the relationship between oil prices and aggregate economic performance. After the collapse of oil prices in 1986, it was argued that the OPM relation had weakened (see Chang and Wong, 2003). Further, Mork (1989), Mork et al. (1994) and Hamilton (1996) established the existence of an asymmetric OPM relation. This was followed by a general trend in the late 1990s which devoted much attention to investigating the weakening of the OPM relation. Particularly, Lee et al. (1995) and Hooker (1996; 1999) argued strongly that the fundamental oil price-macroeconomy relationship identified in earlier studies had eroded.

Though, there are numerous studies that examine the OPM relation, most of them have focused on studying this relationship mainly within developed net oil- importing economies. Explicit studies on net oil-exporters like Nigeria have been rare in the literature. The OPM relation is likely to vary depending on a countries sectoral composition, its institutional structures and its level of economic development. Studies focusing on industrialized economies (see for e.g., Rotemberg and Woodford, 1996; Schmidst and Zimmermann, 2007) have shown that for several industrialized economies, oil price shocks have a significant negative impact on industrial production. However, they all concluded that this relationship has not been stable for these countries over time. The unstable relationship that had been observed in the literature wass recently authenticated by Blanchard and Gali (2007) who compared the current response of inflation and output to oil price shocks in a group of industrialized economies to those in the 1970s. They concluded that the main reason behind the weak responses of economies in recent years is smaller energy intensity, a more flexible labour market and improvements in monetary policy.

On the other hand, studies on the OPE relation for developing economies have reported mixed results. Farzanegan and Markwardt (2009) studied the effects oil price shocks on the Iranian economy and found a strong positive relation between positive oil price changes and industrial output growth and observe the Dutch disease syndrome through significant real effective exchange rate appreciation. Conversely, the study by Chang and Wong (2003) on the Singaporean economy show that the impacts of oil price shocks only had an insignificant adverse effect on Singapore's gross domestic output, inflation and unemployment rate. Berumet and Ceylan (2005) studied the effects of symmetric oil price shocks on output for a group of Middle East and North African countries. Using impulse response and variance decomposition analysis, they find that the effects of world oil price shocks on GDP of Algeria, Iraq, Jordan, Kuwait, Oman, Qatar, Syria, Tunisia, and UAE are positive and statistically significant. However, for Bahrain, Egypt, Lebanon, Morocco and Yemen, they found the existence of positive but not significant impacts. In another work, Jbir and Zounari-Ghorbel (2009) studied the impacts of the recent oil price shocks on the Tunisian economy focusing on the role of subsidy policy and found from their linear and non-linear specification of the OPM model that there is no direct impact of oil price shocks on economic activity in Tunisia.

Focusing on studies on Nigeria, Olomola and Adejumo (2006) examined the effects of oil price shocks on output, inflation, real exchange rate and money supply in Nigeria using quarterly data from 1970 to 2003. They find from their VAR that oil price shocks significantly affect the money supply in the long-run. They conclude that their results suggest the tendency for the Dutch disease. Ayadi (2005) focus on the relationship between oil price changes and economic development via industrial production in Nigeria using a VAR system. His result suggest that oil price changes affects industrial production indirectly through its effect on exchange rate, though, he summits that this relationship is insignificant.

Akpan (2009) study the asymmetric effects of oil price shocks on the Nigerian economy. The findings from her study show a strong positive relationship between positive oil price changes and real government expenditure. Also, the impact of oil price shocks on industrial output growth was found to be marginal with observed significant appreciation of the real exchange rate. A finding which reinforces that of Olomola and Adejumo (2006) and Ayadi (2005) that oil price shocks tend to create the tendency for the Dutch disease syndrome in Nigeria.

Recently, Aliyu (2009) used a non-linear approach to investigate the OPM relation in Nigeria and find evidence of both linear and non-linear impacts of oil price shocks on real GDP. The results of the asymmetric oil price increases in the non-linear models are found to have positive impacts on real GDP growth of a larger magnitude than for other specifications; a result that is an aberration from the previous empirical works earlier reviewed.

Our analysis is an improvements on previous works on the OPM relation in Nigeria because we do not only examine the linear and symmetric impacts of oil price shocks, we also focus on the asymmetric and non-linear relationship over a longer period of time (1970-2003) and with higher frequency of data (quarterly).

2.2 The role of asymmetry in the response of oil price shocks[3]

Symmetry in the responses of oil price shocks implies, for example that the response of real output to a negative oil price shock will be the exact mirror image of the response to a positive oil price shock of the same magnitude; while asymmetry simply implies that the response of an economic variable to a positive oil price shock will not be proportional to the opposite

[3] This section draws liberally from Kilian (2010)

response of the variable to a negative oil price shock of the same magnitude. Asymmetric responses of macroeconomic aggregates to unanticipated oil price decreases and increases can be explained through three kinds of effect: (1) the income effect, (2) the uncertainty effect and (3) the reallocation effect.

Asymmetry arises because these three effects act in a reinforcing way to amplify the response of macroeconomic aggregates to positive oil price shocks, but reduce the corresponding response to negative oil prices shocks. Thus, making it possible to explain why economies experience higher recessions in response to positive oil price shocks, and smaller expansions in response to negative oil price shocks of the same magnitude.

Initially, researchers experimented on the OPM relation with models in which only oil price increases matter. However, research from the 1990s motivated by the works of Mork (1989), Lee et al.(1995), Hamilton (1996; 2003), Davis and Haltiwanger (2001), Lee and Ni (2002) has refined this idea and introduced measures of net oil price increases. Contemporary studies of the OPM relation now almost always focus on studying the asymmetric impacts (see for e.g. Tang et al., 2010; Rafiq et al., 2009; Kilian, 2009a) of oil prices on the macroeconomy.

The net increase measure of oil price shocks is based on the premise[4] that consumers and firms only respond to oil prices if the current oil price is larger than its maximum in recent history. An obvious advantage of this class of empirical models is that they do not require the researcher to take a stand on the mechanism generating the asymmetry in the response to oil price shocks (Kilian, 2010).

Kilian and Vigfusson (2009) have criticized this class of models because the transmission of oil price shocks in these models have generally been misspecified, thereby yielding spurious results since the parameter estimates are inconsistent. They insist on the use of linear models according to their specification which provides a good approximation of the true OPM relation as obtained in their work. The growing body of evidence against asymmetric effects of price shocks is important in that it allows us to remove from consideration all theoretical models of the transmission of oil price shocks that imply asymmetries. Thus, suggesting that oil price shocks have not been one of the key driving forces of recessions in many developed and developing economies.

Though we acknowledge the contributions of Kilan (2010) and Kilian and Vigfusson (2009) in terms of the risk of obtaining spurious results from inconsistent parameter estimates when using asymmetric models, our work experiments on the two modelling approaches (i.e. linear and asymmetric specifications) to testing the OPM relation.

[4] This premise is yet to be tested empirically.

2.3. Transmission mechanisms (channels)

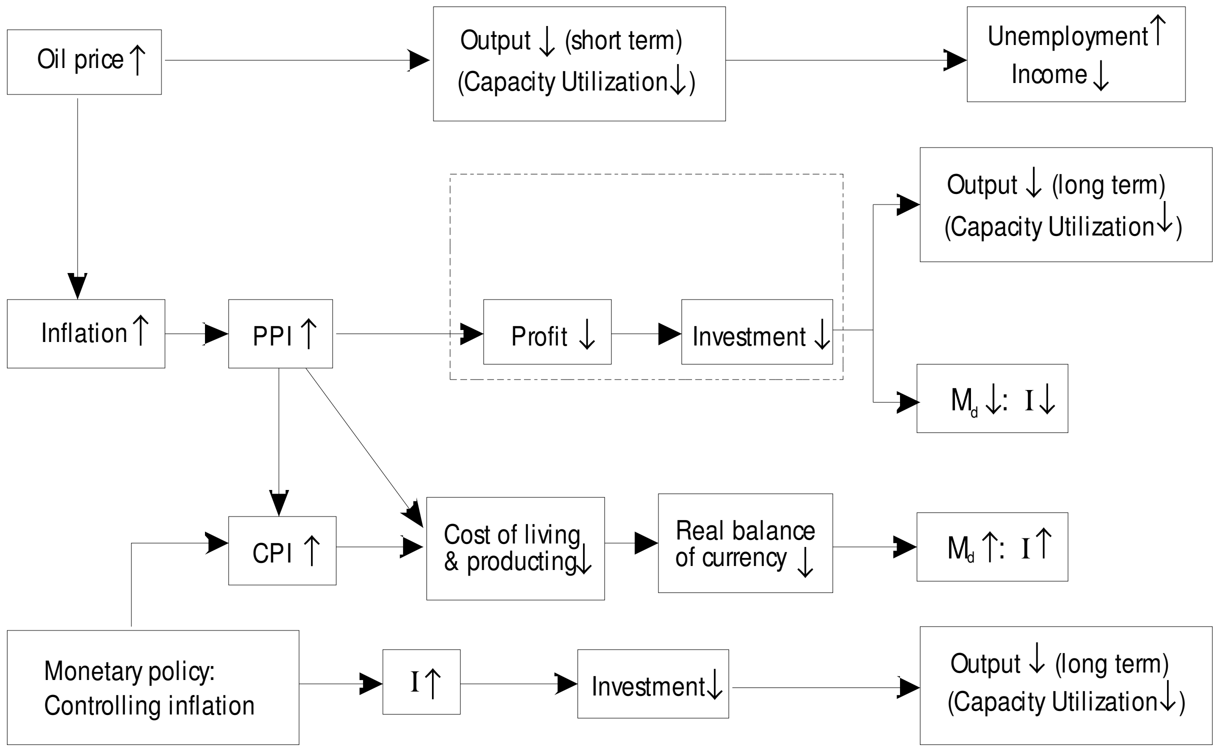
Several transmission channels through which oil price changes affect the performance of macroeconomic variables has been proposed in the literature. Specifically, six transmission channels have been identified (see Brown and Yucel, 2002; Jones et al., 2004; Tang et al., 2010) and includes, the supply-side effect, wealth transfer effect, inflation effect, real balance effect, sector adjustment effect and the unexpected effect. Figure 1 depicts the channels of transmission from oil price shocks to macroeconomic variables. We briefly discuss these mechanisms below.

Under the supply-side channel, crude oil is viewed as a basic input of production. An increase in oil prices impact directly on output via increased costs of production through changing domestic capital and labour inputs and reducing capacity utilization. In other words, oil price shocks changes the marginal costs of production, and hence, contracts production. The decline in productivity reduces total output and increases unemployment. Figure 1 provides an illustration of the supply-side shock: increase in oil prices reduces output in the short-term due to a reduction in capacity utilization thus leading to an increase in unemployment and fall in income.

The wealth transfer effect is another mechanism which captures the transfer of income from oil-importing nations to oil-exporting nations following an increase in oil prices. Oil price increases leads to windfall oil revenue for oil-exporting countries. The transfer of income reduces the consumer demand in the oil-importing countries, and increases at same time, the consumer demand in the oil-exporting countries though more proportionally because of an assumed higher marginal propensity to consume in the latter. From the perspective of an oil-importing country, an oil price shock is transmitted through the demand-side of the economy by triggering a reduction in the demand for good and services (or consumer spending). Oil price shocks affect consumer spending via four complementary mechanisms: the discretionary income effect, uncertainty effect, precautionary savings, and operating cost effects (see Kilian, 2010 for explamnation).

Oil price shock, aside from slowing down total output is found to create inflationary pressures in an economy. Empirical evidence show that reduced output and inflation are the most likely twin effects of oil price shocks. An oil price shock constitutes a cost shocks for domestic production (i.e. supply-side channel) resulting in upward pressure on labour costs and prices. This can be considered as a price shocks too.

Figure 1: Transmission channels of oil price shocks



Transmission channels of oil-price shocks.

Adapted from Tang et al. (2010)

The real balance transmission mechanism is initiated when an oil price shock affects the demand for money in an economy. For instance, if consumers expect the short-term effect of a rise in oil prices to exceed its long-term impact on output, they will borrow or dissave to smoothen consumption which in turn raises interest rates and reduces the demand for real cash balances. Alternatively, working through the price-monetary transmission mechanism, oil price shocks can reduce investment due to the reduction in producers profit and equally reduces money demand (see Figure 1).

The monetary policy channel is another avenue through which monetary authorities' respond to oil price shocks. From Figure 1, we observe that tightening monetary policy through increased interest rates to check inflationary pressure caused by increasing oil prices discourages investment and worsens output in the long-term. Evidence from Brenanke et al. (1997) show that contractionary monetary policy after an oil price shock, leads to further decline in economic activity

The sector adjustment effect channel, explains the asymmetric impact of oil price shocks within the sectors of an economy. Brown and Yucel (2002) argued that possible explanations for asymmetric sectoral adjustments are monetary policy, adjustment costs and petroleum product prices and not the supply-side effect. Following an oil price shock which feeds directly to output, the cost of adjusting to changes in oil prices in each sector of an economy may also retard economic activity. As pointed out by Brown and Yucel (2002) adjustment costs arises due to sectoral imbalances and coordination problems between firms or because the energy-to-output ratio is part of the capital stock. In the case of sectoral imbalances, increasing (decreasing) oil prices would require energy-intensive sectors to contract (expand) and energy-efficient sectors to expand (contract). By implication, asymmetry in oil prices will result in underutilization of resources and rising unemployment.

Finally, uncertainty about future oil prices can affect economic activity adversely by reducing investment demand of firms and consumers' demand, this is referred to as the uncertainty channel. Uncertainty causes firms and consumers to postpone irreversible investment and consumption decisions respectively (see Bernanke, 1983; Pindyck, 1991). For example, if the energy-to-output ratio is embedded in the capital stock, the firm must choose the energy-intensity of its production process when purchasing capital. For consumers, the uncertainty effect mainly applies to consumer durables, especially energy-using consumer durables. Uncertainty about future oil prices applies to both downward and upward movement in oil prices. Worthy of note is that as future prices becomes increasingly uncertain, the value of postponing the investment (consumption) decision increases, and the net incentive to invest (consume) decreases thereby dampening long-term prospects of output.

3. Econometric Framework

3.1. The Model

Following Sims' (1980) seminal paper, the vector autoregression (VAR) model has become one of the leading approaches employed in the analysis of dynamic economic interactions, especially in investigations of the OPM relation (see Killian, 2009; Barsky and Kilian, 2004 for a recent review). This study follows suit by employing the VAR model to examine the short and long-run impacts of oil price distortions on leading macroeconomic indicators in Nigeria. The VAR approach is founded on Granger's (1969) specification of causality. Causality in Granger's sense is inferred when values of a variable, say X_t has explanatory power in a regression of Y_t on lagged values of Y_t and $X_{t.}$.

Following, we consider a VAR model of order k, thus:

$$\boldsymbol{Y}_t = \boldsymbol{C_0} + \sum_{\boldsymbol{i=1}}^{k} \Phi_{\boldsymbol{i}} \boldsymbol{Y}_{t-i} + \boldsymbol{\epsilon}_t \qquad \ldots\ldots\ldots (3.1).$$

Where $\boldsymbol{Y}_t = (Y_{1t}, Y_{2t}, \ \dots \ Y_{nt})'$ is an *n x 1* vector of five endogenous variables[5], while $\boldsymbol{Y}_{t-i}$ is the corresponding lag term for order *i*. $\Phi_{\boldsymbol{i}}$, is the *n x n* matrix of auto regressive coefficient vector $\boldsymbol{Y}_{t-i}$, for *i = 1, 2, ...k*. $\boldsymbol{C_0} = (C_1, C_2 \ \dots \ C_n)'$ is the *C* intercept vector of the VAR model. $\boldsymbol{\epsilon}_t = (\epsilon_{1t}, \epsilon_{2t}, \ \dots \ \epsilon_{nt})'$ is the *n x 1* vector of white noise process. *K* is the number of lagged terms. VAR estimations are very sensitive to lag structure of variables. Using a sufficient lag length may help to reflect the long-term impact of variables on others. However, including longer lag lengths will lead to multicollinearity problems and will increase the degrees of freedom (DOF) (Wooldridge, 2006; Tang et al., 2010). Empirical simulations show that for any $K \geq 11$, the model will become divergent with at least one auto regressive root that is greater than one. According to sequential modified Likelihood Ratio test statistic (LR), lag orders between 1 and 3 are recommended for models of this nature (Wooldridge, 2006). Accordingly, to determine the optimal lag length to use for our model, we employ five different Lag Order Selection criteria (*LR, FPE, AIC, SIC, HQ*) to guide our decision. The essence of the battery of tests is for confirmatory analysis.

3.2. The Data Set

This paper uses quarterly data from 1970Q1 to 2008Q4 for Nigeria. The rationale behind selecting this period is to capture all the effects of oil price distortions that has been experienced by Nigeria, hence, the period captures the Arab Oil price shock of 1973/4 up to the oil price shock of the mid 2008. Our primary focus is to examine the impacts of oil price shocks on various facets of the economy, i.e.: the supply-side of the economy, real balances, inflation and the sector adjustment effects. To that end, we select five endogenous variables to capture the relationship thus:

1. Real Oil Price (denoted by ***ROP***). We choose the Nigerian-Forcados (NF) spot crude prices of oil as published in the BP Statistical Review of World Energy, June 2010, available freely at http://www.bp.com/statisticalreview. Also, we transform the data from annual frequency to the quarterly frequency by the cubic spline approach (Lisman and Sandee, 1964; Denton, 1971) and we eliminate the influence of exchange rates fluctuations by transforming the dollar prices to Nigerian naira (NGA) prices using the corresponding average quarterly exchange rate published by the Central Bank of Nigeria (2009)
2. Real gross domestic product (denoted by ***GDP***). We use quarterly real gross domestic product published by the Central Bank of Nigeria as our measure of economic activity. No further transformation is carried out on the data series since they are already in real terms and in the required frequency (quarterly).

[5] The variable are described in the next section

3. Inflation (denoted by ***INF***). Usually, the log first difference of the consumer price index (CPI) is used to proxy inflation. We follow the trend by using the log first difference of the composite CPI as our proxy for inflation; we compile the quarterly CPI data from the Anniversary Edition of the CBN Statistical Bulletin (2009).
4. Money supply (denoted by ***M2***) following Bernanke's et al. (1997) influential paper, we include money supply of the Central Bank to capture the influence of the monetary sector. This is because the central bank responds proactively or reactively to oil price shocks, which in turn may affect the activity of the economy. We compile quarterly M2 figures from the Anniversary Edition of the CBN Statistical Bulletin (2009).
5. Interest Rates (denoted by ***R***). In Nigeria, interest rates are still partially regulated by the Central Bank, and the influence of money supply on interest rate is still doubtful (see Chuku, 2009). Thus, it is necessary to include interest rates in our VAR model to further capture the influence of monetary policy. We choose the minimum rediscount rate (MRR) of the Central Bank of Nigeria as our proxy. Since the series are published at a lower frequency, i.e. annually, we transform them to the required higher frequency (quarterly) by means of interpolation. Specifically, we use the cubic spline technique for the conversion.

3.3 Data and Model Diagnostics

The efficacy of the VAR model in establishing the relationship among variables is conditional on the assumption of stationarity of the variables constituting the VAR. If the time series are non-stationary, the stability condition of VAR is not met, implying that the usual statistical techniques of coefficient evaluation will not be valid. In that case, the cointegration and vector error correction (VECM) techniques are recommended to investigate the relationship among non-stationary variables (Wooldridge, 2006). Therefore, it is instructive to first conduct preliminary diagnostics on the time series properties of the variables before further evaluation.

Hence, as a preliminary step in our analysis, we ascertain the order of integration of the variables. We test for the presence of unit-roots using two standard tests: the augmented Dickey-Fuller (ADF) test by Dickey and Fuller (1979, 1981) and the KPSS test by Kwiatkowski et al. (1992). The rationale behind the joint use of these techniques is for confirmatory analysis (Wooldridge, 2006; Brooks, 2002). Confirmation is necessary because in many empirical studies, it has been found that the ADF unit root test fails to reject the null hypothesis of a unit root for many time series. Maddala and Kim (2001) attribute this failure to the inherent weaknesses of size distortions and low power in the ADF test.

However, the KPSS technique can be used to complement the traditional unit root test (ADF) since it can make a distinction between time series that appear to be stationary and those that appear to be non-stationary (having a unit root at their levels) and those that are not sufficiently informative to be certain whether they are either of them stationary or non-stationary (Rafiq et al., 2009).

To test for the presence of a long-run relationship, the maximum likelihood method developed by Johansen (1988; 1991) is utilized. Using the Johansen approach, two test statistics can be used in testing the number of cointegrating vectors; the Trace and the Maximum Eigenvalue statistics. The null hypothesis for the trace test is that there are at most r cointegrating vectors, while for the Max Eigenvalue test, the null of $r = 0$ is tested against the alternative that $r = 1$; $r = 1$ is tested against the alternative $r = 2$ and so on. We use the Schwarz Information Criterion (SIC) to select the optimal lag length for the cointegration test.

Next, we conduct innovation accounting to determine the dynamic responses of the variables using impulse response functions. Impulse Response Functions (IRF) trace the responsiveness of the dependent variable in the VAR (VECM) to a unit shock in the error terms. For each variable from each equation, a unit shock is applied in the error term and the effects upon the VAR (VECM) to a unit shock in error terms are observed over a period of time. If there are K endogenous variables in the model, then a total of K^2 impulse responses can be generated. In this work, we confine our analysis to the responses of other variables to the innovations in real oil prices.

Further, to obtain information concerning the relative importance of each innovation towards explaining the behaviour of the endogenous variables, we conduct variance decomposition analysis (VDC). We use the generalized forecast error variance decomposition technique attributed to Koop et al. (1996) and Pesaran and Shin (1998). This technique has the advantage that its results are not sensitive to the ordering of the variables in the VAR (VECM) (Lorde et al., 2009).

Finally, to examine the short-run impacts of oil price shocks on the Nigerian economy, we employ the Granger-casualty test developed by Granger (1969). This test seeks to ascertain whether or not the inclusion of past values of a variable say Y_{t-z} do or do not help in the prediction of present values of another variable X. If X is better predicted by including past values of Y, than by not including them, then Y is said to Granger-cause X.

3.4 Asymmetric specification

There is this perception in theory that the impact of oil price shocks on various macroeconomic variables is asymmetric. That is for example, if oil price increases lead to supply shocks that depress economic activity, corresponding oil price decreases do not bring about the exact opposite effect of the same magnitude, in fact, they may also cause supply-side shocks that depress economic activity. Killian (2009), Hamilton (2009) and Du et al. (2010) and Chuku et al. (forthcoming), provide some theoretical explanation of how asymmetric effects may occur.

The baseline VAR (VECM) specification in the previous section assumes that the impact of oil price shocks on the Nigerian economy is linear and direct. Hence, to examine the asymmetric impacts of oil price shocks, we consider two non-linear (asymmetric) transformations of oil prices. The first kind of transformation we consider was developed by Mork (1989). Using this method, asymmetric response to oil price changes can be captured by specifying oil price increases and decreases as separate variables. This can be defined thus:

$$O_t^+ = \begin{cases} O_t \; if \; O_t > 0 \\ 0 \quad otherwise \end{cases}$$
$$O_t^- = \begin{cases} O_t \; if \; O_t < 0 \\ 0 \quad otherwise \end{cases}$$

Where $O_t$the rate of change in the world oil price, while O_t^+ and O_t^- are positive and negative rates of changes in oil prices respectively. The second transformation we use is the one suggested by Hamilton (1996) which considers the net increase in oil prices over the year. Using the quarterly frequency, this approach compares the price of oil each quarter with the maximum value observed within the preceding four quarters. Following Hamilton (1996), we consider net oil price increase (***NOPI***), and net oil price decrease (***NOPD***), thus:

$$NOPI_t = max\{0, O_t - \ max\{O_{t-1}, O_{t-2}, \cdots, O_{t-4}\}\}$$

$$NOPD_t = min\{0, O_t - \ min\{O_{t-1}, O_{t-2}, \cdots, O_{t-4}\}\}$$

If the value for the current quarter exceeds the previous year's maximum, the percentage change over the year's maximum is calculated. If the price of oil at time ***t*** is lower than it had been at some point during the previous four quarters, the series is defined to be zero for date ***t***. Du et al. (2010), used a similar transformation but with a lower frequency. Unlike Hamilton (1996) and Du et al. (2010) who consider both net-oil price increase and net oil price decrease, in their empirical analysis, this paper considers only the asymmetric impacts of net oil price increase (*NOPI*). The data is obtained as described in the previous section.

4. Empirical Results and Analysis

4.1 Unit root test analysis.

Table 1 presents the results of the unit root tests. The ADF and KPSS tests both agree that *LGDP, INF, LM2* and *MRR* are integrated with order one, i.e. they are *I(1)* stationary. However, our test techniques return conflicting results on the level of integration for the log of real oil prices (*LROP*). While the ADF test suggests that the series are *I(1)* stationary, the KPSS result reveals that the series are stationary at levels, i.e., it is *I(0)*. To enhance the robustness of our conclusion, we further employed the Dickey-Fuller GLS (ERS) approach which validated the conclusion from the ADF test.[6]

Since all the series are non-stationary at the levels and integrated of order one, this suggests the possibility of the presence of cointegrating relations among the variables. Accordingly, we proceed to conduct tests for the existence of at least one cointegrating vector.

Table 1
Unit root test

Variable	**ADF**		**KPSS**		**Conclusion**
	Level	1st Difference	Level	1st Difference	
LGDP	1.25[4]	-5.24[3]***	1.41[10]	0.43[11]***	I(1)
INF	-3.63[3]	-13.53[3]***	0.16[8]	0.08[8]***	I(1)
LM2	0.56[0]	-12.97[0]***	1.51[10]	0.11[8]***	I(1)
MRR	-2.05[0]	-12.14[0]***	1.01[10]	0.19[20]***	I(1)
LROP	2.43[2]	-3.69[1]***	0.34[10]**	-	I(1), I(0)

Notes: ***, ** and * indicates significance at the 1%, 5%, 10% levels respectively. The values in bracket for the ADF test indicates the optimal lag length selected by the SIC within a maximum lag of 13. The values in bracket for the KPSS test indicates the bandwidth selection, using the Newey-West's Bartlett Kernel.

4.2 Cointegration analysis

The results from the Johansen cointegration tests are presented in Table 2. The test assumption we specify allows for a linear deterministic trend in the data series and an intercept in the cointegrating equation. From Table 2, we notice that both the Trace and the Maximum Eigenvalue tests indicate the presence of at least one cointegrating vector. Thus, there is evidence of the existence of a long-run relationship between oil prices, GDP, prices and monetary policy in Nigeria. Consequently, applying the vector error correction model (VECM) will enable us to track the long-run relationship among the variables and tie it to deviation that may occur in the short run. (Lorde et al., 2009)

[6] The Dickey Fuller GLS results are available on request.

Table 2
Johansen cointegration test

Null Hypothesis	Alternative Hypothesis	Test Statistic	P-Value
Trace test			
r = 0	r = < 1	77.66***	0.00
r = 1	r = < 2	40.61	0.68
r = 2	r = < 3	25.04	0.77
r = 3	r = < 4	0.10	0.64
Maximum Eigenvalue test			
r = 0	r = 1	37.04***	0.00
r = 1	r = 2	15.57	0.70
r = 2	r = 3	8.62	0.86
r = 3	r = 4	6.31	0.57

Notes: ***, ** and * indicates significance at the 1%, 5%, and 10% levels respectively. P-values are obtained using response surfaces as in Mackinnon et al. (1999).

4.3 Optimal lag length selection

To estimate the VECM and ensure that the parameters are consistent, it is important that the optimal lag length is utilized in the estimation procedure. We select the lag length of 2, following the results from the lag order selection criteria: Likelihood Ratio (LR); Final Prediction Error (FPE); Akaike Information Criterion (AIC); Schwarz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQ). As Table 3 shows, all the selection criterion except the LR test, select lag order two.

Table 3
VAR lag order selection test VAR(1) to VAR(8)

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	-957.24	NA	0.39	13.27	13.37	13.31
1	52.46	1935.85	5.05	-0.31	0.31	-0.05
2	60.21	14.31	6.41*	-0.07*	1.05*	0.38*
3	72.14	21.22	7.70	0.11	1.75	0.77
4	98.72	45.45	7.58	0.08	2.24	0.96
5	129.09	49.84*	7.11	0.01	2.68	1.09
6	137.41	13.08	9.07	0.24	3.42	1.53
7	151.21	20.74	1.08	0.39	4.09	1.89
8	157.73	9.35	1.43	0.65	4.86	2.36

Notes: * Indicates lag order selected by the criterion

4.4 Analysis of vector error correction estimates (VECM)

Based on the Johansen cointegration results and the results from the lag selection criterion, a VECM(2) with one cointegrating vector is estimated. To ensure that the estimated VECM is not spurious; the residual auto correlation test is performed[7].

The correlograms of the test[8] (see Appendix) indicate that the residuals of the estimated VECM are appropriately uncorrelated, indicating that the estimated VECM is correctly specified and the parameter estimates are consistent. The coefficients from the estimated VECM are not of primary interest in this empirical work. Rather, we focus on the impulse response function (IRFs) and variance decomposition (VDC) generated from the VECM.

4.5 Impulse response function (IRF) analysis

The generalized impulse response functions trace out the responsiveness of the dependent variable in the VECM to shocks to each of the variables. For each equation, a unit shock is applied to the error, and the effects upon the VECM system over twenty quarters are noted. Since the VECM system has five variables, a total of 25 impulses could be generated. However, since our primary objective is to examine the impact oil price shocks on the other four macroeconomic variables, we only trace out the responsiveness of the dependent macroeconomic variables. Also, since it has been observed that IRFs are sometimes subject to the ordering of the variables in the system, we try 20 different permutations of the variables. We observe no significant differences in the shapes of the IRFs for the different permutations. Since it is known in the literature that oil price shocks usually have an immediate and direct impact on inflation, and a long-run effect on GDP, we choose the ordering *INF, GDP, LM2*, and *MRR*.

Figure 2 displays the impulse responses of each variable to a one standard deviation shock in oil prices. We observe a very intriguing response of output to positive oil price shocks. Output increases in the second to fourth quarter after the shock and then stabilizes at the increased rate from the 8th to the 20th quarters. This result is surprising when compared with the theory and empirical evidence that has been observed in other countries (see for e.g. Lorde et al., 2009; Chang and Wang, 2003; Hamilton, 1996; Jbir and Zouari-Ghorbel, 2009) but partially consistent with results previously obtained for Nigeria (see for e.g. Akpan, 2009; Aliyu, 2009; Ayadi, 2005). Usually, oil price shocks impacts on output negatively through the channels described in Figure 1. However, we observe that the reverse is the case for Nigeria, and this may be explained by the fact that Nigeria is a net oil exporter, and the positive effects may be as a result of short-term expansionary fiscal and balance of payments surpluses.

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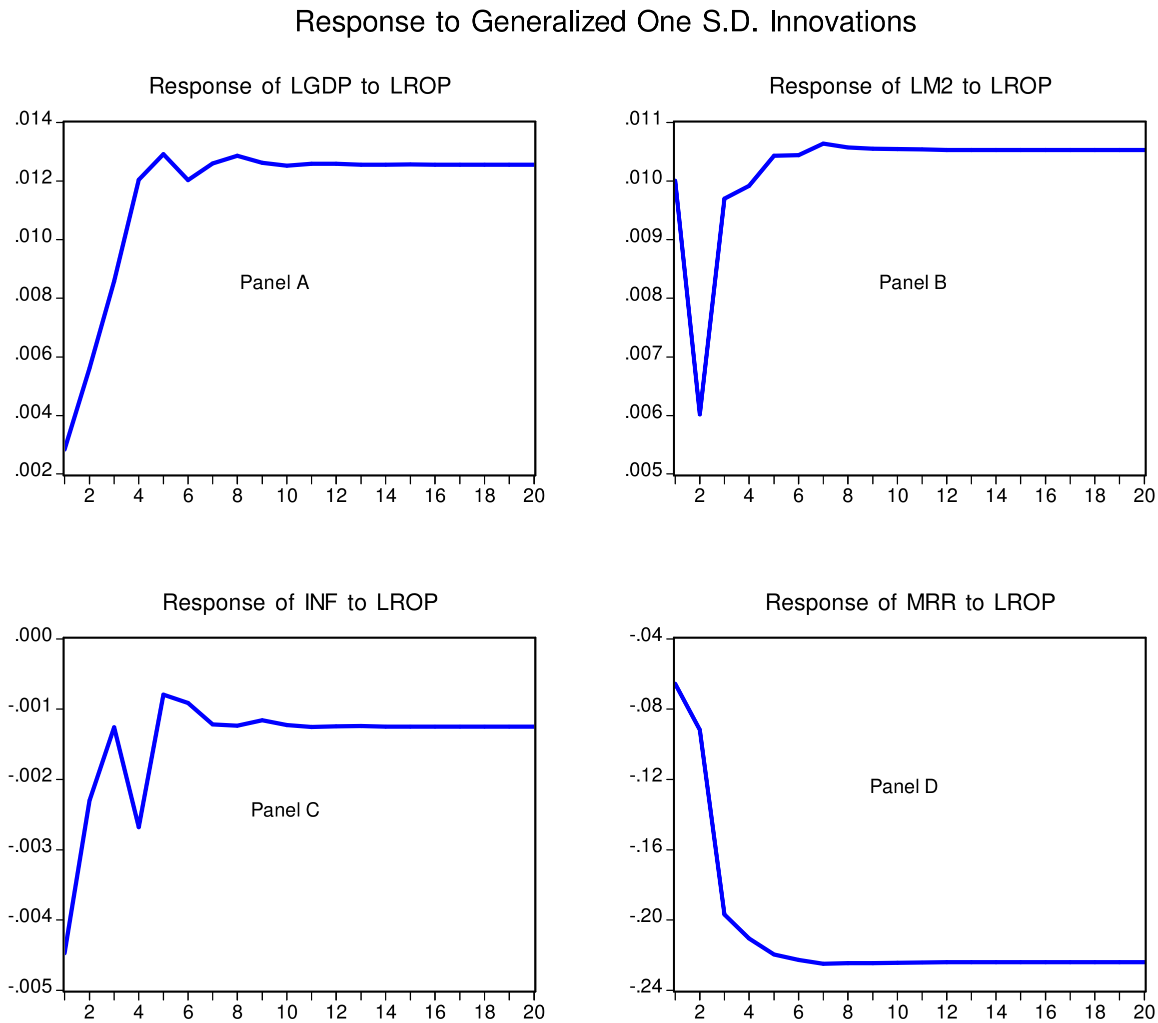
[7] The test results are presented in the Appendix

[8] The correlograms are displayed in the Appendix

Panel C in Figure 2 shows the impact of oil price shocks on inflation in Nigeria. As expected, inflation shoots up almost instantaneously following the oil price shock. The maximum impact is reach around the 6th quarter, and this implies that oil price shocks theoretically and practically causes inflationary pressures on the Nigeria economy in the short-run. Ayadi (2005) and Akpan (2009) also obtained similar results.

The response of money supply and the monetary policy rate (*MRR*) to oil price shocks is also revealing. Figure 2, Panel B shows that the monetary authorities cut money supply after an oil price shock up to the 3rd quarter, the rationale for this policy stance, may be to check the inflationary pressures that oil prices may cause. However, after the fourth quarter, money supply rises again, over and above its initial level before the oil price shock. Figure 2, Panel D indicates that the monetary policy rate (*MRR*) declines by about 16% basis points after an oil price shock and stabilizes at the lower rate for the next 20 quarters.

Figure 2
Response of LGDP, LM2, INF and MRR to LROP



4.6 Variance decomposition (VDC) analysis

The VDC provides a tool of analysis to determine the relative importance of the dependent variable in explaining the variations in the explanatory variables. The result of variance decomposition over a 30-quarter time horizon is summarily displayed in Table 4. As the table suggests, the VDC results are consistent with those obtained from the IRFs. For output, the average contribution of oil price shocks to changes in output is 0.07%. This result implies that though oil price shocks affect output mildly, the impact is however persistent. The implication is that policy makers will be faced with less uncertainty in planning for the long-term.

The VDC for inflation indicates that oil price shocks affects inflation most significantly than all the other macroeconomic variables. The impact of oil price shocks on inflation over a 30-quater period ranges between 0.39% and 1.09%. This contribution is also low and weak compared to the average of 17% obtained by Chang and Wong (2003) for Singapore, a net oil importer; and may suggest the existence of price stickiness in the general domestic price reaction to international oil prices. Also it may be an indication of effective monetary policy regimes in Nigeria.

The VDC also reveals that monetary policy proxied by mean monetary policy rate (MRR) are also mildly affected with average contributions of 0.02% and 0.08% respectively between the first to the thirtieth quarter.

Overall, our baseline linear model indicates that oil price shocks increases output; which can be attributed to the effects of the forward fiscal linkages that oil revenues may generate, since Nigeria is a net oil exporter. Also, oil price shocks as expected drives inflationary pressures upward and has a ambiguous effect on monetary policy.

Table 4
Variance decomposition of LROP to selected macroeconomic variables

Period	S.E	LROP	LM2	LGDP	INF	MRR
1	0.5615	100	0	0	0	0
5	1.3236	99.4681	0.0784	0.0146	0.3964	0.0414
10	1.9006	99.0716	0.0394	0.0094	0.8078	0.0715
15	2.3395	98.9267	0.0267	0.0079	0.9322	0.0858
20	2.7081	98.8612	0.0205	0.0071	1.0233	0.0928
25	3.0322	98.814	0.0168	0.0067	1.0654	0.0969
30	3.3248	98.7861	0.0143	0.0064	1.0933	0.0997

Cholesky ordering: *LROP, INF, LGDP*, and *MRR*

4.7 Granger casualty analysis for short-run impacts

To formally investigate whether a significant short-run relationship exists between oil prices and our macro economic variables, we follow the approach adopted by Lorde et al. (2009) by conducting a Granger-casualty test within the estimated VECM. Our results are presented in Table 5. From the results, we observe that oil price shocks Granger-cause inflation in the short-run. This conclusion is informed by the F-statistic of 3.47 with a significant P-value of 0.001. Granger-casualty test does not provide sufficient evidence to reject the null hypothesis that oil prices do not Granger-cause output and money supply in the short-run. Comparing this results to the IRF and VDC analysis, it implies that since oil price shocks affect output in the short-run, then the interaction between oil price shocks and output is an indirect relation which may be transmitted through monetary or fiscal variables.

Table 5
Granger causality tests for short-run impacts

Null Hypothesis: Oil Prices do not Granger-cause:		
Variable	**F-Statistic**	**P-Value**
LGDP	0.2973	0.9136
LM2	0.3980	0.8491
INF	3.4791	0.0014
MRR	2.0160	0.0801

5.0 Results from asymmetric specification

The analysis from our baseline model assumed that the impact of distortions in world oil prices on the Nigerian economy is linear. However, there has been a growing assertion from studies in industrialized nations that oil price shocks cause asymmetric impacts on the macroeconomy. Thus, as already stated in section three, we consider two methods of no-linear transformations of oil prices; that developed by Mork (1989) and Hamilton (1996). As a preliminary procedure, we test the transformed series for the presence of unit roots and the results are reported in Table 6

Table 6
Unit root test for asymmetric transformation

Variable	ADF		KPSS		Conclusion
	Level	1st Difference	Level	1st Difference	I(0)
PDOP	-3.24[1]***	-	0.67[7]*	-	I(0)
NDOP	-12.01[0]***	-	0.16[4]***	-	I(0)
NOPI	-3.32[1]*	-	0.76[2]***	-	I(0)

Notes: ***, ** and * indicates significance at the 1%, 5%, 10% levels respectively. The values in bracket for the ADF test indicates the optimal lag length selected by the SIC within a maximum lag of 13. The values in bracket for the KPSS test indicates the bandwidth selection, using the Newey-West's Bartlett Kernel.

The results indicate that the three non-linear transformations of oil prices are stationary at levels, thus we can estimate the VAR model from the series directly. We follow the procedure utilized by Du et al. (2010) by first estimating the VAR and then, we generate impulse response functions and variance decomposition from the estimated VAR models and compare the results with those we obtained from the baseline linear model.

The impulse response functions of *GDP*, *INF, M2* and *MRR* to generalized one standard deviation innovations to positive difference in oil prices (*PDOP*), negative difference in oil prices (*NDOP*) and net oil price increase (*NOPI*) are reported in Figures 5, 6 and 7 respectively.

The results from the asymmetric specifications are mixed and variegated. The impact of innovations in the positive difference of oil prices (Fig. 3) appears to be symmetrical (similar) to the results from our linear model. That is, positive oil price changes bring about increases in output. Similarly, innovations to the negative difference of oil prices (Fig. 4) indicates that output will also increase, slow down sometime around the 10^{th} quarter (2^{nd} year) and then continue until the 20^{th} quarter. More illuminating, is the impact of innovation of *NDOP* on inflation as shown in Fig. 5. Shocks to negative changes in world oil prices cause a plummeting effect on the rate of inflation in Nigeria. This effect however stabilizes between the 4^{th} and 8^{th} quarter, and then, resumes its downward move till the 30^{th} quarter.

Figure 3
Response of LGDP, LM2, INF and MRR to PDOP

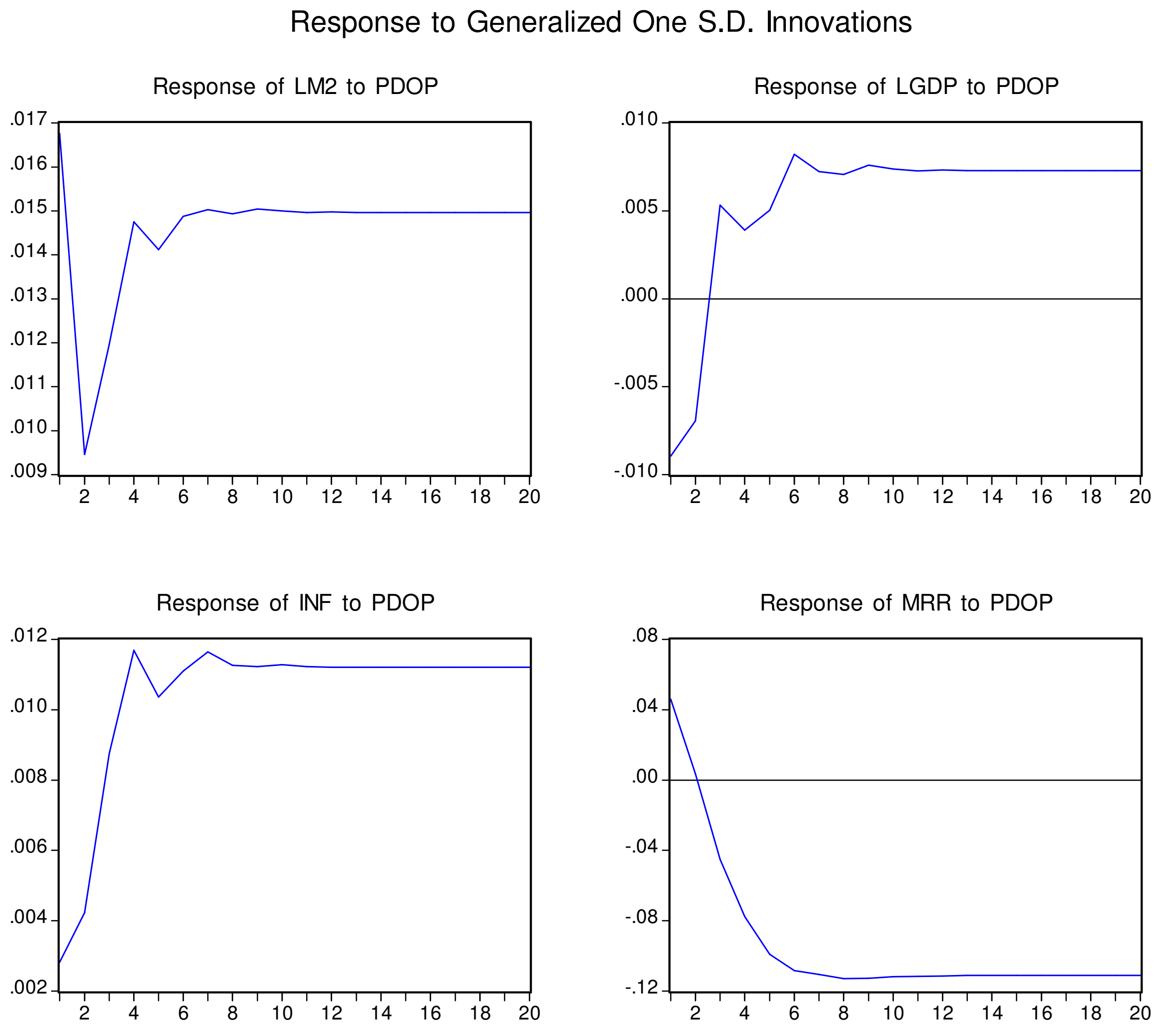


Figure 4
Response of LGDP, LM2, INF and MRR to NDOP

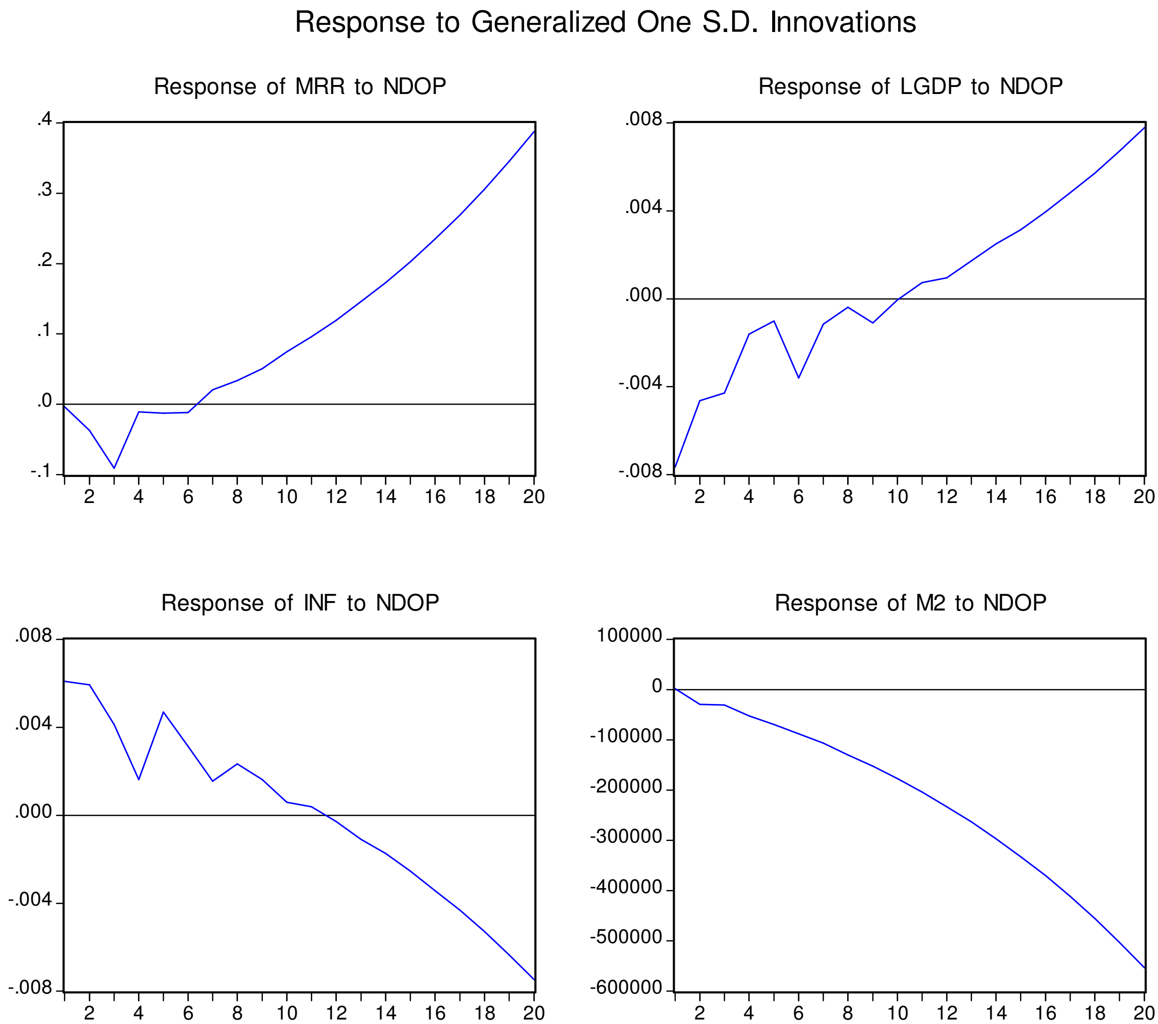
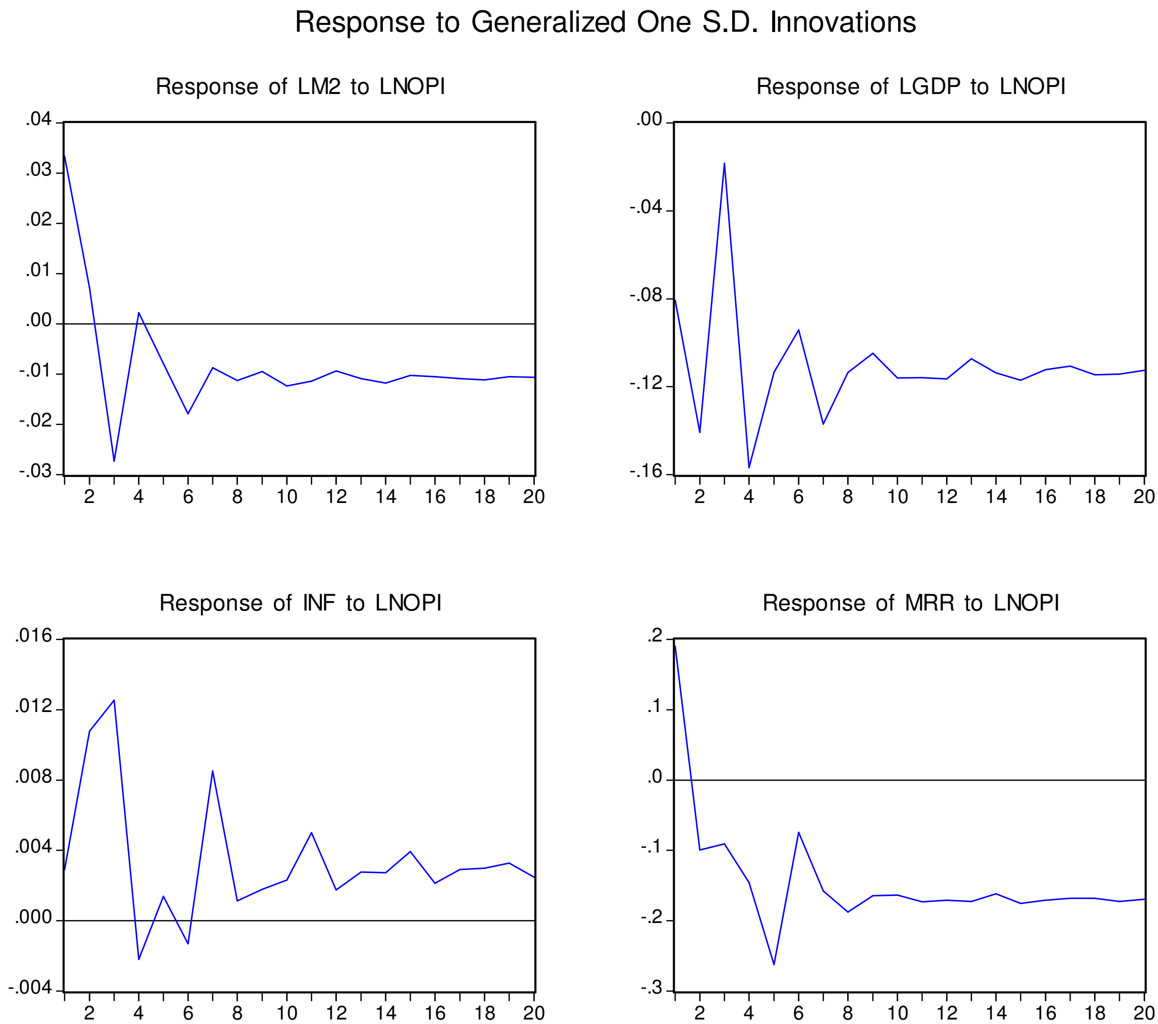


Figure 5
Response of LGDP, LM2, INF and MRR to LNOPI



6. Synthesis and implications for policy

Putting the results from the linear and asymmetric model together, our results imply that changes in the international price of oil l is not a major determinant of economic activity in Nigeria. The main policy implication emerging from these finding is that policy makers must de-emphasis the enthronement of international oil prices as the key determinant for macroeconomic policy formulations[9]. Indeed, a great proportion of the chequered performance

[9] In Nigeria, the entire macro economy is planned based on forecast of international oil prices, hence, monetary and fiscal are based on projected prices of crude oil.

of the Nigerian economy may be due to the undue emphasis placed on oil prices in national development planning.

The Granger casualty test shows that macroeconomic activities in Nigeria do not affect international prices of crude oil. Implying that the world oil price is strictly exogenous in time series sense to the Nigerian economy. This result may be surprising, because though Nigeria is a key exporter of oil to the global market, it has not yet (and may not) obtain the power to affect the world oil markets dynamics[10] (except through its membership with OPEC).

Interestingly, contrary to economic theory and the results obtained in most developed and developing countries (see for e.g. Lorde et al., 2009; Rafiq et al., 2009; Tang et al., 2010; Bernake et al., 1997; Hamilton, 1996; Mork, 1987; Chang and Wong, 2003; Lee et al., 2001), our linear model indicates that oil price shocks are positively correlated with Nigeria's GDP. Since Nigeria is an oil importing as well as exporting country, one would have expected that an increase in oil prices should have increased the domestic production cost, and hence retard growth. But this is not the case. We provide a preliminary explanation for this relationship thus: since Nigeria is both an oil exporting and oil importing economy, and our results indicate that oil price increases have a mild positive effect on GDP; then it implies that the production cost effects of importing oil only partly dampens the positive fiscal linkages that are generated through oil exports. In other word, the positive income effects of oil exports exceeds the negative income effects of oil imports, hence, the reason for the mild positive effects of oil price changes on Nigeria's GDP.

7. Conclusion

To recap, this paper investigates the short- and long-run impacts of world oil price distortions on Nigeria's macroeconomy, based on quarterly time series data from 1970:1 to 2008:4. Using a vector error correction model (VECM) we examine the supply-side effect, wealth transfer effect, inflation effect and real balance effects of oil price shocks on the Nigerian economy. Putting the results together, the study finds that oil price distortions are not a major determinant of economic activity in Nigeria. Our impulse response functions from the linear model suggest that following a positive oil price shocks, output increases within the first four quarters and stabilizes after the fourth quarter over the remaining 20 periods. Also, the impact of oil price shocks is most pronounced on the inflation rate, as it increases within the first six quarters and gradually declines over the remaining period.

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[10] This assertion may not be true for social economic activities, since militia activities in the Niger Delta may significantly disrupt the international supplies of crude oil, as Nigeria is arguable the sixth largest producer of crude oil globally.

The result from the non-linear specification shows that the impact of world oil prices on the Nigerian economy is asymmetric. This result holds only when we define oil price shocks as the negative difference of oil prices (*NDOP*) and as net oil price increase (*NOPI*). The impact when oil price shocks are defined non-linearly as positive difference of oil prices (*PDOP*) is similar to that of the baseline linear model, however, the magnitudes of the impact are different.

Also, we use the Granger-casualty test to investigate whether any short-run relationship exists between oil price shocks and macro economic activity in Nigeria. Our result provide evidence that supports the existence of a short-run casualty from oil prices to inflation, only.

Finally, we submit that there is room for refining the empirical analysis in this study. First, the VECM methodology used in this study may have been overly simplified. A constructive improvement on it would be use a structural vector autoregression (SVAR) model. This is because the construction of IRFs and VDC from VECMs is not as theoretically robust as those from an SVAR model. (See Hoffman and Rasche, 1997; Chang and Wong, 2003). Secondly, the explanatory variables applied here cannot be said to accurately represent the full array of macroeconomic variables. The inclusion of additional macroeconomic variables may generate different kinds of responses and provide more illumination. Thus future research in this area could be pursued using a structural VAR model, with the inclusion of a gamut of macroeconomic variables particularly variables that capture fiscal activities.

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