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OIL PRICE SHOCK AND AGGREGATE ECONOMIC ACTIVITY IN NIGERIA

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Abstract

The objective of this study was to examine the effect of oil price shock on output, inflation, the real exchange rate and the money supply in Nigeria using quarterly data from 1970 to 2003. The VAR method was employed to analyze the data. The findings were contrary to previous empirical findings in other countries; oil price shock does not affect output and inflation in Nigeria. However, oil price shocks do significantly influence the real exchange rates. The implication is that a high real oil price may give rise to wealth effect that appreciates the real exchange rate. This may squeeze the tradable sector, giving rise to the "Dutch Disease".

Introduction

A development in the global economy posing a great challenge to policy makers across countries is the increasing spate of fluctuations in oil prices. The price oil oscillating between $17 and $26 at different times in 2002 hovered around $53 per barrel by October 2004. In fact, the price of oil has witnessed profound fluctuations since 1974. Persistent oil shocks could have severe macroeconomic implications, thus inducing challenges for policy making - fiscal or monetary in both the oil exporting and oil importing countries over the past three decades (Kim and Loughani, 1992; Taton, 1988; Mork, 1994; Hooker, 1996; Caruth, Hooker and Oswald, 1996; Daniel, 1997; Hamilton, 1996; and Cashin et al 2000). Some of these studies suggest rising oil prices reduced output and increased inflation in the 1970s and early 1980s and falling oil prices boosted output and lowered inflation particularly, in the U.S in the mid-to late 1980s.

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
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The transmission mechanisms through which oil prices have impact on real economic activity include both supply and demand channels. The supply side effects are related to the fact that crude oil is a basic input to production, and consequently an increase in oil price leads to a rise in production costs that induces firms to lower output. Oil prices changes also entail demand-side effects on consumption and investment. Consumption is affected indirectly through its positive relation with disposable income. Oil price rises reduces the consumers spending power. Investment may also be affected if the oil price shock encourages producers to substitute less energy intensive capital for more energy-intensive capital. The magnitude of this effect is in turn stronger the more the shock is perceived to be long-lasting. For this reason, the theoretical literature has been of a general equilibrium nature, with different authors assigning different weights to the supply and demand channels (Rasche and Tatom, 1977, 1981, Kim and Loungani, (1992, Rotemberg and Woodford, 1996).

The present study is motivated by the findings that it was not the oil price shocks themselves but monetary policy's response to them that caused fluctuations in aggregate economic activity. In a recent study, Bohi (1989), Bernanke, Gertler, and Watson, (1997) analyzed the possibility that the 1974 economic recession in the United States may have been the consequence of the Federal Reserve's policy response to the inflation triggered by an oil price shock. The studies found out that changes in domestic output arose due to the Federal Reserve's policy of monetary tightening induced inflation sparked off by the oil price shock.

However, most of the empirical studies carried out have focused on the oil importing economies, particularly the developed economies. Few studies exist yet on the effect of oil price shock on key macroeconomic variables for an oil exporting country as Nigeria. This study intends to fill this gap. Thus the specific objectives of this study are to analyze the impacts of oil price shock on key

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

macroeconomic variables in Nigeria and measure the magnitude of such impacts. Quarterly data from 1970 to 2004 are used for estimation.

Therefore, for this paper, a vector autoregressive (VAR) model of the Nigerian economy is constructed to test whether oil price shocks affect economic activities on the one hand, and to examine whether monetary policy's response to oil price shocks accounts for the fluctuations in aggregate economic activity.

Table 1: Definition of Variables

Y	output (measured by the industrial production index to proxy for real GDP)
M	domestic money supply (measured by M2). The result was not significantly different when M1 was used.
REER	the real exchange rate (measured as (exchange rate*U.S CPI)/CPI Nigeria)
P	Inflation rate (measured as changes in the consumer price index)
P_{OIL}	Oil price shock.
CPI	Consumer price index.

Sources of Data: International Monetary Fund, *International Financial Statistics CD-ROM, 2003*

The Methodology

The empirical exercise is now to estimate the effect of oil price shock on the macroeconomic variables in a VAR and decompose the forecast error variance to analyze how a unit shock is transmitted to the variables in the system. The SVAR model is composed of five variables, namely: the real Gross Domestic Output (real GDP), represented by the Industrial Production Index (y); and the domestic price level, measured by the Consumer Price Index (p), the real

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

exchange rate (rer), defined as the product of the domestic currency value of the dollar and the ratio of the U.S and the domestic Wholesale Price Indexes (WPI). The real oil price (p_{oil}) is measured by the domestic price of crude oil deflated by the CPI. The real GDP is used as a measure of aggregate economic activity. All the other variables are indirect channels through which oil price increases (or decreases) affects the economy by bringing about changes in economic policy.

We consider the following vector autoregression model of order (p);

$$y_t = c + \sum_{i=1}^{n} \phi_i y_{t-i} + \varepsilon_t \quad (1)$$

where y_t is a (nx1) vector of endogenous variables, $c=(c_1,\ldots,c_5)'$ is the (5x1) intercept vector of VAR, φ_i is the i^{th} (5x5) matrix of autoregressive coefficients for I=1,2,…p, and $\varepsilon_t =(\varepsilon_{it},\ldots, \varepsilon_{5t})$ the (5x1) generalization of a white noise process.

The VAR system can be transformed into its moving average representation in order to analyse the system's response to a real oil price shock, that is:

$$y_t = \mu + \sum_{i=0}^{\infty} \gamma_i \varepsilon_{t-i} \quad (2)$$

where γ_0 is the identity matrix, μ is the mean of the process. The MA representation is used to obtain the forecast error variance decomposition and the impulse-response function. The variance decomposition shows the proportion of the unanticipated change of a variable that is attributable to its own innovations and shocks to other variables in the system.

Two specific sets of structural restrictions have been examined in different studies in order to allow us to examine the different channels of transmission between the external sector and the domestic sector, and to test the sensitivity of the results to the choice of restrictions. Simple theory can help predict how an oil price shock will affect the variables in either model. Lower oil rents resulting

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

from an oil price shock cause a temporary shift in the production function, leading to decrease in real output. The decrease in output, ceteris paribus, results in an excess demand for goods and an increase in the interest rate. This decrease in output and interest rate, in turn reduces the demand for real cash balances, and given a nominal quantity of money, the price level rises. Therefore, we would expect an oil price shock to lower GDP and increase the price level (Gordon, 1998).

In this model, the real exchange rate (equation 3) is influenced by shocks to both the price of oil. In the money supply equation, the price of oil and the real exchange rate affects the money supply through the balance-of-payment effects on reserves. However, domestic output and prices do not affect money within a quarter. In the aggregate demand equation, output depends on domestic money shocks, while net exports depend on the relative price of oil and the real exchange rate. In equation (7), domestic prices respond to shocks to the price of oil, the real exchange rate, money supply and domestic output. The real exchange rate captures the cost-push effects of rising prices of imported impute to production, while the quantity of money appears due to its effect on the cost of working capital (Joyce and Kamas, 1997).

Three different non-linear transformations of oil prices are available in the literature. First is the asymmetric specification, in which increases or decreases in the price of oil are considered as separate variables. Second method is the scaled specification which takes volatility into account (see for example, Lee et al. 1995). Finally, we have the net specification method adopted by Hamilton (1996). The method adopted in the present study is the scaled specification. This is to enable us examine the effect of oil price volatility on economic activity in Nigeria.

The choice of measure of oil price shock has been a matter for empirical discourse over the years. The formal volatility measure adopted in this study is the

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

conditional variance of the percentage change of the nominal oil price. The conditional volatility of oil price is extracted and modeled as:

$$Z_t = \sigma\varepsilon_t e^{(1/2)}h_t \; ; \; \varepsilon_t - \text{iid } (0,1) \qquad (3a)$$

where

$$h_{t+1} = \pi h_t + \mu_t - \text{NID } (0, \sigma^2_\mu) \; |\pi| \leq 1 \qquad (3b)$$

The term σ^2 is a scale factor and subsumes the effect of a constant in the regression of h_t. π is a parameter and μ_t is a disturbance term that is uncorrelated with ε_t. ε_t are random disturbances symmetrically distributed about zero. The h_t equation is a transition equation in the autoregressive form where the absolute value of π is less than unity to ensure that the process is stationary. Thus equations (3a) and (3b) represents the stochastic volatility model that generates the conditional volatility of oil price to be used in the VAR.

Empirical Results

Unit Roots Test

We proceed by determining the underlying properties of the process that generate our time series variables that is whether the variables in our model were stationary or non-stationary. Macroeconomic data often appear to possess stochastic trend that can be removed by differencing the variables. We employed the Augmented Dickey Fuller (ADF) and Phillip-Perron- z test (PP), to test the order of integration of the variables. The results of the ADF and PP test are presented in Table 2.

From Table 2 it is obvious that all the variables are I(1) series, whether with or without trend. The finding was that all the variables are stationary after their first differences.

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

Table 2: Unit Root Test. The critical level is –2.92 at 5% and –3.55 at 1%.

Variable	ADF				PP			
	Without Trend		With Trend		Without Trend		With Trend	
	Level	FD	Level	FD	Level	FD	Level	FD
Reer	-2.09	-4.33	-2.52	-4.38	-1.72	-9.86	-2.14	-9.88
Poil	-2.77	-5.66	-2.79	-5.63	-1.72	-9.84	-2.75	-9.88
Y	-.2.21	-5.54	-2.40	-5.68	-2.69	-11.58	-2.83	-9.80
P	0.29	-3.84	-2.12	-3.96	-2.54	-8.68	-2.61	-11.86
M	0.60	-2.99	-1.97	-3.00	0.52	-8.99	-1.20	-10.10

Cointegration

A vector of variables integrated of order one is cointegrated if there exists linear combination of the variables, which are stationary. Following the approach of Johansen and Juselius (1990) two likelihood ratio test statistics, the maximal eigenvalue and the trace statistic, were utilized to determine the number of cointegrating vectors. The cointegration tests were performed allowing for both the presence and absence of linear trends.

Table 3: Tests for Cointegration

Maximal eigenvalue statistic			Trace statistic		
Rank	H^{+}	H	Rank	H^{+}	H
R=0	108.44**	120.20**	r=0	146.50**	125.40**
r=1	65.89**	71.31**	r≤1	100.22**	80.30**
r=2	24.94	28.86	r≤2	37.92	33.26
r=3	5.86	9.85	r≤3	5.86	9.85
r=4	0.48	1.66	r≤4	0.59	1.96
Note: Critical values appear in Osterwald-Lenum (1992). Asterisks indicate 1 percent level of confidence.					

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

The results of the maximal eigenvalues and trace test statistics for the two models were presented in Table 3. The procedure followed to determine the number of cointegrating vectors began at the top of the table with the hypothesis that there are no cointegrating vectors and with trends, H^+. A rejection of the hypothesis would lead to testing the alternative hypothesis of no cointegrating vectors, and no trend, H. The testing procedure continues until the hypothesis cannot be rejected.

The test statistics indicate that the hypothesis of no cointegration among the variables can be rejected for Nigeria. The results reveal that at least two cointegrating vectors exist among the variables of interest. Since the variables are cointegrated, the equations of the VARs also include lagged values of the variables in levels to capture their long-run relationships.

Variance Decomposition

The variance decomposition measures the proportion of forecast error variance in one variable explained by innovations in itself and the other variables. But it should be noted that the VAR was estimated with the sets of contemporaneous structural restrictions specified in the equations. First, the results of the likelihood ratio test on the adequacy of the identifying restrictions on the model showed that the model is well behaved. The likelihood ratio test for the model was 26.44. The results are summarized in Table 4 below.

The Real Exchange Rate

The variance decomposition suggests that shocks to oil price as evidenced in Table 4, explained about 48 percent of shocks to the real exchange rate in the 1st quarter declining in effects to about 33 percent in the 8th quarter, and further to about 32 percent in the tenth quarter. The contribution of money supply shocks to real exchange rate shocks was about 4 percent in the fourth quarter rising marginally to about 5 percent in the tenth quarter. Output shocks do not contribute

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

Table 4: Variance Decomposition

	Poil	Reer	M	Y	P
Reer					
1/QTR	48.1	51.9	0.0	0.0	0.0
4/QTR	35.7	57.0	3.95	0.61	2.69
8/QTR	33.0	58.9	5.19	0.40	2.59
10/QTR	32.4	59.4	5.32	0.36	2.53
M					
1/QTR	0.19	2.95	96.91	0.00	0.00
4/QTR	1.08	4.16	94.65	0.14	0.02
8/QTR	10.21	9.31	79.71	0.47	0.35
10/QTR	16.63	11.48	70.71	0.37	0.60
Y					
1/QTR	0.40	0.39	0.06	99.13	0.00
4/QTR	2.09	1.62	8.63	83.05	4.60
8/QTR	3.76	3.04	13.27	76.30	3.64
10/QTR	3.89	5.74	14.84	72.24	3.30
P					
1/QTR	0.06	7.99	0.00	39.38	52.57
4/QTR	3.50	10.39	6.86	32.98	46.27
8/QTR	4.34	14.76	6.44	31.45	43.02
10/QTR	6.56	15.40	6.20	30.53	41.30

significantly to shocks in real exchange rates, as it was less than 1 percent over a ten-month period. Also, shocks to inflation contributed an average of 3

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

percent to real exchange rate shocks over from the fourth quarter to the tenth quarter. This finding is consistent with previous studies that oil price shocks do significantly affect the real exchange rate (Amano and Van Norden 1998a and 1998b). Thus, a high real oil price may have given rise to wealth effects that appreciates the exchange rate. This squeezed the tradable sector and gave rise to the “Dutch-Disease syndrome in Nigeria.

Money Supply

Shocks to oil price did not initially contribute much to the shocks in money supply in the first quarter through to the fourth quarter. However, by the eight and tenth quarters, shocks to oil price contributed about 10 percent and 17 percent respectively to changes in domestic money supply. On the other hand, the effect of real exchange rate shock averaged 3 percent in the first period, rising to about 4 percent in the fourth quarter, 9 percent in the 8th quarter and 12 percent in the tenth quarter. The contribution of real output was low, averaging about 0.3 percent over the entire tent quarter. Similarly, the contribution of inflation rate shocks to shocks in money supply was 0.02 percent for the first quarter period, rising only marginally to about 0.6 percent in the tenth quarter. An important finding here is that both oil price shocks and shocks to the real exchange rates affected domestic money supply at long lags. This supports earlier studies that monetary policy responds to oil price shocks (Bernanke et al. 1997; Bohi 1989).

Output

For output, the largest source of shocks was changes in money supply, which contributed about 0.06 percent in the first quarter, rising to about 9 percent in the fourth quarter, 13 percent in the eight quarter and about 15 percent in the 10th quarter. The contribution of oil price shock to real output violability was about 2 percent in the fourth quarter, 3 percent in the eight quarter and about 6 percent in the 10th quarter. The oil price variable contributed about 2.1 percent to

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

shocks in output was in the second quarter, and averaging about 4 percent over the 7th and the 10th quarters. The contribution of inflation rate shocks declined from about 5 percent in the fourth quarter through 4 percent in the eight quarter to about 3 percent in the tenth quarter. The implication of this finding is that oil price shock does not significantly affect output in Nigeria. This contradicts expectations that oil price shocks tend to lower GDP (Gordon, 1998) and reinforces the fact that oil price shocks are neither necessary nor sufficient to explain downturn in GDP (Barsky and Kilian 2004).

Inflation

Output changes accounts for the largest share of shock to inflation rate, while oil price shock explained relatively little. Output changes contributed about 40 percent to changes in commodity price level in the first quarter, declining through 33 percent in the fourth quarter to about 31 percent in the tenth quarter. Real exchange rate contributed about 8 percent to changes in inflation rate in the first quarter, rising through 11 percent in the fourth quarter to about 15 percent in the tenth quarter. However, oil price explained only 0.1 percent of changes in inflation rate in the first quarter, rising to about 4 percent in the eight quarter and 7 percent in the tenth quarter. This finding confirms that oil price may not be necessarily inflationary contrary to findings by Barsky and Kilian (2002) and Rotemberg and Woodford (1996).

Conclusion

The econometric findings presented in this study demonstrate that oil price shocks do not have substantial effects on output and inflation rate in Nigeria over the period covered by the study. Inflation rate depend on shocks to output and the real exchange rates. However, the findings demonstrated that fluctuations in oil prices do substantially affect the real exchange rates in Nigeria. Also, the it was found out that it is not the oil price itself but rather its manifestation in real

African Economic and Business Review Vol. 4 No. 2, Fall 2006.
ISSN 1109-5609

exchange rates and money supply that affects the fluctuations of aggregate economic activity proxy, the GDP. Thus, we conclude that oil price shock is an important determinant of real exchange rates and in the long run money supply, while money supply rather than oil price shocks that affects output growth in Nigeria.

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African Economic and Business Review Vol. 4 No. 2, Fall 2006.
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