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The Effects of Fluctuating Oil Prices on Selected Macroeconomic Variables: The Case of Nigeria, 1972-2020

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Abstract In this study, we analyze the dynamic relationship or the impact of fluctuating oil prices on some selected macroeconomic variables in Nigeria from 1972–2020 using Vector Autoregressive (VAR) models. The macroeconomic variables examined are Oil Price (OP), Gross Domestic Product (GDP), Consumer price index (CPI), Official Exchange Rate (OER) and Money Supply (M1). The pertinent use of this model can remove impulse response anomalies or puzzle such as price puzzles and or exchange rate puzzles commonly found in studies that apply VARs model in medium open economic countries such as Nigeria. Estimation results indicate that random fluctuation in oil prices significantly affects the domestic economy. The impulse response results indicate that random monetary shocks caused by fluctuating oil prices responded quite differently at the start of the period but returned to the balance line in the long run.

Keywords Random Monetary Shocks, Impulse Response, Puzzle, Domestic Economy, VAR, Official Exchange Rate (OER), Oil Price (OP).

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1. Introduction

Random fluctuation in oil prices has profound effect on the macroeconomic indicators of both the importing and exporting countries. These effects differ largely across countries depending on the country's size, their relative position in the supply chain, the state of financial openness, and their degree of economic development. Additionally, the impact of changing oil prices is more profound if the trade in oil is denominated in the dollar currency. Therefore, changes in foreign factors that affect the value of the dollar currency inherently will impact the domestic variables of oil exporting countries. By nature, macroeconomic indicators of developing oil exporting countries are more susceptible and vulnerable to oil price shocks than advanced oil importing countries. For instance, the collapse of the demand for oil during COVID-19 pandemic put economic pressure on oil exporting countries, while the excess demand for oil in the 70's had detrimental impact on oil importing countries. According to (Cunado et al., 2015), domestic economic development of small open economies is strongly impacted by foreign factors, while the small open domestic economy cannot affect the world economy.

With the denomination of oil trade in dollar currency, variations in oil prices are now regarded as one of the exogenous variables that impacts on a country's domestic economy. This theoretical imposition was further deduced by Hamilton (2003). Hamilton's study concluded that the relationship between oil prices and the economy was nonlinear in nature. The volatility of oil prices (OP) is shown in figure 1 below. From1972 to 1981, the price of oil skyrocketed by 891%. This period was considered as the time of oil boom. The next decade (1982 – 1991), the price of oil took a nosedive to -36.4%. From 1992 to 2001, the average price of oil increased by 19.1% and from 2002 to 2011, it went back up by 281.5%. From 2012 to 2020, it went backdown by -63% on average. The graph showed the volatility of oil prices from 1972 to 2020.

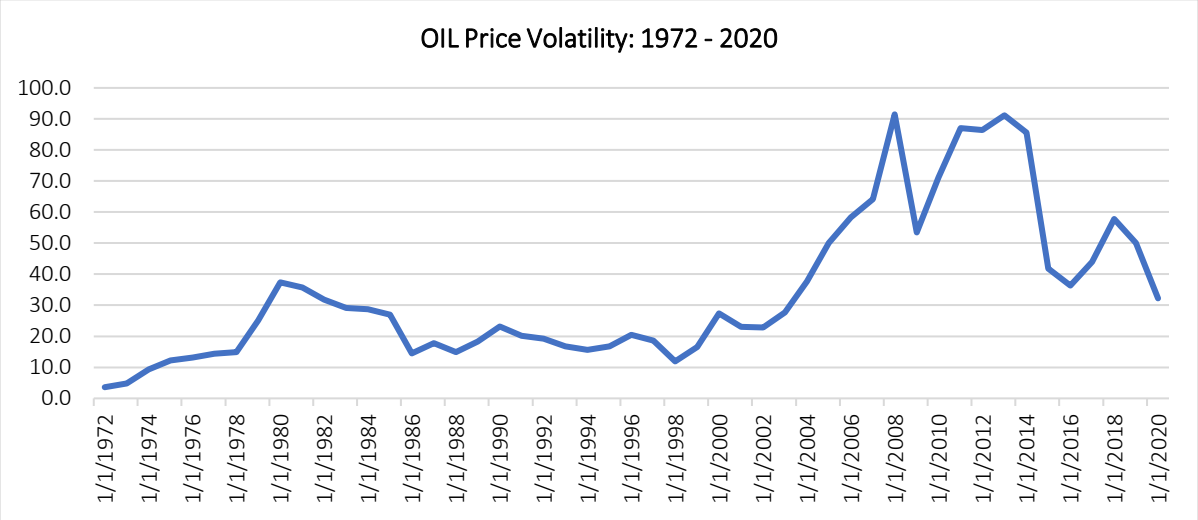

Figure 1. Oil price in US dollars
Data Sources: African Development Indicators

The disturbances of the world economy emanating from random variation in oil trade affect the macroeconomy economy of both exporting and importing countries. The conduit of these effects on macroeconomic variables is through the demand and supply side of the economy. On the supply side of the economy, the increase in oil prices increases the production costs in an oil induced economy. The increases in the price of oil production inputs reduce oil production outputs to a certain level, visa-vi reducing total supply and thereby shifting supply curve to the left. According to Rodriguez and Sanchez (2005), the impact of oil price increase on the domestic economy (GDP) is greater than the effect of a fall in oil price on GDP.

2. Brief History of Oil in Nigeria

This paper addresses the effects of fluctuating oil prices on some selected macroeconomic variables in the Nigerian economy. In the late sixties, close to the end of the civil war (1970), the Nigerian economy became heavily dependent on the oil subsector for its government revenues as well as for its foreign exchange earnings. The dominant role of

oil as a source of revenue in the Nigerian economy was further enhanced by its membership of OPEC (Organization of Petroleum Exporting Countries) in 1973-74. With the collective efforts of OPEC acting as an oligopolistic industry, Nigeria experienced a notable increase in the price of its crude oil exports. Although, at the time of independence in October 1960, Nigeria has attained self-sufficiency in crude oil production.

During the 70's and early 80's, the Nigerian economy witnessed a tremendous increase in its oil aggregate productive capabilities due to the subsequent increase in the price of crude oil. This accelerated increase was visibly noticeable in all facets of the economy, especially from the early to late 1970's even before its membership of OPEC. The increase in the overall level of money supply caused an increase in domestic gross product. This was because, incredible increase was observed in the Nigerian money supply denoted as M1 in this study. The inflationary trends were so prominent that the common price of necessity products skyrocketed.

The objective of this research is to investigate the effects of fluctuating oil prices on money supply, gross domestic product, inflation and the official exchange rate. The rest of the paper is organized as follows. Section 2 presents the literature review. Section 3 describes and summarizes the data and methodology. Section 4 discusses the empirical results. Section 5 offers the conclusion and policy implication of the study.

3. Literature Review

Zhang Qianqian (2011), using cointegration and error correction model found that there exists a long-run relationship between oil price and China's GDP, CPI, Net export and the monetary policy. Increases in oil prices were found to decrease net export and real output while it has a negative impact on the actual money supply. Hamilton (1983) noted that all the U.S. recession since the World War 11 has been preceded by a sharp and dramatic increase in the price of crude petroleum, except during the 1990-1991 recession. Hamilton conclusion showed a strong negative correlation between rising oil prices and the American economic activity. Brown and Yucel (1999) used vector auto-regressive (VAR) model to study the effects of oil price on the U.S. economy and found that oil price fluctuation (shock) may cause real GDP to decline, consumer prices to increase and short/long term interest rates to increase. Burbidge and Harrison (1984), Rotembery and Woodford (1996), Finn (2000) and numerous other studies arrived at the same conclusion that oil price increase led to output decrease and raising price level.

In their study, Bala and Chin (2018) analyzed the short-term and long-term impact of oil changes on inflation using Autoregressive Distributed Lag (ARDL). In addition, they partitioned the oil price into positive and negative changes to capture those impacts. They found that both positive and negative oil price changes had a positive effect on inflation. However, their studies concluded that the negative effects of oil changes were significant. In a similar study, Abdelsalam (2023) found that changes in oil prices and its volatility have an opposite effect on both oil importing and exporting countries.

However, channels of the influence of oil receipts on any economy can be many and varied. Hence a completed theoretical model to address the questions of the impact of oil revenue and the consequent effect on domestic money supply and on other domestic economic variables may not be appropriate. Besides, such a model will necessarily be typical of the so-called simulation models. And such a model often involves imposing many quite arbitrary restrictions. Therefore, the first order auto-regressive model used by Zellner and Tiao (1964), could be potentially more informative.

4. Data and Methodology of the Study

The use of vector autoregressive model (VAR) pertinent in this study. VARs are multivariate linear time series models designed to capture the joint dynamics of multiple time series data. VARs treats each endogenous variable in the system as a function of lagged values of all endogenous variables. VARs are simple and flexible alternatives to the traditional multiple equation models. Following the works of Chris Sims (1980), which criticized large-scale macroeconomic models because of the various strong restrictions that they impose. These highly specified models made strong assumptions about the dynamic nature of the relationship between macroeconomic variables, and they are also largely inconsistent. Basically, that in the world with rational forward-looking agents, no variable can be deemed as exogenous. Therefore, Sim proposed VARs as an alternative that allowed one to model macroeconomic data informatively without imposing very strong restrictions.

The dataset covers the period 1972 – 2020. It consists of real GDP, Consumer price index (CPI), Money supply (M1), official exchange rate (OER) and oil price (OP). Our methodology is based on a linear VAR model (Sim, 1980), which can be written in its reduced form as follows:

$$X_t = \sigma + \sum_{i=1}^{p} A_i x_{t-i} + \sum_{i=0}^{P} \beta_i z_{t-i} + u_t \qquad (1)$$

VAR reduced form expresses each variable as a linear function of (a) its own past values, (b) past values of all other variables being considered, (c) a serially uncorrelated error term. $X_t$is the vector of endogenous variables, Z_t is the vector of exogenous variables, σ is the vector of intercepts, u_t is the vector of error terms while A_i and B_i are parameter matrices or estimates. Equation 1 will be estimates in five different versions, where we vary the elements in the vectors X_t and Z_t. The first step estimates a baseline four-variable model with GDP, CPI, M1, and OER in vector X_t and OP in vector Z_t.

In order to further analyze the impact of the increases and decreases (asymmetric) in oil prices, we explore and build on the approaches of Mork (1989). Mork (1989) viewed the increases and decreases in oil prices as a separate variable by allowing an asymmetric response to oil prices changes. Following these assertions, he postulated the transformation below:

$$AOPD_t = \begin{cases} |OP_t| \text{ if } OP_t < 0 \\ 0 \text{ otherwise} \end{cases} \qquad (2)$$

$$AOPI_t, = \begin{cases} OP_t \text{ if } OP_t > 0 \\ 0 \text{ otherwise} \end{cases} \qquad (3)$$

OP_t is the growth rate of oil prices over the previous period, and $AOPD_t$ and $AOPI_t$ are the corresponding negative and positive growth rates of oil prices.

5. Model Results and Analysis

Table 1 below presents the descriptive statistics of Consumer price index (CPI), Gross domestic product (GDP), Money supply (M1), Oil price (OP) and Official exchange rate (OER). The mean values are 2.65, 26.07, 23.34, 2.84 and 2.35 percent respectively for consumer price index, gross domestic product, money supply, oil price and official exchange rate. Based on the standard deviations, it can be inferred that the official exchange rate (2.53%) fluctuated the most around the group mean. The least fluctuation was exhibited by gross domestic product (0.51%). Based on the values of skewness and kurtosis, the distribution of all the variables is within the range of normality. The Jarque-Bera statistics reveal that gross domestic product and official exchange rate are not normally distributed and the normality assumption is rejected at the 5% and 10% level of significance respectively. The minimum and maximum values reported in Table 1 reveal the degree of high variability in the various series in this study.

Table 1: Descriptive Statistics

	LCPI	LGDP	LM1	LOP	LOER
Mean	2.65	26.07	23.34	2.84	2.35
Median	2.54	25.80	23.09	2.98	2.29
Maximum	4.29	26.96	25.70	4.68	5.50
Minimum	1.24	25.47	20.77	0.73	-1.80
Std. Dev.	0.69	0.51	1.40	1.06	2.53
Skewness	0.63	0.63	-0.04	-0.29	-0.19
Kurtosis	3.01	1.83	1.93	2.29	1.44
Jarque-Bera	3.24	5.99**	2.34	1.73	5.24*
Probability	0.20	0.05	0.31	0.42	0.07
Observations	49.00	49.00	49.00	49.00	49.00

** and*indicate rejection of the normality assumption at the 5% and 10% level of significance, respectively.

LCPI =natural logarithm of consumer price index, LGDP = natural logarithm of GDP, LM2= natural logarithm of broad money supply, LROP = natural logarithm of real oil prices, and LROER = natural logarithm of real official exchange rate.

Table 2: Pearson Correlation Coefficient

	LCPI	LGDP	LM1	LOP	LOER
LCPI	1.00				
LGDP	-0.19	1.00			
LM1	-0.60***	0.77***	1.00		
LOP	-0.73***	0.65***	0.91***	1.00	
LOER	-0.33**	0.85***	0.67***	0.65***	1.00

*** and ** indicate significance at the 1%, and 5%, respectively. LCPI =natural logarithm of Consumer price index, LGDP = natural logarithm of GDP, LM1= natural logarithm of broad money supply, LOP = natural logarithm of oil prices, and LOER = natural logarithm of official exchange rate.

Table 2 displays the correlation coefficients between consumer price index, gross domestic product, money supply, oil price and official exchange rate. The correction coefficients between oil price and the other assumed endogenous variables range from -0.19 to 0.91. The correlation coefficients between oil price and consumer price index, gross domestic product, money supply, and official exchange rate are -0.73, 0.65, 0.91 and 0.65, respectively. The results indicate that the correlations between oil prices and all the variables are statistically significant at the 1 percent level. For instance, the correlation between oil price and consumer price index is negative and statistically significant at the 1 percent level (r = -0.73, p = 0.00).

Table 3: GLS_ADF Unit Root Test Results

Series	**t-stat**	**Lag(s)**	**5%CV**
Panel A: Level			
LCPI	-3.41**	0	-3.19
LGDP	-1.87	2	-3.19
LM1	-2.60	0	-3.19
LOP	-2.35	2	-3.19
LOER	-2.66	0	-3.19
Panel B: Fist Difference			
LCPI	–	–	–
LGDP	-4.73***	0	-3.19
LM1	-6.06***	1	-3.19
LOP	-6.95***	0	-3.19
LOER	-6.43***	1	-3.19

***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. LCPI =natural logarithm of CPI, LGDP = natural logarithm of GDP, LM1= natural logarithm of broad money supply, LOP = natural logarithm of oil prices, and LOER = natural logarithm of real official exchange rate. The optimal lags were determined by the modified Akaike Information Criterion.

To avoid spurious regression results fraught with time series models, table 3 tests and examines the time series properties of the variables in this study. The tool used for detecting the non-stationary of the data was the Augmented Dickey-Fuller (ADF) unit root test. The tests are all based on estimation of the above autoregressive/AR

(1) of equation 1. Most of the variables were found to be non-stationary in their levels (Panel A) except CPI whose t-statistic (-3.41) lies outside ADF critical value (-1.9419). Therefore, we reject the null hypothesis of non-stationarity at 5% level of significance. GDP, M1, OP and OEF respectively were found to be stationary (Panel B) in their first differences at the 1% level of significance.

Table 4: Vector Autoregression Estimates of Selected Macroeconomic Variables

	ΔLGDP	ΔLM1	ΔLOER	LCPI
ΔLGDP (-1)	0.44**	-1.22	1.22	-0.04
	(0.18)	(1.63)	(1.31)	(1.14)
	[2.50]	[-0.75]	[0.93]	[-0.03]
ΔLGDP (-2)	0.11	1.50	-1.00	-0.10
	(0.17)	(1.53)	(1.23)	(1.06)
	[0.67]	[0.98]	[-0.81]	[-0.10]
ΔLM1 (-1)	-0.01	0.34	-0.27	0.24
	(0.06)	(0.54)	(0.43)	(0.37)
	[-0.22]	[0.63]	[-0.62]	[0.64]
ΔLM1 (-2)	-0.01	-0.02	0.06	-0.02
	(0.02)	(0.15)	(0.12)	(0.11)
	[-0.61]	[-0.11]	[0.51]	[-0.23]
ΔLOER (-1)	0.01	0.00	-0.36	0.52
	(0.06)	(0.59)	(0.47)	(0.41)
	[0.24]	[-0.00]	[-0.76]	[1.27]
ΔLOER (-2)	0.01	-0.27*	0.09	0.10
	(0.02)	(0.15)	(0.12)	(0.11)
	[0.88]	[-1.78]	[0.75]	[0.93]
LCPI (-1)	-0.03	-0.18	-1.33*	2.33***
	(0.11)	(1.00)	(0.81)	(0.70)
	[-0.25]	[-0.18]	[-1.67]	[3.33]
LCPI (-2)	0.02	0.40	1.41	-1.48**
	(0.11)	(1.03)	(0.83)	(0.72)
	[0.16]	[0.39]	[1.71]	[-2.07]
ΔLOP	0.04**	0.52***	0.77***	-0.63***
	(0.01)	(0.12)	(0.10)	(0.09)
	[2.64]	[4.23]	[7.74]	[-7.28]
C	0.04	-0.51	0.00	0.30
	(0.05)	(0.45)	(0.36)	(0.31)
	[0.74]	[-1.14]	[0.01]	[0.96]
R-squared	0.37	0.71	0.78	0.82
Adj. R-squared	0.21	0.64	0.73	0.78
F-statistic	2.33	9.83	14.56	18.50

***, ** and * indicate significance at the 1%, 5%, and 10%, respectively. Standard errors in ( ) and t-statistics in [ ]. LCPI = natural logarithm of Consumer price index, LGDP = natural logarithm of GDP, LM1= natural logarithm of broad money supply, LOP = natural logarithm of oil prices, and LOER = natural logarithm of official exchange rate.

Table 4 explains the vector autoregression estimates of this study. It shows a statistically significant (5%) positive (.44) relationship between the previous (-1) value of GDP and the current GDP. Changes in oil price (OP) on GDP displayed similar trends, except that the positive impact of OP on GDP stood at 0.04. The relationship between changes in oil price (OP) on money supply (M1) and official exchange rate (OER) were positive and statistically significant at 1% level respectively. However, the effects of changing oil price (OP) on consumer price index (CPI) were negative at a 1% statistically significant level. The official exchange rate (OER) had a two-lag period effect on money supply at 10% significant level, while consumer price index (CPI) had a one period negative lag effect on official exchange rate (OER) at a 10% statistically significant level. There is a positive relationship between a one period and current CPI at 1% level of statistical significance. 2period lag CPI is negatively related to current period CPI 5%.

In a non-stationary series, there is no long-run mean to which the series return to. In a sense, there is no "steady state". This is crucial from economic aspect as we belief that the long-run equilibrium concept may exist in the same variables. In figure 2, following the initial innovations or shocks in oil prices, GPD, M1, OER and CPI returned to the balance line in the long-run. The blue lines are within 95% confidence interval.

6. Summary and Conclusion

We analyze the effects of oil price shocks on macroeconomic variables of Nigeria using VAR models for the period 1972 – 2020. It can be seen from the above results that random changes in oil prices have positive effects on real GDP, money supply and official exchange rate. The impact of fluctuating oil on GDP is positive, reflecting that Nigeria is an oil exporting country. However, the impact of oil price changes on the consumer price index was negative. These negative effects could be attributed to redistribution restrictions inherent in the economy or the inequitable revenue distribution issues within the economy. Most of the population does not benefit from the increases of oil revenue; therefore, demand is stagnant while supply increases. More so, increased revenue from oil price is used for imports/foreign goods, hence the negative relationship between changing oil price and the consumer price index. A good monetary policy mix could mitigate the adverse effects of fluctuating oil price on CPI.

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Appendix

Figure 2: Response to Cholesky One S.D. Innovations ± 2 S.E.s