EFFECTS OF OIL PRICE SHOCKS ON MACROECONOMIC INDICATORS IN NIGERIA

By

Ogheneyoma Oyibo

Student ID: 7910492

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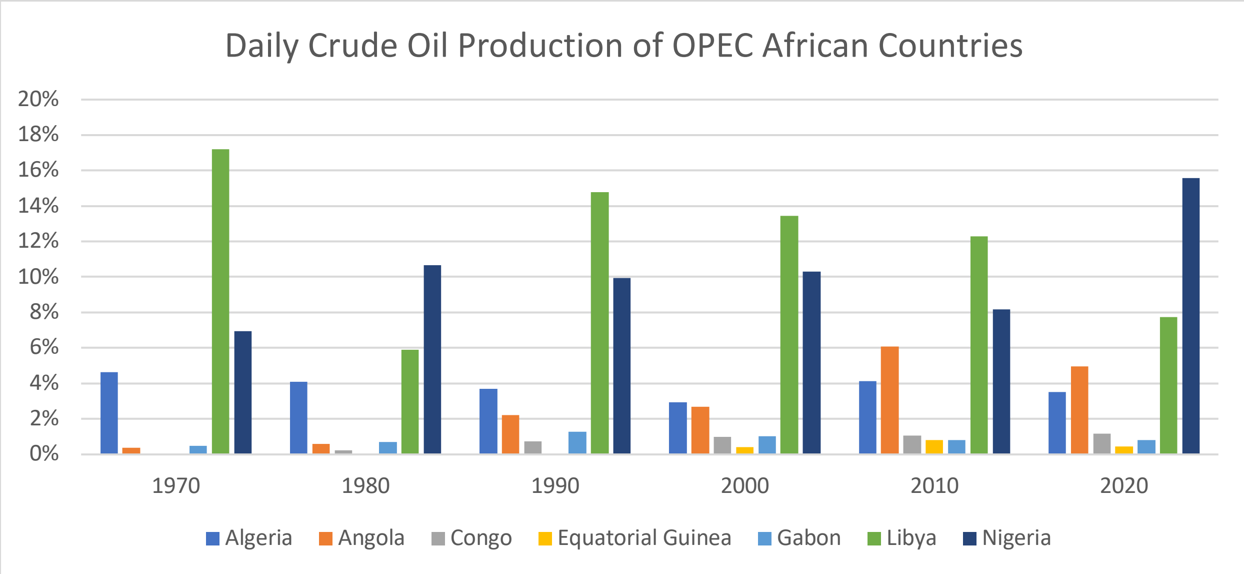
Supervisor: Professor Jared Carlberg

Course Instructor: Professor Wayne Simpson

Introduction

Nigeria is regarded as the "giant of Africa" because of its population – at around 220,000,000 people, it has about 100,000,000 more inhabitants than the second most-populous Ethiopia – and because of its considerable natural resource endowments, arguably the most important of which is crude oil. According to the Organization of the Petroleum Exporting Countries (OPEC), data expressed graphically in figure 1, Nigeria has been one of Africa's biggest oil producers for over five decades (OPEC, 2021). Since the discovery of oil in Oloibiri, Nigeria in 1956, crude oil has played a vital role in the Nigerian economy as its primary source of revenue. The contribution of crude oil to the economy has been so significant that it has become the backbone of the country's economic activities. Therefore, Nigeria is referred to as an oil-dependent economy. This is evident in the rate of participation of Nigeria in the oil trade. Since the 1970s, Nigeria's share of the daily crude oil production in Africa has been consistently below 10%, with Libya being the highest at around 18% (OPEC, 2021). However, Nigeria's daily crude oil production has increased rapidly in recent years and reached a two-digit percentage point. Compared to Libya, the second-highest producer of crude oil in Africa, Nigeria's crude oil production is more than twice the amount, and it is also higher than any other African country's production level (OPEC, 2021).

Figure 1: Daily crude oil production of OPEC African Countries



The impact of crude oil price fluctuations on the Nigerian economy is considered by many to be a double-edged sword. Nigeria is a country whose revenue is heavily dependent on oil exportation, and not only is it an oil exporter, but it also doubles as an importer of refined petroleum products. The broad consensus is that increasing oil prices boosts real national income in net oil-exporting nations by increasing export revenues. However, rising oil prices in countries (including Nigeria) that are net oil importers can cause inflation, resulting in higher input costs, a decline in the demand for non-oil products, and weaker investment (Akpan, 2001).

Furthermore, several elements, such as the current international campaign against environmental pollution, a rise in the popularity of electric vehicles, and an increase in solar architectures, such as solar heating and photovoltaic solar panels (grid parity), have fueled rumors about a falling oil price or an oil market bubble. Due to its reliance on oil compared to other emerging countries, Nigeria's political system and economy may be significantly impacted by all these factors. There has been a recent surge in fuel prices (refined oil) and fuel scarcity in Nigeria. Early empirical investigations discovered a significant negative relationship between oil price shocks and GDP. This was presented as proof that oil shocks were to blame for economic recessions (Hamilton 1983; Mork 1989). Understanding why a country with oil revenue as its mainstay should have such surge and scarcity problems in its economy is essential.

The research objective in this paper is to determine the response of selected Nigerian macroeconomic variables such as per capita GDP, exchange rates, and inflation rate to international oil price shocks. Specifically, the research will examine the symmetric and asymmetric effect of oil price shocks on per capita GDP, exchange rate and inflation rate in Nigeria. Much work exists to determine the relationship between oil price shocks and the macroeconomy in developed oil-importing nations. However, limited research has been carried out on the impact of oil price shocks on developing countries that export and import oil, like Nigeria. Due to its dual status as an oil-importing and exporting economy, Nigeria may serve as a compelling case study to explain the contentious structural phenomenon known as "the Dutch Disease" and its potential effects on economic growth. Dutch Disease is a concept in economics that describes where the rapid development of one sector, particularly natural resources, leads to a decline in other sectors. As a result, this research will offer fresh perspectives on the effects of Dutch Disease and the economic responses of nations with economies that import and export oil. This research will be of great significance to policymakers, both the government and monetary institutions, on how to successfully implement policies to boost its macro economy and avoid significant impacts that the fluctuations in oil price may have on its economy. It will also help in filling an existing gap in the body of knowledge.

The remainder of this paper is organized as follows: the next section will provide an overview of the theory underpinning the empirical approach used. The data and empirical methodology will be presented, including specification testing and determination of the time-series properties of the data series. The next-to-last section of the paper presents and discusses the results of the empirical analysis, and the final section is comprised of conclusions, limitations, and suggestions for extensions of this work.

Theory

The process employed in this paper can be justified by two related theoretical frameworks the Natural resource curse theory (sometimes referred to as the Dutch disease phenomena) and the rentier state theory. The Economist magazine first used the phrase “Dutch disease” in 1977 when it examined a situation that arose in the Netherlands following the 1959 discovery of substantial natural gas reserves in the North Sea. The Dutch guilder’s value rose dramatically because of the country’s sudden wealth and enormous oil exports, reducing the competitiveness of all Dutch exports of non-oil goods on the global market. Dutch disease is used to explain a paradoxical situation where the discovery of a natural resource (like oil) leads to an increase in export earnings but also accompanies negative effects on the nation’s economy. Many academics (Akinlo, 2012; Alaali, Roberts and Taylor, 2015; Karl, 2004; Bawumia and Halland, 2017) have uncovered consistent trends in the impact of oil discovery, extraction, and price swings on economic expansion. The existence of Dutch disease is validated statistically in the case of Nigeria, and it was ascertained that oil exploration leads to economic downturns until a certain threshold is attained. Its continuous exploration will lead to a subsequent economic expansion (Oludimu, 2022).

Otaha (2012) opined that oil is undoubtedly not a godsend if a nation seeks quick progress to escape the vicious cycle of poverty. Oil exports as a source of income for development do not seem to function since oil-dependent governments have performed worse in recent years than non-oil states in terms of economic growth and development. Due to the risk associated with the oil boom, deindustrialization could result if other non-tradeable industries, such as manufacturing and agriculture, become less competitive. In this instance, the Dutch disease demonstrates how the depletion of other economic sectors, and the exploitation of natural resources are related (Corden and Neary, 1982).

However, a state is considered rentier if it receives most of its national revenues from foreign people, businesses, or governments. The studies of Hazem El Beblawi and Giacomo Luciani on the evolution of oil-rich countries made rentier states and rentier states theories (RST) well recognized. They demonstrate that rentier states obtain income without a growth in the domestic economy's production or the state's political development, which is the capacity to levy taxes on residents. According to the rentier state hypothesis, countries that depend primarily on taxes have a different relationship with their residents than those that rely mainly on external rents like oil. These states are less likely than tax-dependent states to be democratic (Ayodele 2004).

The rentier state theory can be seen to sufficiently explain the activities of militancy groups in regions like the Niger-Delta and its relation to the resource curse theory is undeniable. Around 80% of Nigeria's national wealth comes from the Niger-Delta region, which is thought to be among the deltas with the greatest natural resources in the world (Nwogwugwu et al., 2012). This region is known for its richness in crude oil and substantive oil exploration takes place here, but the exclusion and neglect of this area by the Nigerian Federal government have motivated the formation of militancy groups and their activities; their groups are known for vandalization of oil infrastructures, illegal oil bunkering and kidnapping of oil company workers both foreign and local nationals.

This has exacerbated the already unstable situation in the area and hurt Nigeria's economy by hindering the influx of foreign direct investment, which is essential for achieving economic growth and development. Some existing literature has opined that the existence and exploration of natural resources lead to a decline in economic growth and a high tendency to experience a civil war. The Nigerian economy largely depends on the resources found in the Niger-Delta region, yet it has received little to no attention from the government, resulting in poverty, unemployment, and poor infrastructure. Environmental degradation is a consistent challenge facing this region due to the activities of multinationals like oil spillage (Igbani et al., 2017). Since 2006, the Niger Delta has had high insurgency and insecurity. This can be attributed to several things, including the marginalization of the Niger delta's indigenous populations, environmental degradation, poor governance, an inconsistent policy framework, and the divide-and-conquer strategy of the oil industry (Nwogwugwu et al., 2012).

Theory Framework

The theoretical transmission mechanism of the unexpected exogenous changes in the oil price to economic activity can be modeled through the theory of supply and demand side channels (Herrera, Karaki and Rangaraju, 2019). Initially, the nominal oil price (NOP), aggregate supply (AS) and aggregate demand (AD) are all assumed to take on previous values plus a random error term. However, the theoretical framework of this study focuses on the aggregate supply-side channel, following that both the resource curse theory and renter state theory adopted for the study is majorly supply-side theories.

$$NOP_t = NOP_{t-1} + e_t^{NOP} \quad (1)$$

$$AS_t = AS_{t-1} + e_t^{AS} \quad (2)$$

Equation 1 provides the oil price model, while equation 2 is the aggregate supply model. The aggregate supply is a significant aspect of an economy where the goods and services required for the sustenance of the economy are produced. This implies that an exogenous oil price change will lead to a disruption in the production process. Huang and Guo (2007) also assert that higher oil prices may positively impact inflationary pressures in an economy. As a result, this leads to a decline in households' real incomes; hence, private consumption, a significant component of aggregate output, reduces significantly. Also, unexpected changes in oil prices are related to higher energy, like an increase in petroleum prices (Herrera et al., 2019).

However, the higher the price of petroleum, the higher the cost of transportation and the lower the disposable incomes of households, hence, establishing the impact of oil price shocks on both the demand and supply side of the economy (Herrera et al., 2019). This effect could be felt chiefly in an oil-dependent economy like Nigeria, thus, leading to the proposition of the resource curse theory. As pointed out earlier, the oil price has been revealed to impact output and domestic price level negatively; moreover, its impact could also be neutralized using central banks' monetary policies banks (Hamilton, 1996, 2003; Hooker, 2002). Therefore, the monetary policies of the apex bank can thus have an impact on the exchange rate that impacts the import and export of intermediate and final goods in the economy. It is also notable that an increase in oil prices enriches the oil-exporting countries while it reduces the wealth of the oil-importing nations (Krugman, 1980).

$$Y_t^{AS} = AS_t + \delta NOP_t \quad (3)$$

Equation 3 represents how oil price shocks impact an economy's aggregate supply. This specifically impacts government and business investments, especially oil importing business, manufacturing and transportation. Since oil revenue is the mainstay of the Nigerian economy, it is sacrosanct that an unexpected increase or decrease in the price of oil will affect both the aggregate demand and supply of the economy. However, Nigeria's oil supply can be considered a small proportion of the world oil supply. As such, its impact on the world oil price is insignificant and cannot be considered a determinant of world oil price. Therefore, the oil price impact on the macroeconomy of Nigeria can only be considered a unidirectional impact along with other macroeconomic variables such as per capita GDP, exchange rate and inflation rate.

$$Y_t^{AS} = AS_{t-1} + e_t^{AS} + \delta NOP_t \quad (4)$$

Equation 4 can thus be specified as equation 6 by plugging in the study variables. Therefore, the functional representation of the model estimated in this study is given as equation 5.

$$PGDP_t = f(NOP_t, ER_t\,, INF_t) \quad (5)$$

$$PGDP_t = \beta_0 + \beta_1 NOP_t + \beta_2 ER_t + \beta_3 INF_t + \mu_t \quad (6)$$

Where Y_t represents $PGDP_t$, AS_{t-n} (n = 0, 1, …, k) represents variables and $NOP_t, and\ ER_t$ are INF_t.

Asymmetric framework specification

To deviate from considering only the linear effect of oil price shocks on the Nigerian economy, this study estimates both the symmetric and asymmetric impact of oil price shocks on the Nigerian economy from the perspective of household income growth rather than economic growth. Prior studies (Ayadi, 2005; Oyeyemi, 2013; Omisakin, 2008) have assumed that the effect of nominal oil prices on the Nigeria macroeconomy is linear, while some (Olomola and Adejumo, 2006; Akpan, 2009) with that considered the non-linearity effect of oil price requires an update with recent data. Contrary to this revelation, empirical studies on developing and developed economies have found the possibility of asymmetric impacts (Mork, 1989; Hamilton, 1996). It is argued that an increase in oil price can lead to shocks from the aggregate supply side such that economic activities decline; however, a corresponding decrease in oil price is not tantamount to a directly opposite effect of the same scale (Hamilton, 1996). Notably, a decline in oil prices can equally lead to supply-side shocks (Chuku, 2012). Examining the possibility of this argument is essential, especially in the case of Nigeria, which relies heavily on crude oil exportation and importation of its final product for energy supply in the economy. Killian (2009), Hamilton (2009) and Du, He and Wei (2010) theoretically advocate the possibility of an asymmetric effect of oil price shocks occurrence.

Although three different asymmetric transformations of oil prices are available in the literature, the first is the non-linear specification, where increases or decreases in the price of oil are considered different variables (Mork, 1989; Hamilton, 1996). The second transformation method is the scaled specification which accounts for volatility (Lee et al. 1995). Lastly, Hamilton (1996) net oil price increase method.

To capture the asymmetric effects of oil price shocks on the Nigerian economy using recent data given the unfolding of events such as the COVID-19 pandemic, the oil price shock transformation of Hamilton (1996) is adopted. One benefit of this approach is that the changes in oil prices are capturable into decrease and increase, thus, producing two different variables. Equations 7 and 8 are the asymmetric transformation of oil price shocks defined by Hamilton (1986). Equation 7 presents the positive values of the Hamilton transformation. The variable is determined by comparing the current oil price to the previous year's values. Positive values are considered the values of the new variable (NOP_t^+) while all negative values are considered zero. Similarly, equation 8 denotes the second variable from the decomposition where negative values are considered while all positive values are transformed to zeros.

$$NOP_t^+ = (NOP_t - maxNOP) > 0, 0\forall(NOP_t - maxNOP) \leq 0 \quad (7)$$

$$NOP_t^- = (NOP_t - minNOP) < 0, 0\forall(NOP_t - minNOP) \geq 0 \quad (8)$$

Where, NOP_t^+ is an extraction of all net oil price increases and NOP_t^- is an extraction of all net oil price decreases (Omolade et al., 2019). Also, maxNOP is the previous year's maximum oil price, while minNOP is the last year's minimum. These two extractions (NOP_t^+, NOP_t^-) are estimated differently using the VAR model to analyze their impact on the model specifications above. Hence, the non-linear specification of the model is given as equation 9.

$$PGDP_t = \beta_0 + \beta_1 NOP_t^+ + \beta_2 NOP_t^- + \beta_3 ER_t + \beta_5 INF_t + \mu_t \quad (9)$$

Data and Methodology

This paper uses annual times series data from 1980-2021 based on the availability of data in the databases approached for data collection. These data were obtained from multiple sources, including the World Bank (World Development Indicators) and oil price data from the British Petroleum statistical review of World Energy Consumption. Brent crude oil prices were explicitly used. Since the study focuses on oil price shocks and the Nigerian economy, the variables employed are Nominal Oil Price (NOP), Exchange Rate (ER) and Inflation (INF), Per Capita Gross Domestic Product (PGDP) as a deviation from other studies that have focused on Nigerian economic growth.

Table 1: List of variables

Variables	Description	Source
Per capita GDP	The total output of a country divided by its population	World Development Indicators (WDI)
Inflation rate	The rate at which the general level of prices for goods and services is rising at 2010 constant price	World Development Indicators (WDI)
Exchange rate	The annual value of naira to dollar in the international market	World Development Indicators (WDI)
Nominal oil price	The price of Brent crude oil	British Petroleum Statistical Review of World Energy Consumption

Variables Trend

Figure 2: Trend of key variables

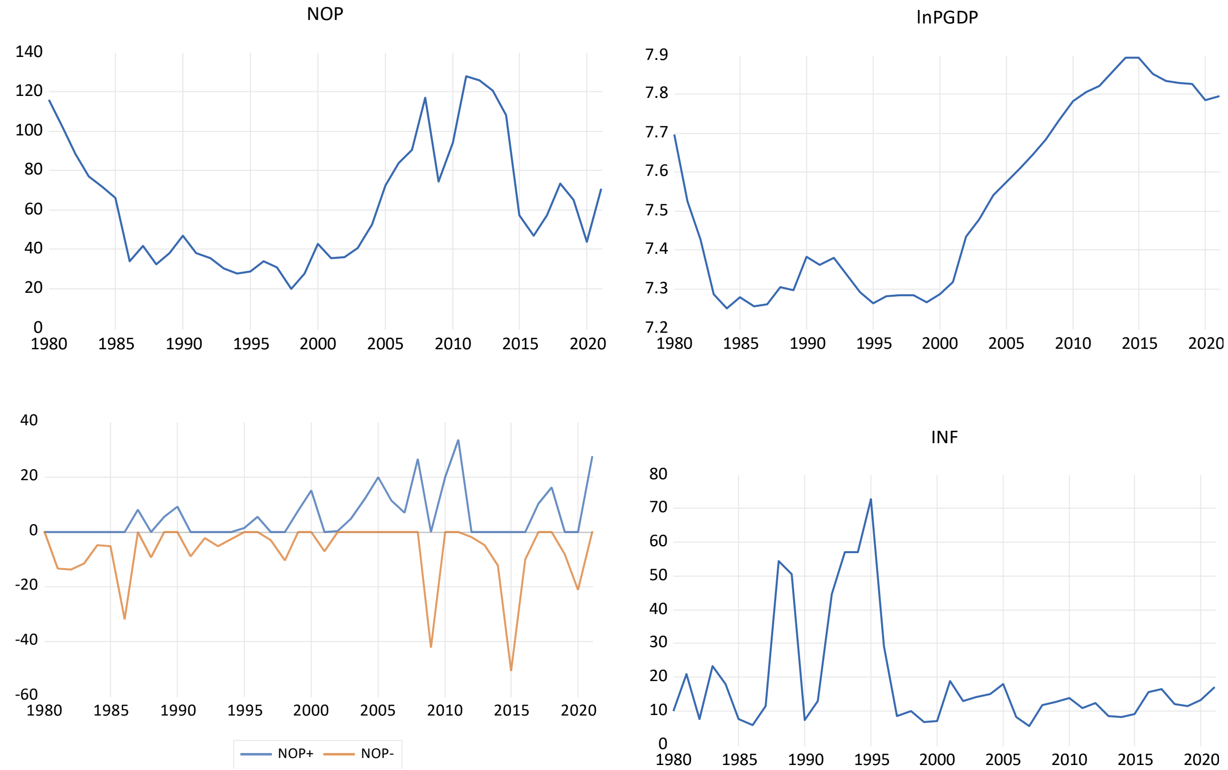


Figure 2 presents the time series trend of the key variables considered in the research. The price of Brent crude oil is relatively unstable as presented in the NOP graph while per capital GDP has been on increase since the two decades ago. Also, inflation rate in Nigeria has been relatively stationary on different as it is graph shows no trend over time. Similarly, the disaggregation of Brent crude oil price to capture the asymmetric effect of oil price shows that the increase and decrease in crude oil price does not mirror each other.

Table 2: Summary statistics of the variables

	NOP	**NOP+**	**NOP-**	**LNPGDP**	**INF**	**ER**
Mean	62.51145	5.704942	-6.77084	7.52362	18.73531	150.7228
Median	54.81524	0	-2.24688	7.456683	12.71577	101.0143
Maximum	128.0088	33.65543	0	7.893406	72.8355	536.885
Minimum	20.1899	0	-50.9687	7.250074	5.388008	49.74454
Std. Dev.	31.34694	8.809552	11.34057	0.236044	16.51313	116.3998
Skewness	0.662857	1.603324	-2.47169	0.276726	1.892215	1.819728
Kurtosis	2.241335	4.721896	9.002869	1.424248	5.460058	5.574111
Jarque-Bera	4.082909	23.18317	105.8249	4.881278	35.65415	34.77545
Probability	0.12984	9.24E-06	1.05E-23	0.087105	1.81E-08	2.81E-08
Sum	2625.481	239.6075	-284.375	315.992	786.8831	6330.358
Sum Sq. Dev.	40287.87	3181.936	5272.946	2.284383	11180.02	555505.2
Observations	42	42	42	42	42	42

The mean provides the central tendency of the distribution of the variable. For example, the mean of NOP is 62.51145. The maximum value shows the highest value observed for each variable. For instance, the maximum value of INF is 72.8355, indicating that the highest inflation rate observed in the sample is 72.84. The minimum value shows the lowest value observed for each variable. For example, the minimum value of ER is 49.74454, indicating that the lowest exchange rate observed in the sample is 49.74.

Stationarity test

The unit root tests of the variables were first conducted to examine the time series properties of each variable. The augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were adopted for the test to determine the order of the integration of the variables. The choice of the two methods is to cross-check the result to ascertain the authenticity of the order of integration of the variables.

Table 3: Stationarity test result of the variables

Variables	**ADF**			**PP**		
	Level	1st diff.	Order of integration	Level	1st diff.	Order of integration
Per capita GDP	-1.3799	-3.3159*	I(1)	-0.9799	-4.4650*	I(1)
Inflation	-3.0940*	-6.4510*	I(0)	-2.9598*	-12.3955*	I(0)
Exchange rate	-1.9698	-4.4141*	I(1)	-2.0870	-4.4032*	I(1)
Nominal oil price	-2.2186	-5.8303*	I(1)	-2.2586	-5.8267*	I(1)
Nominal oil price increase	-2.2075	-8.8115*	I(1)	-4.7669*	-10.9476*	I(0)
Nominal oil price decrease	-6.0964*	-5.7471*	I(0)	-6.0934*	-22.2823*	I(0)

* Significance at 0.01, ** significance at 0.05 and *** significance at 0.10

The unit root test result of the variables is presented in Table 3. The result showed that both the ADF and PP tests confirm the stationarity of the lnPGDP, ER and NOP at the first difference, thus signifies that they are integrated of order one (i.e., I(1)). The result also showed that INF is integrated of order zero in both tests while NOP^- is confirmed by both tests as I(0) variable. However, there seems to be no clear cut in the position of the two tests on the position of stationarity of NOP^+. While the ADF test shows a first difference stationarity of NOP^+, the PP test suggests it is an I(0) variable, the conclusion on the order of integration could be justified through the visual representation in Figure 2. Figure 2 shows that nominal oil price increase has no trend at levels thus confirms the result of the Phillips-Perron test result. Irrespective of the position taken on this discrepancy in positions of the two tests, the stationarity test of the variables reveals that the study variables are integrated of different orders (i.e., I(0) and I(1)), which violates one of the conditions of specifying a VAR model.

Empirical model

The Structural Vector Autoregressive (SVAR) Model

The Vector Autoregressive (VAR) approach has been one of the leading techniques for analyzing economic dynamism, especially when studying oil price shocks/volatility (Barsky and Kilian, 2004; Killian, 2009; Chuku, 2012; Omolade et al., 2019). The symmetric and asymmetric transmission of oil price in this study is estimated using a VAR model of order p, as given below.

The VAR(p) model can be written formally as:

$$y_t = \gamma + \sum_{i=1}^{p} A_i y_{t-i} + \partial q_t + \varepsilon_t \quad (10)$$

where:

$y_t = a\ m\ x\ 1$ vector of the variables of interest, representing Nominal Oil Price (NOP), Per Capita Gross Domestic Product (PGDP), Positive Nominal Oil Price Change (NOP^+), Negative Nominal Oil Price Change (NOP^-) and Exchange Rate (ER)

$\gamma = a\, m\, x$ 1 vector of intercept terms

A_n is a m x 6 coefficient matrix for lags 1 through p

q_t is a n x 1 vector of exogenous variable

$\varepsilon_t = a\, m\, x$ 1 vector of error terms at time t

In this model, it is assumed that the current values of the variables in y_t depend on their past values up to p lags, as well as the error term u_t. To include variables that may affect the Nigerian economy but are not affected by the variables in the system, additional columns can be added to the y_t vector for these variables. After estimating the VAR model, the impulse response function (IRF) analysis and variance decomposition are used to estimate the effect of oil price shocks on the Nigerian economy. Impulse response analysis involves simulating the system's response to a one-time shock to the oil price variable, while variance decomposition can help us understand each variable's relative contributions to the system's variability.

Toda-Yamamoto (TY) extended VAR model.

Due to the mixed order of integration of the variables considered in the study, the Toda-Yamamoto variant of VAR is adopted. This model is preferred as it can handle variables with different orders of integration, unlike other variants of VAR models, which require the same order of integration for all variables. Also, the non-stationarity at the same level of the time series implies that there is a violation of VAR stability condition; hence, the Wald test statistics for Granger causality for the joint significance test of the other lagged endogenous variables in VAR equations is rendered invalid (Ghosh and Kanjilal, 2014). Therefore, the Toda and Yamamoto (1995) model is known for its efficiency in estimating small sample sizes, regardless of the integration order of the variables. Apart from this, the necessity of a cointegration test before estimation is unnecessary for the Toda-Yamamoto model in as much as the series is within the bound of the optimal lag length of the model as such, avoids the possibility of bias associated with stationarity and cointegration tests (Fadol, 2020; Clarke and

Mirza, 2006; Mavrotas and Kelly, 2001; Zapata and Rambaldi, 1997). This is specifically due to its MWALD statistic which its validity is conditioned on the fact that the optimal lag length of the model is greater than the order of integration of the process (Toda and Yamamoto, 1995). TY also proposes causality testing in a system that may have mixed orders of integration and cointegration, which involves using an augmented level VAR model that captures long-run information, which is often ignored in models that require first differencing and pre-whitening (Clarke and Mirza, 2006; Rambaldi and Doran, 2006; Fadol, 2020).

Despite its effectiveness, the Toda-Yamamoto (TY) approach has some limitations. One of the main drawbacks is that the approach can be inefficient and may result in a loss of power (Ghosh and Kanjilal, 2014). This is because the VAR model used in the TY approach is intentionally over-fitted, as pointed out by Toda and Yamamoto (1995). Additionally, Kuzozumi and Yamamoto (2000) caution that the asymptotic distribution may not accurately approximate the distribution of the test statistic, which could further reduce the power of the test for a small sample size. The TY model is a variant of the structural VAR model stated in equation 10, therefore, this study specifies the TY model based on the variable considered in this study. The major difference between the VAR and TY VAR variant model is the inclusion of a maximum difference order of integration to the lag length. Therefore, this study specifies the TY variant optimal lag length as $(\mathrm{k}+\mathrm{d}_{\max})$ and adopted in both the symmetric and asymmetric specification models.

Linear specification

$$lnPGDP_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} lnPGDP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \beta_{2j} lnPGDP_{t-j} + \sum_{i=1}^{k} \alpha_{1i} NOP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \alpha_{2j} NOP_{t-j}$$

$$+ \sum_{i=1}^{k} \delta_{1i} ER_{t-i} + \sum_{j=k+1}^{k+d_{max}} \delta_{2j} ER_{t-j} + \sum_{i=1}^{k} \gamma_{1i} INF_{t-i} + \sum_{j=k+1}^{k+d_{max}} \gamma_{2j} INF_{t-j} + \mu_t$$

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$$INF_t = \beta_0 + \sum_{i=1}^{k} \rho_{1i} INF_{t-i} + \sum_{j=k+1}^{k+d_{max}} \rho_{2j} INF_{t-j} + \sum_{i=1}^{k} \sigma_{1i} lnPGDP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \sigma_{2j} lnPGDP_{t-j} + \sum_{i=1}^{k} \tau_{1i} NOP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \tau_{2j} NOP_{t-j} + \sum_{i=1}^{k} \emptyset_{1i} ER_{t-i} + \sum_{j=k+1}^{k+d_{max}} \emptyset_{2j} ER_{t-j} + \mu_t$$

Where k is the optimal lag length and d is the maximum order of integration of the variables.

Optimal lag length selection

Prior to estimating the linear TY model specified above, the optimal lag length k is a requisite in a VAR model. The result of the lag structure was generated from a structural VAR model estimation with different lag length chosen by each criterion. However, the AIC was used in selecting the optimal lag length for the model because it provides the smallest statistics and to maintain the consistency in the usage of the information criterion adopted during stationarity tests. More so, lower AIC implies a better model. The AIC suggests that the model with a lag length of 2 has the lowest AIC value, indicating that it is the best model among the ones tested. Therefore, based on the AIC criterion, the optimal lag length for this time series model is 2.

The autocorrelation test was also conducted to ensure that the present values of the variables does not autocorrelated with their lag values. The tests are performed at different lags, and they evaluate the null hypothesis of no serial correlation against the alternative hypothesis of serial correlation. The null hypothesis is tested for each lag separately. The results show that for lag 1 and lag 2, the likelihood ratio statistic (LRE* stat) is 20.03221 and 11.36697, respectively. The degrees of freedom (df) for both tests are 16, and the probabilities (Prob.) are 0.2188 and 0.7863, respectively. Since the probabilities are greater than the commonly used significance level of 0.05, we cannot reject the null hypothesis of no serial correlation at either lag 1 or lag 2. The results thus suggest that there is no evidence of serial correlation at lag 1 and 2. Given that there is no autocorrelation, the Toda-Yamamoto VAR model can thus be estimated, and the impulse response function (IRF) and Variance Decomposition can be performed.

Asymmetric specification

$$lnPGDP_t = \beta_0 + \sum_{i=1}^{k} \nabla_{1i} lnPGDP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \nabla_{2j} lnPGDP_{t-j} + \sum_{i=1}^{k} \partial_{1i} NOP_{t-i}^{+} + \sum_{j=k+1}^{k+d_{max}} \partial_{2j} NOP_{t-j}^{+}$$
$$+ \sum_{i=1}^{k} \varphi_{1i} NOP_{t-i}^{-} + \sum_{j=k+1}^{k+d_{max}} \varphi_{2j} NOP_{t-j}^{-} + \sum_{i=1}^{k} \omega_{1i} ER_{t-i} + \sum_{j=k+1}^{k+d_{max}} \omega_{2j} ER_{t-j} + \sum_{i=1}^{k} \pi_{1i} INF_{t-i}$$
$$+ \sum_{j=k+1}^{k+d_{max}} \pi_{2j} INF_{t-j} + \mu_t$$

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$$INF_t = \beta_0 + \sum_{i=1}^{k} \phi_{1i} INF_{t-i} + \sum_{j=k+1}^{k+d_{max}} \phi_{2j} INF_{t-j} + \sum_{i=1}^{k} \Omega_{1i} lnPGDP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \Omega_{2j} lnPGDP_{t-j}$$
$$+ \sum_{i=1}^{k} \Theta_{1i} NOP_{t-i}^{+} + \sum_{j=k+1}^{k+d_{max}} \Theta_{2j} NOP_{t-j}^{+} + \sum_{i=1}^{k} \Psi_{1i} NOP_{t-i}^{-} + \sum_{j=k+1}^{k+d_{max}} \Psi_{2j} NOP_{t-j}^{-}$$
$$+ \sum_{i=1}^{k} \Phi_{1i} ER_{t-i} + \sum_{j=k+1}^{k+d_{max}} \Phi_{2j} ER_{t-j} + \mu_t$$

Where k is the optimal lag length and d is the maximum order of integration of the variables.

Optimal lag length selection

Like the linear specification model, the AIC is also used in selecting the optimal lag length for the asymmetric estimation of oil price shocks on the Nigerian macroeconomic indicators. The result shows that the model with a lag length of 1 has the lowest AIC value, indicating that it is the best model. Therefore, based on the AIC criterion, the optimal lag length for this time series model is 1.The autocorrelation test results also shows that the p-values associated with the Lagrange Multiplier test statistic are greater than 0.05 for all lag orders tested. This suggests that we cannot reject the null hypothesis of no serial correlation at any of the tested lag orders. Similarly, the p-values associated with the Rao F-statistic are also greater than 0.05 for all lag orders, providing additional support for the conclusion that there is no evidence of serial correlation in the data. Hence, we can proceed to estimating the linear and non-linear models specified above.

Results

Oil price shocks symmetric effect results

Impulse response analysis

Figure 3: IRF of macroeconomic variables on nominal oil price shock

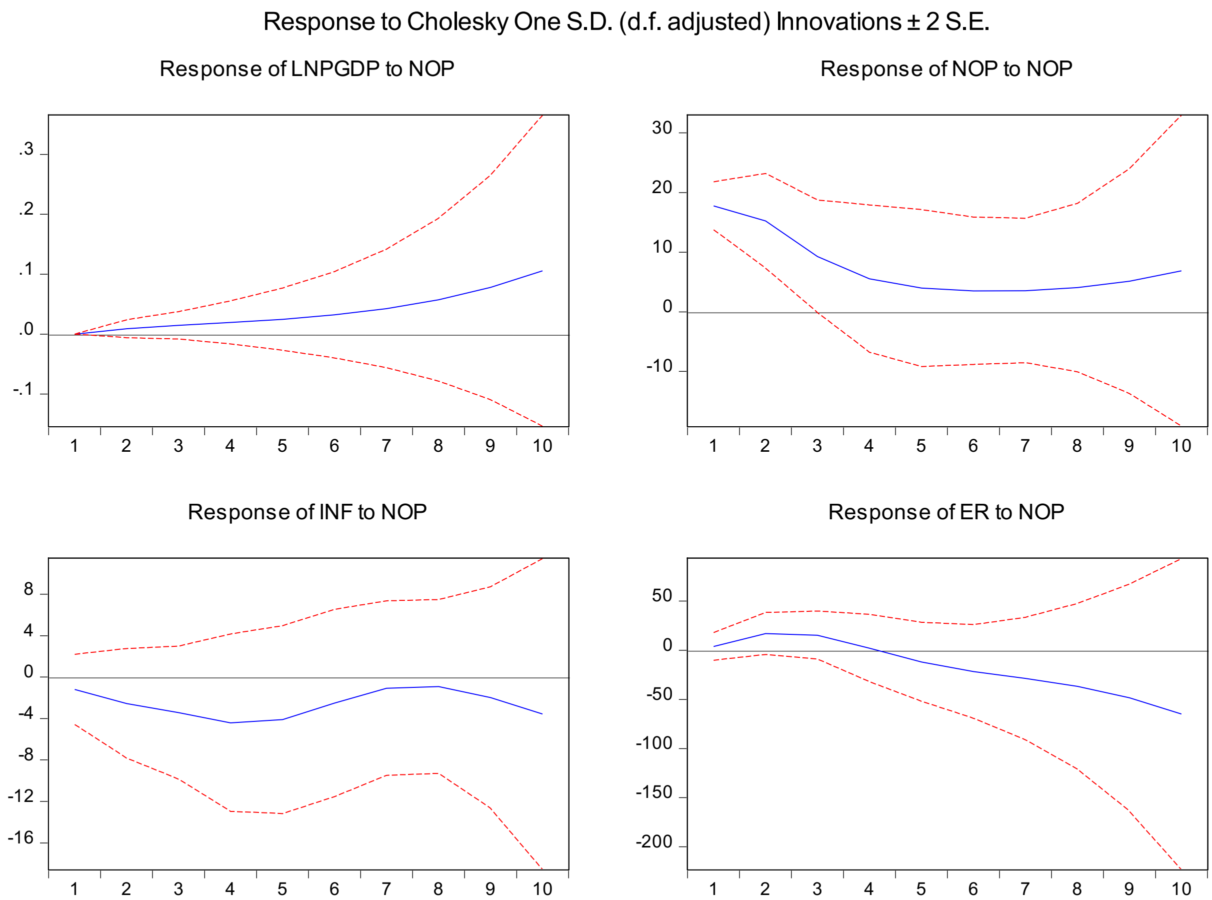

Figure 3 consists of the impulse response functions of the responses of the macroeconomic variables (lnPGDP, INF and ER) considered in this study on linear oil price shock in Nigeria. From the figure, the response of per capita GDP to the linear oil price shock is positive throughout the 10 periods. The response of per capita GDP to oil price shock over the 10 periods is somewhat exponential, which implies that oil price shock has a positive impact on the per capita GDP in the Nigerian economy. The first impact of oil shock is negative for the inflation rate, which continues over 4 periods before a bit of resuscitation, though still negative. However, the response of inflation rate to oil price shock is negative throughout the periods, with a business cycle-like shape formed.

The exchange rate responded positively to oil price shocks in the first four periods. Still, its response to oil price shocks for the remaining 6 months was negative, deepening further down the negative zone. This shows that oil shock has a positive effect on the exchange rate in the short run and a negative impact in the long run.

Table 4: Variance decomposition

Period	S.E.	LNPGDP	NOP	ER	INF
Variance Decomposition of NOP:					
1	18.26336	5.347512	94.65249	0.000000	0.000000
5	28.09804	13.01184	86.26237	0.414813	0.310973
10	52.79885	71.02668	28.57631	0.241877	0.155133

The table shows the variance decomposition of nominal oil price (NOP) into the three components (lnPGDP, ER and INF) considered in the study over a period of 10 periods. For instance, nominal oil price explains only 5.35% of the variance in lnPGDP while it explains zero variance on the exchange rate and inflation in Nigeria. However, in the 5th and 10th periods, NOP explains 13.01% and 71.03% of the Nigerian economy's per capita GDP fluctuations, respectively. Also, NOP explains less than 1% of variations in ER and INF in both 5th and 10th periods, implying that NOP has no significant influence on the variations in ER and INF in Nigeria.

Oil price shock asymmetric specification results

Impulse response analysis

Figure 4: IRF of macroeconomic variables to asymmetric oil price shocks

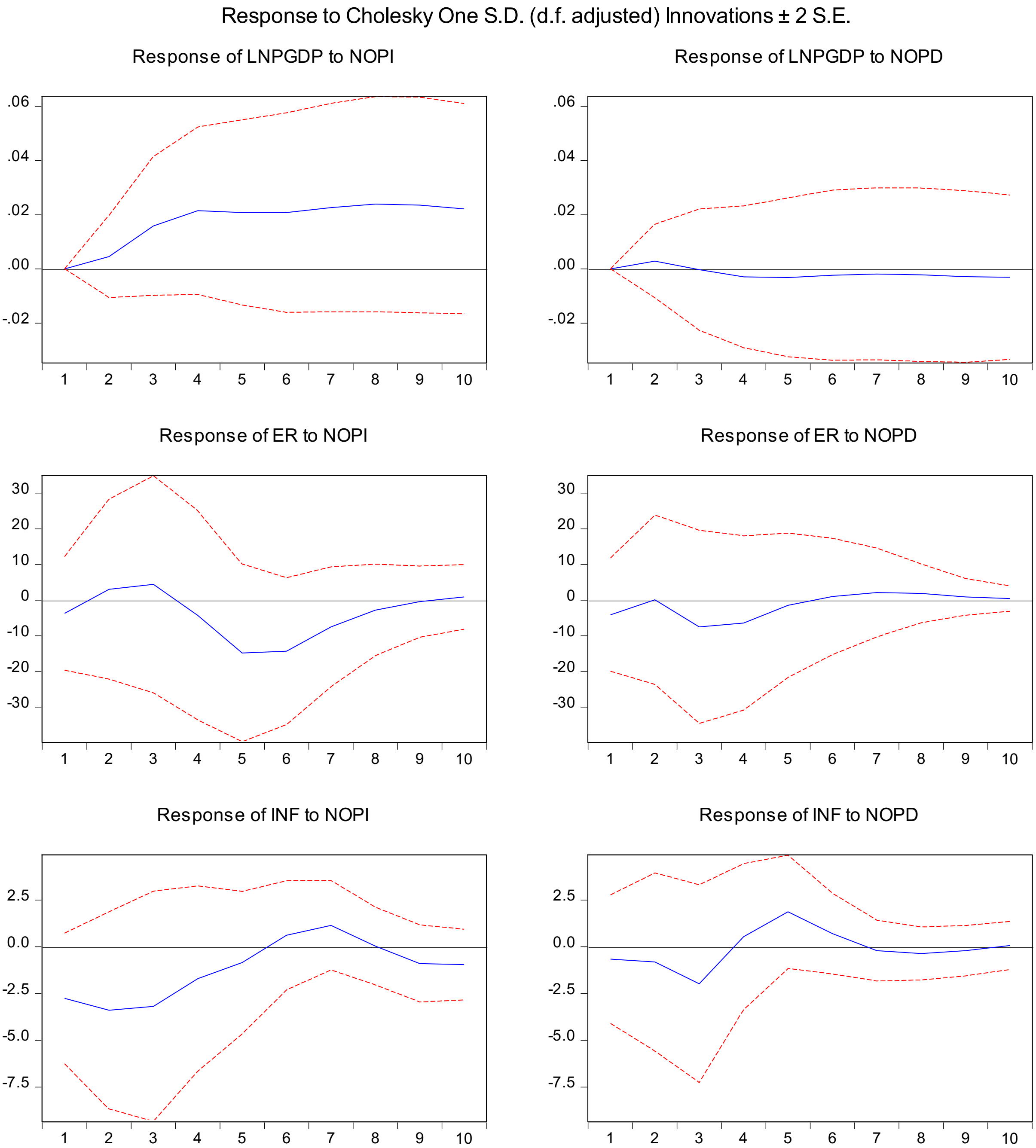

Figure 4 presents the impulse response results of the asymmetric effect of oil price shock on selected macroeconomic variables of the study. It shows the responses of lnPGDP, ER and INF to NOPI, which is the positive oil price shock (NOP^{+}) and NOPD, which is the negative oil price shock (NOP^{-}). Per capita GDP response to positive oil price shock is positive as reflected in figure 4. This shows that a positive increase in oil price shock increases the oil revenue of an oil-dependent economy such as Nigeria and increases the per capita revenue of households in the country. Also, the first response of exchange rate to a positive oil price shock is positive, although the initial position was negative. However, a positive oil price shock has mixed effects on exchange rate given that it leads to appreciation and depreciation of exchange rate of the naira to the dollar. More so, the response of inflation rate to positive oil price shock increases over time, indicating that positive oil price shock leads to an increase in inflation in the Nigerian economy. Although the positive effect of oil price shock finally declines back to the negative zone, the effect of oil price shock at the end of the forecast period shows that the country's inflation rate has increased above what it used to be. Hence, the overall positive oil price shock effect on inflation in Nigeria is positive.

Similarly, from figure 4, the response of per capita GDP to negative oil price shock (NOP^-) is initially positive and could be regarded as insignificant given its magnitude relative to its response to positive oil price shock in the Nigerian economy. Nevertheless, the subsequent responses of per capita GDP to negative oil price shocks remained negative throughout the periods. Although the decline in per capita GDP due to negative oil price shock seems insignificantly different from 0, it is succinct to say at this point that the effect of negative oil price shock does not mirror the impact of positive oil price shock. Also, one would have expected that the response of exchange rate to a negative oil price shock be positive or directly opposite the effect of a positive oil price shock; however, exchange rate response to negative oil price shocks could be termed moderate given that the magnitude of rise and decline is not abrupt relative to positive oil price shock impact. More so, the exchange rate adjustment to negative oil price shock to the origin was achieved earlier (i.e., 5th period) than the positive oil price shock. Lastly, inflation rate response to negative oil price shocks is relatively mild compared to the positive. For instance, the first response of inflation to the shock was negative, implying a decline in inflation before a positive increase commences in period 3. At the same time, it went below zero earlier than the positive oil price shock. It could also be inferred from the figure that there is only but a little and insignificant change in inflation rate when it responds to a negative oil price shock than when the shock is positive.

Table 5: Variance decomposition

Period	S.E.	LNPGDP	NOP^+	NOP^-	ER	INF
Variance Decomposition of NOP^+:						
1	9.217117	6.617263	93.38274	0.000000	0.000000	0.000000
5	10.06359	12.88898	81.45992	4.260209	1.118371	0.272524
10	10.20345	13.79420	80.27500	4.262241	1.245589	0.422968
Variance Decomposition of NOP^-:						
1	11.10026	2.506351	26.90886	70.58479	0.000000	0.000000
5	12.74209	7.334663	25.71503	61.35152	4.720975	0.877819
10	12.98459	9.452512	25.51610	59.18360	4.792301	1.055489

Table 5 presents the result of the variance decomposition of the asymmetric effect of oil price shocks on the macroeconomy of Nigeria. The result showed that NOP^+ explains only 6.62% of the variations in per capita GDP in Nigeria while 93.4% of the variations in NOP^+ is explained by itself. Also, NOP^+ has no variational impact on exchange rate and inflation in the first period. However, the impact of NOP^+ on the variations in per capita GDP, exchange rate and inflation increase with time as reflected in the 5^{th} and 10^{th} period respectively. For instance, approximately 13% and 14% variations in per capita GDP for period 5 and 10, respectively, was caused by NOP^+. Moreover, less than 1.5% of variations in exchange rate was only accounted for by NOP^+ in both 5^{th} and 10^{th} periods while less than 1% was the case of inflation rate in Nigeria. Also, the negative nominal oil price (NOP^-) explains only 2.5% of the variations in per capita GDP for the first period. Its explanatory power only increases to 7.3% and 9.5% in periods 5 and 10, respectively. More so, NOP^- explains only about 5% of variations in exchange rate in both 5th and 10th periods while it explains a maximum of 1% in inflation rate in Nigeria.

Conclusion

The study examines the effect of oil price shocks on the economy of Nigeria. It tests oil price shocks' symmetric and asymmetric effect on the Nigerian economy. Adopting the Toda-Yamamoto VAR estimation technique, the impulse response analysis and variance decomposition analysis were conducted to determine the responses of per capita GDP, inflation rate and exchange rate to shocks from the oil price. The linearity effect of oil price shocks on the Nigerian economy was confirmed, with per capita GDP responding positively to the linear oil price shocks. In contrast, inflation rate and exchange rate respond negatively. Also, the asymmetric effect shows that a positive oil price shock does not produce an equivalent result on the Nigerian economy. In fact, positive oil price shocks impact the Nigerian economy more strongly and disruptively than negative oil price shocks. Additionally, the asymmetric effect of oil price shocks is more acute than the symmetric effect, with positive oil price shocks having a higher impact on the Nigerian macroeconomic variables (PGDP, INF and ER). It is confirmed that oil price shocks affect the Nigerian economy symmetrically and its asymmetric impact is more profound on the economy, especially from the positive oil price shock.

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