FNAS Journal of Mathematical Modeling and Numerical Simulation
Print ISSN: 3027-1282
www.fnasjournals.com
Volume 2; Issue 2; March 2025; Page No. 146-164.

Oil Price Volatility and Economic Development in Nigeria

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Abstract
This study looks at the impact of oil price volatility on Nigerian economic development from 1981 Q1 to 2020 Q1, using data from the National Bureau of Statistics and the Central Bank Statistical Bulletin. Estimating generalised autoregressive conditional heteroscedasticity, exponential generalised autoregressive conditional heteroscedasticity, and threshold generalised autoregressive conditional heteroscedasticity. The changes in the quarterly variation of the oil price (Brent Crude) are used to calculate oil price volatility. Economic development is quantified by a deconstructed human development index, which includes per capita income, life expectancy, and literacy. The exchange rate in Nigeria is measured by its quarterly variation. The empirical findings indicate that oil price volatility promotes economic development. Furthermore, currency rate volatility promotes economic progress in Nigeria. Furthermore, it demonstrates that the combination of interplay of oil price and exchange rate volatility had only a minor impact on economic development via life expectancy and literacy channels. Finally, it was discovered that the volatility of oil prices and exchange rates has an uneven influence on Nigerian economic progress. Based on the aforementioned, the study suggests that: The proceeds from oil should be directed towards infrastructure development, which serves as a springboard for economic development, and the government should encourage economic diversification and reduce external dependence in order to cushion against external shocks such as oil price and exchange rate fluctuations.

Keywords: Oil Price Volatility, Nigerian Economy, Economic Development, Oil Dependency, Macroeconomic Impact

Introduction

Recent developments in economics have shown that fluctuations in the price of crude oil are a significant indicator of a nation's progress. Up until Colonel Drake and Spindle-top discovered oil in Pennsylvania and Texas, respectively, in 1859 and 1901, the Chinese Company's transportation of crude oil through bamboo pipelines marked the beginning of the dominant influence of oil price volatility on world economic development. According to Hamilton (1983), "oil price shocks" are variations in the price of crude oil brought on by shifts in either the supply-side or demand-side of the global oil market. Regardless of the production quotas set by the Organisation of Petroleum Exporting Countries (OPEC) in Baghdad and Iraq in 1960, market dynamics of supply and demand determine oil prices (Hamilton, 1983).

The Organisation of Petroleum Exporting Countries (OPEC) sets crude oil prices to assure market efficiency and stability. To this aim, Ogiri et al. (2013) noted that volatility is a measure of the tendency of oil prices to rise or fall abruptly over a specific time period, which could be daily, monthly, or annual. For instance, the price of oil on the global commodities market will rise in tandem with the cost of production, causing inflation, a decrease in productivity, and a rise in unemployment as real income declines. Therefore, changes in production costs, transportation costs, global pandemics, business cycle changes, and war threats could all have an impact on the volatility of oil prices. Given the aforementioned, Ebrahim et al. (2014) contended that a simulation of supply and demand strategies is necessary to decrease and increase resistance to economic development driven by oil price variability in order to determine macroeconomic exclusion from OPPV.

Since its founding in 1914, Nigeria, a multiethnic and cultural enclave consisting of 36 states and the federal capital area, has had unequal economic development. Remember how Nigeria implemented the National Economic Empowerment Development Strategy in 2004 in an attempt to control its economy? By implementing many reforms, including macroeconomic stability, deregulation, privatisation, accountability, liberalisation, and transparency, the aim was to raise the nation's standard of living (Birdlife International, 2008). Additionally, a push for sustainable economic development was envisioned in the United Nations-sponsored Millennium Development Goals for the years 2000–2015. Additionally, macroeconomic concepts were changed to accomplish a number of objectives, such as international development cooperation, gender equality, health, education, poverty alleviation, and environmental sustainability. However, some of the stated goals were achieved by 2014, according to CIA reports (2020). But things have gotten worse in Nigeria. As of 2019, the inflation rate was 13.4%, GDP was $442.976 billion, the population was predicted to be 195,874,740, the unemployment rate was 23.1%, and the human development index was 0.539 (World Bank Indicator, 2019). The purpose of this study is to investigate how Nigeria's economic progress is impacted by fluctuations in oil prices.

However, by 2014, a number of specified goals had been achieved, according to CIA publications (2020). However, things have gotten worse in Nigeria. With a GDP of $442.976 billion, an estimated population of 195,874,740, an unemployment rate of 23.1%, and a human development index of 0.539, the inflation rate in 2019 was 13.4%. This study aims to assess how Nigeria's economic progress is affected by fluctuations in oil prices. Africa's anticipated growth is lowered by the fiscal imbalance or financial irresponsibility brought about by the nation's wealth managers. Remember that in 1957, Royal Dutch Shell made the first commercial discovery of crude oil in Nigeria at Oloibiri, which is now in Bayelsa State. Since then, there has been volatility in the global price of crude oil. Recent natural variations have led to a rise in political instability, ethnic agitations, financial burden, and a host of other social vices, including indolence. Young people in Nigeria not only depend on the money made from the sale of crude oil, but they have also adopted a way of life that is unsustainable in the long run. International oil prices are the basis for Nigeria's federal, state, and local governments' yearly capital and recurring expenditure projections; any significant declines reduce the likelihood of meeting these projections. Accordingly, the economy is expected to be impacted by changes in oil prices on the global oil market (Chowshury et al., 2020; Akutson et al., 2018).

In many cases, this leads us to the conclusion that Nigeria's oil price volatility impacts economic development, which is the context for this study. By examining the relationship between oil price volatility and economic development, researchers seem to have tried to understand the effects of oil price shocks. For instance, Nwaoha (2008) examined the relationship between Nigeria's life expectancy rate and oil price volatility using the Johansen cointegration econometrics technique, despite the fact that this technology is unable to capture volatility. According to his research, life expectancy was positively impacted by an oil price shock. His results are therefore different from Kamasa et al.'s (2020). Although he contributed to the literature on oil price volatility, the study failed to differentiate between oil price volatility and shocks, and the analysis approach was flawed and inappropriate for volatile series. However, Kamasa et al. (2020) contend that through the life expectancy channel, the volatility of oil prices has a detrimental impact on economic development. The works of Roland (2017), John et al. (2017), Ifeanyi and Ayenajeh (2016), Weliswa (2013), Baimaganbetov et al. (2019), and Adegbie et al. (2019) served as the foundation for this explanation. The application of leverage, asymmetric terms, and short- and long-term causality in volatility assessment is another area of contention.

Although extensive research exists on the relationship between oil price volatility and economic development, limited attention has been given to its impact on the disaggregated Human Development Index (HDI)—a proxy for economic development—and the interactive effects of oil price volatility (OPV) and exchange rate volatility (EXRV) on disaggregated HDI in Nigeria. This study incorporates exchange rate volatility, recognizing the exchange rate's critical role in determining the purchasing power of the national currency. By doing so, it addresses a notable gap in the literature, examining the effects of oil price volatility on economic development in Nigeria while explicitly accounting for exchange rate volatility. Beyond this, the study diverges from previous works by analyzing the interaction between oil price and exchange rate volatility on disaggregated HDI, employing quarterly rather than annual data, and extending the study period from 1981Q1 to 2020Q4.

Oil Price Volatility

Oil price volatility has been defined in various ways by different scholars. According to Okoli (2017), it refers to shocks or fluctuations in crude oil prices over a period of time. Similarly, Ogiri et al. (2013), as cited in Adegbie et al. (2019), describe oil price volatility as changes in crude oil prices, characterized by daily, monthly, or yearly ascents and declines. Another perspective views volatility as the standard deviation within a given period, emphasizing that it exerts a negative and persistent influence on economic growth with effects that manifest annually. Budina and Wijnbergen (2008) define oil price volatility as the rise in oil prices over time, noting that such increases tend to spur government spending and contribute to inflation. Keji (2018) further frames oil price volatility as a measure of disequilibrium, disrupting the exchange of goods and services between the demand and supply sides of the economy. In this study, however, oil price volatility is conceptualized as the sudden and unpredictable fluctuations in crude oil prices, driven by both natural and man-made factors.

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Economic Development:
Akakpan (2011) defines economic growth as an improvement in the overall welfare of a society, reflected in positive changes across various aspects of life. Similarly, Kindleberger (1965) describes economic development as encompassing not only economic growth but also changes in the technical and institutional structures that shape the production process. From this perspective, while economic growth primarily concerns increases in income, economic development emphasizes the equitable distribution of income across different segments of society. According to Takumah (2014), economic development also involves enhancing the quality of human life, introducing modern technologies and methods, reducing risk, and fostering entrepreneurial innovation. In recent times, the concept of economic development has become closely linked to the Human Development Index (HDI), a measure of economic progress proposed by the World Bank. Particularly from the viewpoint of developing countries, HDI is a composite statistic that combines per capita income, life expectancy, and literacy rate. For the purposes of this empirical analysis, economic development is defined as improvements in any of these three areas: life expectancy, literacy rate, or per capita income. These components are combined to form a single composite index. The researcher considers the HDI to be a more comprehensive and reliable indicator of development, especially in developing countries like Nigeria.

Demand and Supply Sides' Impacts of Oil Price Shocks
Dornbusch et al. (2001) posited that oil shocks influence both demand and supply dynamics. According to their theory, fluctuations in oil prices negatively affect the overall economy through adverse supply shocks, resulting in rising price levels alongside declining output and employment. The macroeconomic consequences of oil shocks, therefore, depend on the interplay between supply and demand forces, with economic policy responses serving to moderate these effects. Hunt et al. (2001) further argued that rising input costs could reduce non-oil potential output in the short term due to rigidities such as the existing capital stock and sticky wages. In response to declining real wages and shrinking profit margins, workers and producers may push for higher unit labour costs, driving up the prices of finished goods and services. In summary, the theory emphasizes that oil price shocks are shaped by supply and demand dynamics. Moreover, the transfer of wealth from oil-importing to oil-exporting countries is expected to stimulate national economies, particularly when the marginal propensity to consume is higher in oil-importing nations (Hunt et al., 2001). However, the theory has been criticized for overlooking factors such as literacy rates and the environmental degradation associated with oil extraction. Additionally, the classical assumptions underpinning the theory may not hold universally due to cultural and institutional differences. Given Nigeria's context—where proceeds from crude oil sales have been mismanaged and misappropriated—the application of this theory to assess the impact of oil price volatility on economic development is both relevant and timely.

Mukhtarov et al. (2021) employed the Structural Vector Autoregressive (SVAR) approach to examine the effects of oil price shocks on GDP per capita, exchange rates, and total trade turnover in Azerbaijan, using data from 1992 to 2019. Their findings revealed that rising oil prices positively influence GDP per capita and trade turnover, but negatively impact the exchange rate. Consequently, the study recommended that Azerbaijan and other oil-exporting countries reduce their dependency on oil revenues to stabilize macroeconomic indicators. Similarly, Zhou and Geng (2021) investigated the economic impact of oil shocks by categorizing daily crude oil shocks into demand, supply, and risk shocks. Using the Diebold and Yilmaz connectedness index, they analyzed data from China, Europe, and the United States between 2009 and 2018. Their results indicated that oil demand and risk shocks exert significant and time-varying effects on the economy, while supply shocks have a comparatively lower influence.

Qiangi et al. (2020) explored the dynamic effects of various oil shocks on net oil-importing and oil-exporting countries, using a structural VAR model for the period 2008–2018. Their study found that oil supply shocks had a more severe negative impact on oil-exporting economies than on importers. They recommended that governments actively regulate oil price fluctuations to mitigate environmental damage. Zmami and Ben-Salha (2020) analyzed the impact of oil price fluctuations on macroeconomic performance in oil-importing and oil-exporting nations between 1960 and 2018. Using Kapetanios' (2005) structural break unit root test and Saikkonen's (2000a, b, c) cointegration test, they found no long-term cointegration between oil prices and GDP. Their quantile regression analysis revealed that the impact of oil prices on real GDP varies across countries and business cycles, with stronger effects during recessions than expansions. Ikechi and Nwadiubu (2020) examined the effects of global oil price shocks on Nigeria's economic growth, applying the Augmented Dickey-Fuller unit root test, OLS regression, Johansen cointegration test, VAR analysis, Granger causality test, variance decomposition, impulse response functions, and ARCH/GARCH modeling. Their findings confirmed that oil price fluctuations significantly affect Nigeria's GDP growth, highlighting the need for the government to learn from historical mismanagement to better respond to oil price volatility and its fiscal implications.

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Morina (2020) assessed the impact of real effective exchange rate volatility on economic growth in fourteen Central and Eastern European countries from 2002 to 2018. Using multiple regression analysis with variables such as government expenditure, gross fixed capital formation, inflation, trade openness, domestic credit, and interest rates, the study concluded that exchange rate volatility significantly hinders economic growth, recommending that policymakers prioritize exchange rate stability. In the Nigerian context, Moses et al. (2020) analyzed the influence of exchange rate volatility on GDP growth using monthly time-series data from 2003 to 2017. Applying GARCH models, Granger causality tests, and impulse response functions, they found that exchange rate volatility had a significant negative effect on economic growth. Similarly, Barguellil et al. (2018) studied the impact of exchange rate volatility on economic growth in 45 developing and emerging economies from 1985 to 2015. Using a Generalized Method of Moments (GMM) approach, they found that real exchange rate volatility adversely affects economic growth, particularly under flexible exchange rate regimes and with high financial openness. The study recommended adopting exchange rate policies focused on stabilization.

Musyok et al. (2012) investigated the relationship between real exchange rate volatility and economic growth in Kenya, employing GARCH and GMM models on data from 1993 to 2009. His findings indicated that exchange rate volatility weakened Kenya's international competitiveness and had a negative impact on economic growth.
The reviewed literature presents mixed findings and competing theories, thereby necessitating further research. Notably, no prior study has jointly analyzed the effects of oil price volatility and exchange rate volatility on economic development—measured through per capita income, life expectancy, and literacy. This study addresses that gap by investigating the combined influence of oil price and exchange rate volatility on Nigeria's economic development. The interaction term between these variables is expected to capture the macroeconomic impact more comprehensively.

Research Methods

This study adopts a quasi-experimental research design, as it is deemed most appropriate for research in the social sciences. An eclectic approach is employed, drawing specifically on Keynes' (1936) theory of aggregate demand. The hypothesis builds on Keynes' attempt to address the 1929–1936 global economic crisis, which was largely attributed to a deficiency in aggregate demand. According to Keynesian theory, aggregate demand is represented as:

$$\mathbf{Yt = Ct + It + Gt + (Xt - Mt)}$$

where **Yt** denotes national income, **Ct** is consumption, **It** is investment, **Gt** is government expenditure (influenced heavily by oil output in Nigeria's case), and **(Xt - Mt)** represents net exports. Within this framework, an increase in national income can only occur through higher consumption, greater investment, expanded government spending, or improvements in the trade balance. The study relies on secondary data sourced from the *Central Bank of Nigeria Statistical Bulletin*, the *National Bureau of Statistics*, the *World Bank Databank* (World Development Indicators), the *Ministry of Finance Annual Reports*, and the *World Trade Organization* reports. To better capture the direct effects of key variables on economic growth, the Human Development Index (HDI) is decomposed accordingly.

Empirical analysis follows a three-stage econometric approach: First, the stationarity of the series is tested using the Augmented Dickey-Fuller (ADF) unit root test. This step is essential, as scholars such as Granger and Newbold (1974), Engle and Granger (1987), Dickey and Fuller (1981), Enders (1995), and Pindyck and Rubinfeld (1998) have shown that regressions involving non-stationary macroeconomic variables often produce "spurious" results if time-series properties are not addressed. Since the independent and control variables are centered around volatility, an Autoregressive Conditional Heteroskedasticity (ARCH) test is conducted to confirm the presence of volatility. Based on the results, Generalized ARCH (GARCH), Exponential GARCH (EGARCH), and Threshold GARCH (TGARCH) models are employed. Specifically, GARCH is used to assess linear relationships, while EGARCH and TGARCH models capture potential nonlinear (asymmetric) effects. The stability condition serves as a key decision criterion for model evaluation: volatility shocks are considered mean-reverting and temporary if the sum of ARCH and GARCH terms is less than one ($0 < \lambda 1 < 1$ and $\lambda 1 + \gamma < 1$). If the sum exceeds one, volatility shocks are deemed non-mean reverting or permanent. Given the critical role of news, information, and education in economic decision-making, it is necessary to assess asymmetric effects. As standard ARCH and GARCH models treat positive and negative shocks symmetrically, the study extends the analysis to EGARCH and TGARCH models to properly capture asymmetric volatility responses.

Model Specification

This research work adopted the modified version of the Asteriou and Price (2005) Model. The estimation procedure for the attainment of objective (1) to (9) follows three steps estimation procedure as thus;

i. Test for the presence of Arch effect/ pre-test: Is the series in question volatile?
ii. Estimation of ARCH or GARCH model if the series is volatile.
iii. Post Estimation test: To check if OLS is not violated.

Testing for ARCH (1) effects

The test follows the pattern or procedure of the ARCH LM test proposed by Engle (1982). It starts with the estimation of the AR (1) model shown below;

$Rt = \partial_0 + \partial_1 R_{t-1} + \varepsilon\_t1$ 1

Hypothesis:

H0 = 0 H1 ≠ 0.

The F-test and nR2-test results will provide the test statistic for the null hypothesis. If the likelihood of the Arch test is less than the specified level of significance (5%), the null hypothesis that there is no Arch effect in the series will be rejected. The main argument for rejecting the null hypothesis is the presence of the Arch effect in the residual. The presence of the Arch effect indicates that the series is volatile, whereas the absence of the Arch effect implies that the null hypothesis is not rejected. Thus, if there is no Arch effort, the ordinary least squares will be estimated (b1) = 0, and R2 will be lower, whereas if there is an Arch effect, b1 will be substantial and R2 will be greater.

Arch-LM Models

The Arch model, developed by Engle (1982), states that the variance of the residual at time t is a function of the squared error terms from previous periods, but the variance is not constant. Thus, Engle (1982) proposed estimating or modelling both the mean and variance equations simultaneously. The mean and variance equation is represented as follows:

$$R_t = \alpha + \sum_{i=1}^{p} \beta_i \; R_{t-1} + \varepsilon_t \quad 2$$

$$\sigma_t^2 = il_0 + \sum_{i=1}^{n} 1l_i \; \varepsilon_{t-1}^2 \quad 3$$

Where;

ε_{t-1}^2 = the Arch term,

$\sum_{i=1}^{n} ⅄_i$ < 1 = stationarity

$\sum_{i=1}^{n} ⅄_i$ = 0 slow mean reverting

$\sum_{i=1}^{n} ⅄_i$ = fat mean reverting

However, the Arch model described by Engle (1982) has the disadvantage of appearing to be a moving average specification rather than an autoregressive one. Thus, Bollerslev's (1986) Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model is used in the estimation. This is a variant of the Arch model that incorporates the lag of conditional variance in the variance equation while keeping the mean equation constant. The variance equation is expressed as:

$$\sigma_t^2 = ⅄_0 + \sum_{i=1}^{p} ⅄_i \; \varepsilon_{t-1}^2 + \sum_{j=1}^{q} y_j \; \sigma_{6-1}^2 \quad 4$$

Note:

$$O \leq \sum_{i-1}^{n} ⅄_i + \sum_{j=1}^{q} g_1 \quad < 1 = \text{stationariy} \quad 5$$

$$\sum_{i=1}^{p} ⅄_i + \sum_{j=1}^{q} y_1 = 1 = \text{slow mean reverting} \quad 6$$

$$\sum_{i=1}^{p} ⅄_i + \sum_{j=1}^{q} y_1 = 0 = \text{fast mean reverting} \quad 7$$

The Arch and GARCH models' key weaknesses are that they are symmetric in nature and cannot capture the asymmetric effect of the series and leverage effect, necessitating the incorporation of Zakoain's (1994) Threshold GARCH (TGARCH). The TGARCH model captures asymmetries by inserting a multiplicative Dummy as the control variable in the variance equation - the conditional variance equation becomes:

$$\sigma_6^2 = \curlywedge_0 + \sum_{i=1}^{n} \curlywedge_i \ \varepsilon_{t-1}^{?} \sum_{j=1}^{q} y_j \ \sigma_{t-j}^2 + \emptyset \varepsilon_{t-1}^2 \partial_{t-1} \qquad 8$$

Note: Estimate the models.
The summary variable takes the form;

$$\partial_{t-1} = \begin{cases} 1 & if \varepsilon_{i-1} < o \\ 0 & {}^{i}/\varepsilon_{t-1} \geq o \end{cases}$$

This means that one will be attributed to a period of positive volatility, while zero will represent a time of negative volatility.
Finally, the Exponential GARCH (EGARCH) model proposed by Nelson (1991) and employed in this work captured the asymmetric effects or leverage effect that was not captured by the GARCH model above.

$$\text{In } (\sigma_t^2) = \curlywedge_0 + \curlywedge_1 / \sqrt{\varepsilon_{t-1}^2} /_{\sigma_{6-1}^2 + \emptyset} \sqrt{\varepsilon_{6-1}^2} /_{\sigma_{t-1}^2 + \theta/n} (\sigma_{t-1}^2) \qquad 10$$

The GARCH, TGARCH, and EGARCH models will be used to capture the effect of oil price volatility on economic development as proxy variables for per capita income (PCI), life expectancy (LER), and secondary school attainment rate (SSAR).

GARCH Models

$$\text{PCI}_t = a_o + \beta^1 OPV + \beta EXRV + \beta 3OPV * EXRV + ut \qquad 11$$

$$PCI_t = \beta_0 + \frac{\sum_{i=0}^{n} \curlywedge_0}{PCI_{t-1}} + \sum_{i=0}^{q} \beta_{0_{1i}} OPV_{t-1} + \sum_{i=0}^{q} \beta_{0_{2i}} eEXRV_{t-1} + \sum_{i=0}^{q} \beta_{0_{3i}} OPV * EXRV_{t-1} + ut \qquad 12$$

$$\text{LER}_t = a_o + \beta^1 OPV + \beta EXRV + \beta 3OPV * EXRV + ut \qquad 13$$

$$LER_t = \beta_0 + \frac{\sum_{i=0}^{n} \curlywedge_0}{PCI_{t-1}} + \sum_{i=0}^{q} \beta_{0_{1i}} OPV_{t-1} + \sum_{i=0}^{q} \beta_{0_{2i}} EXRV_{t-1} + \sum_{i=0}^{q} \beta_{0_{3i}} OPV * EXRVxr_{t-1} + ut \qquad 14$$

$$\text{LTR}_t = a_o + \beta^1 OPV + \beta EXRV + \beta 3OPV * EXRV + ut \qquad 15$$

$$LTR_t = \beta_0 + \frac{\sum_{i=0}^{n} \curlywedge_0}{PCI_{t-1}} + \sum_{i=0}^{q} \beta_{0_{1i}} OPV_{t-1} + \sum_{i=0}^{q} \beta_{0_{2i}} EXRV_{t-1} + \sum_{i=0}^{q} \beta_{0_{3i}} OPV * EXRV_{t-1} + ut \qquad 16$$

TGARCH Models

In testing for asymmetric impact of the series of interest, a multiplicative dummy variable is included in the model.

$$PCI_t = \propto_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \varepsilon_{t-1}^2 \partial_{t-1} + \beta_3 PCI_{t-1} + B_4 OPV_{t-1} + \beta_3 EXRV_{t-1} + \beta_3 OPV * EXRV_{t-1} \qquad 17$$

$$LER_t = \propto_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \varepsilon_{t-1}^2 \partial_{t-1} + \beta_3 LER_{t-1} + B_4 OPV_{t-1} + \beta_3 EXRV_{t-1} + \beta_3 OPV * EXRV_{t-1} \qquad 18$$

$$LTR_t = \propto_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \varepsilon_{t-1}^2 \partial_{t-1} + \beta_3 LTR_{t-1} + B_4 OPV_{t-1} + \beta_3 EXRV_{t-1} + \beta_3 OPV * EXRV_{t-1} \qquad 19$$

EGARCH Model

$$PCI_t = \alpha_0 + \sum_{j=i}^{q} \beta_1 \left| \frac{OPV\varepsilon_{t-1}}{PCI_{t-1}} \right| + \sum_{j=i}^{q} \beta_2 \frac{EXRV_{t-1}}{PCIs_{t-1}} \left| + \sum_{j=i}^{q} \beta_3 \right| \frac{OPV * XRV_{t-1}}{PCIs_{t-1}}$$

$$+\sum_{j=1}^{q}\beta_4\frac{OPV\varepsilon_{t-1}}{PCI_{t-1}}+\sum_{j=1}^{q}B_5\frac{EXRV_{t-1}}{PCI_{t-1}}+\sum_{j=1}^{q}\beta 6\frac{OPV*EXRV_{t-1}}{PCI_{t-1}}+n_{\Sigma}\beta_7 Log(PCI_{t-1}) \qquad 20$$

$$LTR_t=\alpha_0+\sum_{j=i}^{q}\beta_1\frac{OPV\varepsilon_{t-1}}{LTR_{t-1}}+\sum_{j=i}^{q}\beta_2\frac{EXRV_{t-1}}{LTRs_{t-1}}++\sum_{j=i}^{q}\beta_3\frac{OPV*XRV_{t-1}}{LTR_{t-1}}$$
$$+\sum_{j=1}^{q}\beta_4\frac{OPV\varepsilon_{t-1}}{LTR_{t-1}}+\sum_{j=1}^{q}B_5\frac{EXRV_{t-1}}{LTR_{t-1}}+\sum_{j=1}^{q}B_6\frac{OPV*EXRV_{t-1}}{LTR_{t-1}}+n_{\Sigma}\beta 7\,Log(LTR_{t-1}) \qquad 21$$

$$LER_t=\alpha_0+\sum_{j=i}^{q}\beta_1\frac{OPV\varepsilon_{t-1}}{LER_{t-1}}+\sum_{j=i}^{q}\beta_2\frac{EXRV_{t-1}}{LERs_{t-1}}++\sum_{j=i}^{q}\beta 3\frac{OPV*XRV_{t-1}}{LER_{t-1}}$$
$$+\sum_{j=1}^{q}\beta_4\frac{OPV\varepsilon_{t-1}}{LER_{t-1}}+\sum_{j=1}^{q}B5_j\frac{EXRV_{t-1}}{LER_{t-1}}+\sum_{j=1}^{q}B_6\frac{OPV*EXRV_{t-1}}{LER_{t-1}}$$
$$++n_{\Sigma}\beta_7\,Log \qquad 22$$

$\propto_0 = Constant$
$\beta_1 = Arch\ effect$ $\beta_2 = oil\ price$
$\beta_{3,}\beta_4 = asymmetric\ effect$
$\beta_5 = Garch\ effect$
$\beta_1 = \beta_2 = \beta_4 = symmetric$
$\beta_2 < 0, \beta_3 < 0\ \beta_4 < 0$ $\quad Bad\ news(negative\ shock)\ generate\ bad\ volatibly\ than\ positive\ shock$

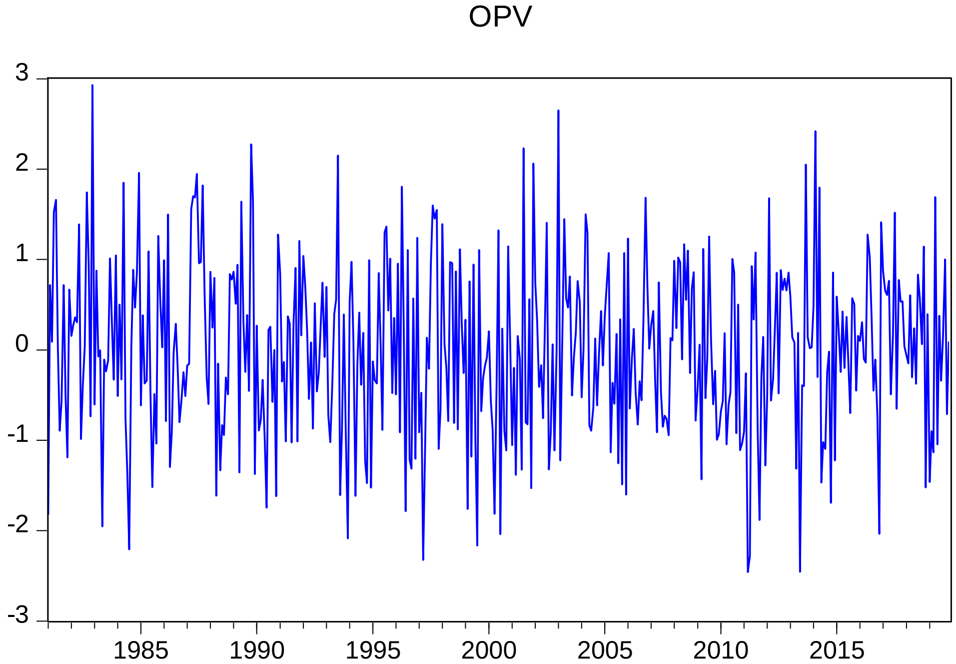
Where;
LER = Life Expectancy Rate
LTR = Literacy Rate
OPV = Oil Price Volatility
EXRV = Exchange Rate Volatility
PCI = Per Capita Income
OPV*EXR = Oil Price Volatility interaction with Exchange Rate
f = Functional Notation
β, a = Unknown coefficients of the independent variables.

Test for the Presence of ARCH Effect
ARCH Test Result

Test	PCI	LER	SSAR	OPV	EXR	OPV* EXE
F-stat	1231257	43840.70	7631.227	66.88191	13307.61	129.918
Obs.	1540729	155.4539	152.9142	47.23601	154.2154	71.38217
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Author's compilation from E-views 10.5

Inferences taken from table 4.3 show that the Arch effect exists in every series in the distribution. This is supported by the importance of the F-test and the observed R-square test (nR2). The graphic presentation below also demonstrates the prevalence of the Arch effect throughout the series. The graph shows that all of the series are volatile. This is the justification for using EGARCH, GARCH, and TGARCH. The Arch test results follow the normal process outlined by Engle (1982), which is stated in the equations above.



To capture hypotheses (i), (iv), and (vii) of the study, the effect of oil price volatility, exchange rate volatility, and their interaction term on per capita income was estimated using the three variants of Autoregressive conditional heteroskedasticity (ARCH) such as Generalised Autoregressive conditional heteroskedasticity (GARCH), Exponential Generalised Autoregressive conditional heteroskedasticity (EGARCH), and Threshold Generalised Autoregressive conditional heteros

Testing the effect of oil price volatility on Per Capita Model

The per capita model captured the three stated above hypotheses

Variables	**GARCH**	**EGARCH**	**TGARCH**
Mean Equation			
Constant (c)	1337.49	1349.714	1350.867
	0.0000***	0.0000***	0.0000***
OPV	-0.103181	0.861947	0.50288
	0.0358	0	0.045**
EXR	3.488229	3.469629	3.442321
	0.000***	0.0000***	0.0000***
OPV x EXR	0.003469	0.0007	-0.001528
	0.013**	0.3934	0.1778
Variance Equation			
Constant (φ) C5	156.4599	-0.506655	184.3997
	0.2344	0.5915	0.0591
Arch (η) C6	1.092789	0.01181	0.90187
	0.0016**	0.0000***	0.006
Garch (θ) C8	-0.104902	0.788257	-0.090194
	0.7034	0.0000***	0.2027

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Threshold (λ)			0.668342
		0.066219	0.3572
Asymmetric (A) C7		0.8733	
Diagnose			
SIC	12.33378	12.3173	12.34408
ARCH LM			
F-stat	0.6163	0.19278	0.16217
P-value	0.074	0.6612	0.07
Obs-R	25.87064	0.19503	0.99786
P-value	0.087	0.6588	0.08

*Source: Author's compilation from e-views 10.5. Note: ***, ** and * indicates 1%, 5% and 10% level of significance.*

The mean equation shows that the constant term average per capita income (PCI) is 1337 490 and statistically significant at 5%. The mean equation depicts how oil prices affected Nigerian per capita income from 1981q1 to 2023q1. The oil price fluctuation series considerably impact Nigerian per capita income (PCI) statistically. Given the likelihood value of 0.0358, a unit increase in oil price will decrease Nigerian per capita income by -0.103181. This implies Nigerian per capita income is connected with oil price volatility. Series posture or exposition matches theory. In theory, oil price volatility should influence the economy asymmetrically. Oil prices affect the economy positively in the short term but negatively in the long term due to inflation (Hamilton,1983). However, the coefficient of exchange rate volatility (EXRV) 3.488229 reveals that exchange rate volatility raises per capita income and is statistically significant because the probability value is 0.0000, which is less than 0.05. All else equal, a unit increase in exchange rate volatility will raise Nigeria's per capita income by 3.488229 units. This shows that exchange rate volatility is a powerful indicator or predictor of per capita income in Nigeria. Also, exchange rate volatility having a positive coefficient is not in agreement with theoretical expectation. According to theory, an increase in the exchange rate will, all things being equal, restrict economic expansion through an increase in the cost of production channels.

Further evolution in the interaction series suggests that exchange rate volatility which is lowered by oil price volatility (OPV*EXR) effects per capita income positively 0.003469 and it is statistically significant. A unit increase in OPV*EXRV will lead to a 0.003469 unit increase in per capita income. This exposition is in line with theoretical expectation. According to the notion, an increase in the exchange rate during the oil boom will raise the revenue base of the government, promote investment, reduce unemployment and increase per capita income. This means that per capita income (PCI) responds to the favourable effect of the macroeconomic effect of oil price volatility.

The outcome of the GARCH estimation reveals that the volatility of the model is mean reverting (the total of the Arch and GARCH term is less than one (1.092789 + (-0.104902 = 0.987887). This shows that the shocks to per capita income as a result of oil price and exchange rate volatility is mean-reverting and temporary in character. The mean equation of the per capita income model is written as thus; PCI=1337.490 -0.103181OPV + 488229 EXRV +0.003469OPV*EXRV. The variance equation is presented as; PCI = 156.4599 – 0.104902 + 1.092789. The mean equation illustrates the time-varying volatility of the model whereas the variance equation indicates the persistence of volatility shocks. These also demonstrate that the persistence of the volatility shock is large as the total of the GARCH term and ARCH term (ʎ + y) is higher than one, and the stability requirement is not met (0 <ʎ, cl, 0<="" 1).=""

The EGARCH model as provided in table 4.5 present the non-linear (asymmetric) influence of the calculated model. In the mean equation, the average of per capita income represented by the constant (1349.714) is statistically significant at 5%. The oil price volatility which measures the variance of oil prices has a positive coefficient of 0.861947 and influence per capita income (PCI) favourably and it is statistically significant. A unit rise in oil price volatility will connect to a 0.861947 unit increase in per capita income in Nigeria. This also corresponded to theoretical premise. Also, it can be inferred that there exists a positive 3.469629 and statistically significant association between exchange rate volatility and per capita income in the second model. A unit spike in exchange rate volatility will emit a 3.469629 unit increase in per capita income in Nigeria. It is believed in theory that an increase in the exchange rate will impair productivity through the pricing channels. This exposition is corroborated by the opinions of Aghion, et al., (2008) and Moses, et al., (2010) who modelled a positive union between exchange rate and economic growth and a contrary declaration by Ubah (2015), that exchange rate lowers economic growth. Contrarily, the coefficient of the interaction term (OPV*EXR) is positive 0.0007 and it has an insignificant impact on per capita income (PCI) in Nigeria. This may be inferred from its probability value of 0.3934 which is larger over the threshold of 0.05. This shows that the macroeconomic influence of oil price volatility is not a strong predictor of per capita income in Nigeria. The causal inference from the mean equation in the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) is that oil price volatility (OPV) and exchange rate volatility (EXRV) generate positive shocks that havx e a long-lasting impact on per capita income (PCI) in Nigeria. The time-varying volatility is calculated by the mean equation PCI= 1349.714 + 0.861947OPV + 3.469629 EXRV +0.000700 OPV*EXRV. The mean equation illustrates the time-varying volatility of the model whereas the variance equation indicates the persistence of volatility shocks.

In the variance equation, it is determined that the volatility of the model is mean reverting (the total of ARCH and GARCH term λ + y is less than one), 0.011810 + 0.788257 = 0.80067. This implies that the persistent of the volatility shock is small since the sum of the GARCH term and ARCH term (λ + y) is less than one. In the (TGARCH) equation, the average or the mean value of per capita income is represented with the constant term in the mean equation (1350.867) and that the coefficient 0.502880 of oil price volatility positively impacted per capita income in Nigeria. The apparent positive relationship is likewise statistically significant at 5% given the probability value of 0.0000 which is smaller than the threshold of 0.05. A unit rise in oil price volatility (OPV) will lead to a 0.502880 unit increase in per capita income in Nigeria. This implies that oil price fluctuation is a major predictor of per capita income in Nigeria. The posture of the series is in line with the theoretical expectation. In theory, an increase in oil price has an asymmetrical influence on growth. This supported the idea of experts like Ocheni (2011) and Aliyu (2009) who simulated the influence of oil price volatility on economic activity using quarterly data and their finding revealed that oil price volatility increases economic growth in Nigeria.

The coefficient of exchange rate volatility (EXRV) 0.3442321 likewise impacted per capita income positively and it is statistically significant at 5%. A unit spike in exchange rate volatility will emit a 0.3442321 unit increase in per capita income (PCI) in Nigeria. This was not in accordance with theoretical anticipation but demonstrates the underlying nature of the exchange rate in Nigeria. The volatility in the currency rate does not create a loss in the per capita income of Nigerians since the increase in the pricing of commodities and services are simply passed to the ultimate consumer. Thus, keeping the business sector afloat, also transfer payments in most cases improve the personal discretionary income of the bulk of Nigerians that depends on transfer income from their relative or assets overseas. This exposition is in line with the declaration of Sanginabadi and Heidari (2012) who opined that exchange rate fluctuation is the cause of the increase in economic growth in Iran.

Also, the coefficient of the interaction term -0.001528 has a negative influence on per capita income (PCI) and it is statistically significant at 5%. A unit rise in OPV*EXRV will lead to a 0.001528 drop in per capita income (PCI) in Nigeria. This shows that the interaction component has a marginal effect on per capita income in Nigeria. Thus, the assumption that the macroeconomic environment is influenced by the oil price residual may have been over-estimated. The leverage impact in the threshold GARCH model is represented by the asymmetric term 0.668342. The asymmetric term is not statistically significant at 5% given its probability value of 0.3572 and it shows that negative news does not worsen per capita income in Nigeria.

Also, the time-varying volatility of the shocks in the system is expressed as the mean equation PCI = 1350.8667 + 0.502880OPV + 3.442321EXRV – 0.001528 OPV*EXRV. The analysis also demonstrates that the volatility of per capita income in Nigeria is mean reverting (the total of ARCH and GARCH term is less than one (0.901870 + -0.090194 = 0.811676)). Thus, the durability of volatility shock on per capita income is temporary. The asymmetric phrase exhibits leverage of 0.668342 from the volatility of oil price and exchange rate coupled interactions.

Diagnostic Checking

To ensure that the entire estimations is in line with the ordinary least square's assumption and the selection of the most appropriate model, the following post estimation test were performed (Heteroscedasticity test, autocorrelation test, checking of lowest value for SIC, higher adjusted R-square and most significant parameter).

Post Estimation Testing for per capita income model.

TEST	GARCH	EGARCH	YGARCH
Significant parameter	Not all	Not all	Not all
ARCH Significant			
GARCH Significant	Yes	No	Yes
Log. likelihood	No	Yes	No
Adj. R^2	-950.5	-952.96	-948.79
Schwartz JC	0.64439	0.66111	0.65637
Heteroscedasticity	12.3338	12.2173	12.3441
Autocorrelation	Lm prob. 0.0740	Lm prob. 0.6612	Lm prob. 0.0700

Given that all the three versions of the Arch model (GARCH, EGARCH and TGARCH) were calculated in line with the basic OLS assumption. Meaning that, the residuals were normally distributed, there is no hint of serial correlation, no heteroscedasticity in the residual. It is evident that the EGARCH models is the best model. The reasons being that, it possesses the most significant GARCH parameters. It has the biggest adjusted R-square and the least SIC than TGARCH and GARCH. Thus, the test of all hypotheses relating to the effect of oil price volatility on per capita income will be based on the EGARCH finding.

The Effect of Oil Price Volatility on Life Expectancy Model

The above model combines assumptions two, five and eight and below is the outcome of the estimation of the model.

Variables	GARCH	EGARCH	TGARCH
Mean equation			
Constant (C)	45.6671	45.67354	45.66447
	0	0	0
OPV	0.002758	0.000568	0.002574
	0	0.0008	0
EXR	0.023925	0.026589	0.024012
	0	0	0
OPV*EXR	-8.9E-08	0.0000318	-0.0000928

Cite this article as:
Wasurum, E. (2025). Oil price volatility and economic development in Nigeria. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(2), 146-164.

	0	0	0
Variance Eg.			
Constance (φ) C(5)	0.002244	-2.7762	0.001525
	0.0452	0	0.0596
Arch (η) C(6)	1.225204	2.84477	1.428811
	0.0002	0	0.0038
Garch (θ) C(8)	-0.245036	0.864511	-0.30357
	0.3506	0	0.0111
Threshold(λ)			0.076845
			0.0268
Asymmetric(A) C(7)		-0.204188	
		0.0051	

Result of the Estimated Life Expectancy Model*Source: Author's compilation from e-views 10.5. Note: ***, ** and * indicates 1%, 5% and 10% level of significance.*

A Generalised Autoregressive conditional heteroskedasticity (TGARCH) framework, Threshold as Generalised Autoregressive conditional heteroskedasticity, and Exponential Generalised Autoregressive conditional heteroskedasticity (EGARCH) were used in the estimation process to test their linear and non-linear interaction. The mean value, or the average of the distribution, is 45.66710, according to the linear model (GARCH). In the mean equation, the constant term is used to express the mean value of life expectancy. Poor health care delivery in the nation may be the cause of this low mean value of life expectancy. Given the p-value (0.0000), which is less than the significance level, the coefficient of oil price volatility (OPV) is 0.002758, indicating that there is a positive relationship between oil price volatility and life expectancy rate (LER).

Thus, the volatility of oil prices acts as a positive shock to Nigeria's life expectancy rate. This explanation is consistent with theory. Oil price shocks are thought to have an uneven impact on the economy in principle (Hamilton, 1983). It is statistically significant at 5% that exchange rate volatility has a positive coefficient of 0.23925, indicating that it increases life expectancy. There will be a 0.023925 unit variance in life expectancy rate for every unit increase in exchange rate volatility. It is not theoretically a priori that the exchange rate parameter's sign follows. The idea is that an increase in the exchange rate will theoretically reduce the value of the national currency (the naira), raise. Life expectancy was significantly impacted by the coefficient of the interaction term (POV*EXR), which has a statistically significant impact (-0.0000928) given the probability value of 0.0000, which is less than 0.05. The macroeconomic impact of oil price volatility on Nigeria's life expectancy rate is negligible, as demonstrated by the fact that a unit increase in the interaction term (OPV*EXR) will translate into a 0.0000928 decrease in life expectancy. Marginal in the sense of having very little of an impact. In the mean equation, LERt = 45.66710 + 0.002758OPV + 0.023925 EXR + 0.0000089 OPV* EXR represents the time-varying volatility. Additionally, the life expectancy equation's persistence to shock resulting from fluctuations in oil prices (OPV), exchange rates (EXR), and their interaction term (OPV*EXR) is expressed as follows: 0.002244 – 0.245036 + 1.225204 = 0.982412.

Moreover, the exchange rate volatility (EXRV) parameter has a favourable impact on life expectancy, as evidenced by its coefficient of 0.026589, which is statistically significant at 5%. The life expectancy in Nigeria will rise by 0.026589 units for every unit increase in exchange rate volatility. This indicates that around 2.6% of the variations in life expectancy in Nigeria are caused by changes in exchange rates. Lastly, life expectancy is significantly impacted by the interaction term's coefficient (OPV*EXR), which is -0.0000318. This effect is statistically significant at 5%. In Nigeria, life expectancy will drop by 0.0000318 for every unit rise in OPV*EXR. This indicates that the interaction term has little bearing on Nigeria's life expectancy rate. Consequently, the explanation of how the Nigerian economy

Since the total of their ARCH and GARCH terms (2.844770 + 0.864511 = 3.3709281) is more than one, the volatility of the shock to life expectancy is not mean reverting. Therefore, the ongoing fluctuations in life expectancy brought on by the price of oil and the exchange rate will always exist in Nigeria and will not alter the fundamental presumption that ώ1 + y < 1. LERt = 45.37654 + 0.000568OPV + 0.02658 +EXR – 0.0000318OPV *EXR is the mean equation, which represents the time-varying volatility. The influence of leverage on oil price volatility suggests that, assuming that the sum of the ARCH and GARCH terms is less than one, oil price volatility (OPV) has a temporal effect on the life expectancy rate. In other words, life is shocked by volatility.

The constant term (c) reports an average life expectancy (LER) of 45.66447 in the threshold GARCH (TGARCH). Life expectancy is positively impacted by the oil price volatility coefficient (OPV), which is 0.002574. In Nigeria, a rise in OPV will result in a corresponding increase in life expectancy of 0.002574 units. Thus, the volatility of oil prices is a significant predictor of life expectancy in Nigeria. Hamilton's (1983) theoretical expectation regarding the coefficient's sign is indeed met. The economy should be impacted asymmetrically by changes in oil prices. This supports the viewpoint of Adedeji and colleagues (2018). Additionally, the exchange rate volatility coefficient (EXRV), which is statistically significant at 5%, has a positive impact on life expectancy (0.024012). volatility of exchange rates. On the other hand, life expectancy in Nigeria was negatively impacted by the coefficient of their joint interaction (OPV*EXR) to the extent that a unit increase would result in a -0.00000923 unit fall in life expectancy rate. This suggests that in Nigeria, life expectancy reacts to negative shocks resulting from the relationship between fluctuations in oil prices and exchange rates. According to the threshold model, the time-varying volatility of life expectancy in Nigeria is as follows: LER= 45.66447 + 0.002974OPV + 0.024012EXR + 0.0000928OPV*EXR
.
Since the sum of the ARCH and GARCH terms (1.428811+(-0.32570) = 1.125241) is more than one, the variance equation's volatility shocks to Nigeria's life expectancy rate are not mean reverting. This indicates that volatility shocks to the life expectancy rate in Nigeria will always exist. The probability value of 0.0268 indicates that the threshold 0.076845 term has a positive and statistically significant coefficient. This suggests the existence of a leveraging effect and the idea that positive news has less of an impact on life expectancy volatility than bad news.

Diagnostic Checking

Diagnostic			
Significant coefficients	Not all	All	Not all
Arch Sign			
GARCH Sign	Yes	Yes	Yes
Lop Likelihood	No	Yes	Yes
Adj. R^2	-114.0552	-114.8267	-113.5544
SIC	0.793625	0.834864	0.793513
Heteroscedasticity	1.678371	1.720404	1.704197
	0.0078	0.6081	0.0543

As there is no indication of serial correlation or heteroscedasticity in the residual, all of the series are consistent with the fundamental OLS assumption. The F (Lm) tests' probability values exceeding 0.05 have been cited as the cause. Out of the three models, we determine that EGARCH is the best model or the best estimation. The EGARCH model exhibits statistical significance for all coefficients, including ARCH and GARCH terms, the highest log-likelihood ratio, the highest adjusted R-square, and the highest probability value of the heteroscedasticity (LM) test. Despite this, the SIC value is currently not the lowest that can be accepted.

Cite this article as:
Wasurum, E. (2025). Oil price volatility and economic development in Nigeria. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(2), 146-164.

Literacy Rate Model

The literacy rate model captures hypotheses three, six and nine.

Result of the estimated Literacy Rate Model

Variables	GARCH	EGARCH	TGARCH
Mean Equation			
Constant	26.84467	26.30697	26.84280
	0.0000***	0.0000***	0.0000***
OPV	-0.064419	-0.095384	-0.064283
	0.0000***	0.0000***	0.0000***
EXR	0.069286	0.074314	0.069270
	0.0000***	0.0000***	0.0000***
OPV*EXR	0.000302	0.000496	0.000302
	0.0000***	0.0000***	0.0000***
Variance Equation			
Constant (φ) C(5)	0.165184	-2.495253	0.162413
	0.0302**	0.0000***	0.0486**
Arch (η) C(6)	1.261430	3.095593	1.228547
	0.0000***	0.0000***	0.0221**
GARCH (θ) C(8)	-0.054471	0.798253	-0.054724
	0.1574	0.0000***	0.1605
Threshold ($ʎ_1$)			0.071139
			0.9138
Asymmetric (A) C(7)		0.093718	
		0.7918	

Source: *Author's compilation from e-views 10.5. Note: ***, ** and * indicates 1%, 5% and 10% level of significance.*

It can be inferred from the linear model that, the coefficient of oil price volatility -0.064419 is negative and it is statistically significant at 5% given the probability value of (0.0000) which is less than the 0.05 limit. Thus, a unit increase in oil price volatility will amount to a 0.064419 decline in literacy. This implies that the oil price shock reduces the level of literacy in Nigeria. The sign of the parameter is in line with theoretical expectation. In theory, the oil price increase will have a positive effect on the economy in the short run and a negative effect in the long run due to the price factor. The way macroeconomic factors interact has an impact on the nation's literacy rate. This is because Nigeria's education sector receives inadequate funding, and corruption permeates every aspect of the country's economy. Despite the enormous amount of money received by Nigeria from the sales of crude oil, the education sector does not receive the necessary funding to operate efficiently. In contrast to Roland's negative opinion, this explanation supports the views of John et al. (2017), who claimed that oil price volatility places negative pressure on education.

Conversely, given the probability value of (0.0000), which is below the 5% threshold, the coefficient of exchange rate volatility (EXRV) of 0.069286 has a positive impact on the literacy rate and is statistically significant. There will be a 0.069286 unit increase in Nigeria's literacy rate for every unit increase in exchange rate volatility (EXR). This suggests that when the exchange rate escalates, the rate of literacy will rise. Lastly, given its probability value of 0.0000, which is less than the threshold 5%, the interaction term's coefficient (OPV*EXR) 0.000302 is positive, suggesting a positive association between the literacy rate and the interaction term. This relationship is statistically significant. An increase of one unit in the interaction term will result in a 0.000302 unit rise in Nigeria's literacy rate. This suggests that the fluctuating currency rates and oil prices help Nigeria's educational industry. Stated differently, the literacy rate is slightly impacted by the macroeconomic impact of changes in oil prices. marginal in the sense that there is very little evidence of causation.

The mean equation is used to show how the literacy rate (LTR) fluctuates over time. +0.061286EXRV +0.000302 OPV*EXRV + LTR = 26.84467 – 0.064419 OPV The total of the ARCH and GARCH terms (1.261430 + (-0.054471)) = 1.206959 is more than one, indicating that the volatility shock to the literacy rate is not mean reverting. Consequently, the oil price and exchange rate volatility shock's long-lasting impact on the literacy rate The average literacy rate, or mean value, as expressed in the constant term of the exponential GARCH (EGARG) model is 26. 30697. In the asymmetry model, this suggests that the literacy rate has increased. Additionally, it can be deduced that the correlation between the volatility of oil prices and Nigeria's literacy rate (LTR) is negative, with a coefficient of -0.095384. This matches the theoretical prediction. The economy is impacted asymmetrically by the volatility of oil prices, according to Hamilton (1983). An increase in unemployment and a decline in aggregate demand result from excessive oil price volatility, which also lowers the revenue from the sale of crude oil. A decline in aggregate demand will result in

In this particular context, the asymmetry indicates that while an increase in oil prices can boost economic development in the near term, over time, the presence of inflation will cause such increases to decline. This disproves Hamilton's (1983) theory while supporting Kamasa et al.'s (2020) and Evangelia's (2009) theories that the price of oil has an asymmetric impact.

Additionally, the literacy rate was positively impacted by the coefficient of exchange rate volatility (EXRV), which is statistically significant given the probability value of (0.0000). This effect was measured at 0.074314. There will be a 0.074314 unit increase in Nigeria's literacy rate for every unit increase in exchange rate volatility. In this particular context, the asymmetry indicates that while an increase in oil prices can boost economic development in the near term, over time, the presence of inflation will cause such increases to decline. This disproves Hamilton's (1983) theory while supporting Kamasa et al.'s (2020) and Evangelia's (2009) theories that the price of oil has an asymmetric impact.

Given its probability value of (0.0000), exchange rate volatility (EXRV) favourably affected literacy. Effect size was 0.074314. Nigeria's literacy rate rises 0.074314 per unit of exchange rate volatility. In the mean equation, literacy shock volatility (LTR) is 26.30697+0.095384OPV+0.074314EXRV+0.000496OPV*EXRV. The sum of ARCH and GARCH terms (3.095593 + 0.798253 = 3.893846) is more than one, hence LTR volatility shocks are not mean reverting. It follows that Nigeria's literacy rate is permanently affected by oil price and exchange rate volatility. The coefficient of the asymmetric term (0.093718) is positive and statistically significant, indicating that unfavourable oil price and exchange rate news affects literacy in Nigeria. This implies that oil price volatility, exchange rate volatility, and their interaction terms temporally shock literacy rate. Good news affects literacy volatility in Nigeria more due to the leveraging effect.

Finally, the threshold GARCH (TGARCH) model present an average of 26.84280 which is not too distant from the GARCH average. The parameter of oil price volatility (OPV) is -0.064285 and it is statistically significant at 5% given that the probability value less than 0.05. A unit rise in oil price volatility is expected to emit a 0.064285-unit reduction in literacy rate (LTR) in Nigeria. This implies that oil price shocks cause a lower literacy rate in Nigeria. This again is in line with theoretical expectation and can be justified by the fact that the presence of free oil money may have caused the adolescents to skip school in quest of white-collar work. This validates the views of Roland (2017) and Kamsa et al (2020) who projected that oil price volatility will effect schooling adversely and contradicts the ideas of Down, et al (2011), Adebie et al (2019), Baimaganboy (2019) who suggested otherwise.

The coefficient of exchange rate volatility (EXRV) is 0.069270, suggesting a positive association exists between literacy rate (LTR) and exchange rate volatility in Nigeria all things being equal. A unit rise in exchange rate volatility will lead to a 0.069270 unit increase in literacy rate in Nigeria. This means that the literacy rate responds to positive shocks from the exchange rate. This though is not consistent with theoretical or a priori anticipation, yet it is important for policy abstraction. The rationale for such behaviour may not be unconnected to the fact that national budgets are dependent to the value of oil price and oil price is drastically affected by exchange rate fluctuation. The Nigeria state is an oil-dependent economy where an increase in the exchange rate will amount to an increase in revenue or income from the sales of crude oil, leading to an increase in government expenditure, increase in employment and disposable income and increase in government revenue needed to finance at education at all levels. This validates the opinions of Morina (2020) and Moses, et al., (2020) who through empirical research claimed that the positive association exists between exchange rate and literacy rate in Nigeria.

Finally, the coefficient of the interaction term (OPV*EXRV) 0.000302 has a positive effect on the literacy rate (LTR) in Nigeria and it is statistically significant at 5%. An exchange rate fluctuation tempered with oil price rising volatility will lead to a 0.000302 increase in literacy rate in Nigeria. The coefficient of the interaction term arrived with the erroneous sign contrarily to the a priori anticipation. In theory, an increase in the interaction term will impose a negative influence on the purchasing power of the home currency, leading to an increase in the cost of production, increase in unemployment, low disposable income and poor investment in education and social infrastructure. Finally, the leverage effect as indicated in the threshold term of (0.071139) is not statistically significant and has the erroneous sign and the negative and positive shocks can be calculated as thus:

Diagnostic Checking

Cite this article as:
Wasurum, E. (2025). Oil price volatility and economic development in Nigeria. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(2), 146-164.

Diagnostics			
Sign. Coeff.	Not all	Not all	Not all
Arch Sign.	Yes	Yes	Yes
GARCH sign.	No	Yes	No
Log Likelihood	-359.6454	-355.5695	-359.6231
Adj. R^2	0.735572	0.720821	0.735618
SIC	4.806908	4.787191	4.838830
Heteroscedasticity	4.806908	0.3106	0.0754
Auto-correlation	0.0900		

Given the fact that all the models created in the empirical investigation of the influence of oil price volatility on literacy rate by controlling with currency volatility, and their interaction term are all in line with the core OLS assumption. The researcher believes that the best models for the estimation are exponential GARCH (EGARCH). Best in that it has the lowest SIC, the highest adjusted R-square, and statistically significant EGARCH terms.

The pursuit of sustainable economic growth has led to a rise in the energy consumption of fossil fuels during the production process. The forces of supply and demand, as well as Organisation of Petroleum Producers control, are stated to have affected the availability and prices of the aforementioned natural resources. Countries that import oil, such as Spain, Germany, France, and India, experience economic hardship during periods of high oil prices, while countries that export oil, such as Nigeria, Russia, Israel, the United States of America, and Saudi Arabia, experience economic prosperity during periods of low oil prices and recession during periods of high oil prices. This is the basis Hamilton (1983) used to demonstrate that the price of oil had an uneven impact on the economy. This suggests that the price of oil is a stochastic series with various global effects. Researchers have made conflicting claims about how directly the volatility of oil prices affects the economy.

Discussion

Oil Price Volatility and Per Capita Income: GARCH results show a negative impact of oil price volatility on per capita income, while EGARCH and TGARCH models reveal a positive and significant effect, suggesting oil price changes increase income in Nigeria. Reject null hypothesis; oil price volatility increases per capita income.

Exchange Rate Volatility and Per Capita Income: Both linear (GARCH) and nonlinear (EGARCH, TGARCH) models indicate exchange rate volatility significantly raises per capita income in Nigeria. Reject null hypothesis; exchange rate volatility improves per capita income.

Interaction Term and Per Capita Income: The interaction of oil price and exchange rate volatility marginally improves income in GARCH but is insignificant in nonlinear models. Accept null hypothesis; the interaction term has no significant effect.

Oil Price Volatility and Life Expectancy: Oil price volatility significantly improves life expectancy by boosting revenue, employment, and healthcare provision. Reject null hypothesis; oil price volatility positively affects life expectancy.

Exchange Rate Volatility and Life Expectancy: EGARCH results show a positive and significant relationship between exchange rate volatility and life expectancy, though this contradicts theoretical expectations. Reject null hypothesis; exchange rate volatility raises life expectancy.

Interaction Term and Life Expectancy: The interaction term significantly reduces life expectancy, reflecting negative macroeconomic effects like lower living standards and higher unemployment. Reject null hypothesis; interaction term negatively impacts life expectancy.

Oil Price Volatility and Literacy Rate: Oil price volatility negatively affects literacy rates, as oil shocks reduce educational funding. Reject null hypothesis; oil price volatility significantly impacts literacy rate.

Exchange Rate Volatility and Literacy Rate: Exchange rate volatility promotes literacy by boosting government revenue and spending on education. Reject null hypothesis; exchange rate volatility significantly improves literacy.

Interaction Term and Literacy:The interaction term marginally affects literacy, with shocks being permanent but statistically insignificant. Reject null hypothesis; the interaction term has a marginal impact on literacy.

Summary

The pursuit of sustainable economic development has driven the intensive use of fossil fuels in production processes. The availability and pricing of these resources have been influenced over time by market forces and regulations, particularly by the Organization of Petroleum Exporting Countries (OPEC). Consequently, economies of oil-importing nations (such as Spain, Germany, France, and India) tend to suffer when oil prices rise and benefit when prices fall. In contrast, oil-exporting countries (such as Nigeria, Russia, Israel, the USA, and Saudi Arabia) thrive during periods of high oil prices but often slide into recession when prices decline. It is on this premise that Hamilton (1983) argued oil prices have an asymmetric effect on economic performance. This suggests that oil

prices are inherently volatile, producing heterogeneous effects across different economies. Given the conflicting evidence among scholars regarding the direct impact of oil price volatility on the economy, this study employed three variants of the ARCH modeling technique—GARCH, EGARCH, and TGARCH—to assess the effects of oil price volatility, exchange rate volatility, and their interaction terms on Nigeria's economic development.
The major findings of this study include:

i. Oil Price and Economic Development: Oil price volatility significantly influences Nigeria's level of economic development, as evidenced in both linear and non-linear models. The strongest causality is observed through its impact on per capita income, with a coefficient of 0.861947.
ii. Exchange Rate Volatility: Results from the EGARCH model show that exchange rate volatility is a powerful predictor of economic development in Nigeria, particularly through its influence on per capita income, with a coefficient of 3.469629.
iii. Interaction Effects: The interaction between oil price and exchange rate volatilities shows a marginal impact on life expectancy and literacy rates, but not on per capita income.
iv. Volatility Shocks: Volatility shocks from oil price changes are temporary in the per capita income model but permanent in the life expectancy and literacy models.
v. Threshold Effects: The threshold term appeared with the wrong sign and was statistically insignificant in the per capita income and literacy models. This indicates that negative shocks in oil and exchange rate volatility do not significantly harm per capita income or literacy but do negatively affect life expectancy.
vi. Asymmetric Effects: The asymmetric term in the life expectancy model had the expected sign and was statistically significant, suggesting that oil price volatility exerts an asymmetric effect on economic development through life expectancy. This finding supports Hamilton's (1983) assertion of the asymmetric impact of oil price changes on the economy.

Conclusion

This study used quarterly time series data covering the period from 1981Q1 to 2023Q1 to examine the impact of oil price volatility on economic development in Nigeria. Four sections summarise the main results. To begin with, the article asserts that fluctuations in oil prices are beneficial to Nigeria's economic growth. Secondly, it may be deduced that fluctuations in currency rates are advantageous to Nigeria's economic growth. Thirdly, changes in the price of oil have very little macroeconomic impact on economic expansion. Fourth, the impact of the fluctuating exchange rate and oil price on the economy is asymmetrical. Therefore, the research demonstrates that fluctuations in oil prices and exchange rates enhance Nigeria's economic growth.

Recommendations

The following suggestions are made: • To lessen the negative consequences of shocks to the price of oil, the economy should be diversified.

i. The money made from oil during the boom should go into building infrastructure, which serves as the foundation for economic growth.
ii. To increase the value of the naira, the country should expand its production base.
iii. To reduce the exchange rate factor, we recommend that the government increase the quantity and quality of domestic food production.
iv. In order to stimulate the economy, state and federal governments in Nigeria ought to fully use the money received from the sale of crude oil by giving contracts to native contractors.

References

Adegbie, F. F., Akintola, I. R., Olayinka, O. G. (2019). Evaluation of petroleum crude oil price volatility on Nigeria national income and Nigeria economy. *European Journal of Accounting, Auditing and Finance Research, 7*(6), 65-83.

Akakpan (2011), *The economy towards a new type of economics*. Belport Publishers.

Akutson, S., Messiah, A. J. & Araf, Y. D. (2018). The impact of unemployment on economic growth in Nigeria: An application of autoregressive distributed lag (ARDL) bound testing. *Journal of Business Management and Marketing, 1*(2), 37-46.

Asteriou, D., & Price, S. (2005). *Uncertainty, investment and economic growth: Evidence from a dynamic panel. Review of Development Economics*, 9(2), 277–288. https://doi.org/10.1111/j.1467-9361.2005.00276.x

Baimaganbetov, S., Kelesbayev, D., Yermankulova, R., Izzatullaeva, B. & Almukhambetova, B. (2019). Effects of oil price changes on regional real income per capita in Kazakhstan: Panel data analysis. *International Journal of Energy Economics and Policy, 9*(4), 356-362.

Barguellil, A., Ben-Salha, O., & Zmami, M. (2018). The effect of urbanization on CO_2 emissions in MENA countries: Evidence from STIRPAT model. *Environmental Science and Pollution Research*, 25, 2402–2413. https://doi.org/10.1007/s11356-017-0585-5

Birdlife International (2008). *Species factsheet*- Numenius minutus. . Available from: http://www.birdlife.org. [Accessed: 24-May-2008].

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31(3), 307–327. https://doi.org/10.1016/0304-4076(86)90063-1

Budina, N. & Wijnbergen, S. (2008). *Managing oil revenue volatility in Nigeria: The role of fiscal policy*. http://siteresources.worldbank.org.

Central Intelligence Agency. (2020). *The world factbook 2020*. https://www.cia.gov/the-world-factbook/

Chowshury, Y., Hamid, M. K. & Akhi, R. A. (2020). *Impact of macroeconomic variables on economic growth: Bangladesh perspective*. https://doi:10.26480/imcs.02.2019.19.22.

Dickey, D. A. & Fuller, W. A. (181). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366), 427-431.

Dornbusch, R., Fischer, S., & Startz, R. (2001). *Macroeconomics* (8th ed.). McGraw-Hill.

Ebrahim, Z., Inderwildi, O. R., & King, D. A. (2014). Macroeconomic impacts of oil price volatility: Mitigation and resilience. *Frontiers in Energy*, 8(1), 9–24. https://doi.org/10.1007/s11708-014-0303-0

Enders, W. (1995). *Applied econometric time series* (1st ed.). John Wiley & Sons.

Engel, C. (1993). Real exchange rates and relative prices: An empirical investigation. *Journal of monetary Economics*, *32*(4), 123-129.

Evangelia, P. (2009). Causality and unit root in panel data analysis: The case of health and GDP. *Theoretical and Applied Economics*, 5(5), 33–48.

Granger, C. W. J., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics*, 2(2), 111–120. https://doi.org/10.1016/0304-4076(74)90034-7

Hamilton, J. D. (1983). Oil and the macroeconomy since World War II. *Journal of Political Economy*, 91(2), 228–248. https://doi.org/10.1086/261140

Hunt, B., Isard, P. & Laxton, D. (2001). *The macroeconomic effects of higher oil price.* IMF Working Paper International Energy Agency "IEA Annual Report" Various Years

Ifeanyi, O. N. & Ayenajeh, M. E. (2016). Impact of crude oil price volatility on economic growth in Nigeria (1980-2014). *Journal of Business and Management (IOSR-JBM) 18*(6), 10-19. http://doi.10.9790/487X-1806011019.

Ikechi, K. C., & Nwadiubu, A. (2020). Economic diversification and sustainable development in Nigeria: A study of the solid minerals sector. *International Journal of Innovative Development and Policy Studies*, 8(1), 78–90.

John, M. M., Yong, S. & Qiao, Y. (2017). *Oil price shocks and economic growth: The volatility link*. https://mpra.ub.uni-muenchen.de/83999.

Kamasa, K., Amponsah, B. D., & Forson, P. (2020). Do crude oil price changes affect economic welfare? Empirical evidence from Ghana. *Ghana Mining Journal, 20*(1), 51 - 58.

Kapetanios, G. (2005). Unit root testing against the alternative hypothesis of up to m structural breaks. *Journal of Time Series Analysis*, 26(1), 123–133. https://doi.org/10.1111/j.1467-9892.2005.00396.x

Kapetanios, G. (2005). Unit?root testing against the alternative hypothesis of up to m structural breaks. Journal of Time Series Analysis, 26(1). doi: 10.1111/j.1467 -9892.2005.00393.x.

Keji, S. A. (2018). An empirical nexus between oil price collapse and economic growth in Sub-Saharan African oil-based economies. *Journal Perspektif Penbiayaan-dau Pembangunan Daerah*, *5*(4), 300-313.

Keynes, J. M. (1937). The general theory of employment. *The quarterly journal of economics*, *51*(2), 209-223.

Kindleberger, C. P. (1965). *Manias, panics and Crashe: A history of financial crises*, (second revised ed). Basic Books.

Morina, F., Hysa, E., Ergün, U., Panait, M., & Voica, M. C. (2020). The effect of exchange rate volatility on economic growth: Case of the CEE countries. *Journal of Risk and Financial Management*, *13*(8), 177.

Moses, U. K., Victor, O. U., Uwawunkonye, E, G., Fumilade. O. S. N. & Nathaniel, G. (2020). Does exchange rate volatility affect economic growth in Nigeria. *International Journal of Economics and Finance, 12*(7), 87-99.

Mukhtarov, S., Humbatova, S., Mammadi, M. & Hajiyev, N. G. (2021). Oil price and economic development. *Journal of Economics*, *14*(6), 1695; https://doi.org/10.3390/en14061695.

Musyoki, 1, D., Pokhariyal, G. P. & Pundo, M. (2012). The impact of real exchange rate volatility on economic growth: Kenyan evidence: BEH. *Business and Economic Horizons, 7*(1), 59-75.

National Planning Commission. (2004). *National Economic Empowerment and Development Strategy (NEEDS)*. Abuja: National Planning Commission.

Nelson, D. B. (1991). Conditional Heteroskedasticity in Asset Returns: A New Approach. Econometrica, 59(2), 347–370

Nwaoha, W. C. (2018). Movements of petroleum pump prices and standard of living: Evidence from Nigeria. *International Journal of Social Sciences and Management Research*, *4*(8), 57-69.

Ogiri, I. H., Amadi, S. N., Uddin, M. M., & Dubon, P. (2013). Oil price and stock market performance in Nigeria: An empirical analysis. *American Journal of Social and Management Sciences, 4*(1), 20-41.

Okolie, P. I. (2017). Exchange rate management and performance of Nigerian manufacturing firms. *Academy of Entrepreneurship Journal*, *8*(4), 58-76. https://www.abacademies.org/articles/exchange-rate-management-and-performance-of-nigerian-manufacturing-firms-8733.html.

Pindyck, R. S., & Rubinfeld, D. L. (1998). *Econometric models and economic forecasts* (4th ed.). McGraw-Hill.

Qiangi, J., Shahzad, S. J. H., Bouri, B. & Suleman, M. T. (2020). Dynamic structural impacts of oil shocks on the economy: Lessons to learn, *Journal of Economic Structures*, *9*(5), 97-108.

Roland, N. O. (2017). The impact of domestic pricing of petrol on the economic growth of Nigeria (1970-2013). *Global Journal of Social Sciences*, *16*(9), 1-8.

Saikkonen, P. (2000a). Asymptotically efficient estimation of cointegration regressions. *Econometric Theory*, 16(1), 1–29. https://doi.org/10.1017/S0266466600161012

Saikkonen, P. (2000b). Testing for a unit root in a time series with a level shift at unknown time. *Econometric Theory*, 16(2), 313–336. https://doi.org/10.1017/S0266466600163025

Saikkonen, P. (2000c). Trends and unit roots in macroeconomic time series: A re-examination. *Econometric Reviews*, 19(3), 211–247. https://doi.org/10.1080/07474930008800456

Takumah, W. (2014). Tax revenue and economic growth in Ghana: A cointegration approach. *Munich personal RePEc Archive, 4*(7), 45-58. https://mpra.ub.uni-muenchen.de/58532/.

Weliswa, M. (2013). The impact of oil price volatility on economic growth in South Africa: a cointegration approach. *The Journal of Sustainable Development*, *6*(7), 1-18

World Bank Indicator (2019). Statistical data for cross-country indices.

World Bank. (2018). *World development indicators*. World Bank. View Publication Stats.

Zakoian, J. M. (1994). Threshold Heteroskedastic Models. Journal of Economic Dynamics and Control, 18(5), 931-955.

Zakoian, J.-M. (1994). Threshold heteroskedastic models. *Journal of Economic Dynamics and Control*, 18(5), 931–955. https://doi.org/10.1016/0165-1889(94)90039-6

Zhou, L. & Geng, J. (2021). Dynamic effect of structural oil price shocks on new energy economies. *Green Finance, Renewable and Non-Renewable Energy, and COVID*, *6*(4), 89-99. https://doi.org/10.3389/fenvs.2021.636270.

Zmami, M., & Ben-Salha, O. (2020). Oil price and the economic activity in GCC countries: Evidence from quintile regression. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *15*(4), 651–673. https://doi.org/10.24136/eq.2020.028

Cite this article as:
Wasurum, E. (2025). Oil price volatility and economic development in Nigeria. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(2), 146-164.