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DYNAMIC ANALYSIS OF THE INTERACTIVE EFFECT OF EXCHANGE RATE AND CRUDE OIL PRICE ON WELFARE IN NIGERIA (2010-2022)

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Eneoli Queeneth Uchenna*
*Department of Banking and Finance, University of Nigeria, Enugu Campus, Enugu, Nigeria
queeneth.eneoli@unn.edu.ng

Ebere Ume Kalu*
*Department of Banking and Finance, University of Nigeria, Enugu Campus, Enugu, Nigeria
ebere.kalu@unn.edu.ng

Wilfred Isioma Ukpere**
**Department of Industrial Psychology and People Management, School of Management, College of Business Economics, University of Johannesburg, South Africa.
wiukpere@uj.ac.za

Francis E. Monyei**
**Department of Industrial Psychology and People Management, School of Management, College of Business Economics, University of Johannesburg, South Africa.
monyei_francis@yahoo.com

The authors declare that there is no conflict of interest

Abstract

This research work carried out a dynamic analysis of the interactive effect of exchange rate and crude oil price on welfare in Nigeria, covering the period 2010 to 2022. The data used for the study were drawn from the CBN statistical bulletin and covered the period 2010Q1to 2022Q3. Exchange rate and crude oil price volatility series were used as the independent variables, whereas real gross domestic product per capita was used as the dependent variable. GARCH (1,1) and Autoregressive Distributed Lag Model were used as the key estimation techniques in this study. The test for heteroscedasticity following the ARMA Model in a GARCH 1,1 series tested the first hypothesis for volatility cluster, while the Autoregressive distributed lag model estimation method was adopted to test hypotheses two, three, and four. In terms of findings, firstly, the study revealed that the exchange rate and crude price in Nigeria are sufficiently volatile to provide grounds for an investigation of their welfare impact. It was also observed that exchange rate volatility exerts a positive influence on the welfare of Nigerians. Also, there is a significant relationship between crude volatility and welfare, on the basis of which the null hypothesis was rejected for the third hypothesis. Hence, we concluded that crude volatility exerts a significant influence on the welfare of Nigerians, even though the welfare impact was found to be negative. The investigation also concluded that the interaction of crude price and exchange rate volatility improved the welfare of Nigerians. On the basis of the findings, the study recommended that an exchange rate regime with the capacity to produce a positive welfare impact should always be adopted by the monetary authorities. This is because, in line with the observation that the exchange rate in Nigeria is not only volatile but also can elicit a positive reaction from welfare, such movement can create an adverse reaction if left uncontrolled. This is where due policy control becomes expedient. Furthermore, it is recommended that stronger policy safety-nets need to be created to ameliorate the adverse welfare effect of crude price volatility, for instance, a petrol price subsidy or any other cushioning policy. Lastly, the study further recommends that policy interdependence and interaction should be heightened to allow for adverse policy reactions to be contained by positive policy reactions.

Keywords: Crude Price. Welfare. Volatility. ARDL. Nigeria.

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1 INTRODUCTION

Crude price and exchange rate shocks, with their associated welfare effect on the citizens, have been observed by many authors as major threats to the economic stability of Nigeria. Shock on a major product that generates income to Nigeria is a challenge to the country's budget, execution of capital projects, legal options, and policy making. Likewise, the exchange rate (which is the conversion value of crude and other internationally traded products) also experiences shocks that reduce the level of international trade, affect investment decisions, distort resource allocation, and affect the welfare and cost of living of the citizens (Olujobi, Olarinde, Yebisi & Okorie, 2022)

Existing literature consistently shows that crude oil prices serve as the primary key factor influencing the use of energy commodities globally. It is also a driver of commercial energy, which is essentially needed in transportation, manufacturing, and technological operations. Consequently, fluctuations in crude oil prices have notable implications for economic growth, broader development outcomes and the overall welfare of a nation's citizens (See Olujobi, 2021; Musa, Maijama'a, Shaibu & Muhammad, 2019). Crude oil exportation represents a major source of revenue to Nigeria as well as other developing economies, especially members of the Organization of Petroleum Exporting Countries (OPEC), as a collusive oligopoly (Kanu & Nwadiubu, 2020). Given that crude oil is a significant article of international trade for these countries, and the exchange rate represents the denominator for currency conversion in foreign dealings, it is easy to establish a linkage between these two major variables.

Nigeria, as an exporting country, tends to experience changes in its revenue growth due to the volatility interaction of exchange rate and crude prices (Bank for International Settlements [BIS], 2021). Further, the CBN statistical bulletin reveals that the oil revenue generated between the period of 2011 to 2013 is on average of 74.8%, which, according to Olujobi (2021), implies that a depreciated crude oil price will negatively impact the country's revenue size. Oil was also reported in 2019 to account for roughly 90% of Nigeria's foreign exchange inflows and nearly 80% of total federally generated revenue (Central Bank of Nigeria [CBN], 2019).

Before oil was discovered in commercial volumes and the boom that followed in the 1970s, agriculture served as the backbone of Nigeria's economy (Ogochukwu, 2016). According to the study, the agricultural sector contributed more than 70% to Nigeria's

gross domestic product at the time. Also, the non-oil export activities provided avenues for job creation, income generation, and foreign exchange earnings for the nation. Nigeria is today the largest oil-producing country in Africa and the 6thin the world. The petroleum industry is made up of major multinational petroleum firms operating in Nigeria, including well-known Shell, Mobil, Addas, Chevron, Agip, and Total. Also, the sector consists of upstream, downstream, and midstream operations (Babatunde, 2018). According to the Petroleum Industry Act 2021, the multinational oil companies operate under the federal government; as such, all agreements and licenses are issued by their authority (Ufua, Olujobi, Tahir, Okafor, Imhonopi, & Osabuohien, 2022).

Olujobi (2021) indicated that apart from oil theft, insecurity, and banditry, a major challenge confronting the country is the persistent instability in crude oil prices in the face of an unstable exchange rate. Oil companies' operations are underwhelming due to insecurity and vandalism of the infrastructure in the Niger Delta areas of the country. Kanu & Nwadiubu, (2020) found that the decline in trade volumes between 2012 and 2015 was driven largely by fluctuations in the exchange rate and instability in crude-related trade activities. (See also, **Blazquez-Lopez, 2020).** Also, there is an emphasis that oil prices are influenced by several macroeconomic factors, including exchange rate movements, the degree of rate of flexibility, exchange rate policy orientation, trade openness, and overall economic complexity. This is because fluctuations in oil prices primarily spill over into the domestic economy through their effect on the exchange rate mechanism. (Nandelenga, and Simpasa, 2020).

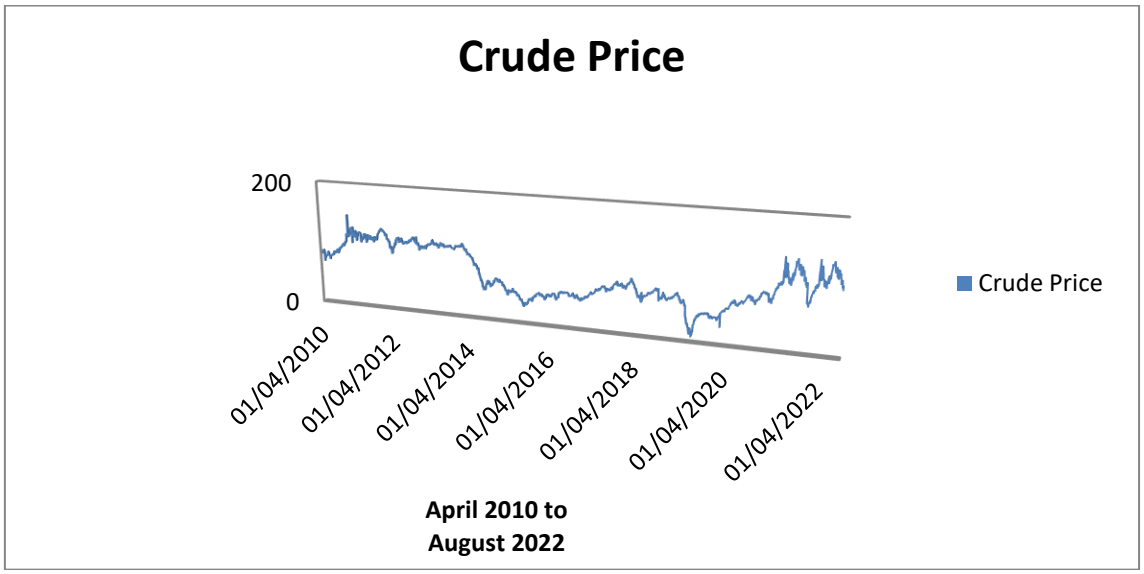
Kalu, Ugwu, Ndubuaku, and Ifeanyi (2019) hold that as the relative price of a country's currency changes, factors such as capital flow, trade, and other foreign transactions are equally affected. This implies that the volatility of the exchange rate and crude oil prices are factors that require strategic policy attention so as to effectively use them in improving welfare through the growth and development of the economy. The relationship between the exchange rate and crude oil price helps in providing important information to trade participants and investors, which guides them in portfolio management for profit-making. This also helps consumers in planning their expenses, as the changes in oil prices and exchange rates may have a transmission effect on their expenditure profile.

The volatility in crude price has different implications; for example, oil-exporting countries could benefit from such changes, while oil-importing countries could

experience unfavorable or fluctuating terms of trade (Manasseh, Abada, Ogbuabor, Okoro**,** Egele, & Ozuzu, 2022). For Nigeria, in the period under review, it was observed that the US dollar to naira exchange rate, as well as crude price, did not fluctuate across the different years from 2010 to 2022 (See Figs. 1 and 2).

Figure 1

Monthly Crude Price Movement Aug 2010 to Aug 2022

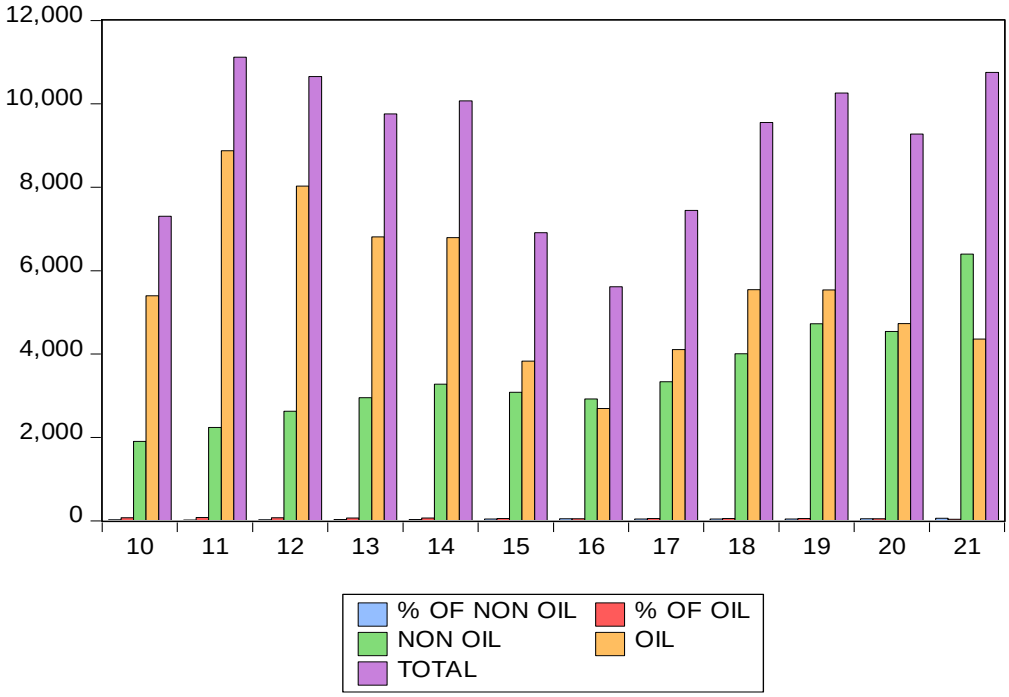


Source: Author's Plot with Data from CBN statistical bulletin Database (2022)

With an all-time low and high crude price in 2019 and 2010 respectively, there is evidence of movement in crude price in a manner that fits volatility investigation within the period. Evidently, the crude oil market remains a factor responsible for the instability in the revenue profile and expectations of oil-dependent economies such as Nigeria. Policies such as budgeting and financial planning have always considered setting a benchmark for the constantly fluctuating crude price. This makes the movement in prices of crude to be of great significance to not just economic agents but, policy makers in Nigeria and other economies with the structure of Nigeria. Table 1 shows the revenue impact of the volatile crude price and exchange rate over the said period.

Figure 2

A Bar Plot of Oil and Non-oil Revenue in Nigeria 2010 to 2021

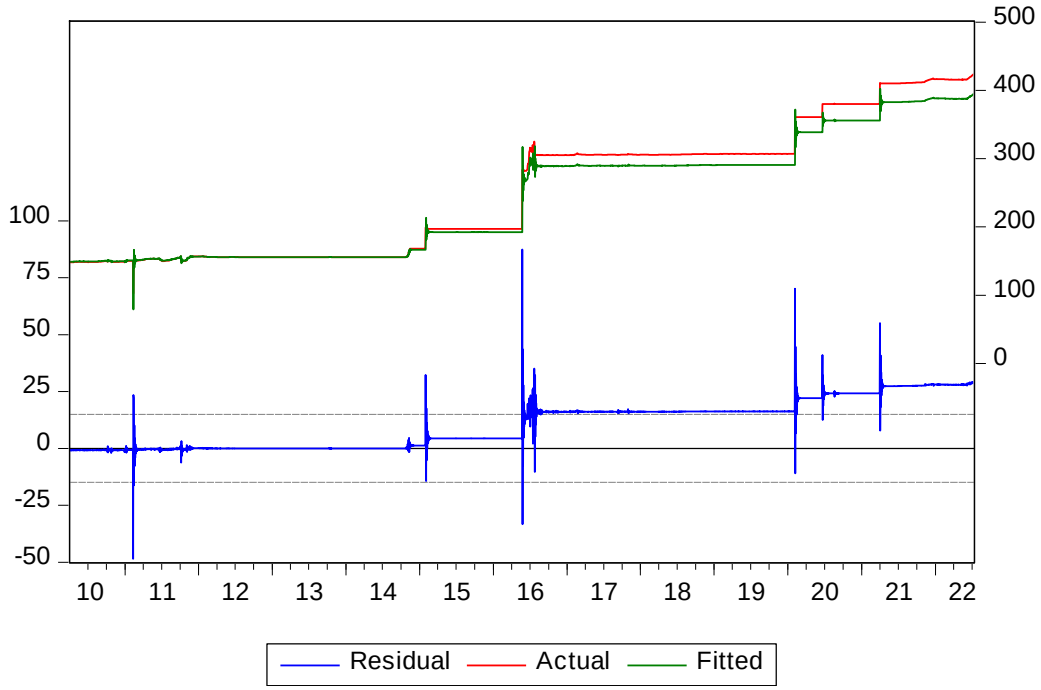


Source: Author's Plot with Data from CBN Statistical Bulletin (2022)

The above table reveals that oil revenue dominated Nigeria's total revenue during the period under review. The oscillatory behavior of the bars in Fig. 2 above also revealed the fluctuation in total revenue across the period, which is subject to the volatility of the exchange rate and crude price in the international market. Since it has been shown that the exchange rate directly affects the crude price revenue in a nation, there is a need, therefore, to study the relationship and the extent to which the exchange rate and crude price volatility affect the welfare of the citizens. Fig. 3 highlights exchange rate movement from 2010 to 2022.

Figure 3

Monthly Exchange Movement April 2010 to Aug 2022



Source: Author's Plot with Data from Central Bank Statistics Database (2022)

A review of historic and current events reveals various triggers of crude price volatility. The Gulf War, which happened in the late 90s and early 2000, created uncertainty in crude price demand and supply, and led to volatility in crude prices. According to Yumeng (2022), when war happens, the utilization of weapons increases oil prices. The investigation reported that the Iraq-Kuwait war led to a global oil price rise from 14.87dollars per barrel to 23.19 dollars per barrel within the period 1988 to 1990. After the war, the price of oil fell by one third of the price during the war (from 15.66 per barrel in 1994 to 20.46 per barrel in 1996).

Another trigger of the fluctuation in crude prices is the OPEC regulation. According to Hamida (2021), the purpose of OPEC is to coordinate the members' policies to make stable prices for petroleum products and for the efficient supply of the products to countries. Bassam (2016), therefore, opined that the fluctuations in the oil prices are influenced by the body through policies and regulations. More so, Nigeria gained membership in the Organization of petroleum exporting countries. (OPEC) Since 1971. Upon joining, the country had 1,673,000bbl/d regulation production limit (Babatunde 2018). Moreover, Olujobi (2022) claims that excessive regulation of the oil sector does not encourage the government to fund the sector for a better fiscal development of the

country. More recently, COVID-19 pandemic and the Russian-Ukraine war are the causes of some unprecedented global shocks that have negatively impacted the international market. Accordingly, Manasseh *et al*. (2022) and the Nigerian Center for Disease Control (2020), affirmed that the COVID-19 pandemic is one of the recent events that triggered crude price volatility through the demand and supply transmission mechanisms.

The welfare impact of this fluctuation is apparent in the reduction in the demand for crude oil and supply to the international market, with an associated increase in oil price. This directly affects production costs in a producing company, which results in reduced returns and supply. The demanding countries are also affected as oil price changes influence consumption size and investment. According to a PricewaterhouseCoopers International Limited report (2020), the Nigerian economy lost approximately 15.8billion USD to COVID-19, thereby diminishing the country's gross domestic product in the second quarter to 6.1%, and 3.62% in the third quarter of 2020. Within the period, such welfare indicators as Human Development Index (HDI), life expectancy, and Income per Capita dropped in ranking to 0.539, placing the country in the low human development category (United Nations Development Programme [UNDP], 2020). The welfare of the citizens was adversely affected such that about an estimated 83 million Nigerians, or 40% of the population, lived below the poverty line, and a further 25% were at risk of poverty (World Bank, 2020). It was within this period that the country was classified as one of the poorest in the world, stating that the poverty rate had worsened due to the effect of the COVID-19 crisis (World Bank, 2022).

Although some empirical investigations have shown that crude prices positively impacted the exchange rate, the magnitude of the volatility spillover between crude price and exchange rate, and

its impact on the welfare of the Nigerian citizens, remains an issue of investigative interest. For the purposes of social, policy, and research implications, it is expedient to resolve the trilemma of oil price volatility, exchange rate swing, and their transmission effect on the well-being of the citizens of Nigeria.

2 REVIEW OF RELATED LITERATURE

2.1 Conceptual review

Maintaining an appropriate exchange rate is essential for sustaining economic growth and ensuring balance across domestic and external sectors. Because it functions as a central price variable, the exchange rate shapes a country's competitiveness and serves as a nominal anchor for domestic price stability (Mordi, 2006). Movements away from equilibrium triggered by inconsistent market signals, speculative pressures, or multiple exchange rate windows are commonly described as exchange rate volatility. Volatility also arises when changes in demand or supply respond sharply to shocks, especially in contexts where elasticities are low, thereby creating wider price fluctuations (Obadan, 2016). Floating exchange rate regimes naturally experience wider variations, while strong economic fundamentals help enhance currency stability and appreciation (Mordi, 2006). The exchange rate indicates how much one currency is equivalent to another (Dornbusch, 2020). Mankiw (2017) similarly describes it as the rate at which currencies are traded between countries. Because of its implications for investment behavior, price formation, and trade decisions, the exchange rate remains a major focus in monetary and international economics. Persistent instability in Nigeria's exchange market has complicated policy efforts and affected key macroeconomic fundamentals.

A realistic exchange rate structure reflects the pattern of foreign exchange inflows and outflows, influences external reserves, and ensures price stability consistent with the country's major trading partners (Ojo, 2018). Stability in the exchange rate reduces uncertainty around price movements, thereby improving living standards. It lowers inflation-related risk premiums, as creditors facing predictable price paths require fewer adjustments to compensate for inflation risk. This encourages borrowing, investment, and employment generation. Stable exchange rates also minimize the need for hedging in financial and commercial contracts. Under volatile conditions, households and firms often divert resources toward protecting the value of their assets, sometimes through stockpiling goods, an inefficient response that limits long-term real income growth. A stable exchange environment reduces such distortions and encourages cash holdings, since inflation acts as a tax on money balances. Predictable price levels, therefore, support smooth financial transactions. Financial stability is closely linked to exchange rate

stability. Sharp and unexpected inflationary swings can distort the real value of banks' assets and liabilities, particularly long-term loans financed through short-term deposits, thereby creating solvency risks. Stable price and exchange conditions avoid these distortions and strengthen the financial system (European Central Bank, 2007).

Debates continue regarding the appropriate method for measuring exchange rate behavior. Many authors argue that measurement choice depends on research scope, the relevant time horizon, and the nature of shocks. Forward exchange rates, although imperfect predictors, are still widely used to estimate exchange rate expectations. They help capture discrepancies between the current spot rate and the previous day's forward rate and remain common in analyses of major currencies.

McKenzie, as reported in Ojebiyi and Wilson (2021), highlights the usefulness of structural models and time-series techniques, including ARCH/GARCH. The standard deviation of the series after taking the first difference of exchange rate logarithms is one of the most frequently used volatility measures. Short-run volatility may be estimated with one-year intervals, while long-run trends often use five-year windows. Currency billing in international trade adds another dimension to volatility analysis. Since many developing countries invoice trade in major currencies like the US dollar, fluctuations in local–dollar rates influence bilateral trade even when neither country uses its domestic currency for invoicing. Thus, the volatility of both countries' exchange rates relative to the dollar can shape trade flows (Ojebiyi & Wilson, 2021).

Empirical studies show mixed findings on the relationship between exchange rate volatility and macroeconomic performance. Many studies, including Pierce and Enzler (2017), Vergil (2019), and Arize, Osang, and Slottje (2020), report negative effects, such as reduced trade volumes and deteriorating balance of payments. In sub-Saharan Africa, Ghura and Greene (2019) find a significant negative effect of volatility on trade. Aliyu (2018) reports that naira volatility reduced Nigeria’s non-oil exports by 3.65%. In South Africa, Bah and Amusi (2018) observe that both short- and long-run variability in the Rand negatively affects exports.

On the contrary, some studies find positive effects. De Grauwe (2018) suggests that risk-averse exporters may increase trade volumes when volatility is high to maximize returns. Franke (2020); Sercu and Vanhulle (2021), Todani and Munyama (2015), and Yusuf and Edom (2017) also report that certain contexts show a positive relationship, especially when depreciation enhances the competitiveness of export sectors such as sawn

and round wood. Oil price shocks have also been linked to macroeconomic outcomes. Jbir (2019) and Zouari Ghorbel (2019) show that rising crude oil prices impose significant economic effects, benefiting oil exporters but raising inflation in oil-importing countries. Hamilton (2018) associates sharp oil price increases in the 1970s with subsequent periods of economic slowdown in the United States.

Since the 1986 oil price collapse, several studies have revisited the oil–growth relationship using asymmetric models. Evidence continues to show a strong negative link between oil price fluctuations and economic activity (Hamilton, 2018). Crude oil prices are determined in major markets such as WTI, Brent, NYMEX, and the OPEC Basket. Nigeria's crude belongs to the OPEC Basket, which typically receives lower prices due to its quality (Hamilton, 2018).

Historically, oil prices were relatively stable until the early 1970s. Prices surged in 1973–1974 due to the Yom Kippur War and again in 1979 due to the Iran–Iraq conflict. Prices rose from $12–$14 per barrel to $35. High oil prices encouraged fuel efficiency and increased production costs for non-OPEC countries (Sharma, 1998). OPEC attempted stabilization through quotas in the early 1980s, but global recession weakened demand, pushing prices below $10 per barrel. Global price swings increased from the mid-1980s as OPEC's share of world production dropped from 55% in 1976 to 42%. Oil price volatility directly affects transportation costs, consumer energy bills, manufacturing costs, and investment behavior (Sill, 2009). Nigeria's oil industry began when Nigeria Bitumen Corporation and Shell BP discovered oil in Oloibiri. Exports commenced in 1958. Following the civil war, the oil boom of the 1970s raised revenue substantially. Nigeria joined OPEC in 1971 and established the NNPC in 1977. Production exceeded 2 million barrels per day in the 1970s but declined due to economic stress and Niger Delta conflicts. Output later recovered to 2.5 million barrels per day in 2004 but remains vulnerable to crises and global shocks. Nigeria's oil wealth did not translate into sustained development due to corruption, mismanagement, and persistent conflicts. Recent studies continue to examine the oil-growth nexus and its implications for economic restructuring (Odularu, 2017; Ogundipe & Ogundipe, 2018).

Adedipe (2014) divides Nigeria's exchange rate history into three phases:

2.1.1 Post-Independence Era (1960–1971)

The naira was fixed in value relative to the British pound and US dollar; overvaluation reflected strong agricultural exports. In this era, the Nigerian naira was fixed to the pound sterling (GBP) of Britain in order to maintain currency parity. Following the 1967 depreciation of the pound sterling, Nigeria switched to the US dollar to strengthen import substitution industries dependent on net imported inputs. During this era, the naira-to-GBP exchange rate was overvalued, reflecting growth in agriculture and in locally produced goods for export.

2.1.2 Oil Boom Era (1972–1986)

Exchange rate management followed oil price trends. The naira was pegged variously to the pound, then the dollar, then a currency basket. The exchange rate was going in a similar trend with the price of oil at an overvalued naira due to a rise in foreign exchange incomes. The naira was fixed against GBP until 1972, when the pounds were allowed to be set by the forex market, and then it was fixed against US dollar. In 1978, though, the currency was anchored on the currencies of major trading partners of Nigeria. Naira went back to the figure used against the US dollars in 1985, and these all benefited the country in generating revenue through oil exports, amidst its availability.

2.1.3 Post-SAP Era (1986 onwards)

Structural Adjustment introduced a market-based exchange system, leading to significant depreciation (from N0.89388/$ in 1985 to N2.0206/$ in 1986). Subsequent devaluations aimed to support non-oil exports, but volatility persisted and continues to influence revenue and welfare. The social welfare, being crucial for an economy, should go hand in hand with the level of growth and development in the country. Therefore, the relevance in government activities should be to make provisions for the welfare of the citizens (Sardar, Islam & Clarke, 2017; Awan, 2015). There is a link between economic growth and welfare, more so, sustainable development. This is reflected in the World Commission on Environment & Development (WCED) write-up, where the link is apparent in three sustainable indices, namely: environment, economic, and social. More

importantly, the WCED strongly laid emphasis on the issues of equality, in the pursuit of poverty reduction especially in the country's areas where most of the citizens gain from the privileges of the development process (Neumayer, 2019).

Meadows and Randers (2021), while analyzing the issues of integrating growth, social welfare, and the needs of future generations, warned that unchecked resource depletion threatens long term prosperity, while Abramowitz, 2018), stressed the need for growth-oriented policies that support welfare and sustainability.

2.2 Theoretical review

2.2.1 Theoretical review

Mundell(1961) and Mckinnon(1963) developed the seminal optimal currency area theory which serves as a key basis for exchange rate policies. This theory stresses the importance of ensuring stability of economic and trade fluctuations. It stakes its basis on the opinion of the movement within the labor market concept, extent of economic openness, and the consistency of shocks. The theory shows that a pegged exchange rate system has the tendency to stimulate trade and economic growth through minimizing exchange rate fluctuations, hedging costs, and motivating investment, lowering the interest rate-related currency premium. However, it can slow down output growth and trade by retarding and halting the adjustment processes of important relative prices. In the present times, exchange rate theories are based on the balance of monetary and asset markets; their method addresses exchange rate and balance of payments issues. In contrast, traditional exchange rate theory focuses on trade flows and promotes clarification of exchange rate swings in the long run. As financial flows become bigger than trade flows, interest shifts to modern exchange rate theories, yet in the long run, traditional theories remain essential (Salvatore, 2012). The theory enforces monetary frameworks across different geopolitical and geographical areas, instead of by countries, which prompts more noteworthy financial effectiveness. The OCA hypothesis is profitable in a geographic locale by expanding the exchange area. However, the advantages of expanded exchange must be more than the expenses of every nation or individual from that area using public money to modify its financial approach.

The Dutch disease theory, as formulated by Corden & Neary (1982), shows the subsequent poor economic performance of a country in reaction to the discovery of natural resources. The theory posits that a natural resources boom can cause a country's exchange rate to rise, undermining the competitiveness of manufactured goods while driving resource sector specialization, increasing vulnerability to resource-specific shocks. This phenomenon, known as Dutch disease, has two main effects: resource movement and spending effects. The resource movement effect occurs when increased resource prices raise their marginal product value, resulting in higher wages in the resource sector and potentially shrinking the tradable sector, causing unemployment as industries close. Conversely, the spending effect boosts revenue from the resources, increasing imports and domestic consumption, which impacts national welfare. According to Ismail (2010), while the disease can foster growth in infant industries, it may also lead to job losses and unemployment in the production sector.

Moreso, the natural resource rent theory was developed by Bulearca, Popescu, Muscalu, and Chiga (2012). The analysis of the extracting industry, such as mineral resources, is different from the non-extracting industry, such as agriculture, manufacturing, and services. This is because the extracting industry is made up of natural accumulations, which become exhaustible with time. Alchian (1987) took economic rent to be the payment made to acquire a factor of a fixed supply, such as crude oil, which is a stock of exhaustible resources. Arnason (2008) further defined resource rent to cover any restricted variable, as the cost to a variable in a fixed supply. Economic rent is obtained from the relationship between fixed supply, such as natural resources, and a normal demand curve. In resource rents, the natural resource supply is not fixed because the price of the resource is dependent on the level of the extraction of the resource and other exogenous factors that could affect its extraction and supply (Arnason, 2008; Alchian, 1987).

In addition, the theory of consumption smoothing lays emphasis on the permanent income of an individual. It focuses on the optimal fiscal policy of a person and suggests that the level of per capita consumption remains the same over a period of time. The theory stated that individuals react when their consumption pattern changes; therefore, ignoring income uncertainty. The theory explains that with the uncertainty of income, however, the level of current consumption is equal to permanent income so that on average, consumption is constant over time (Friedman, 1957). This implies that a rise in

oil revenue increases consumption by the annuity value of the rise in wealth. According to Engel and Valdes (2002), government policies created in this aspect should be projected towards temporal and permanent income shocks and as consumption smoothing policies under income uncertainty. A time-related income shock raises consumption by the annuity value of the favorable income shock shift. Whereas, a permanent income shock happens when the reduction of consumption is one-for-one. An example is the positive oil price shock that arose due to the invasion of Kuwait by Iraq in August 1990, which was rather a temporal one.

3 METHODOLOGY

3.1 Data and model

The entirety of the data applied in this work is quarterly, time series, which were secondary and purely quantitative. They are sourced from materials such as the statistical bulletin of the Central Bank of Nigeria and the World Bank Development Indicators. Crude oil price and exchange rate collected on a daily basis were quarterlized to bring them to the same base as the welfare indicators which are typically reported quarterly. The datasets are for the period 2010Q1 to 2022Q3, which is considered long enough to capture proper volatility spread for a study such as this.

The study follows the model used by Tersoo and Nuruddeen (2019) which examined the effect of pass-through and its effect on disaggregated inflation in Nigeria for the period 2010 to 2019 using the ARDL estimation technique.

$$\Delta dsgcpi = \beta_o + \sum_{i=0}^{n} \beta_i dsgcpi_{t-1} + \sum_{i=0}^{n} \mu_i \Delta oilprice_{t-1} + \varepsilon_t \quad (1)$$

where:

Oil Price = Crude Oil Price
Dsgcpi = Disaggregated inflation
β_o = Intercept
β_i and μ_i = slope or coefficient of the independent variable

This model is modified for the purpose of this study by making welfare (Real Gross Domestic Product Per Capita- RGDPPC) the outcome variable (dependent

variable), and introducing exchange rate volatility and crude price volatility as the effect variables (independent variables), while controlling for inflation rate (INFR) and interest rate (INTR). The aggregated and modified model showing both the short run and long run estimators for the study becomes:

$$RGDPPC_t = \beta_o + \sum_{i=0}^{n=1} \beta_i \Delta RGDPPC_{t-1} + \sum_{i=0}^{n=1} \mu_i \Delta cpvol_{t-1} + \sum_{i=0}^{n=1} \delta_i \Delta exrvol_{t-1} + \sum_{i=0}^{n=1} \rho_i \Delta Intr_{t-1} + \sum_{i=0}^{n=1} \tau_i \Delta infr_{t-1} + \propto_i cpvol_{t-1} + \gamma_i exrvol_{t-1} + \theta_i Intr_{t-1} + \sigma_i infr_{t-1} + \varepsilon_t \quad (2)$$

where:

β_o = constant or intercept of the model
$\gamma_i, \propto_i, \theta_i, \sigma_i$ = long run coefficients
$\beta_i, \mu_i, \delta_i, \rho_i and\ \tau$ = short run coefficients

The apriori expectation for the core model variables in both short run and long run is: $\gamma, \propto, \theta, \sigma < 0$ for the long run parameters $\beta, \mu, \delta, \rho\ and\ \tau < 0$ for the short run parameters

The variables used in this study are presented and described in the table 3.4 below:

Table 1

Descriptive of Model Variables

Variable	Description	Measurement	Role	Source
EXCHANGE RATE	EXR	For each year, the exchange rate is computed by averaging the monthly values, representing local currency units relative to the US dollar	Aided the derivation of exchange rate volatility which is a key explanatory variable	Central Bank Statistical Bulletin
OIL PRICE	OILP	The figure reflects the average yearly oil price globally. Using the annual average accounts for both the international dimension and the exogenous characteristics of oil prices.	Aided the derivation of crude price volatility which is a key explanatory variable	Central Bank Statistical Bulletin
Real Gross Domestic Product Per Capita	RGDPPC	The GDP for each year, calculated at market prices in current US dollars, is aggregated in billions adjusted for price and divided by population.	Dependent Variable	World Bank, 2019
Exchange rate Volatility	EXRVOL	Derived from the GARCH (1,1) process with the standard deviation of the conditional variance of the contemporaneous exchange rate as the volatility series.	Independent Variable	Author Generated
Oil Price Volatility	OILPVOL	Derived from the GARCH (1,1) process with the standard deviation of the conditional variance of contemporaneous crude oil price as the volatility series.	Independent Variable	Author Generated

Generalized Autoregressive Conditional Heteroscedasticity Model, GARCH (1,1) was used to extract the volatility terms of the variables of the exchange rate and crude price, and address objectives 1 and 2. This is because a regular regression cannot be used to measure a rapid change like volatility. The key estimation method is the Auto Regressive Distributed Lag model (ARDL). It overcomes the shortcomings associated with the Ordinary Least Square (OLS) as an estimation method.

Following Pesaran, Shin and Schmidt (1995), this estimation technique accepts variables with different orders of integration I(0), I(1) or combination of I(0) and I(1); remains robust in the face of small sample size; addresses diagnostic problems such as autocorrelation, heteroscedasticity. etc.; models long run and short run elasticity simultaneously while it has the capacity to use different lag lengths for both the regressor and regressand.

The validity of the estimates are confirmed using an array of post-estimation tests and decisions are based on the 0.05 level of significance.

4 RESULTS

The results of pre-estimation tests designed to confirm the goodness of the dataset and help in selecting the appropriate estimation method are presented in this section. The basic and distributional attributes of the variables used in this research are summarized in TABLE 2:

Table 2

Summary of Basic Descriptive Statistics

Series	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Proba.
CRPRICE	80.1	76.4	122.4	33.2	28.2	0.0	1.6	4.4	0.1
CRPRICEVOL	142.5	148.1	172.9	0.0	27.8	-2.9	15.0	370.8	0.0
DCOVID	0.2	0.0	1.0	0.0	0.4	1.2	2.6	13.7	0.0
DUMRUC	0.1	0.0	1.0	0.0	0.2	3.8	15.1	428.7	0.0
EXR	249.9	208.5	417.6	148.1	95.6	0.3	1.6	5.0	0.1
EXRVOL	331.8	162.8	5022.0	0.0	735.1	5.6	34.9	2376.4	0.0
GDPPH	0.001	0.001	0.001	0.001	0.001	0.5	2.4	3.0	0.2
MPR	12.1	12.0	16.5	6.0	2.4	-1.2	4.3	16.1	0.0

The measures of central tendency, such as mean and median of all the variables, are reported in Table 2 as well as the spread and variation of the series represented by the standard deviation, minimum, and maximum. It can be inferred that the variables are closely knit around the mean and have good distributional features that allow for proper combination in a model.

Next, the degree and direction of linear association of the series are evaluated and reported by way of a correlational matrix. The results of the test of linear association of the variables are presented in Table 3. The correlation coefficients and the associated t-statistics are presented in a bivariate form to allow for the determination of the magnitude and direction of the association among the variables as paired.

Table 3

Correlational Matrix

	CRPRICEVOL	DCOVID	DUMRUC	EXRVOL	GDPPH	INTERCPEXVOL
CRPRICEVOL	1.000000					

DCOVID	-0.252560	1.000000				
	-1.808413	-----				
	0.0768	-----				
DUMRUC	-0.006452	-0.141975	1.000000			
	-0.044702	-0.993694	-----			
	0.9645	0.3254	-----			
EXRVOL	0.060115	0.078271	-0.064755	1.000000		
	0.417245	0.543945	-0.449578	-----		
	0.6784	0.5890	0.6550	-----		
GDPPH	-0.117082	0.596047	0.485328	0.174815	1.000000	
	-0.816782	5.142963	3.845733	1.230098	-----	
	0.4181	0.0000	0.0004	0.2247	-----	
INTERCPEXVOL	0.105815	0.050395	-0.061910	0.997284	0.151994	1.000000
	0.737250	0.349593	-0.429751	93.81400	1.065423	-----
	0.4646	0.7282	0.6693	0.0000	0.2920	-----
MPR	0.004261	0.075095	0.391916	0.100813	0.610277	0.101553
	0.029519	0.521746	2.951383	0.702032	5.337269	0.707233
	0.9766	0.6042	0.0049	0.4860	0.0000	0.4828

From the outcome variable and the core influencing variables, exchange rate volatility is found to share a positive relationship with welfare while crude price volatility has a negative correlation with welfare. Evidently, as the swing in crude price happens, there seems to be a deterioration in people's welfare in Nigeria where changes in crude price creates some negative transmission effect on several economic activities. As for the interactive term, it is observed that the interaction of crude price and exchange rate volatility tends to produce positive correlation with welfare of the people. This is not the core estimation method because correlation is not causation and it is only accepted as a preliminary observation or test.

Next, the test for the stationarity properties of the series is reported in table 4 below. The essence of the test is to establish the series order of integration, providing necessary direction for the study in choosing the most appropriate estimation technique for testing the formulated hypotheses.

Table 4

Summary of Structural Break Consistent Unit Root Tests

BREAK WITH INNOVATION OUTLINE (TREND AND INTERCEPT)					BREAK WITH ADDICTIVE OUTLINER (TREND AND INTERCEPT)			
VARIABLE	**ADF STAT**	**Critical Value @5%**	**BREAK DATE**	**ORDER OF INTEGRATION**	**ADF STAT**	**Critical Value @5%**	**BREAK DATE**	**ORDER OF INTERGRATION**
CRPRICE	-7.31	-5.18	2014Q3	I(1)	-7.66	-5.18	2014Q3	I(1)
CRPRICE VOL	-5.76	-5.18	2019Q2	I(0)	-15.84	-5.18	2019Q3	I(1)
DDCOVID	-6.23	-5.18	2018Q4	I(0)	-5.95	-5.18	2017Q2	I(1)
DUMRUC	-4.80	-4.44	2021Q3	I(0)	-8.31	-5.18	2019Q2	I(0)
EXR	-7.15	-5.18	2016Q2	I(0)	-10.36	-5.18	2016Q3	I(1)
EXRVOL	-17.80	-5.18	2016Q4	I(0)	-8.04	-5.18	2017Q2	I(0)
GDPPH	-23.13	-5.18	2020Q1	I(1)	-6.53	-5.18	2020Q2	I(0)
MPR	-6.50	-5.18	2011Q4	I(1)	-6.62	-5.18	2011Q4	I(1)

It is important to note that the structural break consistent unit root test is used instead of the traditional unit root test, that becomes weak in the face of structural breaks and outliers. The choice of this method is hinged on the fact that it accounts for breaks in the series. This innovative and additive test for outliers was used to account for outliers that trigger short-term breaks (additive outliers), as well as for those that trigger breaks that innovate all throughout the series (innovation outliers).

Following the result presented in table 4, the variables display different stationarity dispositions.

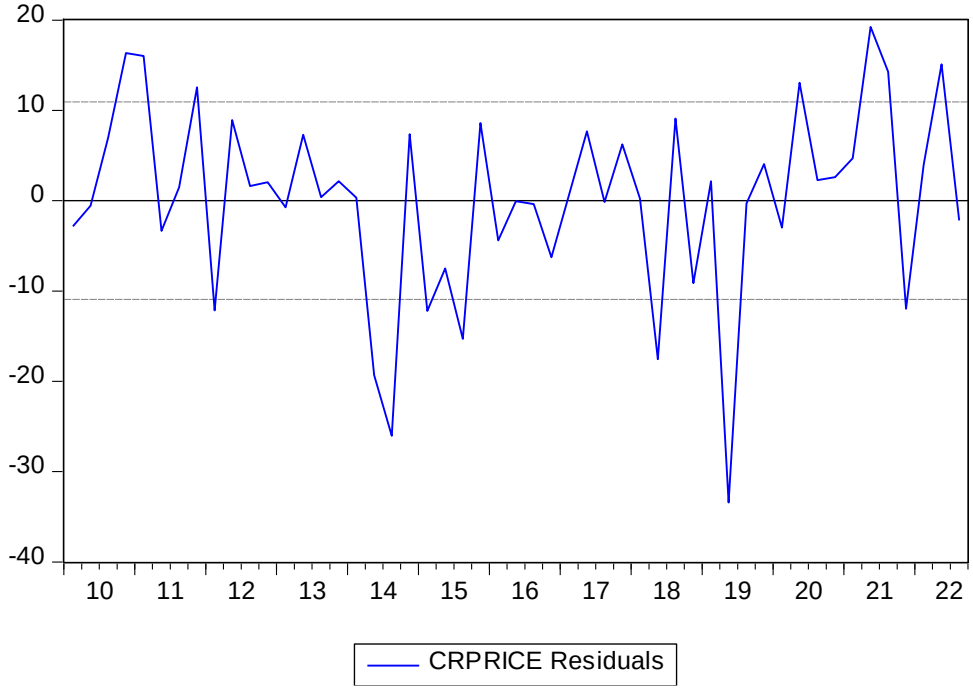
Specifically, all the variables are between levels I(0) and first difference I(1) in their order of integration. With this combination, it validates the choice of the Autoregressive Distributed Lag Model (ARDL) in this study, following Pesaran and Shin (2001). The ARDL accepts a combination of I(0) and I(1) variables; hence, it is the favored technique for the study.

4.1 Presentation of estimation output

The first set of estimation output tests the volatility profile of crude price and exchange rate, respectively. The graph shown as Fig. 4 is the volatility graph of crude price movement covering the period 2010Q1 to 2022Q3. Technically speaking, Fig. 4 is a plot of the residual of the standard variance of the GARCH (1,1) estimation with crude price as the variable of interest.

Figure 4

Volatility Graph of Crude Price Movement 2010Q1 to 2022Q3



A first look at the graph hints at the existence of prominent volatility pooling for the variable in the period under investigation. This can be inferred from the observation that high-volatility periods are typically followed by high volatility, as low-volatility periods are followed by low volatility. This position will further be validated by the GARCH test, which is reported in the succeeding section.

Also, to confirm the volatility profile of the exchange rate, the graph shown as Fig. 5 depicts exchange rate movement covering the period 2010Q1 to 2022Q3.

Figure 5

Volatility Graph of Exchange Rate Movement 2010Q1 to 2022Q3

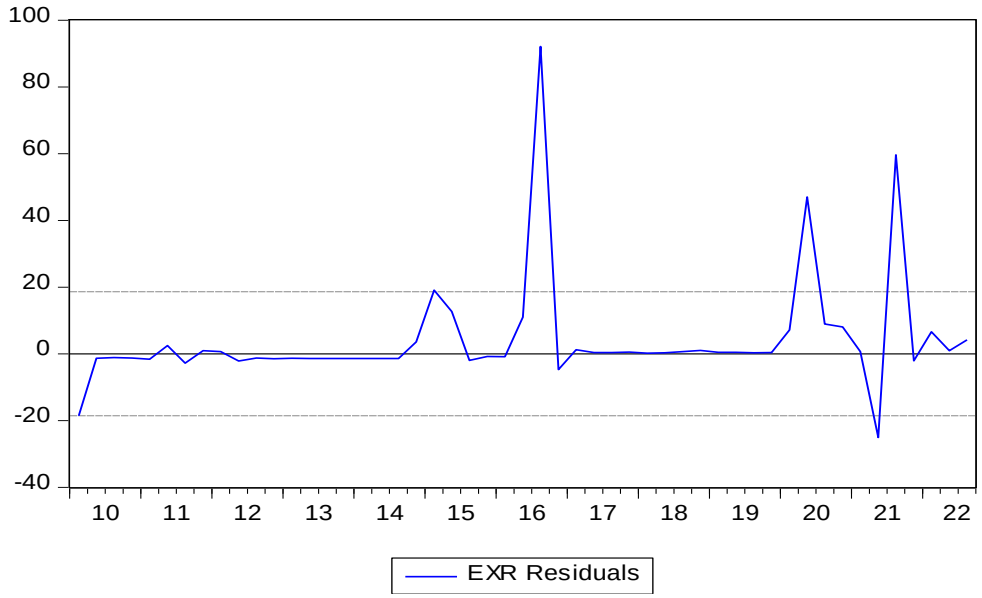


Fig 5 is a plot of the residual of the standard variance of the GARCH (1,1) estimation with exchange rate as the variable of interest. Volatility pooling and clustering are inferred from the graph.

Next, we present a summary of the ARDL estimates on the basis of which the next three hypotheses were tested. Table 5 contains the estimates for the three models with exchange rate volatility, crude price volatility and the interactive term of exchange rate and crude price volatility respectively.

Table 5

Summary of the Ardl Estimates for the Specified Models

DEPENDENT VARIABLE = GDPPH						
Variable	**Model 1**		**Model 2**		**Model 3**	
	Coefficient	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
EXRVOL	0.014	5.409***	-----	-----		
CRPVOL			-0.018	2.014**	---	----
EXRVOL x CRPVOL	---	----	---	----	0.012	2.489**
MPR	0.84	2.32**	0.84	2.32**	0.84	2.32**
C	-9.33	6.915***				
ECT (-1)	-0.98	6.932***				
Bounds Test (F)	11.21(0.0000)					
R^2	0.55					
DIAGNOSTIC TESTS						
BG(LM)	1.68(0.2007>0.05)					
BPG(HET)	1.4672(0.2280>0.05)					

RESET (RAMSEY)	0.1624(0.6894>0.05)
CUSUM^2	Stable

Source: Appendix Five

Before using the reported result to test the formulated hypotheses, it is expedient to show the validity and reliability of the estimates using the relevant diagnostic tests. In the first place the result is found to be without auto-correlated residuals as indicated by the BG serial correlation LM test with an insignificant F-stat. Also, the suspicion of heteroscedastic residuals is removed by the fact that the Bruesch and Pagan test (1.4672, p>0.05) shows homoscedasticity. The stability of the model is confirmed by both the CUSUM graph (See Appendix 5) and the reported Ramsey Regression Error Specification Tests (RESET) (0.1624 p>0.05). This implies that the model follows a correct functional form, is void of specification errors and there are no redundant variables in the specified and estimated models. As such, the models can be used to test our hypotheses and guided inferences can be made.

A noticeable oscillation or swing in the graph of the residuals and an insignificant p-value of the Chi-square and F-statistics of the ARCH tests show evidence of volatility in the variables (exchange rate and crude price), while the reverse suggests absence of volatility clustering. Given the observed swing in the graph of the exchange and crude price residual (See Fig. 4 and 5), we conclude in favor of volatility clustering in the exchange rate profile of the Nigerian economic environment. Observably, exchange rate and crude price are predisposed to shocks emanating from different economic events global financial crises, the Russian-Ukrainian impasse and other domestic socioeconomic issues of various degrees and dimensions. This finding agrees with Osarumwense (2015) who not only confirmed the volatility of the variables in question but also, showed that there is a leverage effect arising from such volatility.

In the exchange rate and welfare interaction, the result shows that exchange rate volatility positively and significantly affects welfare. The result indicates that a unit increase in exchange rate volatility improves welfare by 1.4%. This is significant given that the t-stat of 5.409. The welfare positive impact of exchange rate swing may arise from the gains of arbitrage and diaspora remittances. With a massive diaspora population, Nigerians transfer foreign currencies, which are changed to local currencies and form the basis for enhanced household spending and consumption. This ultimately leads to

improved standards of living for the domestic population, as enhanced by the inflow from the diaspora population (See Ogunbiyi et.al, 2021).

The evaluation of the linkage between crude price and welfare shows that crude price volatility negatively and significantly affects welfare. The result indicates that a unit increase in exchange rate volatility worsens welfare by 1.8% and this is significant given that the t-stat of 2.014 is statistically significant. The fact that the impact is negative is not disconnected from the central nature of crude price to the Nigerian economy and the transmission effect that arises from swings in crude price. Within the studied period, such incidence as the COVID-19 pandemic, global financial crises, Russian-Ukrainian spat, among others, all led to predominant negative swings in crude price, which led to a drop in the Nigerian government's revenue. Nigeria experienced recession twice within the mainly due to dwindling revenue caused by crude price swings. This is hardly surprising given that as a monolithic economy, crude oil represents the mainstay of the economy. From the domestic economic perspective, changes in even the refined elements of crude leaves negative impact on almost every facet of the nation's economic life, not excluding people's welfare. This finding is consistent with the findings of a the Nigerian-specific study of Ogundipe and Ogundipe (2018), Jimenez-Rodriguez and Sanchez (2018), with focus on OECD countries, including Habib and Kalamova (2017) for Saudi Arabia.

Lastly, we evaluated the interactive term of exchange rate and crude price volatility which shows a positive and significant effect on welfare. The result indicates that a unit increase in the interactive term improves welfare by 1.2% and this is significant given that the t-stat of 2.489 is statistically significant. The test observed that a combination of exchange rate and crude price volatility brings about a dousing effect on the negative influence of crude price volatility and cumulatively led to a positive impact of the interactive term on welfare. Markedly, this is a major gap that the study fills and goes to prove that the positive effect of the movement in the exchange rate can create an ameliorating effect on crude price volatility.

5 CONCLUSION AND POLICY IMPLICATIONS

This study investigated the respective and collective impact of exchange rate volatility and oil price turbulence on the welfare of Nigerian citizens. The study is set within the Nigerian economy as the geography of interest, given the exchange rate

problems facing the country and the continuing impact of crude price movement on the welfare of Nigerians.

This study is made more apt by the fact that the poverty and human development indexes of the country keep taking a downward turn. Interrogating whether or not the economic status of citizens of Nigeria benefits from the collective impact of exchange rate and crude price movement is therefore of great importance.

Using a collection of econometric methods, the key finding of the study indicates that the interplay of exchange rate and crude price volatility alters the adverse impact of crude price volatility to produce a positive interactive impact on welfare. Other findings include that:

- Sufficient volatility clustering exists in the exchange rate and crude price in the Nigerian ecosystem. This means that the exchange rate and crude price in Nigeria are volatile enough to provide grounds for an investigation of their welfare impact.
- Exchange rate volatility positively and significantly influences welfare in Nigeria. Given the t-statistic of 5.409 with the associated significant p-value, it is held that exchange rate volatility exerts a positive influence on the welfare of Nigerians.
- Crude price volatility negatively and significantly affects welfare in Nigeria. Given the t-statistics of 2.014 with the associated significant p-value, the study concluded that crude volatility exerts a significant influence on the welfare of Nigerians, even though the welfare impact was found to be negative.
- The interaction of the volatility of crude price and exchange rate positively and significantly affected the welfare of Nigerians. Given the t-statistic of 2.489 with the associated significant p-value, it is inferred that the interaction of crude price and exchange rate volatility improves the welfare of Nigerians.

This study adds to the literature on exchange rate swings, crude price movement, and the welfare of citizens in developing countries such as Nigeria. However, it does not claim to be exhaustive but open to more contributions as it triggers further insight into how exchange rate and crude price adjustments, and policies can improve the standard of living of the citizens.

Based on the findings arising from the study, the following policy, research, and society-based recommendations are made:

1. That exchange rate regime with the capacity to produce a positive welfare impact should always be adopted by the monetary authorities. This is in line with the

observation that the exchange rate in Nigeria is not only volatile but can also elicit a positive reaction from welfare. Such movements can create adverse reactions if left uncontrolled. This is where due policy control becomes expedient.

2. The position of crude oil with its price movement is already very prominent in the literature. The observation that crude price volatility adversely affects welfare is not only theoretically and empirically correct, it is also intuitively right because of the crude oil/ energy position as a major driver for leveraging productivity and alleviating poverty in an economy. It is therefore recommended that stronger policies as safety nets need to be created to ameliorate the adverse welfare effects of crude price volatility. This adds a voice to the desirability or otherwise of a subsidy on petrol price in Nigeria. Even if revoked, what other cushioning policies has the government introduced to mitigate the heavy burden on the citizens they want to alleviate their poverty? The need for consideration is reinforced by this study.
3. The study further recommends that policy interdependence and interaction should be heightened to allow for adverse policy reactions to be contained by positive policy reactions. The fact that the interaction of exchange rate volatility with crude price volatility reverses a negative trend in crude price effect justifies this recommendation.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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