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Impact of Liquefied Natural Gas Exports on the Nigerian Exchange Rate: An ARDL Cointegration Approach, 2000 to 2021

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ABSTRACT

This study aimed to investigate the impact of liquefied natural gas (LNG) exports on the exchange rate of Nigeria. The investigation employed an autoregressive distributed lag model (ARDL) methodology to analyse data spanning the years 2000 to 2021 using a biannual dataset. The empirical findings provided evidence of a statistically significant and positive influence of liquefied natural gas exports on the exchange rate. This is supported by the results obtained from the short-term analysis. The research results revealed no causal link between the exports of LNG and the exchange rate in Nigeria. The study concludes that LNG exports cause the Naira to depreciate. The research suggested that the government should actively endorse and facilitate the expansion of non-oil and gas sectors, including agriculture, manufacturing, and services, to cultivate a more varied export portfolio. Moreover, adequate reserves can be used to stabilize the Naira during periods of volatility caused by fluctuations in LNG exports or other external factors.

INTRODUCTION

Nigeria possesses considerable reserves of natural gas, which have been a source of strategic importance since 1999 with the establishment of the liquefied natural gas (LNG) industry. This development aligns with the Nigerian Gas Master Plan, aiming to broaden the country's revenue streams and diminish reliance on the exportation of crude oil. The exportation of LNG has facilitated the generation of foreign exchange earnings, the attraction of investment, and the promotion of economic growth (Khan, 2015). Nevertheless, the correlation between LNG exports and the exchange rate in Nigeria is intricate and diverse, as it is shaped by a range of economic, policy, and external factors. Over the course of the past two decades, Nigeria has experienced substantial growth in its LNG sector, establishing itself as a prominent producer of natural gas within the African continent. The exploration of natural gas and subsequent development of the Nigerian LNG plant has significantly contributed to the diversification of the nation's export portfolio, thereby mitigating its substantial reliance on crude oil. Exports of LNG refer to the international trade of LNG, which is a clear, odourless, and non-toxic form of natural gas that has been converted into a liquid state through a cooling and condensation process. LNG is characterised by its transparency, lack of odour, and non-toxic properties. LNG is predominantly comprised of methane and is generated through the process of cooling natural gas to a temperature of approximately -162 degrees Celsius (-260 degrees Fahrenheit). This cooling procedure results in a reduction in volume, facilitating efficient and secure transportation of LNG via tanker vessels (Onolehemhen, *et al.*, 2017).

LNG exports encompass the commercial transaction and transportation of LNG from the exporting nation to various importing countries or global markets. Specialised LNG carriers are responsible for the transportation of LNG to designated receiving terminals situated in the importing nations. At the terminals where the LNG is received, a process called vaporisation is employed to convert the LNG back into its gaseous state, enabling its distribution and utilisation. The significance of LNG exports has grown considerably within the global energy market due to the various advantages it offers in comparison to conventional pipeline gas transportation. This technology offers enhanced flexibility with regard to the distribution of natural gas, enabling countries lacking direct pipeline connections to effectively access these valuable resources. The exportation of LNG plays a significant role in enhancing energy security, promoting the diversification of energy sources, and facilitating international trade in natural gas. Countries that export LNG, including Qatar, Australia, the United States, and Nigeria, have a significant impact on satisfying the increasing global demand for natural gas (Chien-Chiang *et al.*, 2011; Barril & Navajas, 2015; Felipe *et al.*, 2018). These nations allocate resources towards the establishment of LNG production facilities, infrastructure, and export terminals to facilitate the processes of liquefaction, storage, and transportation that are integral to the trade of LNG. The growth of LNG exports has been propelled by various factors, including the rising need for more environmentally friendly energy options, economic motivations, geopolitical influences, and advancements in LNG technology (Hong, 2013). The expansion of the LNG trade has significantly altered the energy sector, facilitating the linkage between regions that produce natural gas and those that consume it. This development has played a pivotal role in fostering energy collaboration and enhancing global integration. In

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general, the exportation of LNG constitutes a substantial element within the realm of global energy commerce. This practice facilitates the cross-border utilisation of natural gas reserves and contributes to the enhancement of energy stability and economic progress for both exporting and importing nations.

Exchange Rate Dynamics in Nigeria

Exchange rate dynamics in Nigeria refer to the fluctuations and movements of the Nigerian currency, the Naira, in relation to foreign currencies, particularly major global currencies such as the US dollar, Euro, and British pound. The exchange rate, or the cost of exchanging one currency for another, has a major impact on a nation's capacity to trade internationally, attract foreign investment, and maintain economic growth and prosperity. The value of the Nigerian Naira is set in part by the supply and demand for foreign currency on the international market. On occasion, however, the Central Bank of Nigeria (CBN) steps into the market to control currency rate stability and prevent undue volatility. Several variables affect the fluctuation of the Nigerian currency exchange rate including:

Balance of Trade

Currency supply and demand in Nigeria are both influenced by the country's trade balance, which is the amount by which exports exceed imports. When Nigeria has a trade surplus, there is an increased demand for Naira, strengthening its value. Conversely, a trade deficit puts downward pressure on the Naira.

Foreign Direct Investment (FDI)

The value of a currency may rise or fall in response to changes in the volume of foreign direct investment. Foreign direct investment (FDI) may cause a rise in the value of the Naira since it shows confidence in the country's economy and boosts demand for the Naira.

Oil Prices

Since Nigeria is a major oil exporter, the country's currency value is very sensitive to changes in international oil prices (Yunusa, 2020). Since a large proportion of Nigeria's foreign currency revenues come from oil exports, falling oil prices might cause the Naira to weaken.

Inflation and Interest Rates

Depreciation of a currency may occur if inflation rates are persistently high (Salisu & Ayinde, 2016). Interest rate changes and other monetary policy measures taken by the central bank affect inflation and, by extension, the value of a currency's exchange rate.

The Nigerian exchange rate has experienced periods of volatility and depreciation over the years, attributed to factors such as economic imbalances, external shocks, policy decisions, and market expectations (Vincent *et al.*, 2021). The CBN has used interventions in the foreign currency market, capital controls, and foreign exchange restrictions to maintain exchange rate stability.

Given Nigeria's heavy reliance on oil exports and the potential for LNG exports to contribute significantly to its foreign exchange earnings, it becomes essential to examine the relationship between LNG exports and the Nigerian exchange rate. The economic dynamics, policy ramifications, and possible risks connected with LNG exports may all be better understood with a firm grasp of this connection. The importance of the research is huge. Using the ARDL cointegration method, this research aims to assess LNG exports and the Nigerian currency rate from 2000 to 2021. Consequently, this study will greatly benefit key stakeholders in Nigeria. Specifically, understanding the impact of LNG exports on the Nigerian exchange rate is of utmost importance for policymakers, economists, and industry stakeholders. The exchange rate is a crucial determinant of a country's competitiveness in the global market, investment attractiveness, and overall economic stability. Exploring the dynamics between LNG exports and the exchange rate will shed light on the potential effects of LNG industry developments on Nigeria's macroeconomic performance.

The main goal of this study was to:

i. To assess the impact of LNG exports on the Nigerian exchange rate

ii. To determine the causality between LNG exports and the Nigerian exchange rate.

While many studies in Nigeria and elsewhere have focused only on the effects of exchange rates and volatility on exports, others have examined the role of exchangeratese in stimulating economic expansion. This research set out to address the gap that exists in the literature. Using an autoregressive distributed lag (ARDL) model proposed by Pesaran *et al.* (2001), this study aimed to empirically examine the influence of Nigeria's LNG exports on the country's exchange rate.

Consequently, the following hypotheses in null form (H_0) guided the study:

i. H_{01}: LNG exports have no significant and positive impact on the Nigerian exchange rate

ii. H_{02}: There is no causal relationship between LNG exports and the Nigerian exchange rate

The present paper is structured into distinct sections. The initial segment encompasses several key components, including the introduction, research problem, study objective, hypothesis statement, theoretical background, and empirical literature review. The subsequent section provides an overview of the methodology employed and the data utilised in the study. The subsequent section of the manuscript provides an exposition of the findings and subsequent analysis. Finally, the fourth section discusses the Conclusion and Recommendations.

Theoretical Background

This analysis was founded on the theory of export-led development. The export-led growth theory is founded on the perspectives of classical and neo-classical economic theory. Export is the primary determinant of economic

development, according to this theory (Schmidt, 2020). The theory of export-led development is an economic framework that emphasises the correlation between a country's exports and its overall economic growth. The proposition asserts that increasing the quantity and value of exports can have a positive effect on a country's economic development, resulting in improved quality of life and higher employment rates. This theory emphasises the significance of increasing a nation's competitiveness in the international market by producing in-demand products and services. This is accomplished by offering products of superior quality, at competitive prices, and per international standards. To achieve export-driven economic growth, nations must implement policies and strategies that enable them to access international markets, reduce trade barriers, and negotiate advantageous trade agreements with other nations. According to the theoretical framework utilised in this study, it is posited that an increase in LNG exports has the potential to stimulate economic growth, thereby influencing the exchange rate. Enhanced LNG export revenues have the potential to boost the value of the Nigerian Naira by increasing the inflow of foreign currency and bolstering the country's foreign exchange reserves.

Empirical Literature Review

The study conducted by Musa *et al.* (2019) examined the influence of crude oil price and exchange rate on Nigeria's economic growth from 1982 to 2018 using the ARDL Approach. It was determined that these factors exert a notable positive impact on both the long-term and short-term durations. The study proposes that a strategy of diversifying revenue streams through agricultural activities, industrial development, and investment can effectively mitigate the dependence on crude oil and the consequent income volatility resulting from fluctuations in oil prices.

Sieng *et al.* (2020) examined the factors influencing export levels in Indonesia, the Philippines, Malaysia, and Thailand. The study aimed to estimate the effects of import, exchange rate, foreign direct investment (FDI), inflation, and crude oil on exports. Three econometric techniques and three-panel data estimation models were employed to achieve this. The findings indicated a positive relationship between import and exchange rate with exports in all four countries, while FDI exhibited a significant negative impact. Based on these results, the study recommends that governments prioritise the provision of peace and political stability as a means to stimulate exports and attract greater levels of investment.

Kandil and Mirzaie (2002) looked at how changes in exchange rates impacted production and prices in different industries in the United States. According to the study's results, expansionary and contractionary variables have a neutral effect on the rate of increase in industrial real production. Nevertheless, the appreciation of the dollar results in a noteworthy decrease in price inflation across various sectors, with a particular emphasis on the finance industry. The outcome aligns with the decrease in overall demand caused by net exports and the rise in overall supply resulting from the decreased expense of imported intermediate goods. The study's findings indicate that the limited level of openness observed in US industries results in moderate price effects caused by external shocks and fluctuations in exchange rates, while not significantly impacting output growth. Hence, the lack of empirical support for the detrimental impact of dollar appreciation on economic performance in various sectors of the United States refutes the aforementioned concerns.

Udoudo *et al.* (2023) investigated the influence of LNG exports on inflation in Nigeria during the period spanning from 2000 to 2021. The study employed the Autoregressive Distributed Lag (ARDL) bound co-integration approach to examine the impact of inflation in both the long term and short term, revealing diverse effects. The impact of natural gas prices and crude oil prices on inflation was negative, whereas LNG exports did not have a significant effect. The study suggests that the government should maintain its support for the LNG sector, with a particular emphasis on investing in infrastructure and technology to improve competitiveness and efficiency.

Using a VAR (Vector Autoregression) model, Akpan's (2009) research investigated the dynamic connection between oil price shocks and important macroeconomic indicators in Nigeria. Positive and negative shocks were shown to have equally large and asymmetrical effects on inflation, with the former causing a rise in real national income and the latter in export profits. However, the author discovered that some of the gains are counterbalanced by reduced demand for exports due to economic downturns experienced by trading partners. The study also revealed a strong positive correlation between oil price fluctuations and government expenditures but found minimal influence on industrial output growth. The author emphasizes the need for policymakers to implement policies that enhance and stabilize the Nigerian economy, prioritizing measures like exploring alternative sources of government revenue, implementing fiscal discipline, and saving oil boom proceeds to better withstand future oil shocks.

In their study, Hassan *et al.* (2013) conducted an analysis to examine the influence of various macroeconomic factors, including exchange rate and economic growth, on the performance of Pakistan's exports. The researchers utilised time series data for their investigation. The researchers employed the Augmented Dickey-Fuller (ADF) Unit Roots Test and the Autoregressive Distributed Lag (ARDL) model to ascertain the long-term association between the variables. The research discovered a sustained equilibrium connection between the export performance of Pakistan and its determinants. The impact of the exchange rate, gross domestic production, and trade openness on export performance are found to be positive and statistically significant, whereas the influence of foreign direct investment is deemed to be

insignificant. The labour force estimates suggest that export-oriented sectors, which necessitate a skilled labour force, are adversely impacted by both higher growth and a deficiency in skills.

Alam (2010) evaluated the influence of Taka's actual exchange rate depreciation on Bangladesh's export revenues. The macroeconomic series utilised in this study are non-stationary, specifically integrated at order one, but they do not exhibit cointegration. The application of the Granger Causality test utilising the vector autoregressive (VAR) model yielded results indicating the absence of a causal relationship between real depreciation and export earnings. This underscores the necessity of conducting sub-sector analysis, evaluating incentive policies, and enhancing the proportion of local commodity exports. However, before enacting devaluation or depreciation policies, it is necessary to evaluate the negative impacts of depreciation on macroeconomic indices, particularly inflation.

Aliyu's (2009) research aimed to quantitatively assess the impact of exchange rate fluctuation on the volume of Nigeria's non-oil exports. The research used a basic analytical technique, which postulated that the naira exchange rate volatility, US dollar volatility, Nigeria's terms of trade, and the index of openness (OPN) all have a role in the fluctuation of non-oil exports. The data supported the existence of a unit root at the level, however, the lack of stationarity was rejected as a null hypothesis. The results of the cointegration study show that non-oil exports are linked to the basic variables in a stable, long-term equilibrium. The report suggests methods to increase openness and promote stability in the Nigerian currency market.

Berman *et al.* (2012) studied the response of French firms to real exchange rate fluctuations from 1995 to 2005. They found that high-performance firms increase their markup and export volume, while low-performance firms decrease demand elasticity. This indicates that different approaches to pricing the market may explain why changes in the value of one currency have relatively little effect on export volumes as a whole. Identifying and compensating for the effects of currency exchange rate variations on export volumes was emphasised.

Udoudo *et al.* (2023) used biannual data to analyse the effect of Nigeria's LNG exports on the country's GDP from 2000 to 2021. The study used an ARDL model and a unit root test to analyze the variables. The results showed a positive association between LNG exports and the Nigerian economy, with a 1% increase in LNG exports resulting in a 0.72% increase in GDP. In the short term, a marginal increase in LNG exports would lead to a 0.23% GDP gain. To ensure a steady supply of natural gas to Nigeria's LNG plants, they advised the government to increase spending on the sector and take the initiative to push for the construction of floating LNG plants in regions where laying pipelines would be too costly. However, their study did not consider the effect of LNG exports on Nigeria's exchange rate.

Using monthly data from 1996–2015, Oluyemi and Isaac (2017) studied how currency exchange rates affected Nigeria's exports and imports. They looked at the correlation between the USD/NGN exchange rate, exports, and imports using a vector autoregression (VAR) model with three independent variables. The research indicated that imports and exchange rates had a positive but statistically insignificant association, whereas exports had a negative effect on exchange rates. The research found that fluctuations in exchange rates did not significantly influence imports and exports in Nigeria. The study suggests promoting export activities, focusing on the non-oil sector, to foster entrepreneurial development and mitigate excessive import levels.

Nguyen's (2016) study found a significant positive correlation between exports and Vietnam's economic growth from 1990 to 2015. The study found that exports accelerate industrialization and modernization, positively affecting GDP growth in both current and future years. The author recommended that local governments and export enterprises foster export activities and their effects, promoting sustainable economic growth in emerging and developing nations reliant on commodity exports. However, the study did not consider the potential impact of exports on Vietnam's exchange rate.

The effect of currency rate volatility on Nigeria's export from 2008 to 2021 was researched by Musa *et al.* in 2023. The research used secondary data from the Statistics Database and the ARDL-Error Correction Model and Bound Test. Although only real effective exchange rate volatility was statistically significant, the analysis indicated that long-run exchange rate volatility was negative. While exchange rate volatility generally had a negative short-term impact, real effective and nominal effective exchange rate volatility were statistically significant. To increase trade and broaden export markets, the research suggested stabilising the value of the Naira and diversifying Nigeria's export mix.

Ikechi and Nwadiubu's (2020) study explored the potential positive effects of exchange rate fluctuations on Nigeria's international trade dynamics, specifically looking at the potential for increased export and import transactions. The research used secondary data from 1996 to 2018 and employed econometric methodologies to establish correlations. The VAR model estimations showed a negative correlation between exports, imports, and the real effective exchange rate (REER) during the present period. An increase in both export and import during a specific year resulted in a decrease of approximately 0.9% and 0.4% in the REER, respectively. The analysis of variance decomposition analysis revealed that shocks play a significant role in accounting for the variations observed in the real effective exchange rate and the levels of exports and imports. The impulse response analysis showed a negative correlation between exports and the real effective exchange rate, while imports significantly impacted exports. The ARCH modelling framework posits a primary Arch effect and a statistically significant

GARCH component. The findings suggest that the Real Effective Exchange Rate (REER) exhibits high volatility, leading to a clustering effect on import and export trading activities in Nigeria. Since financial shocks tend to amplify changes in exchange rates, the authors suggest employing monetary and fiscal actions to mitigate the detrimental effects of these swings.

Goya (2020) looked into whether or not there was a connection between a country's currency exchange rate and the diversity of the goods it exported as part of its research project. The primary data utilised in this research was sourced from the World Trade Flows dataset and the International Monetary Fund's International Financial Statistics, covering the period from 1962 to 2000. Various estimation techniques were employed, including fixed effects, dynamic GMM, Mean Group, and Pooled Mean Group estimators. The findings indicate a positive association between export variety and a depreciated exchange rate, while a negative relationship was observed between export variety and exchange rate volatility. Furthermore, these relationships were found to be more pronounced for goods with higher levels of technological intensity.

Rümeysa's (2018) research attempted to learn how fluctuations in the value of the Turkish lira affect the country's exports. For this study, the researcher used an ARDL border test and a model for correcting statistical errors. By evaluating a dataset with monthly observations from January 1995 to January 2017, this study looked into how changes in exchange rates affected export volumes. To check for cointegration between variables, the Bound Test Method was used. The analysis found that both the long-term and short-term indicators' observed coefficients lined up with expectations. As a result, it seems that imports have a favourable effect on the industrial output index and exports, both in the short and long terms. Nonetheless, it can't be denied that the effective exchange rate index and volatility have been negatively affected both in the long and short term.

Djatmiko and Nugroho (2019) performed research between 1996 and 2017 to analyse the effect of Indonesia's oil and gas exports and non-oil exports on the country's foreign exchange reserves. Researchers used 22 yearly observations analysed using SPSS 24. Indonesia's non-oil and gas exports and oil and gas exports are the independent variables, while the country's foreign currency reserves are the dependent variable. The researcher used multivariate linear regression analysis to look at how the independent factors affected the dependent one. The research found that Indonesia's foreign currency reserves are influenced positively and statistically significantly by both oil and gas export and partial export of goods other than oil and gas. The authors suggested that the non-oil and gas sector should engage multiple government agencies, including the Ministry of Trade, the Coordinating Ministry for Economic Affairs, and the Ministry of Transportation, among others. This collaboration would enable private entities to work in synergy with regional governments as contributors to the commodity sector.

In their study, Wildan *et al.* (2020) conducted an analysis of the impact of macroeconomic factors on the management of natural gas exports in Indonesia. The researchers utilised secondary time series data spanning a period of 22 years, specifically from 1995 to 2017. The variables considered in this study encompassed domestic consumption, exchange rate, international price, and GDP per capita of the importing country. The employed analytical approach was the auto-regressive distributed lag (ARDL) method. The findings of the analysis indicated that, in the immediate term, various factors including domestic consumption, exchange rates, natural gas prices, and GDP per capita exert a significant influence on the magnitude of natural gas exports. In the long term, the outcomes align with those observed in the short term, wherein various independent variables, including domestic consumption, exchange rates, international prices, and GDP per capita, notably influence the magnitude of natural gas exports.

Bakari and Mabrouki (2017) analysed the effect of exports and imports on Panama's GDP. Each year's data from 1980-2015 was checked using the Granger-Causality tests and the Johansen co-integration analysis of the Vector Auto Regression Model. The results of the study showed no connection between exports, imports, and GDP growth in Panama. However, it was shown that imports and exports contribute to economic development in both directions. These results indicate that international commerce is a major contributor to Panama's thriving economy.

Dogo and Aras (2021) examined how Naira-Dollar exchange rate volatility affected Nigerian imports and exports between 1990 and 2019. The CBN, NBS, and International Financial Statistics provided data for all indicators except volatility. The autoregressive distributed lagged (ARDL) and exponential generalised autoregressive conditional heteroscedasticity (EGARCH) models were used to evaluate the short- and long-term associations between Naira-Dollar exchange rate fluctuations and imports and exports. Long-term research showed that fluctuations in the Naira-Dollar exchange rate were related to Nigeria's imports and exports, while short-term research did not find any such relationship. To enhance the trade balance, the report advises government to continue export promotion and import reduction.

Using data from 2005's first quarter to 2020's fourth quarter, Duru *et al.* (2022) investigated the impact of fluctuating currency rates on Nigeria's exports. The amount of exchange rate volatility, with an emphasis on the nominal effective exchange rate, was evaluated using the ARCH model and its later expansions, including the GARCH, TARCH, and EGARCH models. The short- and long-term effects of exchange rate volatility on exports were examined using the Autoregressive Distributed Lag (ARDL) Bounds test approach. Results showed that currency fluctuations do occur. Furthermore, while the influence of exchange rate changes on exports was determined to be statistically negligible, the study's

results nonetheless revealed that such fluctuations had a negative effect on exports. The report concludes that the Central Bank of Nigeria should work towards establishing consistent exchange rate systems via the implementation of appropriate exchange rate rules. Additionally, the government must establish a conducive environment that facilitates the production of goods that are suitable for exportation.

Vivoda (2022) looks into the top five LNG producers in the world, which are Australia, Qatar, the USA, Russia, and Malaysia. By focusing on energy exports, the study tried to fix the fact that most research on energy policy is focused on energy imports. In the piece, the supplies of LNG by five companies were compared, taking into account how much they were different from each other. It used eight factors to describe the trends of LNG export diversification among providers from 2009 to 2021. It also used a well-known method, the Herfindahl-Hirschmann index of market concentration, to calculate and classify the amount of LNG export diversification. The paper found that the position and the difference in natural gas prices between regional markets have the most power to explain. This result has important policy implications for how LNG-exporting nations act. It also shows how sensitive these nations are to economic forces.

AboElsoud (2010) research addressed important empirical questions regarding the relationship between natural gas exports and Egyptian economic growth by extending Dirtsakis's model with the addition of the labour force into the model and further by addressing the issue in a disaggregated framework. This study analyzed the issue of ELG and NGELG hypotheses in Egypt using the VAR analysis, quarterly time-series data over the period 1991: q1-2009:q4. The empirical results tend to favour the effectiveness and validity of the ELG and NGELG hypotheses for Egypt. In other words, the results indicated that Natural Gas exports promote economic growth. He recommended that Egypt should be the key gas "trader" for decades to come because based on geographical location we are the African gate to the European and Central Asia gas markets.

Truong *et al.* (2022) conducted a study examining the asymmetric effects of Exchange Rate Volatility (ERV) on Vietnam's international trade during the period spanning from January 2010 to December 2019. The research employed time-series data and the Nonlinear Autoregressive Distributed Lag (NARDL) model to analyse the correlation between exchange rate volatility (ERV) changes and the trade balance. The study's findings indicate that in the short term, positive changes in the exchange rate volatility (ERV) negatively impact the trade balance. However, in the long term, improvements in ERV have positive effects on the trade balance. The negative changes observed in the ERV did not yield a statistically significant impact. To ensure the trade balance in Vietnam can be maintained over the long term, they suggested that the government adopt a policy of a stable currency rate.

METHODOLOGY

Description of Data

This study examines the impact of exporting Liquefied Natural Gas (LNG) on the exchange rate of Nigeria from the year 2000 to 2021. The biannual data series of the Naira/Dollar exchange rate, Nigeria LNG exports, Henry Hub Natural Gas price, and Brent Crude Oil price have been considered. The dependent variable in this study was the exchange rate, while the independent variables were LNG exports, Natural Gas price, and Crude Oil price. This study's data was collected from reputable sources such as the BP Statistical Bulletin, Statista, the Energy Information Administration (EIA), and the World Development Indicators.

Empirical Methodology

The primary objective of this research was to analyse the effect of Nigeria's LNG exports on the country's currency exchange rate. The Autoregressive Distributive Lag (ARDL) test for co-integration, established by Pesaran *et al.* (2001), is used in this research. This methodology is utilised to conduct both abound and cointegration tests. This methodology employs empirical analysis to examine the variables' long-term relationships and short-term dynamic interactions. One of the main benefits of this methodology is its utilisation of regressors that exhibit stationarity at either I(1) or I(0), or potentially a combination of both (Ogunnusi & Ajibode, 2023). This characteristic assists in circumventing the challenges that arise when testing for a unit root. The ARDL approach has been found to effectively address endogeneity concerns, as demonstrated by Javed and Husain (2020). The application of the ARDL test to examine cointegration in a small sample size is relatively straightforward, whereas the Johansen technique necessitates a larger sample size to conduct the cointegration analysis effectively. The aforementioned methodology expeditiously assesses the variables, regardless of their disparate optimal lags (Ozturk & Acaravci, 2010). The multivariate model (Equation 1) was employed to investigate the association between the variables. Prior to conducting further analysis, the values were logarithmically transformed to mitigate potential heteroscedasticity in the data.

$$LEXRt = \beta_0 + \beta_1 LLNGt + \beta_2 LNGPt + + \beta_3 LCOPt + \epsilon_t \quad (1)$$

where: in Eq. (1) LEXR is the natural log of the exchange rate, LLNG is the natural log of LNG exports, LNGP is the natural log of Natural Gas price, and LCOP is the natural log of Crude Oil price. Whereas 't' is the time period, however, β_0, is the intercept, β_1, β_2, and β_3 are the coefficient of slop respectively, and ε is the white noise error.

ARDL Estimation and Specification

Equation 2 presents the formulation of the multivariate unrestricted error correction model (UECM) within the framework of the ARDL-bound approach.

$$\Delta LEXRt = \alpha_0 + \sum^{p}_{(i=1)} \alpha_{1i} \Delta LEXR_{(t-1)} + \sum^{q1}_{(i=0)} \alpha_{2i} \Delta LLNG_{(t-1)} + \sum^{q2}_{(i=0)} \alpha_{3i} \Delta LNGP_{(t-1)} + \sum^{q3}_{(i=0)} \alpha_{4i} \Delta LCOP_{(t-1)} + \beta_1 LEXR_{t-1} + \beta_2 LLNG_{t-1} + \beta_3 LNGP_{t-1} + \beta_4 LCOP_{t-1} + \epsilon_t \quad (2)$$

Here, LEXR refers to the natural log of exchange rate; LLNG is the natural log of LNG export quantity, LNGP is the natural log of natural gas price, and LCOP stands for the natural log of crude oil price. Δ is used to present the operator difference, the error is denoted by ϵt; p is the optimal lag lengths of the dependent variable and q1, q2 and q3 are the optimal lag lengths of the independent variables, α0 is the constant, α1 - α4 are the coefficients of the differenced variables, β1 - β4 are the coefficients of the lagged variables. The bound test is broken down into three distinct steps and relies on joint F-statistics to determine the outcome of the cointegration process.

Step One

This analysis assists in examining the potential long-term relationship between the series using the ordinary least squares (OLS) method. OLS helps determine the combined significance of coefficients at the lagged level in Equation 2. The null hypothesis posited for the series can be formally expressed as "H_0: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0$", Conversely, the alternative hypothesis is articulated as "H_1: $\gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq \gamma_5 \neq \gamma_6 \neq \gamma_7 \neq 0$." The utilisation of bound test is employed to ascertain the upper bound value, represented as I (1), and the lower bound value, represented as I(0), within the realm of regression analysis. If the computed F-statistic falls below the lower bound value, it becomes implausible to dismiss the null hypothesis, thereby signifying the lack of cointegration among the variables. If the calculated F-statistics surpasses the predetermined upper threshold, it serves as an indication to refute the null hypothesis positing the absence of cointegration among the variables. The manifestation of this rejection implies the existence of a long-term association and co-movement between the variables. As per the scholarly work of Javed and Husain (2020), if the computed F-statistic lies within the confines of the lower and upper bound values, the outcomes of the test are deemed to be inconclusive.

Step Two

If cointegration is detected among the variables, the subsequent procedure involves estimating the long-run coefficients. The ARDL model is expressed in equation 3.

$$LEXRt = \beta_0 + \sum^{p}_{(i=1)}\beta_1 LEXR_{(t-1)} + \sum^{q1}_{(i=0)}\beta_2 LLNG_{(t-1)} + \sum^{q2}_{(i=0)}\beta_3 LNGP_{(t-1)} + \sum^{q3}_{(i=0)}\beta_4 LCOP_{(t-1)} \quad (3)$$

Step Three

The final stage involves the estimation of the short-term coefficient when the variables exhibit a long-term relationship, utilising an error correction model (ECM) as depicted in equation 4 below.

$$\Delta LEXRt = \alpha_0 + \sum^{p}_{(i=1)} \alpha_{1i}\Delta LEXR_{t-1} + \sum^{q1}_{(i=0)} \alpha_{2i} \Delta LLNG_{(t-1)} + \sum^{q2}_{(i=0)} \alpha_{3i} \Delta LNGP_{(t-1)} + \sum^{q3}_{(i=0)} \alpha_{4i} \Delta LCOP_{(t-1)} + \varphi ECT_{(t-1)} + \epsilon_t \quad (4)$$

Where φ reflects the rate at which the error correction term's adjustment coefficient is adjusted, and the coefficients α1-α4 represent the short-run dynamic.

The next step is to determine the causal link between the variables once the ARDL-bound cointegration test has been completed. For the goal of analysing the causality, the Toda-Yamamoto Granger causality test is used. Eddrief-Cherfi and Kourbali (2012) argue that the mere existence of causality within the elements is insufficient for determining the directionality. According to Ekeke (2020), the version proposed by Toda-Yamamoto is considered to be more reliable for conducting Granger causality tests. This assertion is based on the fact that the Toda-Yamamoto version is justifiable regardless of the co-integration order of the variables.

RESULTS AND DISCUSSION

Descriptive Analysis

Both the dependent and the independent variables have descriptive statistics shown in Table 1. The exchange rate average value is 4.456676, with the maximum and minimum values recorded at 5.324335 and 3.904902, respectively. The maximum value of LNG exports is recorded as 2.677161, while the minimum value is 1.020651. It is estimated that the average value of LNG exports is 2.244379. The price of natural gas attained its peak at 1.530259 and its minimum at -0.070557, with a mean value of 0.708675. The average price of petroleum oil is 3.356965, with a high of 4.054217 and a low of 2.486000. The table presents the values of Skewness, Kurtosis, Jarque-Bera, and other descriptive statistics parameters for the variables.

Multicollinearity Test

The variance inflation factor (VIF) test was administered to determine the presence of multicollinearity among the variables. The Centred VIF values for all variables, as presented in Table 2, demonstrate values below 10.0. This observation provides evidence that the data utilised in this study does not exhibit any multicollinearity concerns.

Unit Root Tests for Stationarity

Hatmanu (2020) stated that checking the stationarity of the variables under study is the first stage in the methodology of most time series modelling research. The unit root test was used to determine if the data were stationary and the level of correlation between the variables. For this purpose, we used the ADF (Dickey & Fuller, 1979) version of the Dickey-Fuller test. Stationarity at the level is not shown by the variables LEXR, LNGP, and LCOP, as seen in Table 3. Therefore, at the 1%, 5%, and 10% significant levels (Javed & Husain, 2020), it is not possible to reject the null hypothesis, which claims the non-stationarity of these variables. After undergoing first-level differencing, represented by I(1), the relevant variables are significant and stationary. Thus, it may be concluded that H_0 is false. However, for low values of I(0), LLNG displays a stationary characteristic. This lends credence to the use of the ARDL cointegration modelling approach used here.

ARDL Model

The ARDL model is estimated utilising automatic lag selection in E-views version 10, as denoted by Equation (2). The findings presented in Table 4 demonstrate that the LLNG variable exerts a statistically significant influence on the present exchange rate. Nevertheless, the present values of LNGP and LCOP do not demonstrate a statistically significant impact on the current LEXR value. The results of the empirical analysis indicate that the previous values of LEXR, LLNG, LNGP, and LCOP do not have a statistically significant effect on the current value of LEXR, with the exception of the first lag of LEXR and the fifth lag of LNGP. These two variables show statistical significance at a 1% level. The overarching model demonstrates a significant level of statistical significance.

The ARDL Bound Cointegration Test

The ARDL bounds cointegration test is utilised to determine the existence of a long-term relationship between the dependent and independent variables. The assessment of the co-integration relationship among the variables is conducted by utilising Equation (2). The null hypothesis proposed in this study postulates the lack of a significant long-term association. Based on the findings of Udoudo *et al.* (2023) and Nkoro & Uko (2016), when the calculated value of the 'F' statistic is lower than the critical value I(0), it suggests the lack of a statistically significant relationship between the variables, resulting in the failure to reject the null hypothesis. If the calculated 'F' statistic exceeds the critical value of I(1), it indicates a significant relationship and leads to the rejection of the null hypothesis. Conversely, a value falling within the range of I(0) and I(1) is regarded as inconclusive. The results displayed in Table 5 demonstrate that the calculated 'F' statistic (18.14008) exceeds the significance levels for both I(0) and I(1), indicating the presence of a long-term association between the dependent and independent variables.

Table 1: Descriptive Statistics

	LEXR	**LLNG**	**LNGP**	**LCOP**
Mean	4.456676	2.243379	0.708675	3.356965
Median	4.336665	2.443149	0.694079	3.400700
Maximum	5.324335	2.677161	1.530259	4.054217
Minimum	3.904902	1.020651	-0.070557	2.486000
Std. Dev.	0.411366	0.471463	0.406584	0.481371
Skewness	0.791239	-1.134865	0.351119	-0.326850
Kurtosis	2.233465	3.053467	2.33798	2.053623
Jarque-Bera	5.668329	9.449971	1.707581	2.425416
Probability	0.058768	0.008871	0.425798	0.297391
Sum	196.0937	98.70867	31.18171	147.7065
Sum Sq. Dev.	7.276539	9.557929	7.108355	9.963894
Observations	44	44	44	44

Source: Author's estimation (2023)

Table 2: Variance inflation factors

Variable	**Coefficient Variance**	**Uncentered VIF**	**Centered VIF**
LLNG	0.001775	86.5191	3.579859
LNGP	0.001079	6.651327	1.618842
LCOP	0.001533	163.5737	3.222225
C	0.005584	51.84556	NA

Source: Author's estimation (2023)

Table 3: Results of ADF Unit-Root test

Variable	**Level**		**First difference**		**Integration degree**
	t-statistic	**p-value**	**t-statistic**	**p-value**	
LEXR	0.753961	0.9919	-3.887904	0.0047	I(1)
LLNG	-4.339716	0.0015	-1.376465	0.5828	I(0)
LNGP	-1.43085	0.5579	-4.426946	0.0011	I(1)
LCOP	-2.528888	0.1161	-4.322646	0.0014	I(1)

Source: Author's estimation (2023)

ARDL Long-Run and Short-Run Estimation

The long-run coefficients shown in Table 6 were calculated by estimating the long-run model defined by Equation (3) after a co-integration connection had been established among the variables. The analysis found that at the 1% level of significance, the exchange rate in Nigeria was positively affected by LNG exports. This indicates that the exchange rate between the Nigerian Naira and the US Dollar would rise in tandem with an increase in the value of LNG exports from Nigeria. This conclusion indicates that an increase in the Naira's export volume of LNG will cause the Naira to depreciate by 1.62 per cent relative to the dollar. Djatmiko and Nugroho (2019) and Sieng *et al.* (2020) findings are consistent with the results achieved here. There is a negative and insignificant relationship between the price of natural gas and Nigeria's exchange rate. The exchange rate of Nigeria falls by 0.13 percentage points when the price of natural gas at the Henry Hub rises, albeit, not statistically significant. The exchange rate in Nigeria is significantly influenced by the price of Brent crude oil, and this influence is negative. An increase in the export price of Brent crude oil results in an appreciation of the Naira by 1.53 per cent. This finding agrees with Musa *et al.* (2020) and Henry (2019).

Equation (4) is used to define the short-term ARDL model of LEXR, which is shown in Table 7 along with the variables LLNG, LNGP, and LCOP. According to the estimations of the coefficients, the variable, past values of LEXR does have any effect on its present values. The present values and lag 2 value of LLNG exhibit a substantial and negative impact on LEXR, with statistical significance at the 5% level. This finding does not align with the outcomes observed in the long-run analysis. Additionally, the lag 1 value demonstrates a negative and statistically insignificant influence at the 5% level. In examining the association between the LNGP and LEXR, it is evident that the present LNGP values exhibit a negative and substantial magnitude. This stands in support of the outcome in the long term. In support of the long-term findings, the present value of LCOP exhibits a negative but statistically significant outcome. The lag 1 coefficient for LCOP is found to be positive and lacks statistical significance. Nevertheless, the preceding value of LCOP at a lag of 2 exhibits a negative correlation and is deemed statistically insignificant at a 5% level. The error correction term in the econometric model exhibits a value of -0.078286, satisfying the econometric criteria of being negative, statistically significant, and smaller than one. This finding suggests that there is a feedback or convergence rate of 7.8% towards long-run equilibrium. This imply that the short run equilibrium adjustment to long run is slow. Moreover, the adequacy of the model's fit is substantiated by the R-squared, Durbin-Watson statistic, and F-statistic as presented in Table 7. The adjusted coefficient of determination, denoted as R-squared, elucidates that approximately 81.7% of the observed fluctuations in the exchange rate can be accounted for by the independent variables under consideration. All these metrics indicate that the model is well-fitted.

Table 4: The results of ARDL (3, 5, 5, 3) model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEXR(-1)	0.921714	0.042240	21.82087	0.0000
LLNG	-0.107442	0.053872	-1.994402	0.0563
LLNG(-1)	0.154634	0.088724	1.742860	0.0927
LLNG(-2)	-0.041227	0.088831	-0.464110	0.6463
LLNG(-3)	0.121113	0.062833	1.927538	0.0645
LNGP	-0.077969	0.037433	-2.082929	0.0469
LNGP(-1)	0.067651	0.037421	1.807862	0.0818
LCOP	-0.142644	0.048204	-2.959161	0.0063
LCOP(-1)	0.060314	0.076238	0.791136	0.4358
LCOP(-2)	-0.045387	0.082226	-0.551974	0.5855
LCOP(-3)	-0.093725	0.074243	-1.262412	0.2176
LCOP(-4)	0.101724	0.038039	2.674196	0.0126
C	0.516563	0.202305	2.553382	0.0166
R-squared	0.996723	Mean dependent var	4.505003	
Adjusted R-squared	0.995267	S.D. dependent var	0.399963	
S.E. of regression	0.027516	Akaike info criterion	-4.091122	
Sum squared resid	0.020443	Schwarz criterion	-3.542236	
Log likelihood	94.82243	Hannan-Quinn criter.	-3.892662	
F-statistic	684.4153	Durbin-Watson stat	1.705454	
Prob(F-statistic)	0.0000			

Source: Author's estimation (2023)

Table 5: F-bound Test

F-Bounds Test	**Null Hypothesis: No levels relationship**			
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
F-statistic	18.14008	Asymptotic: n=1000		
		10%	2.37	3.2
k	3	5%	2.79	3.67
		2.50%	3.15	4.08
		1%	3.65	4.66

Source: Author's estimation (2023)

Table 6: Long-Run Estimate

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LLNG	1.623251	0.421530	3.850851	0.0007
LNGP	-0.131799	0.244077	-0.539990	0.5936
LCOP	-1.529220	0.497292	-3.075092	0.0048
C	6.598382	1.175499	5.613261	0.0000
EC = LEXR - (1.6233*LLNG-0.1318*LNGP-1.5292*LCOP + 6.5984)				

Source: Author's estimation (2023)

Table 7: Short-Run Estimate

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LLNG)	-0.107442	0.044578	-2.410203	0.0230
D(LLNG(-1))	-0.079886	0.047419	-1.684688	0.1036
D(LLNG(-2))	-0.121113	0.050657	-2.390835	0.0240
D(LNGP)	-0.077969	0.033117	-2.354339	0.0261
D(LCOP)	-0.142644	0.043638	-3.268813	0.0029
D(LCOP(-1))	0.037387	0.041410	0.902856	0.3746
D(LCOP(-2))	-0.007999	0.044511	-0.179711	0.8587
D(LCOP(-3))	-0.101724	0.033186	-3.065261	0.0049
CointEq(-1)*	-0.078286	0.007672	-10.20478	0.0000
R-squared	0.816793	Mean dependent var	0.032122	
Adjusted R-squared	0.769514	S.D. dependent var	0.053489	
S.E. of regression	0.025680	Akaike info criterion	-4.291122	
Sum squared resid	0.020443	Schwarz criterion	-3.911124	
Log likelihood	94.82243	Hannan-Quinn criter.	-4.153726	
Durbin-Watson stat	1.705454			

Source: Author's estimation (2023)

Diagnostics Tests

In order to enhance the dependability of the estimates, model validation is conducted by performing tests related to coefficient stability, model accuracy, and hypotheses regarding residuals, including normality, serial correlation, and homoscedasticity. The visual representations of CUSUM and CUSUM of Squares serve to illustrate the constancy of coefficients, as indicated by the continuous residuals of CUSUM and CUSUM Squared remaining confined within the 95% confidence interval (as depicted in Figures 2 and 3). The results obtained from the Ramsey RESET test (Table 8) suggest that the null hypothesis remains unchallenged, thereby implying that the model has been suitably formulated. Moreover, it has been ascertained that all conjectures pertaining to residual normality, serial correlation, and homoscedasticity have been corroborated, thereby signifying the validation of the model. The results of the residual diagnostics are shown in Figure 1 and Table 8.

Toda and Yamamoto Causality Test

According to Musa *et al.* (2019), the presence of co-integration implies the presence of a causal relationship in at least one direction. The findings of the Toda-Yamamoto causality test are displayed in Table 9. In cases where all-time series exhibit the same integration orders

of stationary, the Granger test is employed for causality analysis. However, if the time series displays varying integration orders of stationary, the Toda-Yamamoto approach (Toda & Yamamoto, 1995) is utilised for conducting the causality analysis. The utilisation of the Toda-Yamamoto Granger causality test in this study was motivated by the existence of variables exhibiting diverse orders of integration. The empirical analysis conducted unveils a conspicuous absence of substantiated evidence pertaining to a causal nexus between LNG exports and the exchange rate within the Nigerian context. In a similar vein, it is worth noting that there exists no discernible evidence of a causal nexus between the exchange rate in Nigeria and the exports of LNG. A two-way (bi-directional) causality between the exchange rate of the Nigerian currency, and the prevailing market price of Brent crude oil. The Toda-Yamamoto causality analysis failed to produce any empirical substantiation for the presence of a causal connection among the remaining variables under scrutiny.

Hypothesis Test

Hypothesis testing serves as a scientific methodology utilised to discern between two assertions, specifically the null hypothesis (H_0) and the alternative hypothesis (H_1). In the realm of hypothesis testing, should the computed P-value be equal to or less than the predetermined level of significance, commonly represented as 0.05 or 5%, it is customary to reject the null hypothesis. On the contrary, in the event that the computed P-value surpasses the designated threshold of significance, the null hypothesis is deemed acceptable.

Hypothesis 1; H_{01}: LNG exports does not impact the exchange rate in Nigeria.

On the basis of the data that are shown in Table 6, it is clear that the P-value associated with LNG exports is lower than the critical threshold of 0.05. As a result, we conclude that the null hypothesis should not be accepted, and we come to the conclusion that the exporting of LNG has an impact on the exchange rate in Nigeria.

Hypothesis 2; H_{02}: There is no causal relationship between LNG exports and exchange rate in Nigerian.

According to the empirical findings outlined in Table 9, it can be observed that the p-values pertaining to the causal relationship between LNG exports and the exchange rate in Nigeria exceed the threshold of 0.05. Based on our analysis, it is concluded that the null hypothesis cannot be rejected. This suggests that there is insufficient evidence to support the idea that there is a causal relationship between LNG exports and the exchange rate in Nigeria. In the same way, the p-value between exchange rate and LNG exports is greater than 0.05 threshold. Therefore, and it is concluded that Naira/Dollar exchange rate does cause LNG exports.

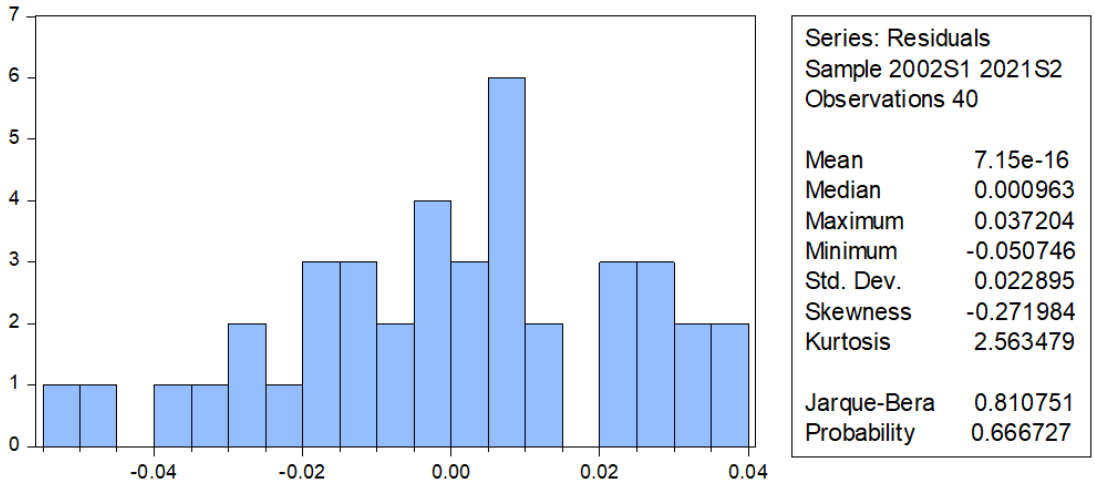

Figure 1: Histogram normality test
Source: Author's estimation (2023)

Table 8: Serial Correlation, Heteroskedasticity, and Ramsey RESET tests

Breusch-Godfrey Serial Correlation LM Test	**F-statistic**	**1.124215**	**Prob. F(2,25)**	**0.3408**
	Obs*R-squared	3.300637	Prob. Chi-Square(2)	0.1920
Breusch-Pagan-Godfrey Heteroskedasticity test	F-statistic	0.420225	Prob. F(12,27)	0.9418
	Obs*R-squared	6.294973	Prob. Chi-Square (27)	0.9005
	Scaled explained SS	2.242144	Prob. Chi-Square (27)	0.9989
Ramsey RESET Test		**Value**	**df**	**Probability**
	t-statistic	0.010027	26	0.9921
	F-statistic	0.000101	(1, 26)	0.9921

Source: Author's estimation (2023)

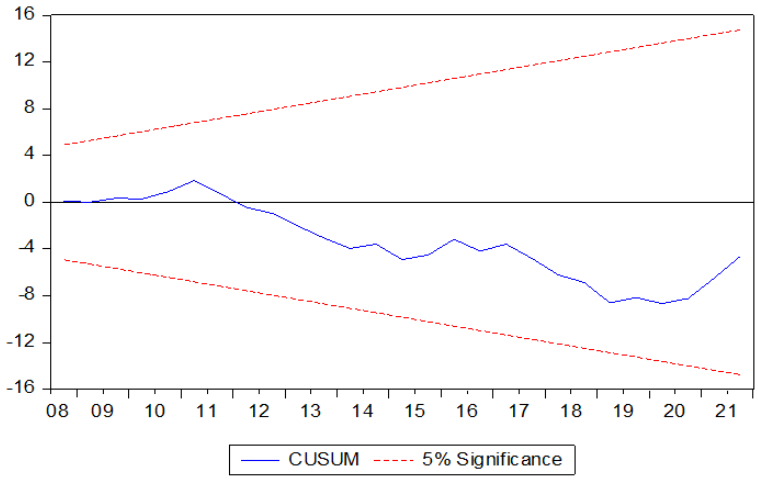

Figure 2: Cumulative sum (CUSUM) of recursive residuals
Source: Author's estimation (2023)

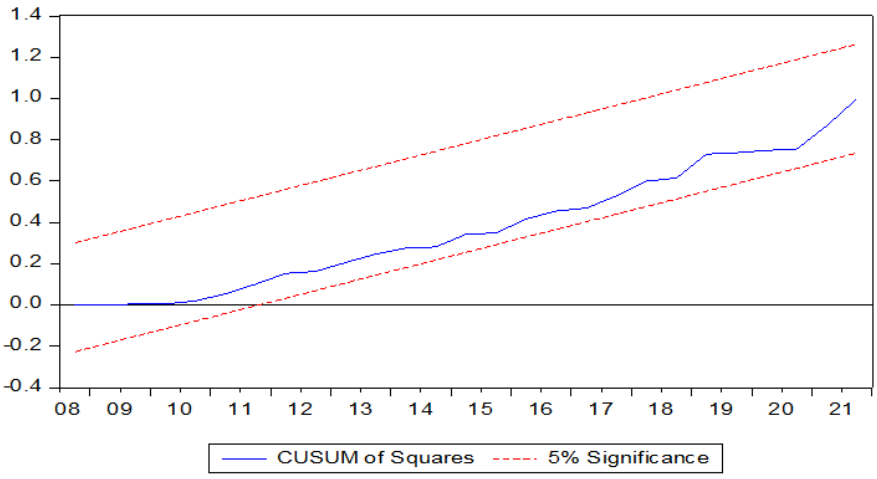

Figure 3: Cumulative sum (CUSUM) of squares of recursive residuals
Source: Author's estimation (2023)

Table 9: Toda and Yamamoto Causality Test Result

Null Hypothesis:	Chi-square	P-value	Granger Causality
LLNG does not Granger Cause LEXR	1.784892	0.6182	No
LEXR does not Granger Cause LLNG	5.397990	0.1449	No
LNGP does not Granger Cause LEXR	2.979326	0.3948	No
LEXR does not Granger Cause LNGP	6.152830	0.1044	No
LCOP does not Granger Cause LEXR	8.772087	0.0325	Yes
LEXR does not Granger Cause LCOP	11.36121	0.0099	Yes

Source: Author's estimation (2023)

CONCLUSION

In this study, we focused on analysing the impact of the LNG exports on the Naira/Dollar exchange in Nigeria from the year 2000 to 2021 using a biannual data set. The study's results unequivocally demonstrated that the time series variables of LNG exports, exchange rate, and other intervening variables exhibited integration of order zero and one. A relationship was established between the dependent and independent variables, characterised by long-run equilibrium, short-run dynamics, and causality. The primary aim of this research endeavour was to assess the influence exerted by LNG exports on the exchange rate within the context of Nigeria. The empirical results indicate that the exportation of LNG had a favourable and statistically significant influence on the exchange rate. An increase in LNG exports causes the Naira to depreciate. This assertion was substantiated by the outcomes observed in the short term. The second objective of this

study aimed to establish a causal relationship between LNG exports and the exchange rate in Nigeria. The re is no causality from Exchange rate to LNG exports. Same applies from LLNG exports to Exchange rate.

Given the observed depreciation of the Naira caused by LNG exports, it is recommended that to build a more balanced export portfolio, the government should diversify export sectors and support the growth of other non-oil and gas industries, such as manufacturing, services, and agriculture. Moreover, the impact of LNG exports on the exchange rate highlights the significance of maintaining adequate foreign exchange reserves. Sufficient reserves can be utilised to stabilise the Naira amidst periods of volatility arising from shocks in LNG exports or other external factors. Policymakers should maintain effective monitoring and management of reserves to ensure stability in exchange rates.

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