AB Journals

African Journal of Mathematics and Statistics Studies

ISSN 2689-5323 • Volume 9, Issue 3, 2026 • pp. 62–84

RESEARCH ARTICLE

Received: 12 Aug 2026, Accepted: 28 Aug 2026, Published: 18 Sep 2026

Cointegration Analysis of Money Supply Effect on Economic Growth in Nigeria: An ARDL Model Approach

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Abstract

This study investigates the impact of money supply on economic growth in Nigeria using the Auto-Regressive Distributed Lag (ARDL) model and data from the National Bureau of Statistics spanning 2001 to 2021. The ARDL model was used to assess the long-term and short-term dynamics between money supply and economic growth. Stationarity tests using the Augmented Dickey-Fuller (ADF) test revealed that Total GDP was stationary both at level and first differencing (p-value: 0.01), while Money Supply M1 and M2 became stationary after first differencing (p-values < 0.05. Descriptive statistics revealed significant variability in economic indicators over the period, with Total GDP showing a mean of ₦44,032.99 billion and a standard deviation of ₦19,487.82 billion, Money Supply M1 a mean of ₦4,525.89 billion and a standard deviation of ₦4,891.06 billion, and Money Supply M2 a mean of ₦10,474.06 billion and a standard deviation of ₦12,258.55 billion. The ARDL (2,3,0) model, selected based on the Akaike Information Criterion (AIC), demonstrates significant relationships between lagged values of money supply and economic growth, with an R-squared value of 0.9987 indicating a strong fit. The Johansen Co-integration Test indicates the presence of one long-term equilibrium relationship among the variables, as confirmed by the Trace test at the 5% significance level. Vector Error Correction Model (VECM) coefficients further confirm these findings, showing that deviations from equilibrium are corrected by adjusting Money Supply M1 and M2 negatively (e.g., -0.0322 and -0.0142 units for second lags) and Total GDP positively (e.g., 0.0015 unit for its second lag), suggesting a robust long-term association between money supply and economic growth. Results also indicated that changes in money supply significantly affect Nigeria's economic growth, with both short-term and long-term implications. Specifically, the regression coefficients reveal significant effects, such as a negative effect of M1 (-0.64, p-value: 0.003) and a positive effect of M2 (0.83, p-value: 0.001) on GDP, indicating complex dynamics.

Keywords: Money Supply, Economic Growth, Nigeria, Co-integration, ARDL Model, Monetary Policy.

How to Cite: Adams, S. O., & Christopher, G. (2026). Cointegration Analysis of Money Supply Effect on Economic Growth in Nigeria: An ARDL Model Approach. African Journal of Mathematics and Statistics Studies, 9(3), 62–84. https://doi.org/10.52589/AJMSS-INNPNXER

INTRODUCTION

Money supply plays a fundamental role in influencing macroeconomic performance by affecting investment, consumption, inflation, and overall economic growth. In Nigeria, monetary authorities have continuously adjusted money supply through various policy instruments to stimulate economic activities and maintain price stability. Despite these efforts, the relationship between money supply and economic growth remains inconclusive due to structural changes, policy inconsistencies, and external economic shocks. Understanding both the short-run and long-run dynamics between money supply and economic growth is therefore essential. The Autoregressive Distributed Lag (ARDL) approach provides a robust framework for examining cointegration among variables with different orders of integration.

The correlation between money supply and economic growth has been a subject of interest in economic studies, especially in developing economies such as Nigeria, where monetary policy is of utmost importance in determining economic performance (Twinoburyo & Odhiambo, 2018; Adams, *et al.,* 2022). Money supply is the total monetary assets in an economy at a given period of time, and it affects major economic activities, including investment, consumption, and production (Mishkin, 2021; Zubair *et al.,* 2022). A good money supply is able to boost these activities, which in turn boosts the economy, whereas too much or too little money supply can cause economic instability, which is in the form of inflation or recession (Friedman & Schwartz, 2008). The Central Bank of Nigeria (CBN) uses a number of monetary policy tools to control money supply in Nigeria in order to realize sustainable economic growth and price stability (Omenyi, 2017; Bamanga & Adams, 2023). Nevertheless, the success of such policies is highly debatable among economists and policymakers due to the peculiarities of the country in terms of economic issues (Adigwe *et al.,* 2015; Ajayi, *et al.*, 2019).

The CBN is keen on the dynamics of money supply in Nigeria and therefore ensures that the rate of money supply growth is compatible with the general macroeconomic goals of the country. The CBN strives to ensure efficient financial intermediation, sustainable economic growth, and an enabling environment to investment and entrepreneurship by ensuring a stable and predictable monetary environment (CBN, 2022). Nigeria, as Africa's largest economy, faces distinct challenges in managing its money supply due to its heavy reliance on oil revenues, persistent high inflation rates, and structural economic issues such as unemployment and infrastructural deficits (Nwosa, 2016). As an example, inflation in Nigeria increased to 24.5 percent in 2023 compared to 18.8 percent in 2022 due to the increase in fuel prices and the weakening of the naira, which makes monetary policy decisions more difficult (African Development Bank, 2024; Yahaya, *et al.*, 2022). These issues highlight the significance of knowing the exact effect of money supply on economic growth in order to design effective monetary policies capable of stabilizing the economy and ensuring sustainable growth. The relationship between money supply and economic growth in Nigeria has been shown to be complex as empirical studies have yielded conflicting results. As an illustration, (Idris, 2019; Hicham, 2020) established that money supply has a positive effect on economic growth and the causality is unidirectional implying that money supply positively influences economic growth but not vice versa. Conversely, (Chude & Chude, 2021) found no significant short-term effect and negative long-term effect, which means that money supply and economic growth can be independent in some cases. On the other hand, a positive and significant effect of money supply on economic growth in Nigeria was found by (Inam, 2014) with the help of an augmented Cobb-Douglas production function. The discrepancy in these findings is due to the effect of varying methodologies, time, and economic circumstances and therefore further studies are required to explain the relationship. More recent work has used sophisticated

ISSN 2689-5323 • Volume 9, Issue 3, 2026 • pp. 62–84

econometric methods to examine this dynamic in more detail. The Autoregressive Distributed Lag (ARDL) model was used by (Omankhanlen, Samuell-Hope & Ehikioya, 2022) to examine how money supply affected economic growth in Nigeria between 1990 and 2018. They found that the broad money supply (M2) positively and significantly affect the real GDP in the long run, and every one percent increase in broad money supply will increase the real GDP by 95.37 percent. Similarly, a study that spans 1980 to 2019 established that currency in circulation (CIC) positively and significantly influences real GDP but is a weak predictor whereas broad money supply (M2) exhibited a significant negative effect and explained 47.1 percent of the forecast error variance in real GDP (Omodero, 2020). These results indicate the complexity of the relationship between money supply and economic growth, which depends on macroeconomic factors such as inflation and interest rates.

The inconsistent and changing results of the previous studies highlight a very important issue which is the lack of consensus on the precise impact of money supply on economic growth in Nigeria. Such uncertainty presents a challenge to policymakers in the effort to develop effective monetary policies to realize sustainable growth amid inflationary pressures and other economic distortions. The ARDL model is especially appropriate to solve this problem, since it can be used to analyse both short-run and long-run relationships, which is useful when the variables have different orders of integration and when one offers a holistic approach to a complex economic relationship (Pesaran et al., 2001). This study will add to the body of literature by using the ARDL model to examine the cointegration and the cause-and-effect relationship that exists between money supply and economic growth in Nigeria. Through this, it aims at offering empirical evidence that can help the Central Bank of Nigeria (CBN) in formulating monetary policies that can achieve a good balance between economic growth and price stability, in consideration of the economic peculiarities of Nigeria.

EMPIRICAL REVIEW

The connection between money supply and economic growth is one of the main fields of macroeconomic research, especially in the case of developing economies such as Nigeria. The empirical evidence of the interaction between money supply and economic growth shows a rather complicated and situation-specific dynamic. Scholars have provided mixed results, which shows their differences in economic structures, methodological approaches, and time.

Oluseyi, Olasehinde & Eweke (2017) carried out comparative research on Unrestricted Mixed Data Sampling (UMIDAS) and ARDL methodologies based on the data of the period 1981-2015 retrieved through World Development Indicators and CBN. U-MIDAS results affirmed a long run and short run relationships between quarterly M2 and annual GDP whereas the statistically significant impact of money supply consequences to GDP were positive and significantly determined in the long run with weaker effects in the short run with the ARDL approach.

Alfa *et al.* (2020) investigated the impact of money availability on economic growth in Nigeria using time series data from 1980 to 2019. The study's findings suggest that CIC has a positive and large impact on RGDP, with an estimated coefficient of around 6.98, however it cannot predict economic growth well using the Cholesky variance decomposition.

These findings were further verified by (Inam, 2014) who employed an augmented Cobb-Douglas production function to show that the effect of money supply on economic growth of Nigeria between 1985 and 2011 was strong and statistically effectual. The analyses revealed that though the effect of the Monetary Policy Rate (MPR) was positive but insignificant, the broad money supply (M2) on the real economic growth was positive and very significant. Okonkwo, Adiele & Umezurike (2025) utilized ARDL model to analysis quarterly CBN data between 1981 and 2021 using ZivotAndrews tests of structural breaks. They found no support of long run cointegration of monetary variables with GDP after controlling structural breaks. Nonetheless, short run ARDL results showed that M2 had a very positive and significant impact on real GDP, whereas other factors such as credit, exchange rate, inflation, and lending rates showed mixed or non-significant results.

Odamusor & Joseph (2019), found a positive short-term effect and a negative long-term effect, which may indicate the possibility of the decoupling between money supply and the growth of the economy over long periods. Such a deviation can be represented by structural issues of Nigeria, including inefficiencies in financial intermediation or external economic shocks.

Aslam (2016) used time series data from 1959 to 2013 in a multivariate econometric framework to investigate the impact of money supply on Sri Lankan economic growth. The findings revealed that the money supply had a positive and statistically significant effect on GDP at the 1% level, with an R-squared value of 92%, indicating good explanatory power.

Daoud & Al-Ezzi (2023) used a quarterly data set of 2004-2020 to test the cointegration relationship between money supply, exchange rate and economic growth in Iraq through Johansen cointegration test, VECM and Granger causality. The research revealed that in the long run, money supply and exchange rate positively and significantly influenced GDP. Real GDP in the short run was influenced positively by its lagged values and money supply, but negatively influenced by exchange rate, inflation, and interest rate, with the latter being statistically insignificant. In the long run, money supply had a positive association with GDP and negative association with exchange rate whereas in the short run, money supply was positively influenced by exchange rate and negatively by inflation.

Galadima & Ngada (2017) examined the effect of money supply on economic growth in Nigeria with annual time series data covering 1981-2015. Using Johansen co-integration methodology, they determined a long-run relationship between money supply (MS), interest rate (INT), real exchange rate (EXR) and GDP. Their Vector Error Correction Model (VECM) analysis indicated that money supply and interest rate had significant positive long-run effects whereas real exchange rate had significant negative effect on economic growth. The lagged value of money supply had a significant negative impact in the short run and lagged exchange rate had a negative impact, but lagged GDP and interest rate were insignificant. Granger causality test revealed that there was a bidirectional causality between MS and GDP, unidirectional causality between EXR and INT to MS, and no causality between EXR and GDP, INT and GDP, and INT and EXR

Kunwar (2020) examined the relationship between money supply and economic growth in Nepal based on annual time series data between 1974/75 and 2017/18. The research was based on the causal research design, the Augmented Dickey-Fuller (ADF) test was used to determine the stationarity, and the Autoregressive Distributed Lag (ARDL) model with a Vector Error Correction Model (VECM) was utilized to investigate both short-run and long-run dynamics. The results indicated that there was a strong long-run association between money supply (LNBM) and gross domestic product (LNGDP). The research also found a bi-directional causality between LNBM and LNGDP, which means that both variables have a significant impact on each other. Also, inflation (LNINF) had a one-way causality to GDP and money supply. The error correction term (ECT) was negative and significant with p-value less than 5 percent, which meets the requirement of a robust ARDL model.

Benazza (2022) studied the correlation between broad money supply (M2) and gross domestic product (GDP) in Algeria based on annual time-series data between 1980 and 2017. The Autoregressive Distributed Lag (ARDL) bounds testing method to cointegration was used in the study, and the model consisted of six macroeconomic variables: GDP, M2, discount rate (DR), inflation rate (INF), real effective exchange rate (REER), and government expenditure (GOV). The empirical results indicated that there was a statistically significant and positive correlation between money supply and GDP in the short run and in the long run and this showed that the growth in M2 is significant in economic growth in Algeria.

Sola & Peter (2013) used a Vector Auto Regressive (VAR) model to study the relationship between Nigeria's money supply and inflation from 1986 to 2012. Although the study's primary focus was on inflation, the findings are noteworthy since inflation can have an indirect impact on economic growth. The findings revealed a one-way causal relationship between money supply and inflation, as well as between interest rates and inflation, implying that an excessive money supply could contribute to inflationary pressures that may stymie growth.

MATERIALS AND METHODS

Data

The data employed in this study were primarily obtained from secondary sources, notably the National Bureau of Statistics (NBS), which offers reliable and up-to-date macroeconomic indicators. Spanning a defined study period (1990 – 2022), the analysis investigates the relationship between money supply and economic growth in Nigeria. Central to the methodology is the application of the Autoregressive Distributed Lag (ARDL) model, well-suited for exploring both short-run and long-run dynamics in time series data. The ARDL framework denoted as ARDL(p, q), where p represents the number of lags for the dependent variable and q for the independent variables facilitates co-integration analysis by capturing the influence of lagged values of money supply on economic output. Model estimation is performed using structured time series data, with diagnostic tests guiding the choice of lag lengths and ensuring the robustness of results. This methodological approach enables an understanding of how fluctuations in money supply impact Nigeria's economic performance over time.

Autoregressive Distributed Lag (ARDL) Model

The general form of an ARDL (p, q) model is:

$$y_t = \alpha + \beta_1 y_t - 1 + \beta_2 y_t - 2 + \dots + \beta_p y_t - p + y_0 x_t + y_1 x_t - 1 + y_2 x_t - 2 + \dots + y_q x_t - q + \varepsilon_t \quad (1)$$

Where:

y_t is the dependent variable at time t,

y_{t-i} are the lagged values of the dependent variable,

x_t is the independent variable at time t,

x_{t-i} are the lagged values of the independent variable,

α is the intercept,

$\beta_1, \beta_2, \ldots, \beta_p$ are the autoregressive coefficients,

$\gamma_0, \gamma_1, \gamma_2, \ldots, \gamma_q$ are the coefficients for the lagged values of the independent variable,

ε_t is the error term.

To estimate the parameters of the ARDL model, you can use methods like Ordinary Least Squares (OLS).For short-term dynamics, you may focus on the autoregressive terms ($y_{t-1}, y_{t-2}, \ldots, y_{t-p}$) as they capture the short-term memory or persistence of the dependent variable.

For long-term dynamics, the distributed lag terms ($x_t, x_{t-1}, \ldots, x_{t-q}$) are important as they capture the cumulative effect of the independent variable over time.The appropriate lag lengths (p and q) can be determined using model selection criteria such as AIC (Akaike Information Criterion) or BIC (Bayesian Information Criterion).In the context of co-integration analysis of the impact of money supply on economic growth in Nigeria using the ARDL model, you typically have the following variables:

Dependent Variable and Independent Variables

Dependent Variable

Economic Growth (Y_t): This is the variable we are trying to explain. It is represented by real GDP.

Independent Variables:

Money Supply (M_t): This is the variable we believe have an impact on economic growth. It is a measure of the total money in circulation in the economy.

Now, let's set up the ARDL model:

Method for Data Analysis and Model Specification

$$Y_t = \alpha + \beta_1 Y_t - 1 + \beta_2 Y_t - 2 + \ldots + \beta_p Y_t - p + y_0 M_t + y_1 M_t - 1 + y_2 M_t - 2 + \ldots + y_q M_t - q + \varepsilon_t \quad (2)$$

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{j=0}^{q} \gamma_j M_{t-j} + \epsilon_t \quad (3)$$

Here:

Y_t is the dependent variable (economic growth).

Y_{t-i} are the lagged values of the dependent variable.

M_t is the independent variable (money supply).

M_{t-i} are the lagged values of the independent variable.

α is the intercept.

$\beta_1,\beta_2,\ldots,\beta_p$ are the autoregressive coefficients for economic growth.

$\gamma_0,\gamma_1,\gamma_2,\ldots,\gamma_q$ are the coefficients for the lagged values of the money supply.

ε_t is the error term.

We then estimate this model using econometric methods, such as Ordinary Least Squares (OLS) or Maximum Likelihood Estimation (MLE), depending on our preferences and the characteristics of your data. We ensured that we choose appropriate lag lengths (p and q) based on statistical criteria, such as AIC or BIC, and conduct diagnostic tests to check the assumptions of the model, such as heteroscedasticity and serial correlation.

Pre-Estimation Tests

This plays a crucial role in ensuring the validity and reliability of the analysis in the co-integration analysis of the impact of money supply on economic growth in Nigeria using an ARDL model approach. Here's a brief overview of the pre-estimation tests and their significance:

Augmented Dickey-Fuller Test of Stationarity

Empirical works on time series data assumed that the underlying time series are stationary. Therefore, it has become important to investigate the stationarity status of a data before estimation in order to avoid the problem of spurious regression. We carried out a stationary test to ascertain the order of co-integration of the variables under study before the short-run analysis (Gujarati, 2004). The null hypothesis tested was stated to show that series contained unit root. Thus, if the series are stationary without differencing, it is of order zero I(0), if stationary after differencing once it is said to be integrated of order I(1) and I(1), if it is order 2. However, Augmented Dickey-Fuller (ADF) test can be applied. Based on Monte-Carlo simulation under the null hypothesis, Dickey and Fuller established that decision is taken using tau statistics and critical value. Augmented Dickey-Fuller (ADF) test is a test created by (Dickey & Fuller, 1979) to test the existence of unit root in time series data and hence identify the stationarity of the variables. ADF test is an extension of the standard Dickey-Fuller (DF) test that includes lagged differences of the dependent variable to address higher-order serial correlation, which makes the test more robust (Maddala & Kim, 1998). Usually, the unit root is conducted on individual variables and stated in three possible forms as shown below:

$$\Delta\mu_i = \gamma_0 + \gamma_1 t + \gamma\mu_{i-1} + \sum_{i=1}^{n} \beta\Delta\mu_{i-1} + e_{3i} \quad (4)$$

$$\Delta\mu_i = \beta_0 + \beta_1\mu_{i-1} + \sum_{i=1}^{n} \beta\Delta\mu_{i-1} + e_{2i} \quad (5)$$

$$\Delta\mu_i = \beta\mu_{i-1} + \sum_{i=1}^{n} \beta\Delta\mu_{i-1} + e_{1i} \quad (6)$$

Where:

$\Delta\mu_i$ is the μ_i- μ_{i-1}

n is the numbers of lag in the dependent variable.

μ_i= (Y_t and M_t) represents the variables used for the unit root test. The equation (6) represents the model without intercept and no trend; equation (5) represents the model with intercept but no trend tile; equation (4) represents the model with intercept and trend. One of the standard conditions required for the implementation of the ADF unit root test is that both the null and alternative hypotheses must be stated and tested. Therefore, we state the hypothesis as follows:

H_0: β= 1, the presence of a unit root using one of equations (4-6).

H_1: β≠1, the absence of unit root using one of equations (3-6.

ARDL Bounds Tests for Cointegration

Co-integration test will enable the study to find out the long-run relationships between variables under study. The stationary combination is known as the co-integration equation and interpreted as a long-run equilibrium relationship among variable of choice. The advantage of co-integration is to enable series to be partitioned into long-run and short-run dynamics. Information lost during test of stationary by differencing can be bridged. Hence, in order to empirically analyse the long-run relationships and short run dynamic interactions among the variables of interest (Economic Growth (Y_t) and Money Supply (M_t)), we apply the autoregressive distributed lag (ARDL) co-integration technique as a general vector autoregressive (VAR) model. The ARDL co-integration approach was developed by (Pesaran & Shin, 1995; Pesaran *et al.*, 2001). It has three advantages in comparison with other previous and traditional co-integration methods. The first one is that the ARDL does not need that all the variables under study must be integrated of the same order and it can be applied when the under-lying variables are integrated of order one, order zero or fractionally integrated.

The second advantage is that the ARDL test is relatively more efficient in the case of small and finite sample data sizes. The last and third advantage is that by applying the ARDL technique we obtain unbiased estimates of the long-run model (Harris & Sollis, 2003). However, trace statistics for the lags chosen was conducted to discover if there is relationship between the gross domestic product and money supply (Economic Growth (Y_t) and Money Supply (M_t)).

$$Y_t = \alpha + A_t Y_{t-1} + \ldots + A_p Y_{t-1} + e_t \tag{7}$$

$$Y_t = \alpha + \sum_{i=1}^{n} A_t Y_{t-1} + e_t \tag{8}$$

Where:

Yt represents (nx1) column vector where order of integration is the same, that is Economic Growth (Y_t) and Money Supply (M_t). Thus, the dimensional vector of non-stationary I(1) variable, y=y-dimensional vector of deterministic variable, α is (nx1) vector of constant, $A_t \ldots A_{i-p}$ are parameters and e_t stochastic error residual which is identically and independently identified. Note that the VAR model provides the accommodation of several variables where changes in a particular variable can affect changes in its lag and changes in other variables and the lags of those variables (Patterson, 2000). Since the VAR expresses the dependent variables in terms of predetermined lagged variables, it is a reduced form model. We re-write above to form Vector Error Correction Model

$$\Delta Y_t = \alpha + \sum_{i=1}^{p-1} \eta_1 \Delta Y_{t-1} + \sum_{i=1}^{p-1} \eta_2 \Delta Y_{t-1} + e_t \tag{9}$$

Where:

Y_t is the vector of P variables representing all variables under study

α and e_t are (nx1) vector of constant and error term

Δ is the difference operator

$\eta_1 \eta_2$ are coefficient matrices which tells us about the long-run relationship and short run impact

To obtain long-run relationship therefore, we specified

$$\Delta GDPG_t=\beta_0+\sum_{i=1}^{n1} \beta_i \Delta M_t+\lambda ECT_{t-1} + \varepsilon_{1t} \tag{10}$$

Where β_i is the coefficient of the change inMoney Supply (M_t), λ is a speed of adjustment, ECT_{t-1} is the Error Correction Term and ε_{1t} is the residual term.

If the value (λ) is negative that means there is a convergence to the long-run equilibrium, meaning there is a co-integration relationship among variables and a negative significant of ECT_{t-1} is a further proof that co-integration relationship exists and if the value (λ) is positive, it means there is a divergence from long-run equilibrium.

Therefore, the hypothesis for Johansen co-integration test is:

H_0: there is no co-integration between the variables

H_1: there is co-integration between the variables

If the variables statistical value is greater than the critical value, the null hypothesis should be rejected. This means there is co-integration between series moving together in the long run. This study used (Johansen's, 1991) approach, which allows it to estimate and test for the presence or multiple co-integration relationship in a single step procedure. The co-integration test represents the long run relationship among the variables.

Co-integration is an econometrics tool used in carrying out research work, especially when dealing with relationship between two variables. Thus, if two variables that are I(1) are linearly combined , then the combination will also be I(1). However, generally, if variables with differing orders of integration are combined, the combination will have an order of integration equal to the largest.

A set of variables is defined as co-integration if a linear combination of them is stationary.

A co-integration relationship may also be seen as a long-term or equilibrium phenomenon, since it is possible that co integration variables may deviate from their relationship in the short run, but their association would return in the long run.

EMPIRICAL RESULT

Descriptive Analysis

Table 1: Descriptive Statistics for Economic Indicators

Measure	Total GDP (N'BILLION)	Money Supply M1 (N'BILLION)	Money Supply M2 (N'BILLION)
Mean	44032.99	4525.89	10474.06
Median	40703.68	2280.65	4027.90

Range	21539.6 - 72393.7	50.06 - 18055.86	87.49 - 44443.07
Variance	379774996	23922440	150272111
Std. Dev.	19487.82	4891.06	12258.55
Std. Error	3500.12	878.46	2201.70

Table 1 is the descriptive statistics for Total GDP, Money Supply M1, and Money Supply M2 provide insights into the economic environment in Nigeria during the observed period. The mean values indicate that on average, Nigeria's GDP was approximately ₦44,032.99 billion, with Money Supply M1 and M2 averaging ₦4,525.89 billion and ₦10,474.06 billion, respectively. The median values for these variables suggest that the distributions of Money Supply M1 and M2 are skewed, as their medians are considerably lower than their means. This skewness indicates that there may be a few periods with unusually high money supply figures, pulling the mean upwards. The range and variance provide further understanding of the variability within the data. Total GDP shows a substantial range (₦21,539.61 billion to ₦72,393.67 billion), reflecting significant fluctuations in economic output during the period. The high variance and standard deviation values for GDP indicate a considerable spread around the mean, suggesting periods of both rapid growth and contraction. Similarly, Money Supply M1 and M2 also display wide ranges and high variability, particularly M2, which shows a broader range and higher variance compared to M1. This implies that while the overall money supply (M2) fluctuated widely, the narrower definition of money (M1) also saw substantial changes, though to a slightly lesser extent. The standard errors associated with each variable provide a measure of the precision of the mean estimates. Total GDP, with a standard error of ₦3,500.12 billion, suggests a reasonably precise estimate given the scale of GDP. Money Supply M1 and M2 have standard errors of ₦878.46 billion and ₦2,201.70 billion, respectively, indicating some degree of uncertainty in these estimates, particularly for M2, which shows higher variability and a broader range. Overall, the data reflects a dynamic economic environment in Nigeria, characterized by significant variability in both economic output and money supply, which may have implications for monetary policy and economic planning.

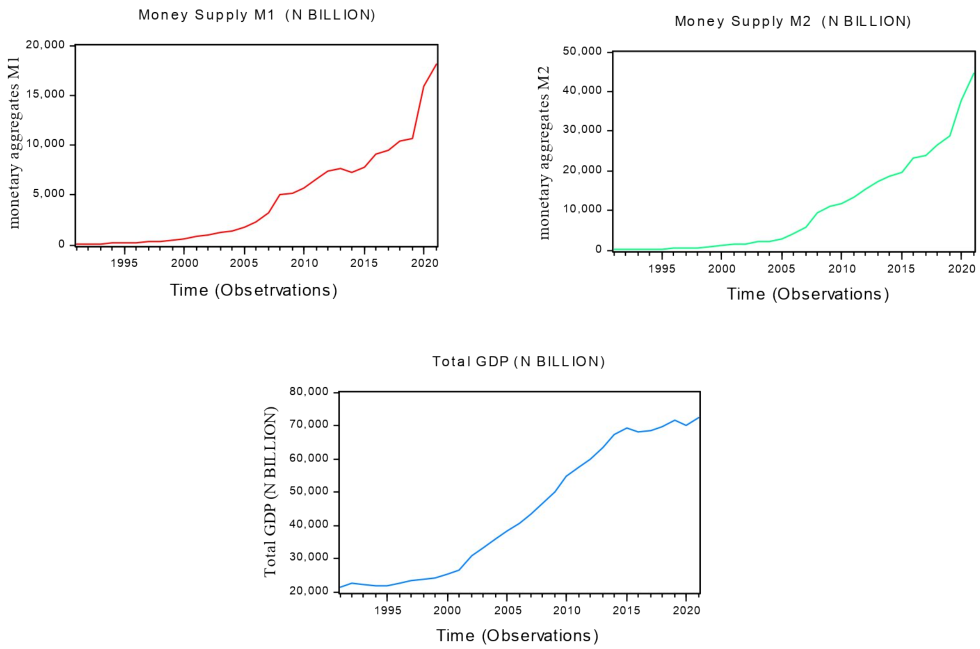

Figure 1: Time Plot of the study Variables (TGDP, M1 and M2) from 1990 to 2022

ISSN 2689-5323 • Volume 9, Issue 3, 2026 • pp. 62–84

The trends in Total GDP (TGDP) and the monetary aggregates M1 and M2 in Figure 1 from 1990 to 2022 illustrate significant economic developments over the period. TGDP, represented by the blue line, shows a steady increase, especially from the late 1990s onward, indicating consistent economic growth. Although there is a slight dip around 2020, likely due to the COVID-19 pandemic, the overall trend continues upward, reflecting the resilience of the economy. The monetary aggregates, M1 and M2, represented by the red and green lines respectively, also display upward trends. M1, which includes the most liquid forms of money, rises gradually from 1990 with a notable acceleration starting around 2008, and experiences a sharp increase from 2019 onward. Similarly, M2, which includes M1 plus savings and other near-money assets, follows a steady increase with a significant upward trend from around 2010, and also sees a sharp rise from 2019. These trends suggest that the post-2010 period saw accelerated growth in both M1 and M2, likely due to economic policies implemented after the global recession. The sharp increases in both monetary aggregates post-2019 may reflect aggressive monetary policies or interventions, possibly in response to the economic challenges posed by the COVID-19 pandemic. The overall upward trends in TGDP, M1, and M2 highlight the interplay between economic growth and monetary policy, with the slight dip in TGDP around 2020 marking the pandemic's impact and subsequent recovery efforts.

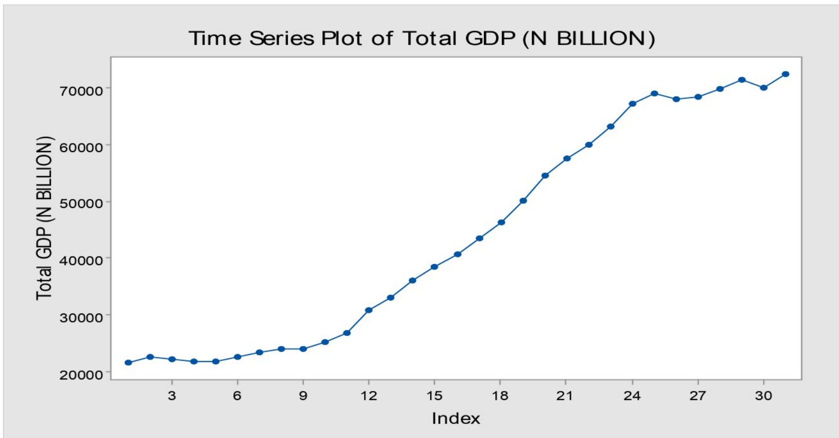

Figure 2: Serial Plot of Total GDP Graph

The time series plot of Total GDP (in N Billion) presented in Figure 2 indicates consistent economic growth from 1991 to 2021. The GDP exhibits a noticeable acceleration around the mid-period, reflecting enhanced growth rates. An inflection points around 2002 marks a significant increase in GDP growth, likely due to favourable economic policies or conditions. Towards the end of the period, GDP growth stabilizes, indicating a more mature phase of economic development. Overall, the plot highlights robust and sustained economic progress over the years.

ISSN 2689-5323 • Volume 9, Issue 3, 2026 • pp. 62–84

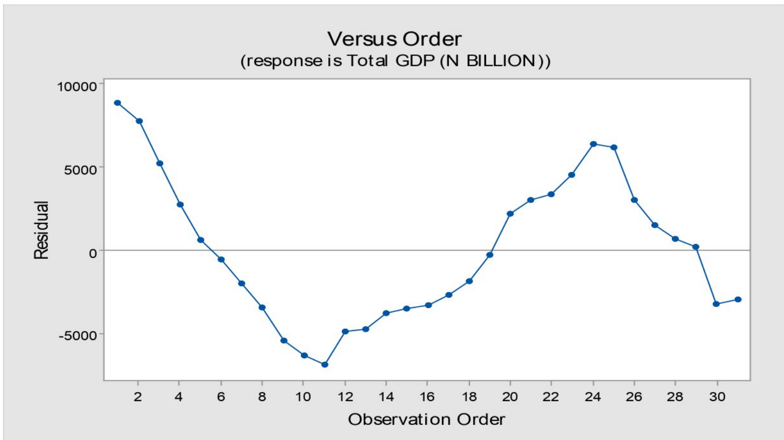

Figure 3: Residual Plot

Figure 3 presents the graph of residuals over time reveals several key insights about the performance of the ARDL model. First, the residuals show clear cyclical or periodic patterns, indicating regular fluctuations that suggest the presence of seasonal components or other recurring effects not fully captured by the model. This pattern implies that the model may be missing some important temporal dynamics. Furthermore, the changing amplitude of the residuals over time suggests heteroscedasticity, meaning the variance of the residuals is not constant. Some periods show larger fluctuations than others, which could indicate that the data's variability increases or decreases over time. This issue points to potential problems with the model's assumptions about constant variance, which could affect the reliability of the model's predictions. The significant variability and patterns observed in the residuals suggest that the ARDL model may not be fully capturing all the important dynamics in the data. This could be due to missing variables, incorrect lag specifications, or the need for a different modeling approach that better fits the underlying data patterns. The findings highlight the need for further refinement of the model to improve its accuracy and reliability.

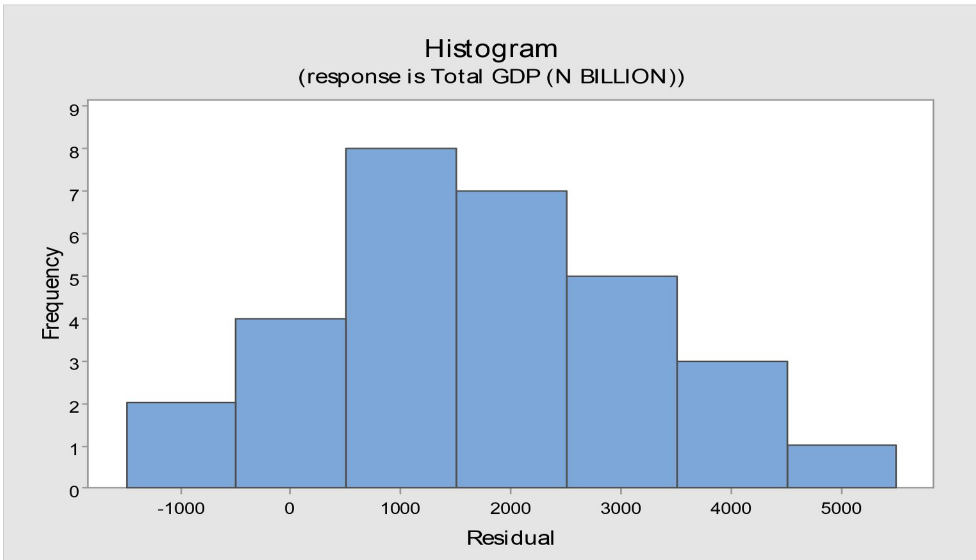

Figure 4: Histogram of Residuals Graph

Figure 4 display the histogram of residuals for total GDP (in billions). It shows the frequency distribution of residuals, indicating how often each range of residual values occurs. The

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distribution appears to be somewhat skewed to the right, with most residuals clustered around positive values, suggesting that the model tends to under-predict the GDP more frequently than it over-predicts.

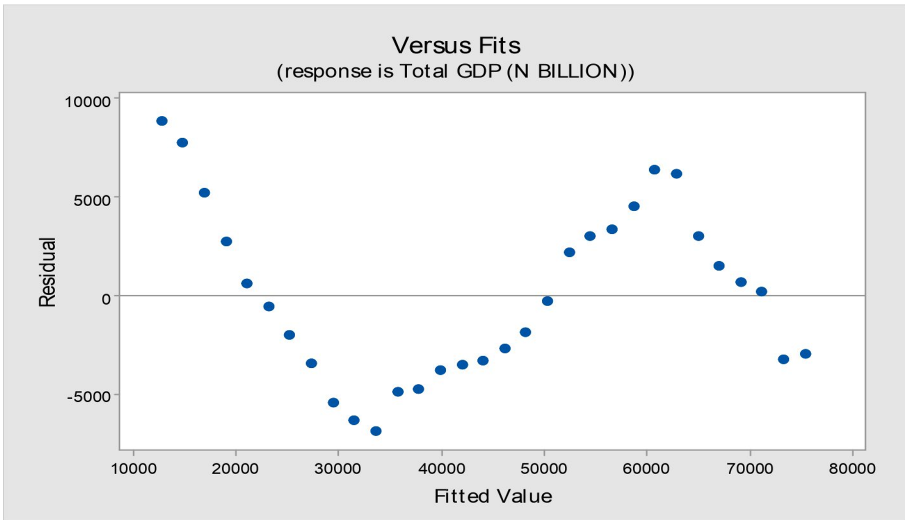

Figure 5: Residuals Vs Fitted Values Plot

Figure 5 shows the residuals (errors) on the y-axis and the fitted values of the total GDP on the x-axis, indicating how the residuals vary with the predicted values. The curved pattern suggests that the model may not adequately capture the relationship between the variables, indicating potential non-linearity or other issues in the model fit.

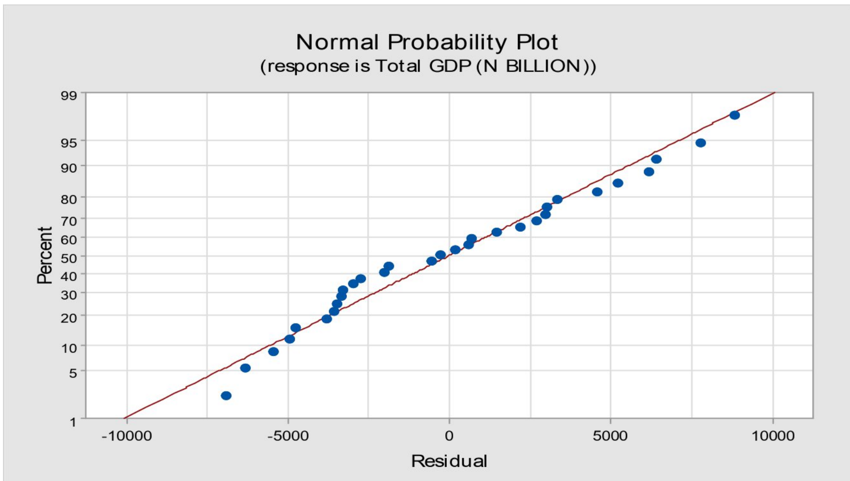

Figure 6: Normal Probability Plot of Residualsfor Total GDP (N Billion)

Figure 6 shows that the residuals are approximately normally distributed, as most points lie close to the reference line. However, there are deviations at the tails, indicating potential outliers or non-normality in the extreme values.

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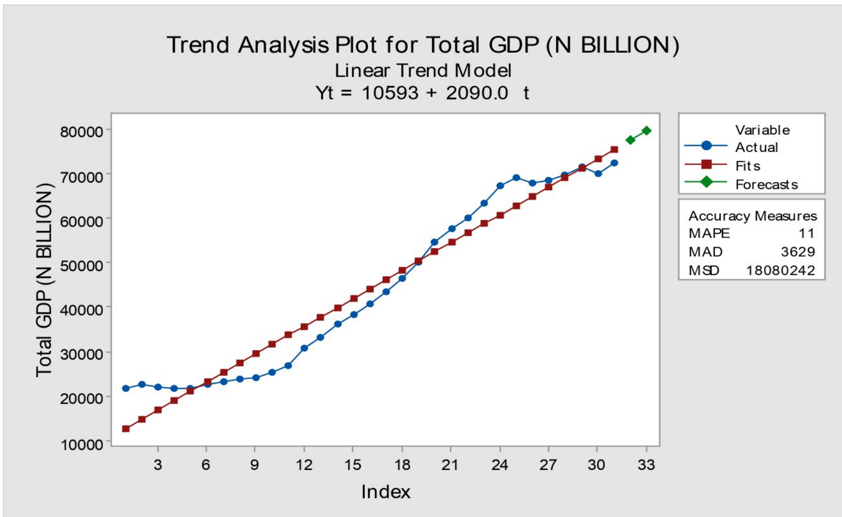

Figure 7: Trend Analysis Plot for Total GDP (N Billion)

The linear trend model provided in Figure 7 shows a strong positive trend in the total GDP over time, as indicated by the increasing fits (red squares) closely following the actual values (blue circles). The forecast values (green diamonds) suggest that this upward trend is expected to continue.

Test of Stationarity: Augmented Dickey-Fuller Test Results

The Augmented Dickey-Fuller (ADF) test was conducted to determine the stationarity of the variables Total GDP, Money Supply M1, and Money Supply M2. The results are presented in Table 2.

Table 2: Augmented Dickey-Fuller Test Results at Level

Variable	Test Statistic	Lag Order	p-value	Conclusion
Total GDP (N'BILLION)	-5.0101	1	0.01	Stationary
Money Supply M1 (N'BILLION)	-2.5202	1	0.103	Non-Stationary
Money Supply M2 (N'BILLION)	-2.671	1	0.085	Non-Stationary

The Augmented Dickey-Fuller (ADF) test was conducted to examine the stationarity of the variables: Total GDP, Money Supply M1, and Money Supply M2 with a lag order of 1.The results of the Augmented Dickey-Fuller (ADF) tests for the first differenced data are summarized in Table 3. The test statistics and p-values indicate that all variables have become stationary after first differencing.

Table 3: Augmented Dickey-Fuller Test Results for First differencing

Variable	**Dickey-Fuller Statistic**	**Lag Order**	**p-value**	**Stationarity Conclusion**
Total_GDP_diff2	-4.3571	1	0.01	Stationary
Money_Supply_M1_diff2	-3.6279	1	0.03	Stationary
Money_Supply_M2_diff2	-3.9712	1	0.02	Stationary

The alternative hypothesis for the ADF test is that the series is stationary. Given the p-values are less than 0.05; we reject the null hypothesis of non-stationarity, indicating that the series are now stationary. These results suggest that after first differencing, the data for Total GDP, Money Supply M1, and Money Supply M2 are stationary, suitable for further time series analysis.

Regression Coefficients

Table 4: Regression Coefficients for The Predictors

Predictor	Estimate	Std. Error	t-value	p-value
Intercept	454.85	334.65	1.36	0.186
M1	-0.64	0.02	-27.40	0.003
M2	0.83	0.21	3.95	0.001
GDP	0.72	0.13	5.61	0.000008

The regression analysis in Table 4 reveals the relationships between the dependent variable and three key predictors: M1 and M2. The intercept, with an estimate of 454.85, is not statistically significant, as indicated by a p-value of 0.186. This suggests that the baseline value of the dependent variable, when all predictors are zero, is not meaningfully different from zero, and thus does not contribute significantly to the model. The predictor M1 shows a significant negative relationship with the dependent variable, with a coefficient of -0.64 and a highly significant p-value of 0.003. This indicates that as M1 increases, the dependent variable decreases, highlighting M1 as a critical factor with a substantial negative impact on the outcome. In contrast, both M2 and GDP exhibit significant positive relationships with the dependent variable. M2 has a coefficient of 0.83, and GDP has a coefficient of 0.72, both with very significant p-values (0.001 for M2 and 0.000008 for GDP). These results suggest that increases in M2 and GDP are associated with increases in the dependent variable, emphasizing their strong positive influence within the model.

Table 5: Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		**Trace**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.515074	33.57994	29.79707	0.0175
At most 1	0.336444	12.59093	15.49471	0.1307
At most 2	0.023742	0.696812	3.841466	0.4039
Trace test indicates 1 cointegratingeqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		**Max-Eigen**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None	0.515074	20.98901	21.13162	0.0523

At most 1	0.336444	11.89412	14.26460	0.1147
At most 2	0.023742	0.696812	3.841466	0.4039

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

Money Supply M1 in Billions	Money Supply M2in Billions	Total GDP
0.001034	-0.000562	2.45E-06
0.003664	-0.001162	-8.44E-05
0.001293	5.99E-05	-0.000299

Unrestricted Adjusted Coefficients (Alpha)

D (Money Supply M1 in Billions)	-404.2720	-239.3791	89.12127
D (Money Supply M2 in Billions)	-869.9244	-155.2050	124.5282
D (Total GDP in Billions)	626.1739	381.6123	47.30914

Money Supply M1 in Billions	Money Supply M2 in Billions	Total GDP in Billions
1.000000	-0.543472 (0.09908)	0.002371 (0.04959)

Adjustment coefficients (standard error in parentheses)

D (Money Supply M1 in Billions)	-0.417926 (0.17127)
D (Money Supply M2 in Billions)	-0.899305 (0.25298)
D (Total GDP in Billions)	0.647322 (0.19977)

Cointegration Equation(s): Log Likelihood -683.1683
Normalized Cointegrating Coefficients (Standard Error in Parentheses)

Money Supply M1 in Billions	Money Supply M2 in Billions	Total GDP in Billions
1.000000	0.000000	-0.058593 (0.02930)
0.000000	1.000000	-0.112176 (0.08177)

Adjustment Coefficient (Standard Error in Parentheses)

D (Money Supply M1 in Billions)	-1.295070 (0.60270)	0.505273 (0.20431)
D (Money Supply M2 in Billions)	-1.468014 (0.92385)	0.669085 (0.31318)
D (Total GDP in Billions)	2.045644 (0.67332)	-0.795209 (0.22825)

The cointegration analysis in Table 5 reveals insights into the long-term relationships between Total GDP, Money Supply M1, and Money Supply M2. According to the Trace test, there is evidence of one significant cointegrating relationship among the variables, indicating a long-term equilibrium among them. This result suggests that despite the variations in individual variables, they tend to move together in the long run. However, the Maximum Eigenvalue test does not support the presence of additional cointegrating relationships beyond this single one, as its results did not meet the critical values. The analysis also presents two sets of cointegrating equations. The first set, based on one cointegrating equation, shows that deviations from equilibrium are corrected by adjusting Money Supply M1 and M2 negatively and Total GDP positively. This indicates that when the system deviates from its long-term balance, the adjustments tend to restore equilibrium by decreasing Money Supply M1 and M2, while increasing Total GDP. In the second set, which considers two cointegrating equations, the relationships among the variables are more complex. The adjustment coefficients for Money Supply M1 and M2 suggest varying magnitudes of correction, and Total GDP shows mixed adjustment behaviors. This highlights the dynamic and interdependent nature of these economic variables, where different adjustments are made based on the specific long-term relationships identified in the model.

Vector Error Correction Model (VECM) Coefficients Estimation

Table 6: Vector Error Correction Model (VECM) Coefficients

Dependent Variable	Total GDP.l2	Money Supply M1.l2	Money Supply M2.l2
Money Supply M1 in Billions	0.0015	-0.0322	-0.0142
Money Supply M2 in Billions	-0.0010	0.0202	-0.0267
Total GDP in Billions	-0.0021	0.0131	-0.0373

The VECM (Vector Error Correction Model) coefficients in Table 6 provide insights into how the lagged values of Total GDP and money supplies (M1 and M2) influence their current changes. For Total GDP, a unit increase in the second lag of Total GDP results in a 0.0015 unit increase in its first difference. Conversely, increases in the second lags of Money Supply M1 and M2 lead to decreases in the first difference of Total GDP by 0.0322 and 0.0142 units, respectively. This suggests that past values of money supply negatively affect the current changes in Total GDP. For Money Supply M1, the coefficient results indicate that a one-unit increase in the second lag of Total GDP is associated with a 0.0010 unit decrease in the first difference of Money Supply M1. However, an increase in the second lag of Money Supply M1 itself results in a 0.0202 unit increase in its own first difference, while a one-unit increase in the second lag of Money Supply M2 leads to a 0.0267 unit decrease in Money Supply M1. These results imply that Money Supply M1 is influenced both by its own lagged values and by the lagged values of other variables.

For Money Supply M2, a one-unit increase in the second lag of Total GDP results in a 0.0021 unit decrease in its first difference. Conversely, a one-unit increase in the second lag of Money Supply M1 leads to a 0.0131 unit increase in Money Supply M2, while an increase in the second lag of Money Supply M2 itself results in a 0.0373 unit decrease in its first difference. The model's statistics reflect its robustness, with a residual standard error of 1359, a Multiple R-squared of 0.6793, and an Adjusted R-squared of 0.6555, indicating that about 67.93% and 65.55% of the variability in the dependent variable is explained by the model. The F-statistic of 28.59 and the very low p-value (2.152e-07) suggest that the model is statistically significant and that the predictors collectively have a substantial effect on the dependent variable.

ARDL Model

Table 7: Estimated Coefficients of the ARDL model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
TOTAL GDP in BILLION (-1)	1.607391	0.153139	10.49628	0.0000
TOTAL GDP in BILLION (-2)	-0.627940	0.161701	-3.883335	0.0009
Money Supply in Billions	-0.521970	0.462334	-1.128990	0.2723
Money Supply M1 in Billions (-1)	1.517706	0.257083	5.903576	0.0000
Money Supply M1 in Billion (-2)	0.556065	0.417073	1.333257	0.1974
Money Supply M1 in Billions (-3)	-1.444436	0.457548	-3.156908	0.0050
Money Supply M2 in Billion	-0.047400	0.237729	-0.199385	0.8440
C	1016.768	1147.696	0.885920	0.3862

R-squared	0.998732	**Mean dependent var**	46388.14
Adjusted R-squared	0.998288	**S.D. dependent var**	19039.82
S.E. of regression	787.7288	**Akaike info criterion**	16.41114
Sum squared resid	12410333	**Schwarz criterion**	16.79177
Log likelihood	-221.7560	**Hannan-Quinn criter.**	16.52750
F-statistic	2250.541	**Durbin-Watson stat**	2.393093
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

The ARDL model results in Table 7 reveal significant relationships between Total GDP and the lagged values of Money Supply M1, with some notable effects. The coefficient for Total GDP from one period ago is positive and highly significant, indicating that past GDP levels have a strong positive impact on current GDP. However, the coefficient for Total GDP from two periods ago is negative and also significant, suggesting that the influence of past economic conditions may have a dampening effect. For Money Supply M1, the lagged values show a mixed impact. The coefficient for Money Supply M1 from one period ago is positive and highly significant, suggesting that previous levels of M1 contribute positively to current GDP. In contrast, the coefficient for Money Supply M1 from three periods ago is negative and significant, indicating a significant negative impact. This suggests that older values of M1 might have a delaying effect on the current GDP. However, the current level of Money Supply M1 and its values from two periods ago do not show statistically significant effects.

The model has a very high R-squared value of 0.9987, reflecting that nearly 99.87% of the variability in Total GDP is explained by the predictors in the model. The F-statistic is highly significant, confirming that the model as a whole is statistically effective. Despite the excellent fit indicated by the R-squared and F-statistic, the coefficients for Money Supply M2 and the

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ISSN 2689-5323 • Volume 9, Issue 3, 2026 • pp. 62–84

constant term are not statistically significant, suggesting that these factors do not significantly impact Total GDP in this model.

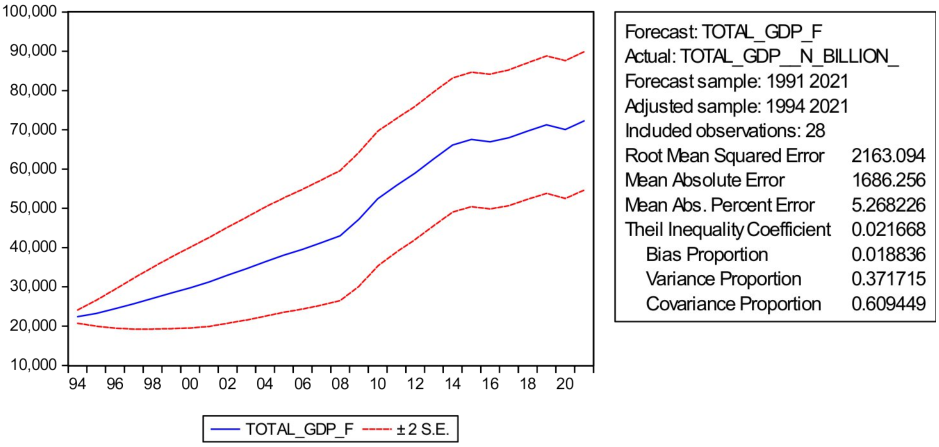

Figure 8: Forecast Plot

The forecast accuracy metrics in Figure 8 indicate that the model predicting Total GDP performs quite well. The Root Mean Squared Error (RMSE) of 2163.094 and the Mean Absolute Error (MAE) of 1686.256 reflect the average magnitude of errors between the forecasted and actual values. These values suggest that while there are some deviations, the model's predictions are reasonably accurate. The Mean Absolute Percentage Error (MAPE) of 5.27% indicates that, on average, the forecasted values deviate from the actual GDP values by about 5.27%. This relatively low percentage demonstrates the model’s effectiveness in capturing the actual GDP trends with a good degree of precision. The Theil Inequality Coefficient of 0.0217, along with its components, reveals that the forecast model is highly accurate compared to a naive benchmark. The minimal bias proportion (0.0188) and the significant covariance proportion (0.6094) show that the model’s errors are mostly due to variability rather than systematic bias, and that it effectively captures variations in the data. Overall, these statistics suggest that the forecast model provides a reliable representation of Total GDP trends.

DISCUSSION

This paper employs the ARDL models to analyse the correlation between money supply and economic growth in Nigeria and provides empirical evidence that has important monetary policy implications. ADF tests indicated that Total GDP was stationary at level and first differencing (p-value: 0.01), and M1 and M2 were stationary after first differencing (p-values < 0.05), which proves the ARDL model. The ARDL (2,3,0) model, chosen through AIC, has a high fit (R-squared: 0.9987), where Money Supply M1 has a negative influence on GDP (-0.64, p-value: 0.003) and M2 has a positive influence on it (0.83, p-value: 0.001). The adverse M1 is probably due to the cash-based informal economy of Nigeria, which restricts productive investment and contributes to inflation (24.5% in 2023, African Development Bank, 2023), whereas M2 is conducive to long-term growth due to savings and investment. Johansen Cointegration Test proves a long-term equilibrium between Total GDP, M1 and M2 (Trace test p-value: 0.0175). VECM outcomes indicate that M1 (-0.0322) and M2 (-0.0142) are negatively adjusted and GDP (0.0015) is positively adjusted, which means that the monetary policy stabilizes deviations, and M2 is the driver of sustained growth. These results are consistent with (Opata & Obasikene, 2021), who reported a positive long-run M2 impact on

GDP. Nevertheless, the negative impact of M1 is against findings by (Inam, 2014), which is probably caused by the high inflation and poor financial intermediation in Nigeria, in contrast to Sri Lanka, where all the effects are positive (Aslam, 2016). The policy implications are significant for the CBN. The positive long-term effect of M2 suggests that policies promoting savings and time deposits, such as competitive interest rates or financial inclusion programs, can enhance economic growth. Conversely, the negative short-term effect of M1 calls for cautious management of narrow money to avoid inflationary spikes. Targeted interventions, such as adjusting reserve requirements or expanding formal banking access, could improve monetary policy transmission and mitigate external shocks like oil price volatility. This study reaffirms M2's role in Nigeria's growth and suggests future research incorporate additional variables or post-2021 data to deepen understanding.

CONCLUSION

This paper aimed to analyse the correlation between money supply and economic growth in Nigeria with the help of the Autoregressive Distributed Lag (ARDL) model and the related co-integration methods. The results indicate that there is a complex relationship between the monetary aggregates-Money Supply M1 and M2 and economic performance as indicated by Total GDP. The analysis establishes that although M1 has a negative effect on GDP that is statistically significant, M2 has a positive effect, which means that the short-term and long-term effects of various forms of money supply are different. The Johansen Co-integration Test and Vector Error Correction Model (VECM) also confirms the existence of a long-run equilibrium relationship between the variables, with M2 being a more stable and growth-friendly monetary element. The negative coefficient of M1 indicates that the excess liquidity in the currency and demand deposits can increase the inflationary pressure and weaken the growth, particularly in the cash-based economy of Nigeria. Conversely, M2, which includes time deposits and other quasi-money elements, facilitates investment and savings, which leads to sustainable economic growth. These results support the need to have a differentiated monetary policy where the Central Bank of Nigeria (CBN) is encouraged to promote the processes that promote the accumulation of broad money and reduce the inflationary risks of narrow money. Overall, the empirical evidence highlights the significance of the monetary policy adjustment to the structure and peculiarities of the Nigerian economy. In this regard, the study suggests that monetary authorities should adopt measures that will enhance financial intermediation, increase access to banking, and improve liquidity management. Future studies ought to take into account the inclusion of more macroeconomic factors, including inflation expectations, interest rate patterns, and fiscal dynamics, and explore post-2021 data to determine the changing effects of monetary policy in the Nigerian economy. This work contributes to the broader understanding of monetary policy's role in driving growth and provides a solid empirical basis for more targeted, evidence-based policy formulation.

Limitation of the Study

Despite the utilization of data from the National Bureau of Statistics, it is important to acknowledge certain limitations that may affect the study's outcomes. One such limitation pertains to the availability and reliability of the data, which, despite being from an authoritative source, may still contain certain gaps or inconsistencies. Additionally, the study's exclusive focus on the co-integration analysis of money supply and economic growth may not fully capture the influence of other important macroeconomic variables, such as fiscal policy measures, external shocks, and sector-specific dynamics, which could potentially impact the overall economic performance of Nigeria. These limitations underscore the need for cautious interpretation of the study's findings and highlight the importance of considering a broader range of factors for a more comprehensive understanding of the Nigerian economy.

Contribution of Authors

This study represents the collective work of all authors. All authors contributed to the revision process and have approved the final version of the manuscript.

Acknowledgment

The researchers would like to express their gratitude to the department of Statistics, University of Abuja for their support during the period of writing this research.

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