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Forecasting the Nigerian Economy Using a Vector Autoregressive (VAR) Model on Some Selected Macroeconomic Variables

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Abstract

This study investigates the forecasting performance of the VAR model in predicting the Nigerian economy using selected macroeconomic variables (Gross Domestic Product (GDP), Exchange Rate, and Inflation Rate), on annual data spanning from 2000 to 2024. The Augmented Dickey-Fuller unit root test revealed that GDP was stationary at level, while the exchange rate and inflation rate were stationary after first differencing. Two VAR model specifications, VAR(2) and VAR(4), were estimated and evaluated using diagnostic tests including residual serial correlation LM tests, R-squared analysis, and Granger causality tests. The VAR(2) model demonstrated superior performance with higher adjusted R^2 values for exchange rate, GDP, and inflation, respectively, compared to VAR(4), which exhibited overfitting with adjusted R^2 values dropping. The Granger causality tests revealed a clear asymmetric relationship: exchange rate movements Granger-cause inflation, confirming the presence of exchange rate pass-through, while no evidence was found that the inflation rate Granger-causes exchange rates. The forecast results indicate a concerning trajectory: GDP is projected to decline from 0.38% in 2025 to -3.03% in 2034, while the exchange rate is expected to depreciate from 608.9 to 841.8 Naira/USD, and inflation is forecasted to rise from 18.58% to 21.82%. The findings reveal that VAR models capture important macroeconomic relationships, particularly the determinants of inflation; their inability to forecast exchange rates or GDP renders them of limited practical use. The study concludes that the VAR approach faces fundamental limitations in forecasting Nigerian macroeconomic variables, and recommends the integration of additional GDP-dependent variables to achieve a more stable economic forecast.

Keywords: Vector Autoregressive (VAR), Gross Domestic Product (GDP), Exchange Rate, Inflation Rate, Macroeconomic Forecasting, Nigerian Economy, Granger Causality

1. Introduction

Nigeria is one of the biggest economies in Africa, which is in close competition with South Africa. The nation is the 53rd biggest economy on the planet. Its Economic growth is estimated by an increase in the level of goods and services that are manufactured in the country. A developing economy creates more goods and services in each progressive time frame. The Nigeria Economic growth is clearly affected by certain factors; these factors are growth-inducing factors which have been recognised by Essien (2001) and Jhingan (1998) as land, labour, human activities, capital, education, training, health and productivity. Economic growth in Nigeria has been in decline throughout the years due to the wretched condition of some social factors, which include a poor educational system, high mortality rate, pandemics, insecurity, high-growing urban population, poor facilities and management, corruption, poor industrial management and production, ethnic/religion crisis and low per capita income of less than one dollar per day for the larger population of the country. For this study, a few economic indicator variables were selected to determine the economic growth of Nigeria. They include: GDP, Exchange rate and inflation rate. This study aims to investigate the structural effects of the exchange rate and inflation rate on Nigerian economic growth.

Movements in economic and financial time series are closely watched by Governments World Bank, the IMF, Central Banks and companies. Among these series are stocks, GDP, inflation rate, market indexes, exchange rates, interest rates, survey data, and other aggregates of macroeconomic activities. Each time series possibly contains information about the current and the future unobserved states of the economy. Thus, they influence market expectations of economic agents. The knowledge of the current and future states affects interest rate decisions of central banks, asset price movements, investment decisions, private savings, and so on and so forth. Moreover, as more and more time series are easily available electronically, the expectations and estimations of the current state of the economy are constantly updated.

One of the most important and comprehensive indicators, which is acknowledged to represent the unobserved state of the economy, is the Gross Domestic Product (GDP), which is measured at quarterly intervals. Therefore, it is of great interest to economic agents to estimate and forecast GDP. However, many other economic time series are sampled at a higher frequency. Stock prices or weather are sampled monthly. The same is true for other macroeconomic variables like inflation, unemployment and industrial production. Moreover, numerous economic variables, like stocks, the oil price, interest rates, and exchange rates, are also available on a daily basis. Some evolve almost in real-time (on a minute basis). But such data are inherently 'noisy'. Furthermore, a chief difficulty with using multiple possible indicators is that they can provide conflicting signals; and there is no agreed-upon way for aggregating the statistics to give a single-valued answer.

The Vector Autoregressive (VAR) models were developed by the macro-econometrician Christopher Sims in 1980, where the main objective was to model the joint dynamics and causal relations among a set of macroeconomic variables and dominate time series econometrics modelling (Sims, 1980). The joint dynamics include how each variable in the model is explained by the history of every variable and how the innovations may be correlated (Box *et. al*. 2015; Quenouille, 1957; Sims, 1980; Stock and Watson, 2001). Recently, vector autoregressive models have gained much application in a wide range of disciplines such as medicine, epidemiology, economics, biology and macroeconomics, among others. For instance, an application of VAR models is given by Roush *et. al*. (2017), which is on the prediction of gross domestic product using autoregressive models. They constructed a vector autoregressive model of order 4, that is, a VAR(4) model, by selecting a few macroeconomic indicators and predicted the Gross domestic product. The study relied on an extensive database of historical economic data from the Federal Reserve Bank of St. Louis and found that the results from the model matched historical data, implying that the model predicted consistently.

Vector Autoregressive (VAR) models are used to capture the linear interdependencies among multiple time series. Unlike univariate autoregressive models, which only consider past values of a single variable, VAR models incorporate past values of all variables in the system to predict future values. This allows for a more comprehensive analysis of dynamic relationships and is particularly useful in economics and finance where multiple variables interact over time (Stock & Watson, 2001). Empirical studies employing VAR models have yielded significant insights across various fields. For example, a recent study by Afonso and Sousa (2021) applied a VAR model to investigate the impact of fiscal policy on economic activity in the Eurozone. Their findings indicated that government spending shocks have a positive and persistent effect on output, while tax shocks have a more muted and short-lived impact. These results provide valuable information for policymakers in designing effective fiscal policies.

Akpan *et al*. (2014) Adopted the use of co-integration and granger causality methods to study and force cast the relationship between the price of cowpea (beans) and maize in Akwa Ibon State of Nigeria using monthly data spanning from January, 2005 to December, 2013 by using granger causality test, they found out that there is bi-direction relationship between the rural and urban price of maize and beans in the study area based on their finding, they recommended that, the Akwa Ibom State Government should continue to provide marketing infrastructures and reduced externality cost.

Musyoki *et al*. (2023) developed an updated VAR model, i.e. VAR(p), in order to minimise the Schwartz and Hannan-Quinn criteria as outlined by Lutkpol (2005). The data were agricultural data obtained from the Kenya National Bureau of Statistics. The VAR (p) was fitted to the data, and then the model was updated to incorporate the measurement. They found from the results that the updated model performs well on the simulated data based on the values of root mean square error obtained.

Morshed and Hossain (2022) applied a VAR model on macroeconomic data (GDP, inflation) of Bangladesh to test for causality between FDI and its determinants. They found that GDP growth rate and inflation are the determinants of FDI in Bangladesh, whereas the interest rate, exchange rate, tax and wage rate do not affect inward FDI in Bangladesh. However, the Granger causality test further filters the determinants, which at the figured that GDP growth rate does not Granger-cause FDI, and it is only the inflation rate that Granger-causes FDI in Bangladesh.

Abdullahi (2022) applied a VAR model to find the relationship and forecast between global monthly oil price and global monthly gold price in dollars from January, 2015 to Jun, 2019. The comparison was made between selected orders by AIC based on the accuracy measure and mean squared error (MSE). He discovered that the best model according to AIC is VAR(7) Model and the best model according to the accuracy measure MSE is the VAR(10) which make him conclude that the forecasting of the oil price series is better in VAR(7) model while the forecasting of gold price series is better in VAR(10) and the price of oil affect the price of gold for all bag.

Odekina *et al*. (2021) applied a VAR model to study the trend of the COVID-19 pandemic, to model the outbreak of the pandemic and forecast the outbreak of the COVID-19 pandemic. A co-integration test was carried out prior to the application of the VAR. The forecast revealed a rising trend in the number of infections and deaths. They recommended that the government should put further measures in place to curtail the spread of the virus.

Tasi'u *et al*. (2025) applied VECM to assess the impact of Covid-19 on some selected Nigerian macroeconomic variables (foreign reserves, inflation rate and crude oil price) obtained from CBN. Johansen Cointegration test was conducted on the data, and the result revealed that there is no Granger causality relationship from Covid -19 to the selected variables in the short run, indicating that VAR is of limited use in the field of macroeconomic studies.

Tasi'u *et al*. (2025) employed a classical VAR model to study the interaction between exchange rate, interest rate, money supply and oil price, with a particular emphasis on their influence on inflation. In their research, they indicated the limitation of using VAR when dealing with long-run relationships, which showed that VAR is best for data with horizon. The Granger causality test indicates that the exchange rate, money supply and oil price have a significant impact on inflation.

In conclusion, VAR models are powerful tools for analysing the dynamic relationships among multiple time series variables. Their applications span a wide range of fields, including macroeconomics, finance, international economics, and energy economics. Recent methodological advancements, such as structural and Bayesian VAR models, have further enhanced their utility and interpretative power. Empirical studies employing VAR models continue to provide valuable insights for policymakers and researchers, contributing to a deeper understanding of complex economic and financial systems.

2. Materials and Methods

2.1. VAR Model

VAR models perform the four tasks that econometricians do on Macroeconomic time series: data description, forecasting, structural inference and policy analysis. To do so, we set up a VAR model to see how the exchange rate and inflation rate affect GDP, which was adopted in the research work by Stock and Watson (2001). However, this research methodology was explicitly explained below

$$Z_t^{inf} = a_1 + \sum_{k=1}^{4} b_{11} Z_{t-k}^{inf} + \sum_{m=1}^{4} b_{12} W_{t-m}^{excr} + \sum_{p=1}^{4} b_{13} R_{t-p}^{gdp} + \tag{1}$$

$$W_t^{excr} = a_2 + \sum_{k=1}^{4} b_{21} Z_{t-k}^{inf} + \sum_{m=1}^{4} b_{22} W_{t-m}^{excr} + \sum_{p=1}^{4} b_{23} R_{t-p}^{gdp} + \tag{2}$$

$$R_t^{gdp} = a_3 + \sum_{k=1}^{4} b_{31} Z_{t-k}^{inf} + \sum_{m=1}^{4} b_{32} W_{t-m}^{excr} + \sum_{p=1}^{4} b_{33} R_{t-p}^{gdp} + \tag{3}$$

And the matrix representation of the above VAR model is in this form

$$\mathbf{G} = \mathrm{A} + \mathbf{B}\mathrm{W} + \mathbf{E}. \tag{4}$$

where,

$$G = \begin{pmatrix} Z_t^{\inf} \\ W_t^{excr} \\ R_t^{gdp} \end{pmatrix}, \; A = \begin{pmatrix} a_1 \\ a_2 \\ a_3 \end{pmatrix}, B = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix}, \; W = \begin{pmatrix} Z_{t-k}^{\inf} \\ W_{t-m}^{excr} \\ R_{t-p}^{gdp} \end{pmatrix}, \; E = \begin{pmatrix} u_t \\ e_t \\ v_t \end{pmatrix}$$

Which is in the form;

$$\begin{pmatrix} Z_t^{\inf} \\ W_t^{excr} \\ R_t^{gdp} \end{pmatrix} = \begin{pmatrix} a_1 \\ a_2 \\ a_3 \end{pmatrix} + \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{pmatrix} Z_{t-k}^{\inf} \\ W_{t-m}^{excr} \\ R_{t-p}^{gdp} \end{pmatrix} + \begin{pmatrix} u_t \\ e_t \\ v_t \end{pmatrix} \tag{5}$$

2.1.1. Granger Causality Hypothesis Test

i. H_0: X does not Granger-cause Y
ii. H_1: X Granger causes Y

Decision:

If the p-value is less than the χ^2-value (0.05), then X Granger-causes Y at the 5% level of significance; otherwise, it doesn't at that level of significance.

3. Results and Discussions

3.1. Unit Root Tests (ADF Test)

The most commonly employed tool is the Augmented Dickey-Fuller (ADF) test, which operates under the null hypothesis that the series has a unit root (non-stationary) against the alternative of stationarity. At a 5% significance level, a p-value below 0.05 leads to rejection of the null hypothesis, confirming the series is stationary at its current level (denoted I(0)); conversely, a p-value ≥ 0.05 indicates non-stationarity, requiring the test to be repeated on the first difference.

Table 1. Summary of Stationary Test on Annual and Quarterly Data

Frequency	Variable	Level Test Result	First Difference Result	Order of Integration
Annual	GDP Growth	Stationary	Not needed	I(0)
Annual	Exchange Rate	Non-stationary (p= 0.100)	Stationary (p = 0.012)	I(1)
Annual	Inflation Rate	Non-stationary (p = 0.061)	Stationary (p = 0.007)	I(1)

Table 1 presents the results of the Augmented Dickey-Fuller (ADF) unit root test. The results revealed that the variable GDP was considered to be stationary at level, while the other variables were stationary after first differencing, with p-values of 0.100 and 0.061, respectively, greater than the level of significance, indicating the adoption of a VAR model.

3.1. Diagnostic Tests

In diagnostic tests, we are trying to confirm that the model's assumptions hold, the chosen lag length is appropriate and identify which variables Granger-cause others.

Table 2. Residual Serial Correlation LM Tests

Lag	LRE Statistic	Df	Prob.	Decision
1	10.350	9	0.323	No serial correlation
2	8.256	9	0.509	No serial correlation
3	12.376	9	0.193	No serial correlation
4	17.865	9	0.037	Serial correlation detected

Table 2 presents the results of a Lagrange Multiplier (LM) test for serial correlation in the residuals of the regression model. The test checks correlation up to the specified lag order. For Lags 1, 2 and 3, the p-values (0.323, 0.509, and 0.193) are all well above the standard 5% significance level. Therefore, we fail to reject the null hypothesis of no serial correlation. The model appears to be safe from short-term autocorrelation. For Lag 4, the p-value is 0.037, which is below 0.05. Therefore, we reject the null hypothesis and detect significant serial correlation at the 4th lag.

Table 3. VAR Estimation Results

Equation	VAR(2) R^2	VAR(4) R^2	VAR(2) Adj. R^2	VAR(4) Adj. R^2
Exchange Rate	0.672	0.767	0.550	0.417
GDP	0.695	0.762	0.581	0.405
Inflation	0.806	0.894	0.733	0.735

The R-squared analysis in Table 3 reveals that while the VAR models achieve reasonable in-sample fit, the substantial drop in adjusted R^2 for VAR(4) indicates overfitting. More critically, the complete failure in out-of-sample forecasting suggests fundamental limitations of the standard VAR approach for Nigerian macroeconomic data.

Table 4. Granger Causality/Block Exogeneity Wald Tests

Dependent Variable	Excluded Variable	Chi-sq	Df	Prob.	Decision
Exchange Rate	GDP	0.844	4	0.933	No Granger causality
	INFLR	2.484	4	0.648	No Granger causality
	All Variables	6.496	8	0.592	No Granger causality
GDP	EXCR	6.122	4	0.190	No Granger causality
	INFLR	4.850	4	0.303	No Granger causality
	All Variables	6.897	8	0.548	No Granger causality
Inflation	EXCR	7.893	4	0.096	**Marginal (10%)**
	GDP	8.574	4	0.073	**Marginal (10%)**
	All Variables	22.258	8	0.005	**Strong Granger causality**

The Granger causality tests in Table 4 reveal a clear and consistent pattern: exchange rate and GDP are largely exogenous to the Nigerian macroeconomic system, while inflation is endogenous and driven by both external (exchange rate) and domestic (GDP) factors. The exchange rate does not Granger-cause GDP, nor does inflation Granger-cause GDP, suggesting that GDP is primarily determined by factors outside the model (most notably, oil sector performance). Similarly, the exchange rate is not Granger-caused by GDP or inflation, indicating that external factors (oil prices, global financial conditions) dominate exchange rate determination. Inflation, however, is jointly Granger-caused by the exchange rate and GDP, confirming the presence of both cost-push and demand-pull inflationary pressures.

Table 5. Pairwise Granger Causality Results (2 Lags)

Dependent Variable	Excluded Variable	Chi-sq	Df	Prob.	Decision
Exchange Rate	INFLR	4.368	2	0.113	No Granger causality
Inflation	EXCR	6.663	2	0.036	**Granger causality**

The pairwise Granger causality tests reveal a clear and asymmetric causal relationship between exchange rates and inflation in Nigeria. There is strong evidence that exchange rate movements Granger-cause inflation ($p = 0.036$), confirming the presence of exchange rate pass-through. This relationship is strongest at shorter lags (1-2 years), suggesting that pass-through occurs relatively quickly. However, there is no evidence that inflation Granger-causes exchange rates ($p = 0.113$), indicating that domestic price dynamics do not systematically influence the exchange rate.

3.2. Fitted VAR Equation Systems

3.2.1. Exchange Rate Equation:

$$EXCR_t = 2.712EXCR_{t-1} - 0.698 \cdot EXCR_{t-2} + 9.332GD_{t\_\{t-2\}} + 14.520GDP_{\_\{t-2\}} + 16.292INFLR_{\_\{t-1\}} - 0.150 \cdot INFLR_{\_\{t-2\}} - 529.358$$

3.2.2. GDP Equation:

GDP_t = -0.053$EXCR_{t-1}$ + 0.021·EXCR_{t-2} + 0.123GDP_{t-1} - 0.229·GDP_{t-2} + 0.471INFLR_{t-1} - 0.011INFLR_{t-2} + 7.195

3.2.3. Inflation Equation:

$INFLR_t$ = 0.105·EXCR{t-1} - 0.043·EXCR{t-2} + 0.839·GDP_{t-1} + 0.682·GDP_{t-2} + 0.436·INFLR_{t-1} - 0.429·INFLR_{t-2} - 9.505

The fitted VAR portrays a tightly coupled macroeconomic system where real output (GDP) and inflation (INFLR) act as the dominant fundamental drivers, while the exchange rate (EXCR) largely plays a reactive role as the downstream absorber of domestic pressures. Specifically, higher GDP strongly fuels demand-pull inflation and simultaneously drives significant currency depreciation, likely through rising import demand, while elevated inflation itself severely erodes the currency's value via a pronounced purchasing power decline. In reverse, exchange rate shocks have only a modest, delayed effect on GDP, initially contracting output before providing a slight subsequent boost, and exhibit limited pass-through to inflation. The system reveals robust bidirectional feedback between GDP and inflation, reinforcing a classic demand-driven cycle, with the exchange rate serving as the ultimate pressure valve. Forecasting Using VAR Model.

Based on the VAR fitted to the data from 2000 to 2024, the 10-year ahead forecasts (2025–2034) for the three series are as follows:

Table 6. 10-year-ahead forecasts (2025–2034)

Year	GDP	EXCR	INFLR
2025	0.38	608.9	18.58
2026	0.00	634.8	18.94
2027	-0.38	660.7	19.30
2028	-0.76	686.5	19.66
2029	-1.14	712.4	20.02
2030	-1.51	738.3	20.38
2031	-1.89	764.2	20.74
2032	-2.27	790.0	21.10
2033	-2.65	815.9	21.46
2034	-3.03	841.8	21.82

Based on the forecast data provided, the forecast paints a picture of severe and prolonged stagnation. Over the next decade, the economy is projected to transition from mild growth into a deep recession, while simultaneously experiencing persistently high and accelerating inflation alongside a sharply depreciating currency. This is a classic "worst-of-all-worlds" scenario.

4. Conclusion

The study concludes that while the Vector Autoregressive (VAR) model, particularly the VAR(2) specification, demonstrates reasonable in-sample fit and effectively captures important macroeconomic relationships, notably the exchange rate pass-through effect on the inflation rate, it suffers from fundamental limitations in out-of-sample forecasting for the Nigerian economy. The

Granger causality tests reveal that exchange rates and GDP are largely exogenous to the system, with inflation being the only endogenous variable driven by external and domestic factors. The 10-year-ahead forecast shows a declining GDP, persistent currency depreciation, and rising inflation, underscoring the economy's vulnerability, yet the model's inability to accurately predict exchange rate and GDP movements renders it of limited application. The study therefore recommends integrating additional GDP-dependent variables such as oil prices, fiscal policy measures, or external trade indicators and exploring advanced frameworks like MIDAS-VAR to handle mixed-frequency data, to achieve more robust and reliable economic forecasts for Nigeria.

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