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Multiple Regression Analysis of the Impact of some Selected Macro - Economic Variables on the Gross Domestic Product (GDP)

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Abstract

The economy of many nations is dwindling with the recent happenings in the globe. This development has made macro-economic variables unpredictable and volatile. Understanding the interrelationships between GDP and key macroeconomic variables is pivotal for navigating economic challenges, fostering sustainable growth, and enhancing overall economic stability. This study employs multiple linear regression analysis to investigate the relationship between Gross Domestic Product (GDP) as the dependent variable and four prominent macroeconomic indicators namely, inflation rate, interest rate, exchange rate, and the all- share index as independent variables. Utilizing a robust dataset spanning historical records of GDP and corresponding data on inflation rates, interest rates, exchange rates, and stock market performance, this research evaluated the quantitative impact and significance of these variables on GDP. The model obtained is $GDP = 22.995\breve{}0.265INF + 2.452INT + 0.75EX - 0.323ASI.$. The analysis revealed compelling results that indicate a statistically significant relationship between GDP and the selected macroeconomic factors. The findings suggested that inflation rate, interest rate, and exchange rate exhibit varying degrees of influence on GDP, with inflation rate demonstrating a moderately negative impact, while interest rate and exchange rate display positive associations with GDP fluctuations. It is recommended that policymakers should consider adopting measures to manage inflationary pressures while utilizing interest rate and exchange rate policies strategically to stimulate economic growth.

Keywords: Inflation Rate, Interest Rate, Exchange Rate, Gross Domestic Product, All Share Index.
MSC2010: 46L53, 35Q62.

1 Introduction

In recent years, people have been talking a lot about how money supply, foreign exchange, and economic growth are all connected in the world of monetary economics. Economists don't all see eye to eye on how money supply affects economic growth. Some say that changes in the amount of money floating around are the big players in economic growth. They also believe that countries paying more attention to how money moves around tend to have more stable economic activities with fewer ups and downs [1]. Exchange rate is an important variable as its appreciation or depreciation affects the performance of other macroeconomic variables in any economy. Exchange rate is one of the most important policy variables in an open economy, as it affects the macroeconomic variables like; trade, capital flows, foreign direct investment, international reserves, GDP and remittances. An exchange rate is not only important for the business circle, but it can also significantly influence the growth process of a small open economy. Exchange rate comprises both nominal foreign exchange and real exchange rate. According to [2], nominal exchange rates are the number of units of foreign exchange that might be obtained in return for unit of the domestic currency. It is the price of one country's currency in terms of another [3]. According to [2], real exchange rate is the number of baskets of foreign produced goods and services for which a corresponding basket of domestically produced goods and services could be traded. It was observed by [4] that real exchange rate is a relative price and that, as such, it is not under direct control of the authorities, but it can be influenced by policy. Inflation, which measures the rate at which the general level of prices for goods and services rises, has been widely studied for its impact on GDP. According to [5], inflation can negatively impact GDP growth by eroding purchasing power and creating uncertainty in the economy. However, moderate inflation may also stimulate spending, thus having a complex relationship with GDP. Interest rates are another crucial determinant of GDP. According to the classical theory of interest rates, higher interest rates can slow down economic growth by increasing the cost of borrowing, thereby reducing consumer spending and business investments. Studies by [6] support this view, highlighting that lower interest rates are often associated with higher GDP growth. Government spending is a significant driver of economic activity. Keynesian economics suggests that increased government expenditure can stimulate demand and, consequently, GDP growth. Research by [7] indicates that government spending, particularly on infrastructure and social services, positively correlates with GDP. However, the efficiency of spending and the nature of the expenditure are critical factors. The exchange rate is the price of one country's currency in terms of another and is a significant factor in determining a country's trade balance. Research by [8] suggests that an appreciation of the domestic currency may hurt GDP by making exports less competitive, while a depreciation might boost GDP by making exports cheaper and imports more expensive. The relationship between unemployment and GDP is often explained by Okun's law, which posits an inverse relationship between unemployment and GDP. The empirical study conducted by [9] established that a reduction in unemployment leads to an increase in GDP, as more people are employed and contributing to economic output. FDI is considered a significant contributor to GDP growth, especially in developing economies. It was discovered by [10] that Foreign Direct Investment contributes to GDP by bringing in capital, technology, and managerial know-how, which can lead to improved productivity and economic expansion. Several empirical studies have utilized multiple regression analysis to investigate the impact of macroeconomic variables on GDP. For instance, [11] conducted a study on Nigeria's economy and found that government expenditure, inflation, and exchange rates significantly impact GDP. Similarly, a study by [12] demonstrated that in the European Union, inflation and interest rates are critical determinants of GDP growth. Another notable study by [13] employed a robust regression approach to analyze data from multiple countries and found that government spending, inflation, and trade openness are significant predictors of GDP growth. Their findings underscore the importance of policy decisions in shaping economic outcomes. According to [14], macroeconomic variables such as population, interest rates, unemployment rates, amongst others, can be used to predict the GDP of a country. He explored the overview on how various macroeconomic indicators can serve as predictors for a country's economic performance.

In a study by [15] which investigated the effects of variables such as exchange rate, inflation rate, and interest rate on Nigeria's economic growth using an Autoregressive Distributed Lag (ARDL) model. The findings indicated that exchange rate fluctuations have a significant negative impact on economic growth, while inflation and interest rates are statistically insignificant in both short and long runs.

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Statement of the Problem

Gross Domestic Product (GDP) serves as a critical indicator of a nation's economic health and growth. It is influenced by various macroeconomic variables such as inflation rate, exchange rate, interest rate and all share index (ASI). Understanding the extent and nature of these relationships is crucial for policymakers, investors, and economists in developing strategies that promote sustainable economic growth. However, in many economies, including Nigeria's, the interactions among these variables and their collective impact on GDP remain unclear. This lack of clarity hampers informed decision-making and the development of effective policies to enhance economic performance.

Gap in the Existing Literatures

While numerous studies have explored the relationship between individual macroeconomic variables and GDP, most focus on isolated factors rather than a holistic examination of multiple variables simultaneously. Furthermore, the existing literature often relies on data from developed economies, leaving a significant gap in understanding how these variables interact in developing countries with unique economic dynamics, such as Nigeria. There is also limited research employing advanced statistical techniques like multiple regression analysis to quantify the simultaneous impact of selected macroeconomic variables on GDP in the Nigerian context. This gap underscores the need for a comprehensive study to bridge the divide and provide actionable insights.

Aim and Objectives of the Study

The aim of this study is to address the identified gap by achieving the following specific objectives:

1. To evaluate the relationship between selected macroeconomic variables (inflation rate, exchange rate, interest rate and all share index and GDP in Nigeria.

2. To quantify the collective and individual impact of these macroeconomic variables on GDP using multiple regression analysis.

Materials and Methods

Regression Analysis

Regression analysis reveals average relationship between two variables and this makes prediction or estimation possible.
The term 'regression' was first used by Sir Francis Galton in 1877 while studying the relationship between the height of fathers and sons, in a paper titled 'Regression towards Mediocrity in Hereditary Stature'.
Regression analysis can be carried out by fitting or drawing a line on the scattered plot of the bivariate data under study, this line is used to predict or estimate average relationship between the two variables. The line is being referred to as Regression line also known as equation of straight line, and it is also being recently called estimating line.

Definitions:

Regression: Regression is the mathematical modeling of average linear relationship between two variables. While,
Regression Analysis: Regression analysis refers to the methods by which estimates are made of the values of a variable from knowledge of the values of the other variable and to the measurement

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of errors involved in the estimation process.
From the above definition(s) it is clear that regression analysis is a statistical device used to estimate or predict the unknown values of one variable from the known values of the other variable. The variable that is used to predict the variable of interest is called the independent variable or explanatory variable and the variable we are trying to predict is called the dependent variable or explained variable. When only two variables are being considered; for example, 'X' as independent variable and 'Y' as dependent variable. The type or regression analysis used is called Simple Regression Analysis – simple because there is only one predictor or independent variable and linear because of the assumed linear relationship between the dependent and independent variables. The term 'linear' means that an equation of straight line of the form; , where, a and be are constants called coefficient regression lie, Y is dependent variable and X is independent variable, is used to described the average relationship between variables X and Y.
[16] opined that Mathematical models for the transmission dynamics of dengue fever can be traced back from 1970 with well-known complex epidemiological dynamics, over the years, those models tried to incorporate factors focusing on different aspects of the disease and vectors, which could provide rich dynamical behavior even in the most basic models. [16] presented a novel mathematical model for HIV/AIDS transmission in Africa, using Cape Verde as a case study, by incorporating the ART treatment, resulting in U=U. In real life situation there could be other unexplainable factors that might be influencing the predicted value of Y apart from X in $Y = \alpha + bX$. These unexplainable factors are represented using error term $'\epsilon'$ in the model:

$$Y = \alpha + \beta X + \epsilon \tag{1.1}$$

eliminating the error term $'\epsilon'$ we have

$$\hat{Y} = \hat{\alpha} + \hat{\beta}; \tag{1.2}$$

where, $\hat{\alpha} = \alpha$, $\hat{\beta} = \beta$ and for convenience sake

$$\hat{Y} = Y \tag{1.3}$$

These gives rise to the estimated regression line

$$Y = \alpha + bX \tag{1.4}$$

Assumption of Simple Linear Regression

The general assumptions for the model are:

$$\sum_{j=i}^{N} \epsilon = 0; \tag{1.5}$$

sum of the error term is zero

$$var(\epsilon_i) = \sigma^2 : \cdots \tag{1.6}$$

variance of the error term is population variance

The Least Squares Regression Line

To obtain the least square regression line, we assume that the straight line relationship between X and Y is given by the model:

$$Y_i = \alpha + \beta X_i + \epsilon_i \cdots \tag{1.7}$$

Where, Y_i is the observed i^{th} observed value of dependent variable for a fixed i^{th} value of independent variable Xi, α and β are the coefficient of the least regression line and ϵ_i is the error term.
The estimate of the regression coefficients α, β are obtained by eliminating the error term ϵ_i in the

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model as shown below:
From the model, we have,

$$\epsilon_i = Y_i - \alpha - \beta X_i \cdots \tag{1.8}$$

Summing and squaring, we have,

$$\sum_{i=i}^{n} \epsilon_i^2 = \sum_{i=1}^{n} (Y_i - \alpha - \beta X_i)^2 \tag{1.9}$$

Let

$$L = \sum_{i=1}^{n} \epsilon_i^2 \cdots \tag{1.10}$$

Differentiating with respect to α and equating the derivative to zero, we have,

$$\frac{\partial L}{\partial \alpha | \alpha = \hat{\alpha}} = -2 \sum_{i=1}^{n} (Y_i - \hat{\alpha} - \hat{\beta} X_i) = 0 \cdots \tag{1.11}$$

$$\Rightarrow \sum_{i=1}^{n} (Y_i - \hat{\alpha} - \hat{\beta} X_i) = 0 \cdots \tag{1.12}$$

$$\Rightarrow \sum_{i=1}^{n} Y_i - n\hat{\alpha} - \hat{\beta} \sum_{i=1}^{n} X_i = 0* \tag{1.13}$$

Differentiating with respect to β and equating the derivative to zero, we have,

$$\frac{\partial L}{\partial \beta | \beta = \hat{\beta}} = -2 \sum_{i=1}^{n} X_i (Y_i - \hat{\alpha} - \hat{\beta} X_i) = 0 \cdots \tag{1.14}$$

$$\Rightarrow \sum_{i=1}^{n} X_i (Y_i - \hat{\alpha} - \hat{\beta} X_i) = 0 \cdots \tag{1.15}$$

$$\Rightarrow \sum_{i=1}^{n} X_i Y_i - \hat{\alpha} \sum_{i=1}^{n} X_i - \hat{\beta} \sum_{i=1}^{n} X_i^2 = 0 ** \tag{1.16}$$

Multiplying equations $*$ and $**$ by and $sum_{i=1}^{n} X_i$ and n respectively, we have,

$$\sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y - n\hat{\alpha} \sum_{i=1}^{n} X_i - \hat{\beta} \left(\sum_{i=1}^{n} X_i \right)^2 = 0 *** \tag{1.17}$$

$$n \sum_{i=1}^{n} X_i Y_i - n\hat{\alpha} \sum_{i=1}^{n} X_i - n\hat{\beta} \sum_{i=1}^{n} X_i^2 = 0 **** \tag{1.18}$$

Equating $***$ to $****$, we have,

$$\sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y - n\hat{\alpha} \sum_{i=1}^{n} X_i - \hat{\beta} \left(\sum_{i=1}^{n} X_i \right)^2 = n \sum_{i=1}^{n} X_i Y_i - n\hat{\alpha} \sum_{i=1}^{n} X_i - n\hat{\beta} \sum_{i=1}^{n} X_i^2 \tag{1.19}$$

$$\Rightarrow \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i - \hat{\beta} \left(\sum_{i=1}^{n} X_i \right)^2 = n \sum_{i=1}^{n} X_i Y_i - n\hat{\beta} \sum_{i=1}^{n} X_1^2 \tag{1.20}$$

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$$\Rightarrow n\hat{\beta}\sum_{i=1}^{n}X_i^2-\hat{\beta}\left(\sum_{i=1}^{n}X_i\right)^2=n\sum_{i=1}^{n}X_iY_i-\sum_{i=1}^{n}X_i\sum_{i=1}^{n}Y_i \tag{1.21}$$

$$\Rightarrow \hat{\beta}\left\{n\sum_{i=1}^{n}X_i^2-\left(\sum_{i=1}^{n}X_i\right)^2\right\}=n\sum_{i=1}^{n}X_iY_i-\sum_{i=1}^{n}X_i\sum_{i=1}^{n}Y_i \tag{1.22}$$

$$\Rightarrow \hat{\beta}=\frac{n\sum_{i=1}^{n}X_iY_i-\sum_{i=1}^{n}X_i\sum_{i=1}^{n}Y_i}{\hat{\beta}n\sum_{i=1}^{n}X_i^2-\left(\sum_{i=1}^{n}X_i\right)^2} \tag{1.23}$$

The error term has been eliminated so that the original model now becomes:

$$Y_i=\hat{\alpha}+\hat{\beta}X_i \tag{1.24}$$

To obtain the $\hat{\alpha}$,we have,

$$\hat{\alpha}=Y_i-\hat{\beta}X_i \tag{1.25}$$

Since there 'n' observations in both Y and X, the best representation for each are their means, i.e $\bar{Y}$ and $\bar{X}$. Then , we have,

$$\hat{\alpha}=\bar{Y}-\hat{\beta}\bar{X} \tag{1.26}$$

$$\therefore \hat{\alpha}=\frac{1}{n}\sum_{ei=1}^{n}Y_i-\hat{\beta}\frac{1}{n}\sum_{i=1}^{n}X_i \tag{1.27}$$

The coefficients of the regression line α and β is now estimated $\hat{\alpha}=a$ and $\hat{\beta}=b$ respectively. The least squares regression line is now; $Y_i=a+bX$,
where,

$$b=\frac{n\sum_{i=1}^{n}X_iY_i-\sum_{i=1}^{n}X_{i\sum_{i=1}^{n}Y_i}}{n\sum_{i=1}^{n}X_i^2-\left(\sum_{i=1}^{n}X_i\right)^2} \tag{1.28}$$

and

$$a=\bar{Y}-b\bar{X} \tag{1.29}$$

$$\therefore a=\frac{1}{n}\sum_{i=1}^{1}Y_i-b\frac{1}{n}\sum_{i=1}^{n}X_i \tag{1.30}$$

Other formula for estimating β are;

$$b=\frac{\sum_{i=1}^{n}X_iY_i-\frac{1}{n}\sum_{i=1}^{n}X_i\sum_{i=1}^{n}Y_i}{\sum_{i=1}^{n}X_i^2\frac{1}{n}\left(\sum_{i=1}^{n}X_i\right)^2} \tag{1.31}$$

or

$$b=\frac{\sum_{i=1}^{n}(X_i-\bar{X})(Y_i-\bar{Y})}{\sum_{i=1}^{n}(X_i-\bar{X})^2} \tag{1.32}$$

Multiple Regression Analysis

Multiple Regression Definition

Multiple regression analysis is a statistical technique that analyzes the relationship between two or more variables and uses the information to estimate the value of the dependent variables. In multiple regression, the objective is to develop a model that describes a dependent variable y to more than one independent variable. Multiple regression works by considering the values of the available multiple independent variables and predicting the value of one dependent variable. It allows us to explicitly control for many other factors that simultaneously affect the dependent variable. This is important both for testing economic theories and for evaluating policy effects when we must rely on non-experimental data.

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Multiple linear regression formula

In linear regression, there is only one independent and dependent variable involved. But, in the case of multiple regression, there will be a set of independent variables that helps us to explain better or predict the dependent variable y.
The formula for a multiple linear regression is:

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon \tag{1.33}$$

where y = the predicted value of the dependent variable, $\beta 0$ = the $y-$ intercept (value of y when all other parameters are set to 0), $\beta_i X_i$ = the regression coefficient (β_1) of the independent variable (X_i) (the effect that increasing the value of the independent variable has on the predicted y value) for $i = 1, 2, \ldots, n$ and ϵ = model error (a.k.a. how much variation there is in our estimate of y).
Note that sometimes the independent variables are called covariates, regressors or explanatory variables, whereas the dependent ones are called regressand or explained variable.
To find the best-fit line for each independent variable, multiple linear regression calculates three things:

1. The regression coefficients that lead to the smallest overall model error.
2. The t-statistic of the overall model.
3. The associated p-value (how likely it is that the t-statistic would have occurred by chance if the null hypothesis of no relationship between the independent and dependent variables was true).

It then calculates the t-statistic and p-value for each regression coefficient in the model.

Assumptions of multiple linear regression

Linearity: A linear relationship is specified between explained and explanatory variables, i.e., the line of best fit through the data points is a straight line, rather than a curve or some sort of grouping factor.
Independence of observations: the observations in the dataset were collected using statistically valid methods, and there are no hidden relationships among variables.
In multiple linear regression, it is possible that some of the independent variables are actually correlated with one another, so it is important to check these before developing the regression model. If two independent variables are too highly correlated, then only one of them should be used in the regression model.
Normality: The error terms are normally and identically distributed with mean zero and variance, σ^2.
Homogeneity of variance (homoscedasticity): the size of the error in our prediction doesn't change significantly across the values of the independent variable.
Ordinary least squares (OLS) estimation method:
Multiple variable case The general formula for a multiple linear regression model is defined as

$$y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_n X_{in} + \epsilon_i \tag{1.34}$$

Suppose that the sample is composed of k observations for the explanatory variables, X_i, The above equation can be expressed as

$$y_1 = \sum_{i=1}^{k} \beta_i X_{ik} + \epsilon_i \qquad ; i = 1, 2, \cdots, k \tag{1.35}$$

or, in simple matrix form:

$$Y = X\beta + \epsilon \tag{1.36}$$

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where Y, β and ϵ are the following vectors:

$$Y = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_1 \end{pmatrix}, \quad \beta = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_1 \end{pmatrix} \mathit{and} \;\; \epsilon = \begin{pmatrix} \epsilon_1 \\ \epsilon_2 \\ \vdots \\ \epsilon_1 \end{pmatrix} \tag{1.37}$$

On the other hand, X is the following kn matrix:

$$X = \begin{pmatrix} 1 & x_{21} & x_{31} & \cdots & x_{n1} \\ 1 & x_{22} & x_{32} & \cdots & x_{n2} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & x_{2k} & \cdots & \cdots & x_{nk} \end{pmatrix} \tag{1.38}$$

If $\hat{\beta}_1, \hat{\beta}2, \cdots, \hat{\beta}_n$ are estimated values of the regression parameters, then $\hat{Y}$ is the predicted value of y. Also, here residuals are $\epsilon = y_i - \hat{y_i}$, and ϵ is the vector collecting all the residuals.
We suppose to minimize the sum of squares of the residuals, i.e.,

$$\epsilon = Y - X\hat{\beta} \tag{1.39}$$

Let

$$S = \sum_{i=1}^{n} \epsilon_i^2 = \epsilon^T.\epsilon = (Y - X\hat{\beta})^T(Y - X\hat{\beta}) = (Y^T - \hat{\beta^T} X^T)(Y - X\hat{\beta}) \tag{1.40}$$

$$= Y^TY - \hat{\beta}^T X^T Y - Y^T X\hat{\beta} + \hat{\beta}^T X^T X\hat{\beta} \tag{1.41}$$

$$= Y^TY - 2\hat{\beta}^T X^T Y + \hat{\beta}^T X^T X\hat{\beta} \tag{1.42}$$

To minimize S, we differentiate with respect to β and equate to zero.
Hence,

$$\frac{\partial S}{\partial \hat{\beta}} = -2X^TY + 2X^TX\hat{\beta} = 0 \tag{1.43}$$

$$\Rightarrow X^TX\hat{\beta} = X^TY \tag{1.44}$$

Therefor,

$$\hat{\beta} = (X^TX)^{-1}X^TY \tag{1.45}$$

Note:

$$X^TX = \begin{pmatrix} N & \sum X_1 & \sum X_2 & \cdots & \sum X_k \\ \sum X_2 & \sum X_1^2 & \sum X_1X_2 & \cdots & \vdots \\ \sum X_n & \sum X_1X_2 & \cdots & \cdots & \vdots \\ \cdots & \cdots & \cdots & \cdots & \vdots \\ \sum X_n & \sum X_1X_k & \cdots & \cdots & \sum X_k^2 \end{pmatrix} \tag{1.46}$$

and

$$X^TY = \begin{pmatrix} \sum Y \\ \sum X_1Y \\ \sum X_2Y \\ \vdots \\ \sum X_kY \end{pmatrix} \tag{1.47}$$

$$\hat{\beta} = \begin{pmatrix} \hat{\beta}_0 \\ \hat{\beta}1 \\ \hat{\beta}_2 \\ \vdots \\ \hat{\beta}_n \end{pmatrix} = \begin{pmatrix} N & \sum X_1 & \sum X_2 & \cdots & \sum X_k \\ \sum X_2 & \sum X_1^2 & \sum X_1 X_2 & \cdots & \vdots \\ \sum X_n & \sum X_1 X_2 & \cdots & \cdots & \vdots \\ \cdots & \cdots & \cdots & \cdots & \vdots \\ \sum X_n & \sum X_1 X_k & \cdots & \cdots & \sum X_k^2 \end{pmatrix} \begin{pmatrix} \sum Y \\ \sum X_1 Y \\ \sum X_2 Y \\ \vdots \\ \sum X_k Y \end{pmatrix} \tag{1.48}$$

We employed multiple regression analysis to assess the relationship between GDP and the selected macro-economic variables-Inflation Rate, Interest Rate, Exchange Rate and the National Stock Index. The model is formulated as follows:

$$GDP = \beta 0 + \beta_1 InflationRate + \beta_2 InterestRate + \beta_3 ExchangeRate + \beta_4 NationalStockIndex + \epsilon \tag{1.49}$$

Where:
GDP represents Gross Domestic Product,
Inflation Rate denotes the inflation rate,
Interest Rate represents the interest rate,
Exchange Rate denotes the exchange rate,
NASI represents the national stock index
$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ are the regression coefficients, and ϵ is the error term.
We utilized secondary data for this study The analysis was conducted using statistical software (SPSS), and appropriate diagnostics are performed to ensure the validity of the results.

Tests of the assumptions

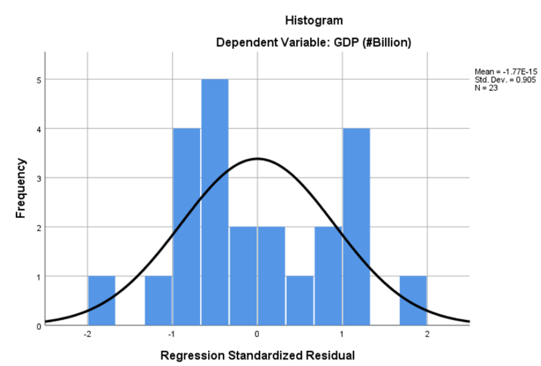

Figure 1: Normality test for the residuals

Figure 1: Normality test for the residuals
The above figure shows that the data is normally distributed.

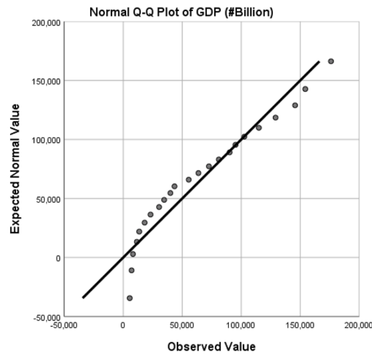

Figure 2: Normal Q – Q Plot of the GDP

The Normal Q – Q Plot of the GDP confirms the normality of the data as we can see that the data points are clustered and close to the diagonal line.
H_0: There is no heteroskedasticity.
H_1: There is heteroskedasticity.
Heteroskedasticity Test: Breusch-Pagan-Godfrey

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F-statistic	0.766295	Prob. F(4,18)	0.5609
Obs * R-squared	3.346716	Prob. Chi-Square(4)	0.5016
Scaled explained SS	1.204057	Prob. Chi-Square(4)	0.8774

Heteroskedasticity Test: Harvey

F-statistic	1.127448	Prob. F(4,18)	0.3748
Obs * R-squared	4.608003	Prob. Chi-Square(4)	0.3299
Scaled explained SS	2.912159	Prob. Chi-Square(4)	0.5726

Heteroskedasticity Test: White

F-statistic	0.787315	Prob. F(10,12)	0.6427
Obs * R-squared	9.111917	Prob. Chi-Square(10)	0.5215
Scaled explained SS	3.278220	Prob. Chi-Square(10)	0.9741

Decision rule: since the p values for the three heteroskedasticity tests namely: Breusch-Pagan-Godfrey, Harvey and White are all greater than 0.05, this implies that heteroskedasticity does not exist in the data.
Test of autocorrelation
Breusch-Godfrey Serial Correlation LM Test:

F-statistic	10.38432	Prob. F(2,17)	0.0011
Obs * R-squared	12.64705	Prob. Chi-Square(2)	0.0018

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
· | * * · |	· | * * · |	1	0.226	0.226	1.3397	0.247
· | · |	·* | · |	2	-0.030	-0.086	1.3644	0.505
· | *· |	· | *· |	3	0.094	0.129	1.6209	0.655
· | *· |	· | · |	4	0.088	0.033	1.8533	0.763
· | *· |	· | *· |	5	0.101	0.093	2.1799	0.824
· * * | · |	* * * | · |	6	-0.297	-0.376	5.1699	0.522
· * * | · |	·* | · |	7	-0.333	-0.201	9.1669	0.241
· * * | · |	· * * | · |	8	-0.218	-0.225	10.986	0.202
· | · |	· | *· |	9	-0.051	0.077	11.093	0.269
·* | · |	·* | · |	10	-0.166	-0.161	12.311	0.265
·* | · |	· | *· |	11	-0.098	0.180	12.770	0.309
·* | · |	·* | · |	12	-0.076	-0.194	13.073	0.364

The above result shows that the data are linearly correlated since the p value (0.0011) is less than 0.05. This is expected of time series data especially the variables under consideration.

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Results

Data Presentation, Analysis and Interpretation

Histogram Plot for GDP

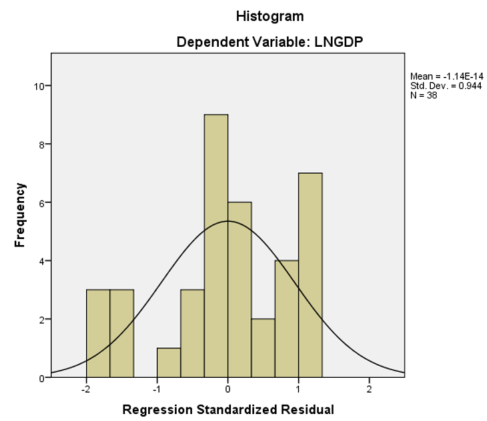

Figure 4.1 above is a histogram of the residuals from a regression analysis. The residuals are the errors between the predicted values of the dependent variable and the actual values. The histogram shows the distribution of the residuals. In this case, the residuals are approximately symmetric which suggests that the regression model is a good fit for the data.

Descriptive Statistics

Table 1: Descriptive statistics Table

	Mean	Standard Deviation	Range	Maximum	Minimum
GDP	25.858116	0.8874677	2.5687	27.0762	24.5075
Inflation Rate	0.191109	0.1720378	0.6745	0.7284	0.0539
Interest Rate	0.068338	0.0247903	0.1075	0.1106	0.0032
Exchange Rate	0.298441	0.2799440	1.000	1.000	0.000
NASI	8.874792	1.9252467	6.0799	10.8445	4.7645

The table 4.2.1 presents statistical measures for various economic indicators. The first column represents the variables, including GDP (Gross Domestic Product), Inflation rate, Interest rate, Exchange rate, and NASI (National All Share Index). The mean values provide a central tendency measure for each variable. For instance, GDP has a mean of 25.86, suggesting an average GDP value. The standard deviation indicates the degree of variability or dispersion around the mean, with GDP having a relatively low standard deviation of 0.89, indicating relatively stable GDP values. The range shows the difference between the maximum and minimum values, highlighting the spread of the data. The maximum and minimum values represent the extremes observed in the dataset.

Analysis of Results and Interpretations

Descriptive Statistics

GDP = 22.995 - 0.265 inflation rate - 2.452 interest rate + 0.750 exchange rate + 0.323 national stock index The table 4.3.1 presents the results of a regression analysis, detailing the coefficients, standard errors, t-statistics, and significance levels for each predictor variable in the model. The constant term, represented by the "Constant" row, is 22.995 with a standard error of 0.508, and

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Table 2: Regression Coefficients

Model	B	Std. Error	T	Sig
Constant	22.995	0.508	45.252	0.000
Inflation Rate	-0.265	0.491	-0.539	0.593
Interest Rate	-2.452	4.112	-0.596	0.555
Exchange Rate	0.750	0.414	1.812	0.079
NASI	0.323	0.076	4.249	0.000

the associated t-statistic of 45.252 is highly significant ($p < 0.000$), suggesting a strong influence on the dependent variable. The "Inflation rate" coefficient is -0.265, but its t-statistic of -0.539 is not statistically significant ($p = 0.593$), indicating that changes in inflation may not have a significant impact on the dependent variable. Similarly, the "Interest rate" variable has a coefficient of -2.452, but its t-statistic of -0.596 is not statistically significant ($p = 0.555$). The "Exchange rate" variable has a coefficient of 0.750, and its t-statistic of 1.812 suggests marginal significance ($p = 0.079$). The "NASI" variable has a coefficient of 0.323 with a highly significant t-statistic of 4.249 ($p < 0.000$), indicating a substantial impact on the dependent variable. Overall, this regression model suggests that the constant and "NASI" are statistically significant predictors, while the impact of "Inflation rate," "Interest rate," and "Exchange rate" on the dependent variable may not be statistically significant. The table 4.3.2 summarizes the goodness-of-fit statistics for

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
1	0.873	0.761	0.732	0.4591

a regression model. The correlation coefficient (R) is 0.873, indicating a strong positive linear relationship between the independent and dependent variables. The coefficient of determination (R Square) is 0.761, suggesting that approximately 76.1% of the variability in the dependent variable is explained by the independent variables in the model. The Adjusted R Square, which accounts for the number of predictors in the model, is 0.732, providing a more accurate representation of the model's explanatory power. The standard error (Std. Error) is 0.4591, reflecting the average deviation of the observed values from the predicted values. Overall, the high R Square and Adjusted R Square values indicate that the model is a good fit for the data, capturing a significant proportion of the variability in the dependent variable. The relatively low standard error suggests that the model's predictions are precise. The table 4.3.3 presents the results of analysis of variance (ANOVA) for the

Table 4: ANOVA TABLE

Model	Sum Of Squares	Df	Mean Square	F	Sig
Regression	22.187	4	5.547	26.21	0.000
Residual	6.954	33	0.211		
Total	29.141	37			

regression model. The "Regression" row provides information about the overall performance of the model, including the sum of squares (SS) attributed to the regression, the degrees of freedom (Df), the mean square (MS), the F-statistic, and its associated significance level (Sig). The regression sum of squares is 22.187, indicating the variance in the dependent variable explained by the model. With 4 degrees of freedom, the mean square is 5.547. The F-statistic of 26.21 is calculated by dividing the regression mean square by the residual mean square, and the associated p-value (Sig) is highly significant ($p < 0.000$), suggesting that the overall regression model is statistically significant in explaining the variability in the dependent variable. The "Residual" row provides information about the unexplained variance in the model, with a sum of squares of 6.954 and 33 degrees of freedom, leading to a residual mean square of 0.211. The "Total" row summarizes the total variance in the dependent variable. In conclusion, the ANOVA table indicates that the regression model as a whole is significant, suggesting that the predictors collectively contribute to explaining the variability in the dependent variable.

Discussion of Results

The model obtained in this study is GDP = 22.995 - 0.265INF + 2.452INT + 0.75EX - 0.323ASI. The analysis revealed compelling results indicating a statistically significant relationship between GDP and the selected macroeconomic factors. The findings suggested that inflation rate, interest rate, and exchange rate exhibit varying degrees of influence on GDP, with inflation rate demonstrating a moderately negative impact, while interest rate and exchange rate display positive associations with GDP fluctuations. This is in line with a study by Oladipo et al (2024) which investigated the effects of variables such as exchange rate, inflation rate, and interest rate on Nigeria's economic growth using an Autoregressive Distributed Lag (ARDL) model. The findings indicated that exchange rate fluctuations have a significant negative impact on economic growth, while inflation and interest rates are statistically insignificant in both short and long runs. Also, Faria and Carneiro (2001), inflation can negatively impact GDP growth by eroding purchasing power and creating uncertainty in the economy. However, a study by Asteriou and Hall (2011) demonstrated that in the European Union, inflation and interest rates are critical determinants of GDP growth and nother notable study by Levine and Renelt (1992) employed a robust regression approach to analyze data from multiple countries and found that government spending, inflation, and trade openness are significant predictors of GDP growth.

Conclusion

This study employs multiple regression analysis to examine the impact of Inflation Rate, Interest Rate, and Exchange Rate on Gross Domestic Product (GDP). The findings highlight the complex interplay between these macro-economic variables and GDP. By providing empirical evidence on these relationships, this research contributes to a deeper understanding of economic dynamics and informs evidence-based policy making. Further research could explore additional variables and extend the analysis.

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