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COMPARATIVE ANALYSIS OF THE IMPACT OF SOME ECONOMIC VARIABLES ON INFLATION RATES IN NIGERIA USING ROBUST REGRESSION.

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ABSTRACT: *This study examines the impact of Economic Variables (FDI, Money Supply, GDP per Capita, Population Growth and Real Interest rate) on Inflation rate in Nigeria over the period of 2006 to 2023 using OLS regression and Robust Regression (M-estimation, Bi-square Estimation, Iteratively Re-weighted Least Squares (IRLS), S-Estimation). It was found out that M-estimation and Iteratively Re-weighted Least Squares (IRLS) give similar result as Bi-square robust estimation method. From the results of OLS regression it was found that Money Supply shows a positive significant impact on inflation rate, Real Interest Rate shows a negative significant impact on inflation rate while FDI, GDP per capita and population growth shows insignificant negative impacts on inflation rate. Robust regression estimation method using bi-square estimation method indicates that money supply shows significant positive impacts on inflation rates; population growth rate shows insignificant positive impacts on inflation rates while GDP per capita and real interest rate shows negative significant impact on inflation rate; FDI shows insignificant negative impact on inflation rate. From the results of S-robust regression analysis method it is seen that FDI, GDP per capita, population growth rates and real interest rates have negative and significant impacts on inflation rates whereas money supply has a positive but insignificant impact on inflation rates in Nigeria. Also the nature of impact of the variables in the model does not change but there is a reduction in the standard error of the residual from 0.21 in OLS and 0.13 in S- Estimation model to 0.084 in bi-square regression; R^2 has increased from 77.2% in OLS to 90.3% in Bi-Square regression; S-estimation model has the highest R^2 of 96.6%. Comparing the three measures, bi-square, M and IRLS estimation methods has been considered since a higher R^2 with a higher standard error of residual may indicate over fitting problems.*

KEYWORDS: OLS Regression, Robust Regression, FDI, Money Supply, GDP per Capita, Population Growth and Real Interest rate.

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INTRODUCTION

Robust regression is an alternative to least squares regression when data is corrupted with outliers. When fitting a least squares regression, there may be some outliers, these data points are not data entry errors, neither are they from a different population, so excluding them from the analysis may affect the inference. Robust regression is useful here since it is a concession between excluding these outliers entirely from the analysis and including all the data points.

Inflation is a macroeconomic variable that causes significant challenges to economies worldwide. It refers to a consistent and substantial increase in the overall price level within an economy (Jhinghan, 1990). The potential for domestic businesses to raise their prices is increased by this; many economists argue that inflation is primarily a result of monetary factors, occurring when the growth rate of the money supply surpasses the growth rate of the economy (Akcay et al., 1996). This phenomenon is particularly prevalent in developing nations in Africa, including Nigeria. According to Oladipo and Akinbobolo (2011), some African countries have experienced an average annual inflation rate of over 15 percent, with certain countries even reaching rates of 20 percent or higher. These factors include high public sector budget deficits, the monetization of these deficits, excessive military expenditure, inadequate rainfall, populist policies implemented prior to elections, the persistent inflationary expectations of economic agents, an increase in the money supply, rising costs of imported raw materials, inputs, and manufactured goods, escalating interest rates resulting from the crowding-out effect of government borrowing, and unstable exchange rates both before and after the adoption of IMF/World Bank adjustment programs. Nyong (2001) argues that inflation is positively related to the growth of money supply, all else being equal, and negatively related to the growth of real income or output. Ogunmuyiwa and Francis (2010) discovered that during Nigeria's oil boom period, characterized by rapid monetary growth, the country experienced double-digit inflation. Usoro (2021) focused on modeling Nigeria’s Gross Domestic Product and some macroeconomic variables. Kumpayi et al., (2012), observed that high inflation in Nigeria has led to a decline in investment yield and has negatively impacted government policy objectives. As inflation rises, the real size of the budget shrinks, which hampers economic growth. The causes of inflation are a subject of controversy, with various economists and finance experts attributing different factors as the main causes. These factors include money supply, exchange rates, interest rates, government deficit budget, and others. Developing countries, such as Nigeria, are particularly affected by inflation. Money supply is considered a crucial variable that determines the pace of economic activities.

Data from the Central Bank of Nigeria (2024) show that inflation is around 34.6%per cent and this high level of inflation is a major issue confronting monetary authorities. High inflation will decrease the real value of money used for effective demand of consumption and production of goods and services for households and firms. Inflation effectively reduces the basket of goods and services that the private sector can demand as well as increases the operating cost of firms. Inflation causes serious economic discomfort to households, businesses, government, and foreign investments all over the world (Adeniyi, 2020). Inflation rate has social and economic dimensions as it is a shock, eroding real purchasing power, savings and investments (Moodley, 2020). However, the resultant shortage of goods and services for local consumption spurred a rapid and continuous rise in the cost of goods and services in the economy which has largely continued till date. As a result of the devastating

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effects of inflation on the Nigerian economy, many attempts have been made to formulate policies aimed at restructuring the economy for diversification and self-reliance.

In view of the above results there have been some divergent and conflicting inferences on the impacts of these economic variables on inflation rates in Nigeria. These may be due to the period under study, the type of model used or analysis techniques, mi-specification of models and modelling under violations of assumptions. These factors have to be taken into consideration in order to have valid and reliable inferences on such analysis.

This work used OLS and robust regression methods of analysis to investigate the impact of some economic variables (FDI, broad money, population growth rate, GDP per capita, and real interest rate) on inflation rates in Nigeria.

METHODOLOGY:

The method of analysis adopted in this research work is OLS Regression and Robust Regression.

Multiple Linear Regression Model

The general multiple linear regression model is expressed as:

$$\mathrm{Y_i} = \beta_0 + \beta_1 \mathrm{X_1} + \beta_2 \mathrm{X_2} + \cdots + \beta_k \mathrm{X_k} + \varepsilon_i \quad (1)$$

While the estimated equation is

$$\hat{\mathrm{Y}}_i = \hat{\beta}_0 + \hat{\beta}_1 \mathrm{X_1} + \hat{\beta}_2 \mathrm{X_2} + \cdots + \hat{\beta}_k \mathrm{X_k} \quad (2)$$

Where

$\hat{\mathrm{Y}} =$ Predicted value of the dependent variable, $\hat{\beta}_1, \hat{\beta}_2, \ldots \hat{\beta}_k (\mathrm{i} = 1,2)$ are the estimated regression coefficients.

$\mathrm{X}_i'^{s}$ = values of the explanatory variables defined in Table 3.1.

ε_i= error term associated with the model

Estimation of parameters of the model

The general model can be expressed in a matrix form as:

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \quad (3)$$

where

$$\varepsilon = \mathrm{Y} - \mathrm{X}\beta \quad (4)$$

$$\varepsilon'\varepsilon = (\mathrm{Y} - \mathrm{X}\beta)'(\mathrm{Y} - \mathrm{X}\beta)$$

$$= \mathrm{Y}'\mathrm{Y} - \mathrm{Y}'\mathrm{X}\beta - \mathrm{X}'\beta'\mathrm{Y} + \mathrm{X}'\beta'\mathrm{X}\beta \quad (5)$$

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$$\frac{\delta\varepsilon\prime\varepsilon}{\delta\beta\prime} = -X'Y + X'X\beta = 0 \tag{6}$$

$$\beta X'X = X'Y \tag{7}$$

$$\widehat{\boldsymbol{\beta}} = (\mathbf{X'X})^{-1}\mathbf{X'Y} \tag{8}$$

$$\hat{e}'\hat{e} = Y'Y - \hat{\beta}'X'Y \tag{9}$$

$$\sigma^2 = \frac{\hat{e}'\hat{e}}{(n-k)} \tag{10}$$

$$\mathbf{Var - Cov}\big(\widehat{\boldsymbol{\beta}}\big) = (\mathbf{X'X})^{-1}\boldsymbol{\sigma}^2 \tag{11}$$

Standard error of $\boldsymbol{\beta}$ = $\sqrt{(\mathbf{X'X})^{-1}\boldsymbol{\sigma}^2}$ (12)

$$\mathbf{X'X} = \begin{pmatrix} \mathbf{n} & \sum \mathbf{X_1} & \sum \mathbf{X_2} & \sum \mathbf{X_3} & \sum \mathbf{X_4} \\ \sum \mathbf{X_1} & \sum \mathbf{X_1^2} & \sum \mathbf{X_1X_2} & \sum \mathbf{X_1X_3} & \sum \mathbf{X_1X_4} \\ \sum \mathbf{X_2} & \sum \mathbf{X_2X_1} & \sum \mathbf{X_2^2} & \sum \mathbf{X_2X_3} & \sum \mathbf{X_2X_4} \\ \sum \mathbf{X_3} & \sum \mathbf{X_3X_1} & \sum \mathbf{X_3X_2} & \sum \mathbf{X_3^2} & \sum \mathbf{X_3X_4} \\ \sum \mathbf{X_4} & \sum \mathbf{X_4X_1} & \sum \mathbf{X_4X_2} & \sum \mathbf{X_4X_3} & \sum \mathbf{X_4^2} \end{pmatrix}$$

3.3.3 Test for significance of the model and parameters

Hypothesis for testing the significance of the parameters of the model is

1. $H_0: \hat{\beta}_i = 0$, against $H_1: \hat{\beta}_i \neq 0$; for $i = 0,1,2,3,4,5$

The test statistic to be used is

$$t = \frac{\hat{\beta}_r}{s(\hat{\beta}_r)} \sim t_{n-k}\,;\ r = 0,1 \ldots 5, n = 17, k = 6$$

Decision rule: If $t_{cal} > t_{tab}$, H_0 is rejected, otherwise H_0 is accepted.

Test for the significance of the general model:

$H_0: \beta_i = 0$

against $H_1: \beta_i \neq 0$ for at least one i

The calculation of F-statistic can be summarized in the form of an analysis of variance (ANOVA) table given below:

Table 3.1 ANOVA Table

Source of variation	Sum of squares	Degrees of freedom	Mean square	F- Ratio
Regression	SSR	$k-1$	$MSR = \frac{SSR}{k-1}$	$\frac{MSR}{MSE}$

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Error	SSE	$n-k$	$MSR = \frac{SSR}{n-k}$
Total	SST	$n-1$	

Decision rule: If $F_{cal} > F_{tab}$, reject H_0 otherwise acceptH_0.

Rejection of H_0 indicates that it is likely that at least one$\beta_i \neq 0 (i = 0, 1,2, \ldots,5)$.

Assumptions in multiple linear regression model:

Some assumptions are needed in the model $Y = X\beta + \varepsilon$ for drawing the statistical inferences.

These assumptions are:

Linearity: The relationship between independent and dependent variable should be linear.

Normality: The error (i.e the residuals of the regression) between observed and predicted values should be normally distributed with mean zero and variance σ2

Multicollinearity: The predictor variables should be independent of each other.

No outliers: Data points that have unusually large or small values.

Test of Assumptions:

Linearity: Scatter plots of dependent and independent variables are used for detecting non-linear relationships.

Normality: This assumption may be checked through histogram of the error.

Multicollinearity: Examining the correlation matrix of the independent variables (usually above 0.8 or below -0.8).

To check outliers, plot the variable and observe if any points are far from all other points.

ROBUST REGRESSION

When data adopted for analysis violate some of the assumptions of the Ordinary Least Squares (OLS) estimation method, such as the presence of outliers and the existence of heteroscedasticity, the least squares estimation always provide misleading and unreliable estimates and tests, which may lead to inaccurate inferences. Consequently, a more robust and reliable method could be adopted for estimation and analysis. This method is called Robust Regression Analysis method. In this work, we adopt the robust method in addition to OLS for estimation and analysis. Some of the methods considered are explained here.

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M-ESTIMATION

According to Deng et al (2014), Huber was the first to propose the M-estimation method, the M-estimation is an extrapolation of the location M-estimation, generally, the method exposes a balance between the resistance of the Least Absolute Value estimator and the efficiency of the least squares approach.Maximum likelihood estimation denoted by the letter M is a type of estimation used in this case. The M-estimation method is represented by equation (13) as given by Susanti et al. (2014). The objective funtion of M-estimation is :

$$\text{Minimize} \sum_{i=1}^{n} \rho\,(e_i) = \text{Minimize}\ \rho(y_i - x_i'\beta) \quad (13)$$

Where: $e_i = y_i - \hat{y_i}$ (the residuals)

ρ gives the contribution of each residual to the objective function. A reasonable ρ should have the following properties:

$\rho(e) \geq 0$ implies non-negativity

$\rho(0) = 0$

$\rho(e) = \rho(-e)$ implies symmetric property

$\rho(e_i) \geq \rho(e_i)$ for $|e_i| > |e_i|$ implies monotone in $|e_i|$ for example the least squares $\rho-$ function $\rho(e_i) = e_i^2$ satisfies this requirements, many other functions do. The M-Estimator is not necessarily scale invariant; that is , if the errors $y_i - x_i'\beta$ were multiplied by a constant, the new solution to equation (13) might not be the same as the old one. To obtain a scale invariant version , we solve,

$$\text{Minimize} \sum_{i=1}^{n} \rho\left(\frac{e_i}{\tau}\right) = \text{Minimize} \sum_{i=1}^{n} \rho\left(\frac{y_i - x_i'\beta}{\tau}\right) \quad (14)$$

Where τ is a robust estimate of scale. A population choice for τ is the median absolute deviation (MAD) given as:

$$\tau = \text{Med}\,\frac{\text{Med}|e_i - \text{Med}(e_i)|}{0.6745} \quad (15)$$

0.6745 is the tuning constant that makes τ an approximately unbiased estimator of σ if n is large and the error distribution is normal. To handle equation (14), the first partial derivative of ρ-function with respect to β_j which yields a necessary condition for a minimum, thus gives a p +k system of equations.

$$\text{Thus, } \sum_{i=1}^{n} x_{ij}\varphi\left(\frac{y_i - x_i'\beta}{\tau}\right) = 0 \text{ for } j = 0,1,\ldots p \quad (16)$$

Where $\varphi = \rho'$and $\varphi =$ first partial derivative of ρ with respect to β_j and x_{ij} is the i^{th} observation on the j^{th} regressor.

φ is called an influence curve and is non-linear. Equation (16) is solved using iterative methods. Several non-linear optimization techniques such as iteratively re-weighted least squares (IRLS) is most widely used.

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Using iteratively re-weighted least squares (IRLS) , suppose that an initial estimate $\hat{\beta}_0$ is available and that τ is an estimate of scale . Then,

$$\sum_{i=1}^{n} x_{ij}\varphi\left(\frac{y_i - x_i'\beta}{\tau}\right) = \sum_{i=1}^{n} \frac{x_{ij}\{\varphi(y_i - x_i'\beta)/\tau\}(y_i - x_i'\beta)}{\tau} \qquad \text{for} \quad j = 0,1,\ldots p.$$

$$= \sum_{i=1}^{n} x_{ij} w_i^{(0)}(y_i - x_i'\beta) = 0, \quad j = 0,1,\ldots p \qquad (17)$$

$$w_i^{(0)} = \begin{cases} \dfrac{\varphi\left(\frac{y_i - x_i'\hat{\beta}^{(0)}}{\hat{\tau}^{(0)}}\right)}{\left(\frac{y_i - x_i'\hat{\beta}^{(0)}}{\hat{\tau}^{(0)}}\right)} & \text{if } y_i \neq x_i'\hat{\beta}^{((0))} \\ 1 & \end{cases} \qquad (18)$$

At the next step we re-compute the weights from equation (18) but using $\hat{\beta}^{(1)}$ instead of $\hat{\beta}^{(0)}$. The iteratively reweighted least-squares procedure was done using R program.

M-estimation is distinct from square regression in that it entails parameter estimation using OLS as well as the calculation of the residual value and weighted values. The fundamental distinction is that whereas square regression models seek to find the best fit line, M-estimation looks for outliers in the data. The steps for calculating M is detailed below:

STEPS:

1. OLS is used to estimate regression coefficients on data.

2. Regression model's assumptions are validated.

3. Determine whether any data points are outliers.

4. Calculate the parameter that is estimated $\hat{\beta}_0$ with OLS

5. Determine the residual value $e_i = y_i - \hat{y}_i$

6. Calculate value $\hat{\sigma}_i = 1.4826$ MAD

7. Calculate value $u_i = \frac{e_i}{\sigma_i}$

8. Calculate the weighted value $w_i = \begin{cases} \left[1 - \left(\frac{u_i}{4.685}\right)^2\right]^2 & |u_i| \leq 4.685 \\ 0 & |u_i| > 4.685 \end{cases}$

9. Calculate $\hat{\beta}_m$ using weighted least squares (WLS) method with weighted w_i

10. Repeat steps 5-8 to obtain a convergent value of $\hat{\beta}_m$.

11. To ascertain whether independent variable have a significant effect on the dependent variable, a significance test is used.

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Bi-Square Estimator:

The same procedure is used to obtain the Bi-square estimate but with different objectives weight function. The table below summarizes the least squares methods, their objective functions and their weight functions.

Method	Objective Function	Weight Function
Least Squares	$\rho_{LS}(e) = e^2$	$w_{LS}(e) = 1$
Huber	$\rho_{H(E)} = \begin{cases} \frac{1}{2}e^2, for\ \lvert e\rvert \leq k \\ k\lvert e\rvert - \frac{1}{2}k^2, \quad for\ \lvert e \end{cases}$	$w_H(e) = \begin{cases} 1, & x < 0 \\ x, & x \geq 0 \end{cases}$
Bisquare	$\rho_{B(e)} = \begin{cases} \frac{k^2}{6}\left\{1 - \left[1 - \frac{e^2}{k}\right]^3\right\} for \lvert e\rvert \leq k \\ \frac{k^2}{6}, \quad for\ \lvert e \end{cases}$ Where k=4.685	$W_B(e) = \begin{cases} \left[1 - \left(\frac{e}{k}\right)^2\right]^2, & \lvert e\rvert \leq k \\ 0, & \lvert e\rvert \geq \end{cases}$

S- Estimation

The regression estimates associated with M-scales is the S-estimators which proposed by Rousseeuw and Yohai (1984). S estimation is based on residual scale of M estimation. The weakness of M estimation is the lack of consideration on the data distribution and not a function of the overall data because it is only using the median as the weighted value. This method uses the residual standard deviation to overcome the weaknesses of median. According to Salibian and Yohai (2006), the S-estimator is defined by $\hat{\beta}_s = \min\beta\hat{\sigma}_s$ $(e_1, e_2, \ldots, e_n)$ with determining minimum robust scale estimator $\hat{\sigma}_s$ and satisfying min $\sum_{i=1}^{n} \rho\left(\frac{y_i - \sum_{i=1}^{n} x_{ij}\beta}{\hat{\sigma}_s}\right)$

Where $\hat{\sigma}_s = \sqrt{\frac{1}{nk}\sum_{i=1}^{n} w_i e_i{}^2}$ k = 0.199, $w_i = w_r(u_i) = \frac{\rho(u_i)}{u_i^2}$, and the initial estimate is $\hat{\sigma}_s = \frac{median\lvert e_i - median(e_i)\rvert}{0.6745}$. The solution is obtained by differentiating to β so that $\sum_{i=1}^{n} x_{ij}\varphi\left(\frac{y_i - \sum_{j=0}^{k} x_{ij}\beta}{\hat{\sigma}_s}\right) = 0$
(19)

φ is a function as derivative of ρ_i.

$$\varphi(u_i) = \rho(u_i) = \begin{cases} u_i\left[1 - \left(\frac{u_i}{c}\right)^2\right], & \lvert u_i\rvert \leq c \\ 0, & \lvert u_i\rvert > c \end{cases} \tag{20}$$

Where w_i is an IRLS weighted function:

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$$w_i(u_i) = \begin{cases} \left[1-\left(\frac{u_i}{c}\right)^2\right]^2, & |u_i| \le c \\ 0, & |u_i| > c \end{cases} \tag{21}$$

$u_i = \frac{e_i}{\sigma_s}$ and c = 1.547. we can solve equation (20) by using IRLS method.

Stages in S Estimation

(1) Estimate regression coefficient on the data using OLS

(2) Test assumptions of the classical regression model.

(3) Detect the presence of outliers in the data

(4) Calculate $\hat{\beta}^0$ with OLS

(5) Calculate residual value $e_i = y_i - \hat{y}_i$

(6) Calculate value $\hat{\sigma}_i = \begin{cases} \frac{median|e_i - mediane_i|}{0.6745}, & iteration = 1 \\ \sqrt{\frac{1}{nk}\sum_{i=1}^{n} w_i e_i^2}, & iteration > 1 \end{cases}$

(7) Calculating value $u_i = \frac{e_i}{\sigma_i}$

(8) Calculate weighted value

$$w_i = \begin{cases} \begin{cases} \left[1-\left(\frac{u_i}{1.547}\right)^2\right]^2, & {\scriptstyle |u_i| \le 1.547} \\ 0 & {\scriptstyle |u_i| > 1.547}, \end{cases} & iteration = 1 \\ \frac{\rho(u)}{u^2}, & iteration > 1 \end{cases}$$

(9) Calculate $\hat{\beta}_s$ with weighted least squares method with weighted w_i.

(10) Repeat steps 5-8 to obtain a convergent value of $\hat{\beta}_s$.

(11) Test to determine whether independent variables have significant effect on the dependent variables.

The equation for the iteration is written in matrix notation as follows:

$$\hat{\beta} = (X'WX)^{-1}X'WY \tag{22}$$

Equation (22) suggest an iterative scheme that converges to a solution, hence the use of iteratively re-weighted least squares method.

$$\hat{\beta}^{(M)}_{IRWLS} = (X'WX)^{-1}X'WY$$

The Robust Regression Analysis was estimated with the use of R-program software.

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Numerical Verification:

Graphical Analyses of the economic variables and inflation rates

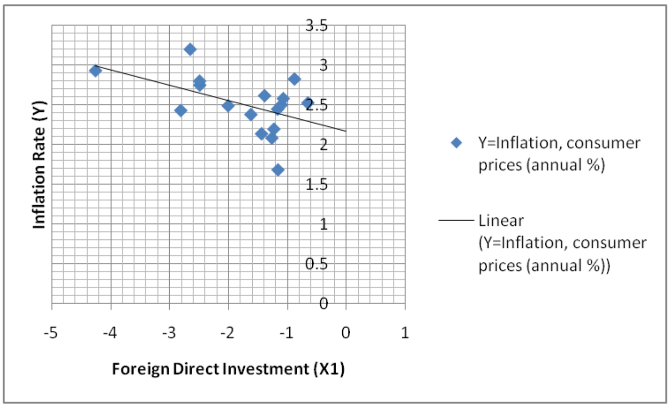

Fig. 1**:** Scatter plot of log of inflation rates against the log of FDI

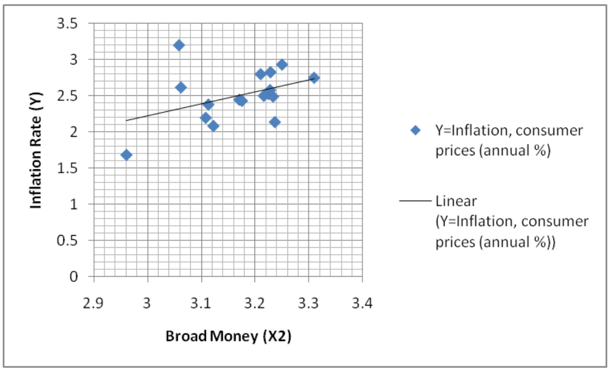

Fig. 2 **:** Scatter plot of log of inflation rates against the log of Broad money

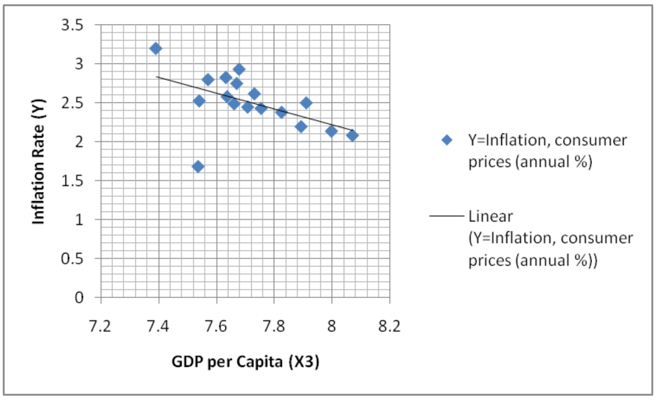

Fig. 3 **:** Scatter plot of log of inflation rates against the log of GDP per capita

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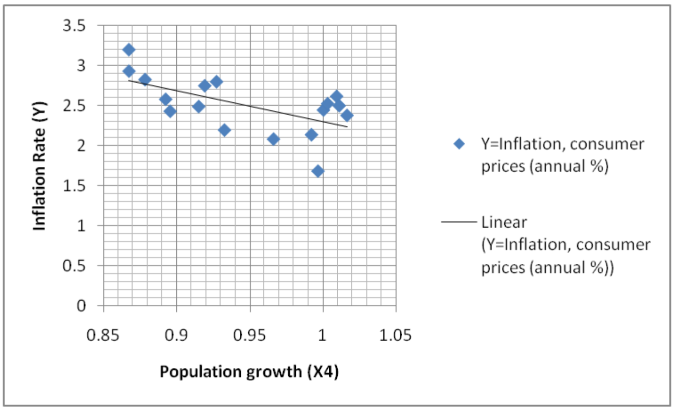

Fig. 4 **:** Scatter plot of log of inflation rates against population growth

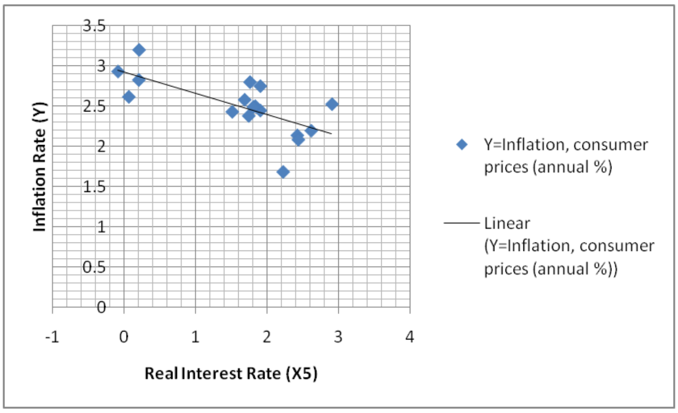

Fig. 5 **:** Scatter plot of log of inflation rates against real interest rates

Exploratory Analysis of the actual data

This section makes use of the various descriptive statistics tools and measures to explore the nature of the data, their possible distributions, shapes, variations, peakedness and other patterns inherent in them, so as to suggest ways of stabilizing and further making them suitable for the analysis.

Table 4.1: Statistical Measures

Variables	Descriptive Statistics							
	Min.	Max.	Median	Mean	Variance	Standard Dev.	Skewness	Kurtosis
Y	5.388	24.660	12.224	13.014	20.9708	4.5794	0.7776	3.7280
X_1	0.0142	0.5171	0.2484	0.2289	0.02032	0.1426	0.0832	2.303
X_2	19.29	27.38	24.78	23.91	4.2225	2.0549	-0.5857	2.7397
X_3	1621	3201	2163	2284	172628.8	415.486	0.6934	2.826
X_4	2.380	2.764	2.541	2.580	0.0205	0.1430	-0.0544	1.4147
X_5	0.9192	18.180	6.0560	6.7641	22.5867	4.7525	0.7592	3.1444

From table 4.1, it is observed that the minimum and maximum values of annual inflation rates (Y) are 5.39% and 24.66% respectively, this indicates a wider range causing it's

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variability to be as large as 20.97% with a standard deviation of 4.58%. It's coefficient of skewness stands at 0.78 indicating a right skewed shape of the distribution while it's coefficient of kurtosis (3.73) shows a leptokurtic (high peaked) distribution. These features showcases the existence of outliers and non-stability of the variable (Y). It is further observed that the average inflation rate for the period 2007-2023 is 13.01% with a median of 12.22%. Also foreign direct investment FDI (% of GDP) X_1 has a minimum value of 0.014% and a maximum value of 0.5171% indicating a smaller variation of 0.02% with a standard deviation of 0.1426%. The coefficient of skewness is 0.0832 (mild positive skewness) and that of kurtosis is 2.303 which indicates a platykurtic distribution, this indicates a moderate existence of outliers and the average FDI is 0.2289%. For broad money(% of GDP) X_2, the minimum value is 19.29% and a maximum value of 27.38% indicating a smaller range. This gives a variance of 4.223 and standard deviation of 2.0549, the coefficient of skewness is -0.5857 indicating that it is negatively skewed while the coefficient of kurtosis is 2.74 which shows a platykurtic distribution.The average broad money is 23.91% for the period under consideration. For GDP per capita (X_3), the minimum value is \$1621 while the maximum value is \$3201, this shows a greater variation with a variance of 172628.8 and a standard deviation of 415.486. The coefficient of skewness is 0.6934 which shows that it is rightly skewed while the coefficient of kurtosis is 2.826 indicating a moderate platykurtic distribution. The average GDP per capita is 2284 for the period under consideration. For population growth (X_4), the minimum value is 2.764% this shows a greater variation with a variance of 0.0205% and a standard deviation of 0.1430%.The coefficient of skewness is -0.0544 which shows that it is negatively skewed while the coefficient of kurtosis is 1.4147 indicating a platykurtic distribution. The average population growth is 2.580% for the period under consideration. For real interest rate (X_5), the minimum value is 0.92% while the maximum value is 18.18%, this shows a greater variation with a variance of 22.5867 and standard deviation of 4.7525. The cofficient of skewness is 0.7592 which shows that it is rightly skewed while the coefficient of kurtosis is 3.1444 indicating leptokurtic distribution. The average real interest rate is 6.76% for the period under consideration. With these descriptive measures indicating the non stabilization, skewness and peakness of the variables, there is need for log transformation of variables.

In view of the nature of the characteristics and distributions of the variables described earlier, logarithmic transformations of the variables have been done in order to stabilize the data. Hence, all analyses in this work are done based on the log transformed data.

Ordinary Least Square (OLS) Regression Analysis

Results of the multiple Regression Analysis using Matrix Approximation step by step Approach

$$X'X = \begin{pmatrix} 17 & -29.7422 & 53.9026 & 131.2197 & 16.0906 & 27.0834 \\ -29.7422 & 65.6277 & -94.5841 & -229.0054 & -27.6672 & -40.6167 \\ 53.9026 & -94.5841 & 171.0370 & 416.0919 & 50.9952 & 85.9416 \\ 131.2197 & -229.0054 & 416.0919 & 1013.3575 & 124.2619 & 210.0244 \\ 16.0906 & -27.6672 & 50.9952 & 124.5619 & 15.2792 & 26.0456 \\ 27.0834 & -40.6167 & 85.9416 & 210.0244 & 26.0456 & 56.9948 \end{pmatrix}$$

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$$(X'X)^{-1} = \begin{pmatrix} 226.9802 & 0.4781 & -28.7691 & -13.4596 & -35.7489 & 1.7972 \\ 0.4781 & 0.1253 & 0.1195 & 0.0357 & -0.9014 & -0.0376 \\ -28.7691 & 0.1195 & 9.8839 & -1.1067 & 6.9250 & -0.2341 \\ -13.4596 & 0.0357 & -1.1067 & 2.6417 & -3.3863 & -0.0971 \\ -35.7489 & -0.9014 & 6.9250 & -3.3863 & 41.5090 & -0.5871 \\ 1.7972 & -0.0376 & -0.2341 & -0.0971 & -0.5871 & 0.1160 \end{pmatrix}$$

$$X'Y = \begin{pmatrix} 42.6299 \\ -77.2201 \\ 135.3765 \\ 328.5427 \\ 40.1592 \\ 64.2500 \end{pmatrix}$$

$Y'Y$ =109.9544

$\hat{\beta}_0$ =2.3137

$\hat{\beta}_1 = -0.0147$

$\hat{\beta}_2 = 1.8487$

$\hat{\beta}_3 = -0.6695$

$\hat{\beta}_4 = -0.1962$

$\hat{\beta}_5 = -0.2136$

SE	**T- STATISTICS**	**P-VALUES**
3.1108	0.7438	0.4726
0.0731	-0.211	0.8443
0.6491	2.8479	0.0159
0.3356	-1.9948	0.0714
1.3303	-0.1475	0.8854
0.0703	-3.0383	0.0113

The estimated model for Y is given as:

$$\hat{Y} = 2.31368 - 0.01470X_1 + 1.84867X_2 - 0.66945X_3 - 0.19615X_4 - 0.21363X_5$$

Article DOI: 10.52589/AJMSS-LDVQDX10
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Table 4.2: Summary results of OLS regression analysis

Variables	Coefficients' estimates	Standard error	t-value	pr(> |t|)
Intercept	2.31368	3.11076	0.744	0.4726
X_1	-0.01470	0.07310	-0.201	0.8443
X_2	1.84867	0.64914	2.848	0.0159 *
X_3	-0.66945	0.33560	-1.995	0.0714 .
X_4	-0.19615	1.33028	-0.147	0.8854
X_5	-0.21363	0.07031	-3.038	0.0113 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 4.3	Regression Statistics
Multiple R	0.87845598
R Square	0.771684908
Adjusted R Square	0.667905321
Standard Error	0.206477184
Observations	17

Table 4.4 ANOVA Table

Source of Variation	*Df*	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.585047	0.317009	7.435806	0.002831
Residual	11	0.468961	0.042633		
Total	16	2.054008			

Residual standard error: 0.2065 on 11 degrees of freedom

Multiple R-squared: 0.7717, Adjusted R-squared: 0.6679

F-statistic: 7.436 on 5 and 11 DF, p-value: 0.002831

Test of Significance of the model:

Tabulated F-value

$F_{Critical} = F_{5,11,0.95} = 3.20$

The estimated OLS equation is

$$\hat{Y}_{ols} = 2.31368 - 0.01470\, X_1 + 1.84867X_2 - 0.66945X_3 - 0.19615X_4 - 0.21363X_5$$

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Robust Regression analysis:

Bi - Square Regression

Table 4.5: Summary of results of bi-square robust regression analysis

Variables	Coefficients' estimates	Standard error	t-value
Intercept	4.9263	2.3773	2.072.
X_1	-0.0252	0.0559	-0.4510
X_2	1.2491	0.4961	2.5179*
X_3	-0.8253	0.2565	-3.2180**
X_4	0.2387	1.0166	0.2348
X_5	-0.1640	0.0537	-3.0514**

tabulated: 0.05 (2.201)*; 0.01 (3.106)**; 0.1(1.796) '.'

Residual standard error: 0.08395 on 11 degrees of freedom

$R^2 = 0.9033$

Bi-square robust regression equation gives

$$\widehat{Y}_{br} = 4.9263 - 0.025\,X_1 + 1.2491X_2 - 0.8253X_3 + 0.2387X_4 - 0.1640X_5$$

S-robust regression analysis

Table 4.6: Summary of results of S-robust regression analysis

Variables	Coefficients' estimates	Standard error	t-value	P-value
Intercept	11.56282	2.40628	4.805	0.000549 ***
X_1	-0.06208	0.02442	-2.542	0.027377 *
X_2	0.10356	0.40204	0.258	0.801473
X_3	-1.12343	0.16963	-6.623	3.75e-05 ***
X_4	-0.63677	0.46487	-1.370	0.198071
X_5	-0.09944	0.02574	-3.864	0.002636 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Robust residual standard error: 0.1287

Multiple R-squared: 0.9661, Adjusted R-squared: 0.9506

Robustness weights:

3 observations c(1,7,17) are outliers with |weight| = 0 (< 0.0059);

3 weights are ~= 1.

$R^2 = 0.9660692$

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S-robust regression equation yields

$$\widehat{Y}_{sr} = 11.56282 - 0.06208X_1 + 0.10356X_2 - 1.123X_3 - 0.63677X_4 - 0.0994X_5$$

Evaluation of the performance of the models

The measures for the evaluation of the models include standard error of residuals, number of significant variables and R^2.

Table 4.7

Measures	OLS	Bi-square, M, IRLS-Estimation	S- Estimation
Unadjusted R - squared	77.2%	90.3%	96.6%
Number of significant variables	X_2, X_5	X_2, X_3, X_5	X_1, X_3, X_5, intercept
Standard error	0.2065	0.084	0.13

RESULTS

Looking at Table 4.2, it is seen from the sign of the coefficients of the variables, that there are negative and statistically insignificant impacts of FDI (net outflows), GDP per capita and population growth on inflation rates in Nigeria; while there is a negative but significant impact of real interest rates on inflation rates. Also, there exists a positive and significant effect of money supply on inflation rates. On magnitude, it is shown from the analysis that a 10% change in money supply brings about 18.49% increase in inflation rates; whereas a 10% change in FDI, GDP per capita, population growth and real interest rates bring about 0.1%, 6.7%, 2.0% and 2.1% decrease in inflation rates.

From table 4.3, the residual standard error stands at 0.2065, while the multiple coefficient of determination (R^2) is 0.772, indicating that 77.2% of variation can be explained by the variables, while 22.8% is attributable to other factors not defined by the model.

From table 4.4 (the ANOVA table), the calculated value (F-ratio) is 7.4358 greater than the table value 3.20. the null hypothesis is rejected and we conclude that there is a significant difference on the impact of the independent variables on inflation.

In Table 4.5, which summarizes the results of bi-square robust regression analysis, it is observed that there is a negative but insignificant impact of FDI on inflation rates, negative but significant impacts of GDP per capita and real interest rates on inflation rates and positive but significant impact of money supply and positive but insignificant effect of population growth rate on inflation rates. These imply that a 10% increase in FDI, GDP per capita and real interest rates has 0.3%, 8.3% and 1.6% decreasing effect on inflation rates, while a 10% change in money supply and population growth rate bring about 12.5% and 2.4% increase in inflation rates respectively. Here, the overall model residual standard error is 0.084 with $R^2 = 0.903$, showing a 90.3% contribution of the variables to explaining the response variables.

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It is noteworthy to state here that robust regression analysis using M-estimation and Iteratively re-weighted least squares (IRLS) give similar result as bi-square robust estimation method.

From the summary results of S-robust regression analysis method displayed in Table 4.6, it is seen that FDI, GDP per capita, population growth rates and real interest rates have negative and significant impacts on inflation rates in Nigeria, whereas money supply has a positive but insignificant impact on inflation rates. Analytically, a 10% change in FDI, GDP per capita, population growth rates and real interest rates can cause 0.62%, 11.2%, 6.4% and 1.0% decrease in inflation rates respectively, while a 10% change in money supply can cause a 1.04% increase in inflation rates. From the model, the residual standard error is 0.129 with $R^2 = 0.97$ indicating about 97% contribution of the variables to inflation rates.

CONCLUSION

Looking at Table 4.2, it is seen from the sign of the coefficients of the variables, that there are negative and statistically insignificant impacts of FDI (net outflows), GDP per capita and population growth on inflation rates in Nigeria; while there is a negative but significant impact of real interest rates on inflation rates. Also, there exists a positive and significant effect of money supply on inflation rates. On magnitude, it is shown from the analysis that a 10% change in money supply brings about 18.49% increase in inflation rates; whereas a 10% change in FDI, GDP per capita, population growth and real interest rates bring about 0.1%, 6.7%, 2.0% and 2.1% decrease in inflation rates.

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It is noteworthy to state here that robust regression analysis using M-estimation and iteratively re-weighted least squares (IRLS) give similar result as bi-square robust estimation method. From the summary results of S-robust regression analysis method displayed in Table 4.6, it is seen that FDI, GDP per capita, population growth rates and real interest rates have negative and significant impacts on inflation rates in Nigeria, whereas money supply has a positive but insignificant impact on inflation rates. Analytically, a 10% change in FDI, GDP

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per capita, population growth rates and real interest rates can cause 0.62%, 11.2%, 6.4% and 1.0% decrease in inflation rates respectively, while a 10% change in money supply can cause a 1.04% increase in inflation rates. From the model, the residual standard error is 0.129 with $R^2 = 0.97$ indicating about 97% contribution of the variables to inflation rates.

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