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The Impact of Macroeconomic Factors on Nigerian-Naira Exchange Rate Fluctuations (1981-2021)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Abstract

This study majorly considered establishing the relationship that existed among the Nigerian-Naira (NGN) Exchange Rate and External Reserve, Inflation Rate, GDP Growth, Public Debt, Unemployment Rate and Exports for the period, (1981-2021). Also, the macroeconomic variables that influenced the NGN exchange rate fluctuations were determined. Multiple linear regression and correlation analyses were employed in this study. Results showed that the significant variables that influenced the NGN exchange rate fluctuations were External Reserve, Public Debt and Unemployment Rate; and each of them had very strong significant positive relationships with NGN exchange rate fluctuations. It was equally revealed that about 97% of the total variations in the NGN exchange rate fluctuations, from 1981 to 2021, were accounted for by variations in External Reserve, Public Debt and Unemployment Rate; while about 3% of the total variations in the NGN exchange rate could be attributed to other macroeconomic factors outside the ones used in this study. It was concluded that External Reserve, Public Debt and Unemployment Rate were the most macroeconomic factors that influenced the Nigerian-Naira exchange rate fluctuations from 1981 to 2021.

Keywords: Macroeconomic; exchange rate; factors; Nigerian-Naira; relationship.

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1 Introduction

Exchange rate is the price of a country's currency in terms of another country's currency, which can be quoted either directly or indirectly. In a direct quotation, the price of a unit of foreign currency is expressed in terms of the domestic currency, while in an indirect quotation; the price of a unit of domestic currency is expressed in terms of the foreign currency. The exchange rate serves as an important price factor in the economy [1]. According to Balogun [2], one major importance of exchange rate is that its policy guides investors on the best way they can strike a balance between their partners and investing at home and abroad. Exchange rate is used to compare GDP of two countries; the usual method is to convert the value of GDP of each country into U.S. dollars and then compare them [3].

Gross Domestic Product (GDP), inflation, interest rate, unemployment, external/foreign reserve, public/government debt, import and export are some of the known macroeconomic factors that influence exchange rate. According to Patel et al. [4], the GDP of a country (which is a measure of all of the finished goods and services that a country generated during a given period) gives the best measure of health of country's economy. Patel et al. [4] further explained that increase in GDP indicates economic growth, and a country with good GDP will attract more foreign investors which lead to better valuation of the country's currency. Inflation is a factor that influence exchange rate. A country with a consistently lower inflation rate exhibits a rising currency value as its purchasing power increases relatively to other currencies [5]. Interest rate is also a factor that influences exchange rate. If a country keeps its interest rates at a relatively high level, it usually attracts large short-term capital flows and the country's currency will appreciate [6]. Unemployment is one of the factors that influences exchange rate. According to Patel et al. [4], the value of country's currency increases as the number of unemployed people decreases.

Furthermore, external reserve is also a factor that influence exchange rate. According to Amaedo [7], foreign investors will get spooked if a country has a war, military coup, or other blow to confidence. Amaedo [7] further explained that a country with such negative attributes will make the investors to withdraw their deposits from the country's banks, creating a severe shortage in foreign currency and will cause country's currency to decrease. Under some circumstances, the value of government debt can influence the exchange rate. If markets fear a government may default on its debt, then investors will sell their bonds causing fall in the value of the exchange rate [8]. Import and export are the component of current account balance. For any country current account deficit indicates higher values of imports of services and goods in comparison to the values of exports [4]. This will result to less capital from others countries and there will be depreciation in the country's exchange rate.

Nigeria is the most populous country in Africa, blessed with abundant natural resources but she still finds herself battling with high unemployment rates, many imports from other countries, high inflation rates and huge public debt, and also all these influences the NGN rates. According to DMO [9], Nigeria's external debt accounted for N3,478,915.40 million or 20.04% while domestic debt accounted for N13,881,094.18 or 79.96%. Nigeria's public debt keeps on rising, while the exchange rate keeps on depreciating, from one government regime to the other.

Nigeria has adopted various types of exchange rate management relating to different macroeconomic policies in the bid to achieve a realistic and sustainable exchange rate. Sanusi [10] asserted that exchange rate regime was shifted from fixed exchange rate in the 1960s to pegged arrangement between the 1970s and the mid-1980s, and finally to the various types of the floating regime since 1986 following the adoption of the SAP. The reforms under the Structural Adjustment Programme (SAP) in July1986 brought about free market determination of the NGN exchange rate as one of the objectives of SAP. Ndubuisi [11] explained that among the various regimes of exchange rate management are the Dutch Auction System (DAS) in April 1987, the Autonomous Foreign Exchange Market (AFEM) in 1988, the Inter-Bank Foreign Exchange Market (IFEM) in 1989, and again DAS was reintroduced in July 2002 and has remained in existence till date. A stable system of exchange rate is seen to be dependent on stable macroeconomic policies at the national level. Between 1986 and 2002, the Federal Government of Nigeria experimented with different exchange rate policies without allowing any of them to make remarkable impact in the economy before it was changed. This inconsistency in policies and lack of continuity in exchange rate policies has aggregated unstable nature of the Nigerian Naira [12].

Despite Nigerian government adoption of various types of exchange rate management at different points in time to improve the country's exchange rate, the country still experiences continuous depreciation in the Naira, which has been a problem to Nigerian economy. The ability of the key players in the Nigerian economic sector to understand the dynamics in exchange rate attributable to the macroeconomic factors will go a long way in assisting them in forecasting and predicting the future movement of the NGN exchange rate. Therefore, there is a need for a research to be centered on establishing the relationship that exists between the NGN exchange rate and the associated macroeconomic factors, as well as assessing the contribution of these factors to the NGN exchange rate.

This paper is aimed at establishing the relationship that exists among the NGN exchange rates and some of the known macroeconomic factors, and to determine the factors that influence it. Specifically, the objectives of this study strive; to determine long-term movement of the NGN exchange rate over the period under study and to establish the relationship that exists between the NGN exchange rates and some of the macroeconomic factors (namely; external reserves, inflation rate, GDP growth, public debt, unemployment rate and exports) for the period, 1981 to 2021. In addition, to determine the contributions of the macroeconomic factors to the NGN exchange rates over the years under study, and also to determine the total variation in the NGN exchange rates that is accounted for by the variations in the macroeconomic factors.

2 Literature Review

Some works have been carried out in the past which bothered on factors that influenced exchange rate fluctuations.

Abdoh et al. [13] used an annual secondary data spanning from 2005 to 2015 to empirically analyze the macroeconomic factors that influenced exchange rate fluctuations in ASEAN countries. Multiple regression analysis was used to explain the effect of explanatory variables on exchange rate. The result showed that export had a statistically significant relationship with exchange rate fluctuation at 5% level of significance (p-value = 0.045) while interest rate and inflation rate were not statistically significant. An R^2 value of 0.0424 was obtained, which indicated that about 4.24% of the total variation in exchange rate fluctuation were accounted for by variations in export, interest rate and inflation rate. This implied that about 95.76% of this fluctuation may come from other macroeconomic variables apart from the three included in the study. It was concluded that the most factor that influenced the exchange rate fluctuation was export.

Khan [14] carried out empirical research on the factors that affected exchange rate variability in Pakistan using time series data from 2006 to 2013. Multiple regression analysis was employed to explain the impact of control variables on the exchange variability. The result showed that inflation, interest rate and oil price had a statistically significant relationship with exchange rate fluctuation at 5% level of significance (p-values = 0.000, 0.002 and 0.000, respectively) while export and import were not statistically significant. An R^2 value of 0.619 was obtained, which indicated that about 61.9% of the total variation in exchange rate variability were accounted for by variations in inflation, interest rate, oil price, export and import. This revealed that about 38.1% of this variability may come from other macroeconomic variables outside the model. It was concluded that the most factor that influenced the exchange rate were inflation, interest rate and oil price.

Udousung et al. [15] studied the real exchange rate determinants in Nigeria using time series data from 1971 to 2000. Multiple regression analysis was employed to expound the effect of explanatory variables on the exchange rate. The result revealed that trend, openness of economy, budget deficit and import tax had statistically significant relationship with exchange rate at 5% level of significance (p-values = 0.0397, 0.0000, 0.000 and 0.0000, respectively), while balance of payment and export tax were not statistically significant. An R^2 value of 0.96 was obtained, which indicated that about 96% of the total variation in exchange rate fluctuation were accounted for by variations in Balance of payment, Trend, Openness of economy, Government deficit, Import tax and Export tax. This implied that about 4% of this fluctuation may come from other macroeconomic variables apart from the six included in the study.

Twarowska and Kaķol [16] carried out empirical research on the factors that affected fluctuations in the exchange rate of Polish Zloty against Euro using annual secondary from 2000 to 2013. Multiple regression analysis was used to explain the impact of regressors on the exchange rate fluctuations. The result showed that financial account, inflation, interest rate and government deficit had statistically significant relationship with exchange rate at 5% level of significance, while GDP and current account balance were not statistically significant. An R^2 value of 0.623 was obtained, which indicated that about 62.3% of the total variation in exchange rate fluctuation were accounted for by variations in GDP, inflation rate, interest rate, current account balance, financial account balance and government deficit. This implied that about 37.7% of this variation in exchange rate could be attributed to some other factors that were not been taken into account in the study. It was concluded that the most factor that influenced the exchange rate fluctuation were financial account balance, inflation rate, interest rate and government deficit.

Baljinnyam and Hong [17] investigated the influencing factors on the exchange rate variations between Chinese Yuan (CNY) and Mongolian Tugrik (MNT) using an annual secondary data ranging from 2000 to 2012. Multiple regression analysis was employed to explain the impact of macroeconomic factors on exchange rate variation of CNY/MNT. The result showed that only interest rate had a statistically significant relationship with exchange rate variation at 5% level of significance (p-value = 0.0000); while inflation, export and import were not statistically significant. An R^2 value of 0.5832 was obtained, which indicated that about 52.32% of total variation in exchange rate variability were accounted for by the four independent variables used in the study. This implied that about 41.68% of this variation could be attributed to some other macroeconomic variables apart from the ones been included in the study. It was concluded the most factor that influenced exchange rate was interest rate.

Muchiri [18] used annual secondary data ranging from 2007 to 2016 to empirically analyze the effect of inflation and interest rate on foreign exchange rate in Kenya. Multiple regression analysis was used to determine the effect of independent variables on the exchange rate variation. The result showed that consumer price index and foreign direct investment had statistically significant relationship with exchange rate fluctuation at 5% level of significance (p-value = 0.002 and 0.049, respectively) while, interest rate, GDP and money supply were not statistically significant. An R^2 value of 0.879 was obtained, which indicated that about 87.9% of the total variation in exchange rate fluctuation were accounted for by variations in CPI, interest rate, GDP, money supply and foreign direct investment. This showed that about 12.10% of this fluctuation may have come from other macroeconomic variables apart from the four included in the study. It was concluded that there was no significant relationship between money supply and foreign exchange rate in Kenya for the period under study.

3 Materials and Methods

The data used in this study cover a period of 41years (1981-2021), and come from secondary sources, which include the 2021 Edition of the Statistical Bulletin of the Central Bank of Nigeria (CBN), the Annual Abstracts of the National Bureau of Statistic (NBS) from 1981 to 2021, as well as the World Bank data (Macrotrends). The data featured Nigerian-Naira Exchange Rate and some macroeconomic variables, which include External Reserve, Inflation Rate, Gross Domestic Product Growth (GDPGR), Public Debt, Unemployment Rate and Export. The data are as shown in Table 1.

Table 1. Yearly data of Nigerian-Naira exchange rate and some other macroeconomic variables

Year	Exchange Rate	External Reserve	Inflation Rate	GDPGR	Public Debt	Unemployment Rate	Export
1981	0.61	4682.90	20.81	-13.1	13.52	5.4	101011.10
1982	0.67	1027.03	7.70	-1.1	23.83	3.9	9196.40
1983	0.72	597.62	23.21	-5.1	32.80	6.4	7737.41
1984	0.76	456.64	17.82	-2.0	40.48	6.2	9127.90
1985	0.89	981.81	7.44	8.3	45.25	6.1	11720.79
1986	2.02	1576.84	5.72	-8.8	69.89	5.3	9047.54
1987	4.02	5212.86	11.29	-10.8	137.58	6.5	29577.99
1988	4.54	6022.24	54.51	7.5	180.99	4.6	31192.83
1989	7.39	3662.77	50.47	6.5	287.44	4.5	59985.53
1990	8.04	3357.77	7.36	12.8	382.71	3.5	82577.94
1991	9.91	4051.67	13.01	-0.6	444.65	3.1	76569.30
1992	17.30	2782.66	44.59	0.4	722.23	3.4	205613.10

Year	Exchange Rate	External Reserve	Inflation Rate	GDPGR	Public Debt	Unemployment Rate	Export
1993	22.05	4902.01	57.17	2.1	906.98	2.7	189777.70
1994	21.89	7944.09	57.03	0.9	1056.40	2.4	103424.50
1995	21.89	2695.42	72.84	-0.3	1194.60	1.9	567211.00
1996	21.89	2157.97	29.27	5.0	1037.30	3.3	741752.00
1997	21.89	6124.34	8.53	2.8	1097.68	3.4	785472.70
1998	21.89	7814.73	10.00	2.7	1193.85	3.1	483193.60
1999	92.69	5309.10	6.62	0.5	3372.18	8.2	1559300.00
2000	102.11	7590.77	6.93	5.3	3995.64	18.1	2745102.00
2001	111.94	10277.49	18.87	4.4	4193.27	13.7	2007127.00
2002	120.97	8592.01	12.88	3.8	5098.89	12.8	2167413.00
2003	129.36	7641.81	14.03	10.4	5808.01	14.8	3109288.00
2004	133.50	12062.75	15.00	33.7	6260.60	13.4	5129026.00
2005	132.15	24320.78	17.86	3.4	4220.98	11.9	6621304.00
2006	128.65	37456.09	8.24	8.2	2204.72	12.3	7555141.00
2007	125.83	45394.31	5.38	6.8	2608.53	12.7	6881502.00
2008	118.57	58472.88	11.58	6.3	2843.56	14.5	9568949.00
2009	148.88	44702.35	11.54	6.9	3818.47	14.9	7434544.00
2010	150.30	37355.70	13.72	7.8	5241.66	21.4	13009906.00
2011	153.86	32580.28	10.84	4.9	6519.69	23.9	19440357.00
2012	157.50	38092.16	12.22	4.3	7564.44	10.6	22446320.00
2013	157.31	45612.95	8.48	5.4	8506.31	10.0	14245272.00
2014	158.55	37220.33	8.06	6.3	9535.55	6.4	16304041.00
2015	193.28	29805.48	9.02	2.7	10948.53	26.4	9593042.00
2016	253.49	26054.37	15.70	-1.6	14537.12	13.4	8527431.00
2017	305.79	32226.12	16.52	0.8	18377.00	23.4	13598277.00
2018	306.08	44525.07	12.09	1.9	20533.64	20.3	18532040.00
2019	306.92	42249.06	11.40	2.2	23295.07	17.6	19192234.00
2020	358.81	35791.14	13.25	-1.8	28729.50	11.7	12522684.00
2021	399.96	36632.03	16.95	3.7	35097.79	22.9	18907789.00

Multiple linear regression and correlation analyses are employed in this study to estimate the coefficients for the independent variables and to evaluate the contributions of each of the independent variables (External Reserve, Inflation Rate, Gross Domestic Product Growth (GDPGR), Public Debt, Unemployment Rate and Export) to the dependent variable (the exchange rate movement/fluctuation).

The multiple linear regression model, which explains the relationship that exists among the dependent and independent variables, is given as,

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + e_i \tag{1}$$

where,

Y, X 's, β 's and e_i (i = 1, 2, $\cdots$, k) are the dependent variable, independent variables, the estimated parameters, and the error term, respectively.

Equation (1) can also be expressed in matrix terms (see, for example Kurtner et al. [19]) as,

$$\underset{(n\times 1)}{\mathrm{Y}} = \underset{(n\times k)}{X}\,\underset{(k\times 1)}{\beta} + \underset{(n\times 1)}{\varepsilon} \tag{2}$$

where,

$$Y' = (Y_1, Y_2, \cdots, Y_n) \tag{3}$$

$$X = \begin{pmatrix} X_{11} & X_{21} & \cdots & X_{k1} \\ X_{12} & X_{22} & \cdots & X_{k2} \\ \vdots & \vdots & \ddots & \vdots \\ X_{1n} & X_{2n} & \cdots & X_{kn} \end{pmatrix} \tag{4}$$

$$\beta' = (\beta_0, \beta_1, \beta_2, \cdots, \beta_k) \tag{5}$$

and

$$\varepsilon' = (\varepsilon_1, \varepsilon_2, \cdots, \varepsilon_n) \tag{6}$$

Applying the Ordinary Least Squares (OLS) method (see, for example Kurtner et al. [19]) the regression model parameters, β_i 's, are estimated as,

$$\hat{\beta} = (X^T X)^{-1} X^T Y \tag{7}$$

Then, the estimated regression model will be obtained by substituting the values of the $\hat{\beta}_i$'s in (7) into (1).

3.1 Classical assumptions for regression analysis

According to Gujarati [20], the following assumptions are the Gaussian Standard for the estimation of the parameters, β_i 's, which requires to be fulfilled so that for the estimated parameters will be reliable.

(i) The regression model must be linear in the parameters.
(ii) The independent variable X is assumed to be non-stochastic. That is, the values taken by the independent variables X are considered fixed in repeated samples.
(iii) The error term has a normal distribution.
(iv) The expected value or mean of the error terms, e_i , is zero.
(v) Homoscedasticity or equal variance of the error terms, e_i . That is, the variance of the error term, e_i , is the same for all the observations.
(vi) No serial correlation or zero autocorrelation between the disturbances. Given that any two X values, X_i and X_j $(i \neq j)$, the correlation between any two error e_i and e_j is zero.
(vii) Zero covariance between e_i and X_i. That is, $E(e_i \mid X_i) = 0$.
(viii) The independent variables are linearly independent. That is, it is not possible to express any independent variable as a linear combination of the other). In other words, there is no perfect multicollinearity.
(ix) The number of observations n must be greater than the number of parameters to be estimated.
(x) Variability in the X_i values. The X_i values in a given sample must not all be the same.
(xi) The regression model is correctly specified bias and the independent variables are measured with no error.

3.2 Tests for the assumptions of regression analysis

It is usually expected that the tests for the assumptions of regression analysis be conducted first before the regression analysis is carried out because it is the most important aspect of regression analysis which indicates that the model will be perfectly fitted. The procedures for the various tests are as follows;

(a) Test for the Normality Assumption: One of the assumptions required by OLS method for the estimability of the parameters in the regression model is that the error terms are normally distributed. Gujarati [20] stated that a simple graphical representation can be used to explain whether the residuals are normally distributed. The simple graphical representation that can be used is either histogram of residuals or normal probability plot. The histogram of residuals is simply computed by plotting the values of expected error terms against the random variable which will produce erect rectangles equal in height to the number of observations and the shape of normal distribution curve can be ascertained on the histogram. While for normal probability plot, Anderson-Darling test will be used to study the shape of the probability density function of the random variables.

According to Gujarati [20], for example, the null hypothesis of a normally distributed error terms is to be rejected if and only if the Anderson-Darling test statistic, A^2, is greater than or equal to the critical value, c (that is, H_0 is to be rejected if and only if $A^2 \geq$ c). The Anderson-Darling test statistic (see, for example, Stephens, [21]), is given by,

$$A^2 = \frac{\sum_{i=1}^{n} X_i \left\{(2i-1)\, In\left(1-\mathrm{F}_X\left(x_{n+1-i}\right)\right)\right\}}{n} - n \tag{8}$$

where,

F_X is the cumulative distribution function of the specified distribution.

The critical value for this Anderson-Darling test is given by,

$$c = a\left[1 - \frac{b}{n} - \frac{d}{n^2}\right] \tag{9}$$

where,

a, b and c are given in Anderson-Darling table; which is usually read off from a statistical table.

(b) Test for Homoscedasticity Assumption: Homoscedasticity or equal variance of the error term is another assumption required by the OLS method for the estimability of the parameters in the regression model. In order to confirm the existence of heteroscedasticity, some commonly used tests are namely; Breusch-Pagan Test, Spearman Rank Correlation Test and Goldfeld-Quandt test.

The Spearman Rank Correlation Test is simple and it is applicable to data with small and large sample sizes. See, for example, Nwankwo (2011), for the steps in testing homoscedasticity using Spearman rank correlation test.

The Goldfeld-Quandt test is applicable when the number of observations, n, is greater than twice the number of independent variables (that is, when n>2k). See, for example, Gujarati [20], for the steps in testing homoscedasticity using Goldfeld-Quandt test.

(c) The Breusch–Pagan–Godfrey (BPG) Test: The success of the Goldfeld-Quandt test depends on the value of *c* (the middle observations being omitted) and identifying the correct *X*-variable with which to order the observations. This limitation of the GQ test can be avoided if the BPG test is considered [20]. The procedure of testing the homoscedasticity assumption, using BPG test, is as outlined in Gujarati [20].

According to Gujarati [20], for example, the null hypothesis which states that the error terms are homoscedastic is to be rejected if and only if the calculated Breusch–Pagan–Godfrey test statistic, Θ, is greater than or equal to the critical value (that is, H_0 is to be rejected if and only if $\Theta \geq \chi^2$-critical).

The test statistic for the Breusch–Pagan–Godfrey test is given by

$$\Theta = \frac{1}{2} SS_E \tag{10}$$

where,

SS_E is the sums of squares error.

The critical value for the BPG test is given by $\chi^2_{\alpha(m-1)}$; where, m – 1 is the degree of freedom. The critical value can be read off from a statistical table, such as Neave [22].

(d) Test for Multicollinearity Assumption: The term multicollinearity is used to denote the presence of linear relationships (or near-linear relationships) among the independent variables [23]. Farrar-Glauber test and Variance Inflation Factor (VIF) are some common methods of testing for multicollinearity.

(i) The Farrar-Glauber Test: The Farrar-Glauber test is really a set of three tests conducted in three stages (see, for example, Koutsoyiannis, [23]; Nwankwo, [24]). The first test is the Chi-Square test for the detection of the existence and severity of multicollinearity; the second test is the F-test for locating which independent variables are multicollinear; and the third test is the student's t-test for finding out the pattern of multicollinearity. The procedures in testing the three stages tests are as outlined in, for example, Koutsoyiannis [23] and Nwankwo [24].

(ii) The Variance Inflation Factor (VIF): The VIF, according to Yoo et al. [25], measures how much the variance of the estimated regression parameters are inflated as compared to when the independent variables are not linearly related. According to Rawlings et al. [26], for example, the null hypothesis which states that there is no perfect multicollinearity among the independent variables is to be rejected if and only if calculated test statistic, VIF, is greater than or equal to 10 (That is, H_0 is to be rejected if and only if VIF ≥ 10).

The test statistic for the VIF test is given by

$$VIF_j = \frac{1}{\left(1 - R^2_{x_i x_j . x_1 x_2 \cdots x_k}\right)} \tag{11}$$

where,

$R^2_{x_i x_j . x_1 x_2 \cdots x_k}$ is the coefficient of multiple determination for each of the independent variables.

The critical value for the VIF test is given as 10; which implies that the muticollinearity among the independent variables is perfect (see, for example, Hair et al, [27]; Rawlings et al, [26]).

(e) Test for Autocorrelation: Another important assumption for the estimability of the parameters in the regression model is that the error terms, e_i, are independent. Durbin-Watson method is usually employed to test for autocorrelation. According to Koutsoyiannis [23], the null hypothesis for the Durbin-Watson test which states that there is no autocorrelation is to be rejected if and only if the calculated Durbin-Watson test statistic, DW , is not approximately equal to 2 (That is, H_0 is to be rejected if and only if DW , is greater than or less than a value that is approximately equal to 2).

The test statistic for the Durbin-Watson test is given by.

$$DW = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2} \tag{12}$$

where,

e_t are the residuals from an OLS regression.

The critical value for the Durbin-Watson test is given as the value of the DW is less than 2 or the value of DW is greater than 2. This implies that if the calculated test statistic, d is less than or greater than 2, the null hypothesis will be rejected (see, for example Koutsoyiannis, [23]; Nwankwo, [24]).

3.3 Remediations to Unsatisfied Assumption(s) of Regression Analysis

(a) Remedying the Incidence of Heteroscedasticity: The presence of heteroscedasticity in the multiple linear regression model does not destroy the unbiasedness and consistency properties of the OLS estimators, but they are no longer efficient, not even asymptotically. According to Gujarati [20] this lack of efficiency makes the usual hypothesis-testing procedure of dubious value. Gujarati [20] further elaborated that there are two approaches to remediation; the first one is when the error variance, σ_i^2 , is known and the second one is when σ_i^2 is unknown. Gujarati [20] further explained that if σ_i^2 is known, Feasible Generalized Least Square (FGLS), Weighted Least Square (WLS), etc., can be applied for correcting the heteroscedasticity in the regression model, in order to obtain the estimators that are BLUE. However, when σ_i^2 is unknown, Log-transformation of the variables, Inverse and Square root transformations can be applied for correcting the heteroscedasticity in the regression model.

Nwankwo [24], also contributing to this, states that in a situation where the test for homoscedasticity is significant, the following remedies can be considered;

(i) Transform the values using the appropriate technique like semi-logarithm, double logarithm or reciprocal logarithm.
(ii) Reduce the sample size, not by removing too many values and re-run the homoscedasticity test. Otherwise, the above remedy for heteroscedasticity is preferable.

(b) Remedying the Incidence of Multicollinearity: According to Koutsoyiannis [23], if the existence of multicollinearity has serious effects on the estimates of the coefficients, any of the following remedies should be adopted as a solution;
(i) Application of Method Incorporating Extraneous Quantitative Information: The most important of these methods are; the method of restricted least squares, the method of pooling cross-section and time series data (which is a special case of restricted least squares method), Durbin version of generalized least squares and mixed estimation technique proposed by Theil and Goldberger.
(ii) Increase of the Size of the Sample: Increase of the sample size is one the remedy for multicollinearity which may reduce or avoid multicollinearity between the independent variables, one should only increase the sample size by gathering more observations. According to Koutsoyiannis [23], this is true only if

multicollinearity is due to errors of measurement, as well as when inter-correlation happens to exist only in original sample but not in the population of the X's values.

(iii) Substitution of Lagged Variables for other Explanatory Variables in Distributed-Lag Models: The use of lagged values of explanatory variables (distributed lags) has been useful in econometrics analysis. This means that one understands the certain pattern of behavior is determined not only by the current values of the explanatory variables but also by the past values of the explanatory variables.

(iv) Introduction of Additional Equation in the Model: Multicollinearity will be overcome if only one introduce additional equations into the regression model to express how meaningful the relationship that exist between the multicollinear of the X-variables. One may look at set of explanatory variables that make economic sense to find the relationship between the existing variables and the new variables. By explicitly, formulating these relationship one can form a simultaneous-equation model, which, if identified, can be estimated with simultaneous-equation technique.

(v) Application of the Principal Component Method: One of the methods to remedy multicollinearity is using principal component method, in which one constructs some artificial orthogonal variables. By transforming the multicollinearity X's values into orthogonal variables would provide a defensible solution to the multicollinearity problem only if the artificial variables can be given any specific economic meaning.

However, if the main purpose of the estimation is to forecast the values of the dependent variable, one need not to worry about the problem of multicollinearity and may ignore adopting one of the remedies for the incidence of multicollinearity. According to Koutsoyiannis [23], the estimates of the original model may be accepted despite the existence of multicollinearity, only if the purpose of the estimation is to do forecast and provided that the same pattern of multicollinearity of the independent variables continue in the period of prediction. If one tries to remove the independent variables responsible for multicollinearity, it will lead to specification bias.

4 Results and Discussion

The graphical representation of the data Nigerian-Naira (NGN) Exchange Rate from 1981 to 2021 is shown in Fig. 1. The long-term movement of the NGN exchange rate exhibits an upward trend which steeped up from 1998 and got to 2021; and is suggestive of possible influence of some macroeconomic factors to the fluctuations of the NGN exchange rate over the years under study.

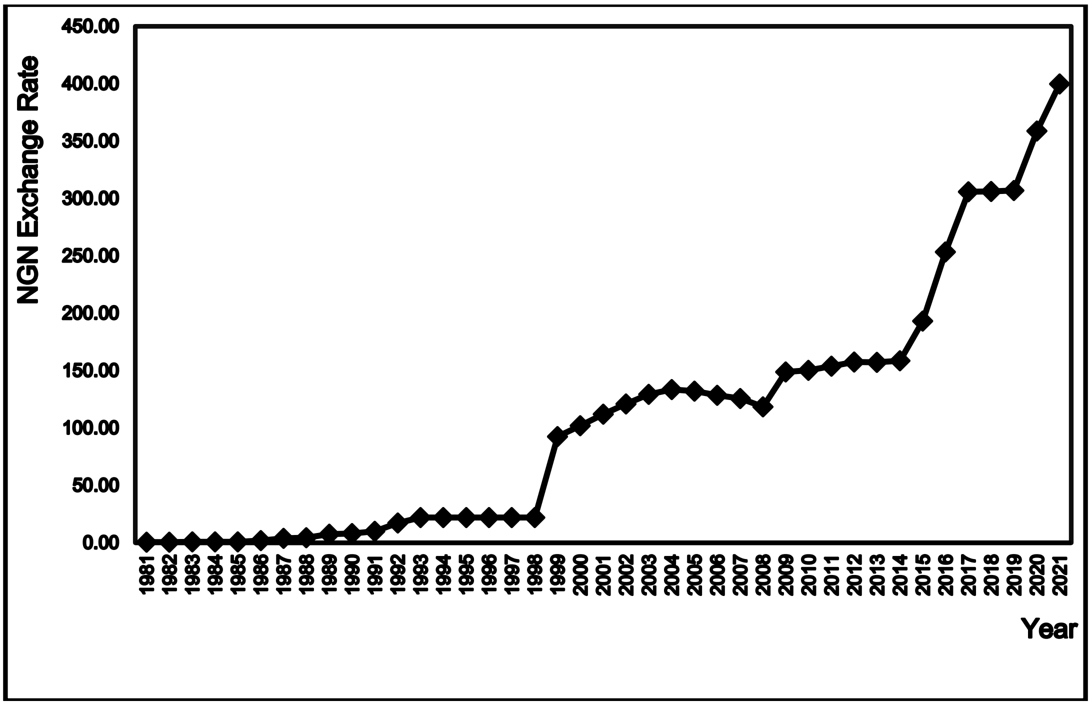

Fig. 1. Plots of Nigerian-Naira exchange rate (1981-2021)

This study seeks to determine the relationship that exists among the dependent variable (NGN Exchange Rate) and the independent variables (External Reserve, Inflation Rate, GDP Growth, Public Debt, Unemployment Rate and Exports) and also to investigate the macroeconomic factors that significantly influenced the NGN exchange rate fluctuations for the period under study. Thus, this study invariably accommodates the following null hypotheses, that there exists significant relationships between NGN exchange rate and External reserve; between NGN exchange rate and Inflation rate; between NGN exchange rate and GDP Growth; between NGN exchange rate and Public debt; between NGN exchange rate and Unemployment rate; and between NGN exchange rate and Exports, for the period under study.

Adopting (1), this study uses the following theoretical model to assess the macroeconomic variables that are associated with the NGN Exchange rates;

$$\mathrm{XR} = \beta_0 + \beta_1(\mathrm{ExtR}) + \beta_2(\mathrm{InfR}) + \beta_3(\mathrm{GDPG}) + \beta_4(\mathrm{PD}) + \beta_5(\mathrm{UR}) + \beta_6(\mathrm{EX}) + e \quad (13)$$

where,

XR, ExtR, InfR, GPDG, PD, UR and EX are, Exchange Rate, External Reserve, Inflation Rate, GDP Growth, Public Debt, Unemployment Rate and Exports, respectively.

This study analyses the data using the following statistical data analysis packages; Microsoft Office Excel (2016), Minitab (2019), SPSS version 26, NCSS (2012) and RStudio. The results outputs from the various computer packages employed in testing the relevant assumptions of the multiple linear regression and correlation analyses, as well as the main data analyses are as presented Tables 2 to 10 and Figs. 2 to 3.

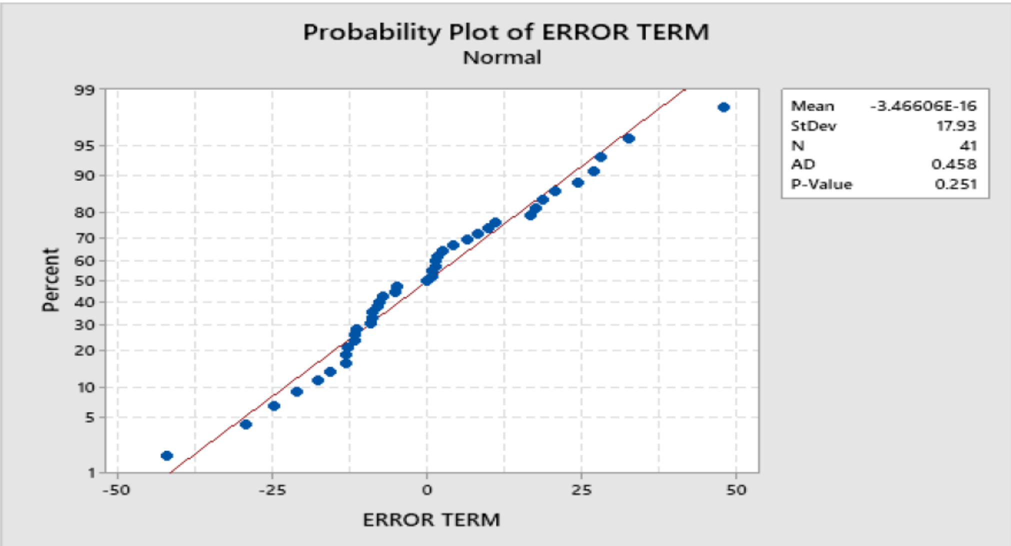

Fig. 2. The Anderson-Darling test for normality assumption

Table 2(a). Shapiro-Wilk Test for Normality Assumption

W-stat	0.977946
P-value	0.598394
alpha	0.05
Normal	yes

Table 2(b). d'Agostino-Pearson Test for Normality Assumption

DA-stat	**1.909792**
P-value	0.384852
alpha	0.05
Normal	yes

Table 3. Breusch-Pagan test for heteroscedasticity assumption

LM stat	10.4603652
df	6
P-value	0.10655631

F stat	1.94093359
df1	6
df2	34
P-value	0.10231635

Table 4. Regression model summary

R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
			R Square Change	F Change	df1	df2	Sig. F Change	
.973	.969	19.45048	.973	207.211	6	34	.000	1.605

Table 5. Regression model coefficients

Variable	Unstandardized Coefficients		Standardized Coefficients	t-stat	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
Intercept	-3.370	8.487		-.397	.694					
ExtR	.001	.000	.231	4.209	.000	.744	.585	.118	.260	3.840
InfR	-.070	.206	-.011	-.339	.736	-.318	-.058	-.009	.799	1.251
GPDG	.675	.446	.044	1.512	.140	.139	.251	.042	.919	1.088
PD	.010	.001	.726	16.348	.000	.945	.942	.457	.397	2.517
UR	3.007	.687	.191	4.374	.000	.778	.600	.122	.412	2.429
EX	-7.9E-7	.000	-.051	-.765	.450	.828	-.130	-.021	.179	5.594

Table 6. Descriptive statistics

Variable	Count	Mean	Standard Deviation	Minimum	Maximum
XR	41	108.17	109.91	0.61	399.96
ExtR	41	18683.33	17561.87	456.64	58472.88
InfR	41	18.93	16.67	5.38	72.84
GPDG	41	3.3	7.2	-13.1	33.7
PD	41	5906.81	8298.34	13.52	35097.79
UR	41	10.5	7.0	1.9	26.4
EX	41	5965909.00	7049603.00	7737.41	399.96

Table 7. Correlations

	Variable	XR	ExtR	InfR	GPDG	PD	UR	EX
Pearson Correlation	XR	1.000	.744	-.318	.139	.945	.778	.828
	ExtR	.744	1.000	-.363	.187	.577	.657	.849
	InfR	-.318	-.363	1.000	-.070	-.218	-.419	-.340
	GPDG	.139	.187	-.070	1.000	.024	.214	.154
	PD	.945	.577	-.218	.024	1.000	.630	.741
	UR	.778	.657	-.419	.214	.630	1.000	.706
	EX	.828	.849	-.340	.154	.741	.706	1.000
Sig. (1-tailed)	XR	.	.000	.021	.193	.000	.000	.000
	ExtR	.000	.	.010	.121	.000	.000	.000
	InfR	.021	.010	.	.332	.086	.003	.015

Variable	XR	ExtR	InfR	GPDG	PD	UR	EX
GPDG	.193	.121	.332	.	.440	.089	.168
PD	.000	.000	.086	.440	.	.000	.000
UR	.000	.000	.003	.089	.000	.	.000
EX	.000	.000	.015	.168	.000	.000	.

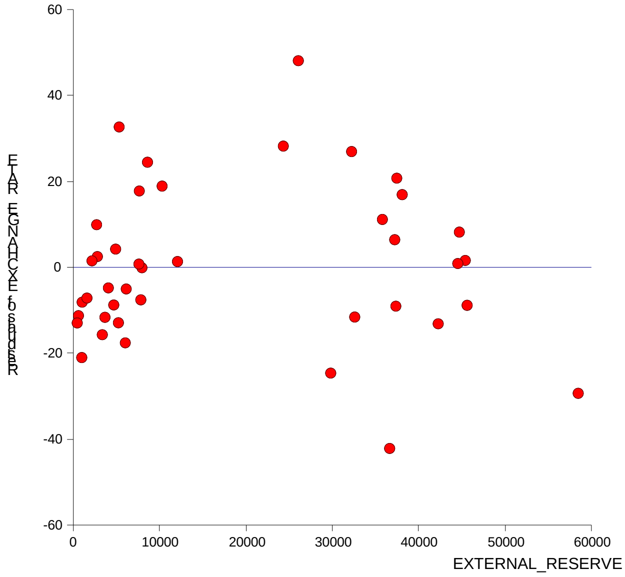

Fig. 3(a). Residuals of EXCHANGE_RATE VS. EXTERNAL_RESERVE

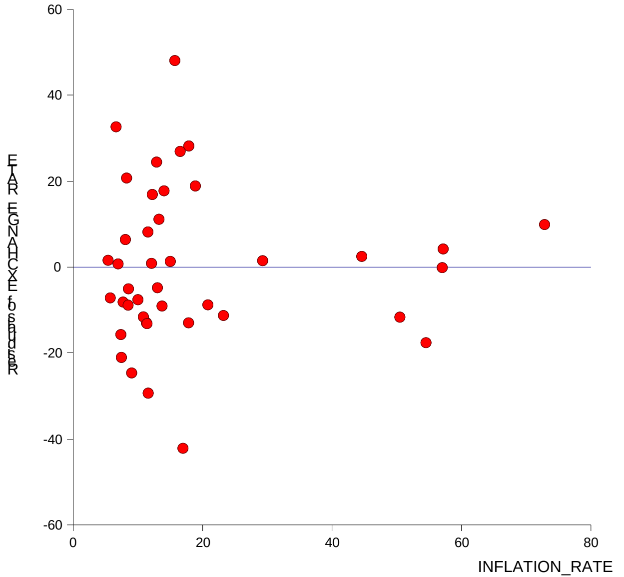

Fig. 3(b). Residuals of EXCHANGE_RATE vs. INFLATION_RATE

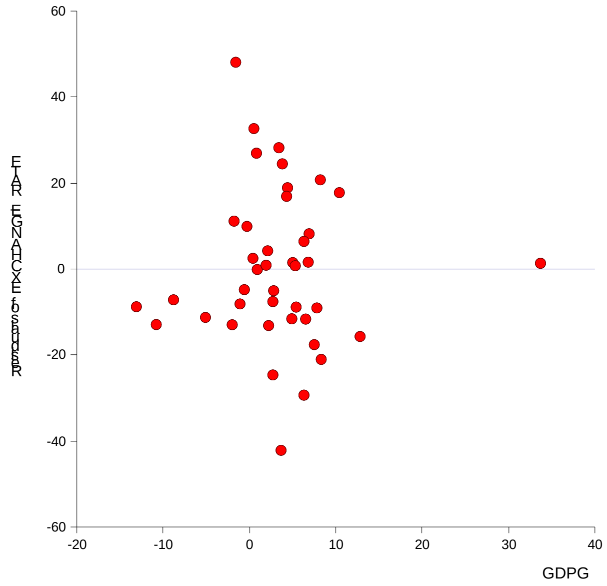

Fig. 3(c). Residuals of EXCHANGE_RATE vs. GDPG

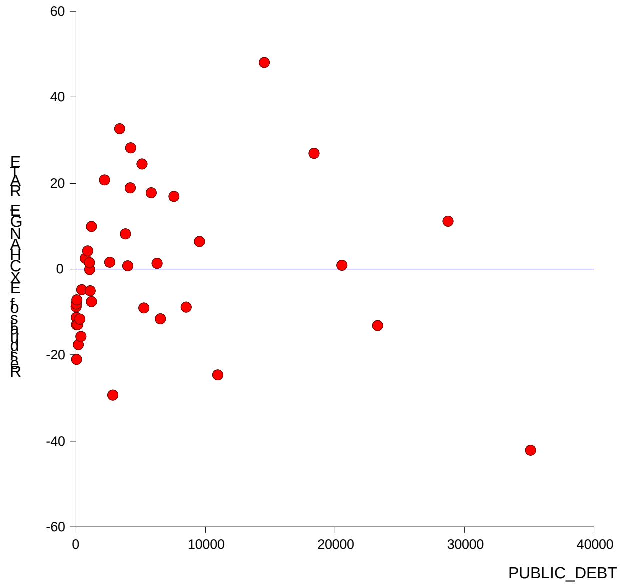

Fig. 3(d). Residuals of EXCHANGE_RATE vs. PUBLIC_DEBT

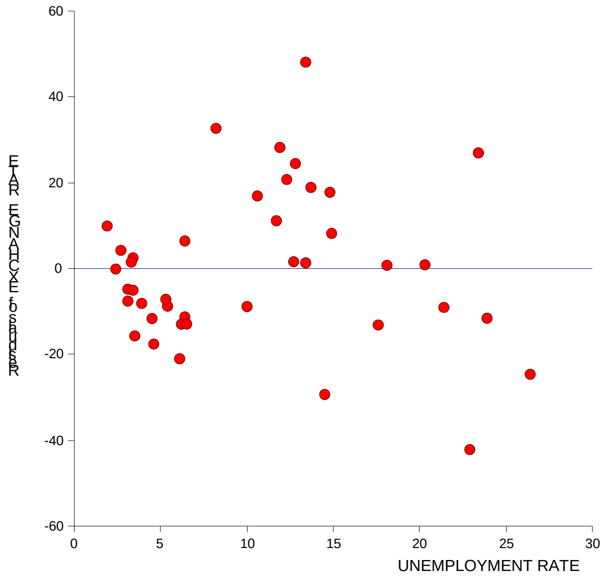

Fig. 3(e). Residuals of EXCHANGE_RATE vs. UNEMPLOYMENT RATE

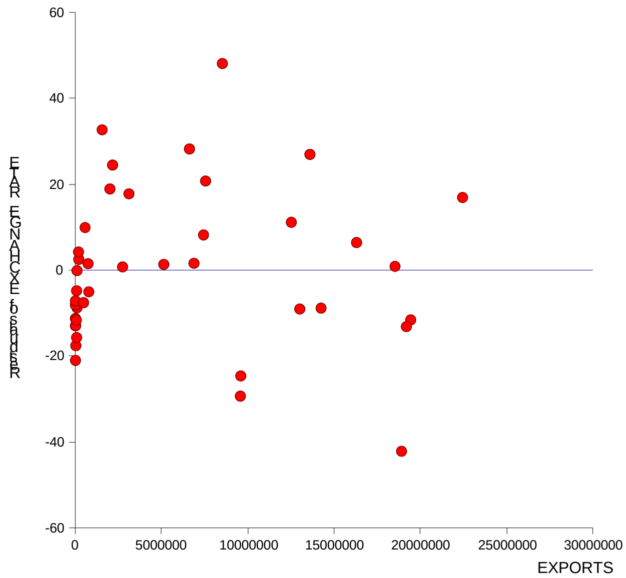

Fig. 3(f). Residuals of EXCHANGE_RATE vs. EXPORTS

From the Normal probability plot and the Anderson-Darling (AD) test in Fig. 2, which were used to verify that the error terms are normally distributed, the computed Anderson-Darling statistic, A^2, is 0.458, with (P=0.778); which is greater than the level of significance, $\alpha = 0.05$. Therefore, the null hypothesis (which states that the error terms are normally distributed) is not rejected; thus the conclusion is that the error terms are normally distributed. Also giving support to this conclusion are the Shapiro-Wilk test in Table 2(a) (where the computed W-statistic is 0.977946, with (P=0.598); which is greater than the level of significance, $\alpha = 0.05$) and the d'Agostino-Pearson test in Table 2(b) (where the computed *DA*-statistic is 1.9098, with (*P*=0.385); which is greater than the level of significance, $\alpha = 0.05$).

Breusch-Pagan test in Table 3 was used to test for the heteroscedasticity assumption, the value of the computed test statistic is 10.4603652, with (*P*=0.107); which is greater than the level of significance, $\alpha = 0.05$. Therefore, the null hypothesis (which states that the error terms are homoscedastic) is not rejected; thus the conclusion is that the error terms are homoscedastic (that is, the error terms are not heteroscedastic).

From Table 4, the computed value of the Durbin-Watson test statistic, DW, is 1.605, and is approximately equal to 2; which is equal to the critical value of the Durbin-Watson test (which is 2). Therefore, the null hypothesis (which states that the error terms are not correlated) is not rejected; thus the conclusion is that the error terms are not correlated (that is, no autocorrelation).

From Table 5, the values of the computed test statistic, VIF, for each of the variables (External Reserve, Inflation Rate, GDP Growth, Public Debt, Unemployment Rate and Exports) are 3.840, 1.251, 1.088, 2.517, 2.429 and 5.594, respectively. Each of these values is less than the critical value of the VIF test (which is 10). Therefore, the null hypothesis is not rejected, and the conclusion is that there is no perfect multicollinearity among the independent variables.

Having met the assumptions stated above, the study proceeds with fitting the MLR model. From the values of the regression model coefficients obtained in Table 5, the estimated multiple linear regression model for this study becomes,

$$\mathrm{XR} = -3.370 + 0.001\mathrm{ExtR} - 0.070\mathrm{InfR} + 0.675\mathrm{GDPG} + 0.010\mathrm{PD} + 3.007\mathrm{UR} - 7.9\times10^{-7}\,\mathrm{EX} \tag{14}$$

From Table 4, the regression model is of good fit to the dataset, as the value of the computed F-test statistic is 10.4603652, with a p-Value of 0.0000; which is less than the level of significance, $\alpha = 0.05$. Therefore, the null hypothesis (which states that the model is not of good fit) is rejected.

The results output of the test for significance of the multiple linear regression model parameters, in Table 5, show that the *P*-values for External Reserve, Inflation Rate, GDP Growth, Public Debt, Unemployment Rate and Exports are 0.000, 0.736, 0.140, 1.12E-17, 0.000 and 0.450, respectively. From the p-Values displayed, it is seen that 0.000177, 1.12E-17 and 0.000109 are greater than the level of significance, $\alpha = 0.05$. Thus, the conclusion is that only External Reserve, Public Debt and Unemployment Rate had statistical significant relationships with the Nigerian Naira exchange rate, at 5% level of significance. On the other hand, with the following *P*-values, 0.736, 0.140 and 0.450, being less than the level of significance, $\alpha = 0.05$, it is concluded that Inflation Rate, GDP Growth and Exports Rate, respectively, had no statistical significant relationships with Nigerian Naira exchange rate, at 5% level of significance.

The descriptive statistics in Table 6 has shown that the dependent variable, Exchange rate, has a mean of 108.17, a standard deviation of 109.91, a minimum of 0.61 and a maximum of 3.99.96. also, the independent variables, External Reserve, Inflation Rate, GDP Growth, Public Debt, Unemployment Rate and Exports, have means of 18683.33, 18.93, 3.26, 5906.81, 10.51 and 5965909.00; standard deviations of 17561.87, 16.67, 7.19, 8298.34, 6.97 and 7049603.00; minimums of 456.64, 5.38, -13.1, 13.52, 1.9 and 7737.41; and maximums of 58472.88, 72.84, 33.7, 35097.79, 26.4 and 22446320.00, respectively.

Furthermore, Figs. 3(a) to 3(f) show the residuals of exchange rate and each of the six macroeconomic variables. Also, the results outputs of the correlation analysis (as shown in Table 7) show that the relationship that exist between the dependent variable, NGN exchange rate, and each of Inflation Rate, GDP Growth and Exports are significantly positive, at the level of significance, $\alpha = 0.05$. The correlation coefficients of the relationship between the NGN exchange rate, and each of Inflation Rate, GDP Growth and Exports are 0.744, 0.945 and 0.778; with the associated *P*-values, 0.000, 0.000 and 0.000, respectively.

Finally, an R^2 value of 0.973 (as shown in Table 4) indicates that about 97.30% of the total variations in the NGN exchange rate fluctuations were accounted for by variations in all independent variables used in this study (namely; External Reserve, Inflation Rate, GDP Growth, Public Debt, Unemployment Rate and Exports). This implies that about 2.70% of the total variations in the NGN exchange rate fluctuations could be attributed to other factors affecting exchange rate outside the ones used in the established model in this study.

Since the results output of the test for significance of the multiple linear regression model parameters show that the following three independent variables, Inflation Rate, GDP Growth and Exports, had no statistical significant relationships with the dependent variables, the Nigerian Naira exchange rate, they are therefore dropped and the multiple linear regression analysis is then redone with the other three independent variables that had statistical significant relationships with the Nigerian-Naira exchange rate. The results outputs of the redone multiple linear regression analysis are as shown in Tables 8 to 10.

Table 8. Regression Statistics for the Reduced Model

Multiple R	0.985466046
R Square	0.971143328
Adjusted R Square	0.968803598
Standard Error	19.41302372
Observations	41

Table 9. ANOVA Table for the reduced model

Source of Variation	df	SS	MS	F	Significance F
Regression	3	469272.5788	156424.2	415.0664	1.59667E-28
Residual	37	13944.02313	376.8655		
Total	**40**	**483216.602**			

Table 10. Regression coefficients for the reduced model

Variable	Coefficients	Standard Error	t Stat	*P*-value
Intercept	-4.15433835	5.641221017	-0.73643	0.466
ExtR	0.00131322	0.000241344	5.441282	3.59E-06
PD	0.009240401	0.0004958	18.63735	2.14E-20
UR	3.15873788	0.639124771	4.942287	1.69E-05

From Table 10, the new and reduced estimated multiple linear regression model is given as,

$$XR = -4.154 + 0.001ExtR + 0.009PD + 3.159UR \tag{15}$$

The p-Values of the test of significance of the regression model parameters for the reduced model, as shown in Table 10, are given as 3.59E-06, 2.14E-20 and 1.69E-05, respectively. Furthermore, the result output in Table 9 shows that the regression model is of good fit to the dataset, as the value of the computed F-test statistic is 415.0664, with a *P*-value of 1.597E-28; which is less than the level of significance, $\alpha = 0.05$. Therefore, the null hypothesis (which states that the model is not of good fit) is rejected. Finally, the R^2 value of 0.9711 is obtained (as shown in Table 8); which indicates that about 97.11% of the total variations in the NGN exchange rate fluctuations were accounted for by variations in External Reserve, Public Debt and Unemployment Rate.

5 Conclusion

All the classical assumptions of the multiple linear regression analysis, which include normality, homoscedasticity, no autocorrelation and no perfect multicollinearity assumptions, were duly met in this study. Accordingly, the relationship that exists among the Nigerian-Naira exchange rate and External Reserve, Inflation Rate, GDP Growth, Public Debt, Unemployment Rate and Exports was established, and it was tested to be of good fit. From further test carried out, it was concluded that the significant variables that influenced the

NGN exchange rate fluctuations are External Reserve, Public Debt and Unemployment Rate (with each of them having very strong significant positive relationships with NGN exchange rate fluctuations). Also revealed is that about 97% of the total variations in the NGN exchange rate fluctuations, from 1981 to 2021, were accounted for by variations in External Reserve, Public Debt and Unemployment Rate.

In general, the findings of this study have led to the conclusion that External Reserve, Public Debt and Unemployment Rate are the most macroeconomic factors contributing to the Nigerian-Naira exchange rate fluctuations from 1981 to 2021.

Competing Interests

Authors have declared that no competing interests exist.

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