(RESEARCH ARTICLE)

Contributions of Naira-USD, Naira-Franc and Naira-Yuan exchange rates on inflation and its volatility in Nigeria

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Abstract

The alarming increase in consumers goods and services with concurrent devaluations of naira have necessitated the need to examine the effects of NUSX(Nigerian naira/1 US dollar), NFX (Nigerian naira/1 France franc) and NCX (Nigerian naira/1 Chinese yuan) rates on inflation(measured by CPI) and its volatility in Nigeria using data sets spanning from 2008 to 2022. The auxiliary autoregressive AAR(3) order of integration test specify that all the variables are stationary at first difference. Adopting multiple regression model with least square method of estimation and generalized autoregressive conditional heteroskedasticity (GARCH(1, 1)) as measure of volatility, the results indicate that NCX (Nigerian naira/1 Chinese yuan), NFX (Nigerian naira/1 France franc) and NUSX(Nigerian naira/1 US dollar) have no influence on both inflation and its volatility in Nigeria. This implies that variation in exchange rates system is not sufficient to explain the sudden increase in the prices of goods and services in Nigeria. Therefore, the government should look beyond exchange rates in finding solution to rising inflation phenomenon in Nigeria's economic space.

Keywords: Exchange rates; Inflation; GARCH model; Volatility

1   Introduction

The ability of any Government to maintain a relative stability in the price level of goods and services the time of shocks and fluctuations of exchange rate is the litmus test of a developed economy. In Nigeria, the exchange rate system has been volatile as the economy has been experiencing shocks necessitated by a consistent devaluation of Naira at the international exchange market. This has caused the price level n all sectors of the economy to go up, and inflation rate has risen from a single digit to a double digits. However, becomes imperative to examine the contribution of Naira-US Dollar, Naira-Franc and Naira-Yuan exchange rates on inflation in Nigeria.

In an import dependent economy like Nigeria, price level is a function of exchange rate dynamics, even the prices of locally made goods and services are tied to the speculative exchange rate levels. Maintaining price stability is one of the key functions of the monetary policy committee arm of the Central bank of Nigeria as it is practiced across the globe.

Nigeria is endowed with several mineral resources including crude oil which constitutes the major main stay of the economy. Nevertheless, Nigeria imports more than it exports and this creates disequilibrium in the demand and supply of foreign exchange. This disequilibrium together with the jump up in the price of petroleum motor spirit (PMS) necessitated a triple negative effect on the prices of goods and services. The Nigerian economy is experiencing the worst scenario of inflation since independence.

Exchange rate dynamics affects the volume of trade and the overall net earnings in times of bilateral trade agreement between two countries. There is no doubt that the value of a country's currency with the highest trade volume relative to Nigeria has a great impact on prices of goods in Nigeria.

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Nigeria ranks 58th position among the trade partners of US. The bilateral trade volume between both countries in 2022 was valued at $4.45 billion. According to the National Bureau of Statistics, 6.5% of all of Nigeria's imports in the 3rd quarter of 2022 came from the United States, making it Nigeria's 5th largest import partner. Nigeria's major imports from the United States include durum wheat valued at over $173 million and used vehicles at $158 million, spare parts, machinery, refined petroleum products, and military hardware. The major export of Nigeria to US is crude oil [16]. According to the data from the World Integrated Trade solution(WITS) of the World Bank, Nigeria's export and import partners are China, India, Spain, France, Netherland, Belgium and United States, South Africa([21]). These countries form the main sources of foreign capital inflow into all major sectors of the Nigerian economy.

According to the PUNCH newspaper by National Bureau of Statistics (NBS), "In October 2023, the headline inflation rate increased to 27.33 % relative to the September 2023 headline inflation rate which was 26.72 %."[17], The naira experienced the worst devaluation hit in Nigerian exchange rate history and the implication is the untold hardship due to precipitated inflation. However, evaluating the influence of bilateral exchange rate between Nigeria and some of the export and import partners on the inflation movement cannot be overemphasized.

The high rate of inflationary pressure and the need for stability on the general price level of goods and services have become a concern to every stake holder in the Nigerian economic space and any research that is geared towards solving this macroeconomic challenge cannot be overemphasized

The relationship between exchange rate and inflationary pressure has been a subject of research with divergent opinions and findings across different economic space. [20] Stressed that one of the key and still unsettled, macroeconomic policy challenges facing many government is the appropriate exchange rate policy to tame inflationary pressure.

In theory, divergent opinions exist; the structuralist argued that if the price of non-tradable goods does not rise in response to wage increments devaluation may likely cause a rise in the general price level or its growth rate ([12], [1], [2],). Unlike the Structuralist, Monetarist differs. In their view they see inflation as a monetary phenomenon and argue that for sustained economic growth, macroeconomic stability is considered as a source of inflation as it affects income distribution significantly.

[18] investigated inflation movement relative to money supply, exchange rate index, domestic price levels, foreign price index and real output in Kenya. He observed that the rate of inflation and exchange rate explained each other.

[10] examined the impact of exchange rate depreciation on inflation in Nigeria and found that although Naira depreciation is relevant in ensuring an improvement in the production of exportable commodity, it must not be relied upon as a potent measure for controlling inflation in Nigeria.

Exchange rate is a crucial factor in relation to inflation; there is an expectation that inflation and exchange rate influence each other in many theoretical models, particularly in developing countries, during exchange rate crisis period [13].

In Mexico, [3] used the threshold vector autoregression model and observed that exchange rate above the threshold level 0.7 % exhibits significant pass-through and insignificant when the threshold level is below 0.7 %.

In Ukraine, [8] validated the existence of exchange rate pass-through and observed that above the threshold levels of 3 % exchange rate depreciation has a larger ERPT effect on Ukraine inflation. Similarly, [9] examined the relationship between foreign exchange reserve and inflation in four West African countries and discovered that foreign exchange reserves lead to rise in inflation rate. Indicating that reduction in foreign exchange reserves will stabilize an economy.

[15] study observed the existence of exchange rate pass-through(ERPT) in Nigeria, and noted that ERPT effect on Nigerian import prices only exists beyond the threshold values of 9.63 % and 10.99 %. Nevertheless,

2   Materials and Methods

This section deals with the materials and methods such as; sources and method of data collection, order of integration test, regression model specification, generalized autoregressive   conditional heteroskedasticity (GARCH) model for volatility measure and method of estimation.

2.1. Sources of data and variable definition

The data frequency is monthly covering the period of January 2008 to December 2022. The data on the bilateral exchange rate includes exchange rate of naira relative to that of China, USA, and France. Inflation is measured using consumer price index (CPI). The data used is a secondary data and it is obtained through transcription from the already documented data at National Bureau of statistics and published by the central bank of Nigeria ([6]) statistical bulletin.

The variables are defined as follows;

NCX   -   Naira –Yuan exchange rate (Nigerian naira/1 Chinese yuan)

NUSX   -   Naira –USD exchange rate (Nigerian naira/1 USD)

NFX   -   Naira- Franc exchange rate (Nigerian naira/1 France franc)

CPI   -   Consumer price index (a proxy measure of inflation)

Each of the above variables will be expressed as the first difference as presented below;

$$ncx_t = NCX_t - NCX_{t-1}, \quad nusx_t = NUSX_t - NUSX_{t-1}, \quad nfx_t = NFX_t - NFX_{t-1} \text{ and } \inf_t = CPI_t - CPIX_{t-1}.$$

2.2. Order of Integration Test

The order of integration test (OIT) introduced by [4] offers the leverage to see the number of unit roots present in data variable and it is as presented in (1) below;

$$\left.\begin{aligned}
x_t &= \pi_0 + \pi_1 tre + \sum_{j=1}^{3} \delta_i x_{t-i} + u_t \\
x_t &= \pi_0 + \sum_{j=1}^{3} \delta_i x_{t-i} + u_t \\
x_t &= \sum_{j=1}^{3} \delta_i x_{t-i} + u_t
\end{aligned}\right\} \tag{1}$$

where,   there is no evidence of trend in the series, the trend parameter (π_1 is the trend coefficient) is excluded as shown in the second model in (1) above. The intercept is denoted by π_0. The stochastic error term $u_t \sim N(0, \sigma^2)$. The $\delta_i (i = 1,2,3)$ are the autoregression coefficients.

Test conditions are;

For I(1); $|\delta_1| \geq 1, |\delta_2| < 1, |\delta_3| < 1$ and $\left|\frac{\delta_1}{\delta_2}\right| > 1$

For I(2); $|\delta_1| > 1, |\delta_2| \geq 1, \frac{|\delta_1|}{|\delta_2|} > 1$

Test Hypothesis

The hypothesis is generally stated as; $H_0 : \delta_i < 1$ versus the alternative H_a :at least one of the δ's is greater than or equal to one.

2.3.   Model Specification

The multiple regression model specification to unravel the effects of manufacturing, mining and quarrying is structure in the following form;

$$\inf_t = c_0 + c_1 \inf_{t-1} + c_2 \inf_{t-2} + c_3 ncx_t + c_4 nusx_t + c_5 nfx_t + u_t \tag{2}$$

In (2), $c_i (i = 0,1,\cdots,5)$ are the regression coefficients. The error term $u_t \sim N(0,\sigma^2)$. The generalized autoregressive conditional heteroskedasticity (GARCH(1, 1)) is presented in (3) as follows;

$$\inf_t = c + e_t$$
$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i e_{t-1}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-1}^2 + \tag{3}$$

Where $\alpha_0 > 0, \alpha_i \geq 0, \beta_j \geq 0$ and $\sum_{i=1}^{p} \alpha_i + \sum_{j=1}^{q} \beta_j < 1$. The error term e_t is normally distributed with mean zero(0) and variance σ^2. The GARCH(1, 1) variance series in (3) will be used as the volatility measure for inflation, hence, we have

$$\sigma_{\inf,t}^2 = c_0 + c_1 \sigma_{\inf,t-1}^2 + c_2 \sigma_{\inf,t-2}^2 + c_3 ncx_t + c_4 nusx_t + c_5 nfx_t + a_t \tag{4}$$

Equation (4) examines the effects of the bilateral exchange rate system on inflation volatility in Nigeria. The c_i's $(i = 1,2,\cdots,10)$ are the coefficients or the impact factors of the exchange rates on inflation volatility. The error term $a_t \sim N(0,\sigma^2)$.

2.4.   Techniques of Estimation and Residual Analysis

The estimation techniques for the regression models will be based on the generalized Least squares, whereas the GARCH model is estimated using maximum Likelihood Method of estimating ARCH (Marquardt steps).

Analysis of the residuals is a form of diagnostic test carried on the model to ascertain its adequacy. Some of these tests are the serial correlation test, hetroskedasticity test and the normality test.

3   Results

The results of the data analysis and the discussion of the findings are presented in this section.
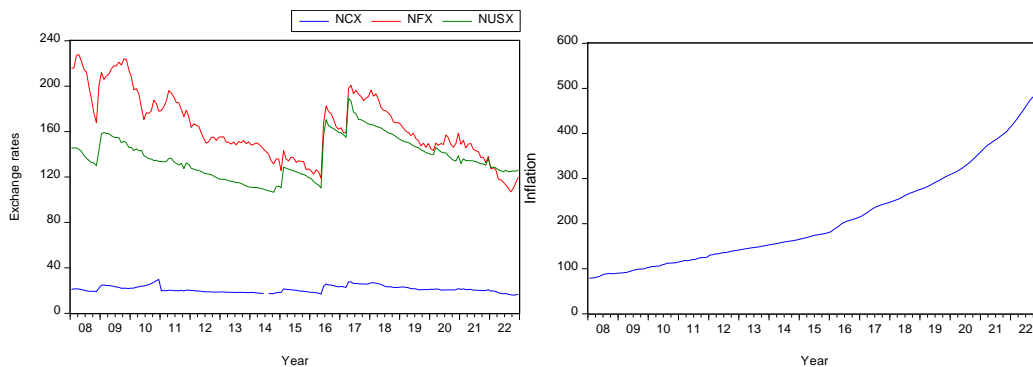
Figure1 Time plot of NCX, NFX, NUSX and Inflation

The plot in Figure1 shows that inflation exhibits a consistent rise as domestic currency depreciates over the sample period. It is observable that from 2008 to 2016, the Naira at the foreign exchange market experienced a gradual

attenuation. This ugly experience occurred from 2017 to 2022. The growth of the consumer price index which is a proxy measure of inflation can be described using quadratic trend.

3.1. Correlation and Regression Results

The summary of the degree of relationship between the exchange rates and inflation is summarized in Table1 below.

Table1 Summary of the correlation analysis

Variable	*ncx*	*nusx*	*nfx*
inf	-0.0131	0.1700	0.0138

The result of Pearson correlation in Table1 indicates that *ncx* (Naira –Yuan exchange rate) correlate negatively with inflation. But *nusx* (Naira –USD exchange rate) and *nfx* (Naira- Franc exchange rate) correlate positively with inflation in Nigeria.

3.2. Order of integration test Analysis

The order of integration test (OIT) for all the variables under study using auxiliary autoregressive order three (AAR(3)) model is summarized in (5) – (12).

$$NCX_t = 1.9227 - 0.0012t + 1.0016NCX_{t-1} - 0.1312NCX_{t-2} + 0.0430NCX_{t-3} + u_t \tag{5}$$

The values of the coefficients of the lag NCX in (5) shows that $|\delta_1| > 1, |\delta_2| < 1$ and $|\delta_3| < 1$. Hence, NCX_t is integrated order one (I(1)) and requires first difference to be stationary.

$$ncx_t = 0.0552 - 0.0010t + 0.03252ncx_{t-1} - 0.0870ncx_{t-2} - 0.0331ncx_{t-3} + u_t \tag{6}$$

In (6) all the values of $|\delta_i|$ are strictly less than 1, hence, ncx_t is integrated order zero (I(0)) or stationary.

$$NFX_t = -0.6642 - 0.0007t + 0.691NFX_{t-1} + 0.2753NFX_{t-2} + 0.0391NFX_{t-3} + u_t \tag{7}$$

The values of $|\delta_1| \to 1$, indicating a near unit root problem, $|\delta_2| < 1$ and $|\delta_3| < 1$ in (7). Hence, NFX_t is treated as integrated order one (I(1)) and requires first difference to be stationary.

$$nfx_t = -0.8923 + 0.0029t + 0.0938nfx_{t-1} - 0.1167nfx_{t-2} + 0.0588nfx_{t-3} + u_t \tag{8}$$

In (8) all the values of $|\delta_i|$ are strictly less than 1, hence, nfx_t is integrated order zero (I(0)) or stationary.

$$NUSX_t = 5.8889 + 0.0011t + 1.0745NUSX_{t-1} - 0.2130NUSX_{t-2} + 0.0941NUSX_{t-3} + u_t \tag{9}$$

The values of $|\delta_1| > 1, |\delta_2| < 1$ and $|\delta_3| < 1$ in (9) entail that, $NUSX_t$ is integrated order one (I(1)) and requires first difference to be stationary.

$$nusx_t = -0.0424 - 0.0006t + 0.0996nusx_{t-1} - 0.1198nusx_{t-2} + 0.0093nusx_{t-3} + u_t \tag{10}$$

In (10), the absolute values of $\delta_i's$ are strictly less than 1, hence, $nusx_t$ is integrated order zero (I(0)) or stationary.

Table 2 Estimate of Regression Model of Equation 2

Dependent Variable: D(INF)				
Method: Least Squares				
Date: 05/27/24 Time: 23:49				
Sample (adjusted): 2008M04 2022M12				
Included observations: 175 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.148244	0.102105	1.451880	0.1484
D(INF(-1))	0.616553	0.074104	8.320144	0.0000

D(INF(-2))	0.343258	0.074504	4.607266	0.0000
D(NCX)	-0.032128	0.075515	-0.425454	0.6710
D(NFX)	-0.008272	0.015911	-0.519889	0.6038
D(NUSX)	-0.003921	0.023958	-0.163660	0.8702
R-squared	0.823371	Mean dependent var		2.386699
Adjusted R-squared	0.818145	S.D. dependent var		1.945465
S.E. of regression	0.829632	Akaike info criterion		2.498016
Sum squared resid	116.3210	Schwarz criterion		2.606523
Log likelihood	-212.5764	Hannan-Quinn criter.		2.542029
F-statistic	157.5616	Durbin-Watson stat		1.986549
Prob(F-statistic)	0.000000			

The regression result in Table 2 above shows that the bi-lateral exchange rates; NCX, NFX and NUSX have no effect on inflation in Nigeria. Inflation is significantly influence by its previous one(at lag1) and two(at lag2) months values, significant under 5% level respectively. The R-squared indicates that about 82.3% variations in the inflation is explained by the regressor variables. The D-W statistic (1.99) indicates absence of serial correlation in the residuals of the model and this agrees with the result of serial correlation test in Table3 as shown below.

Table 3 Breusch-Godfrey Serial Correlation LM Test

F-statistic	**0.146343**	**Prob. F(2,167)**	**0.8640**
Obs*R-squared	0.306171	Prob. Chi-Square(2)	0.8581

The Breusch-Pagan-Godfrey test of heteroskedasticity in Table4 below, indicates that the model residuals is homoskedastic. Hence, the specified model is adequate.

Table 4 Heteroskedasticity Test

F-statistic	**1.140595**	**Prob. F(5,169)**	**0.3409**
Obs*R-squared	5.712669	Prob. Chi-Square(5)	0.3352

The volatility of inflation is examined using GARCH(1, 1) model in (11) below.

$$\sigma_t^2 = 0.0284 + 0.8432\varepsilon_{t-1}^2 + 0.4270\sigma_{t-1}^2$$
$$prob. \quad (0.2583) \quad (0.0025) \quad (0.0001)$$

(11)

The lagged squared error and the conditional variances are significant under 5% level respectively. The GARCH(1, 1) variance for measuring inflation volatility is exhibited in Figure2 below.
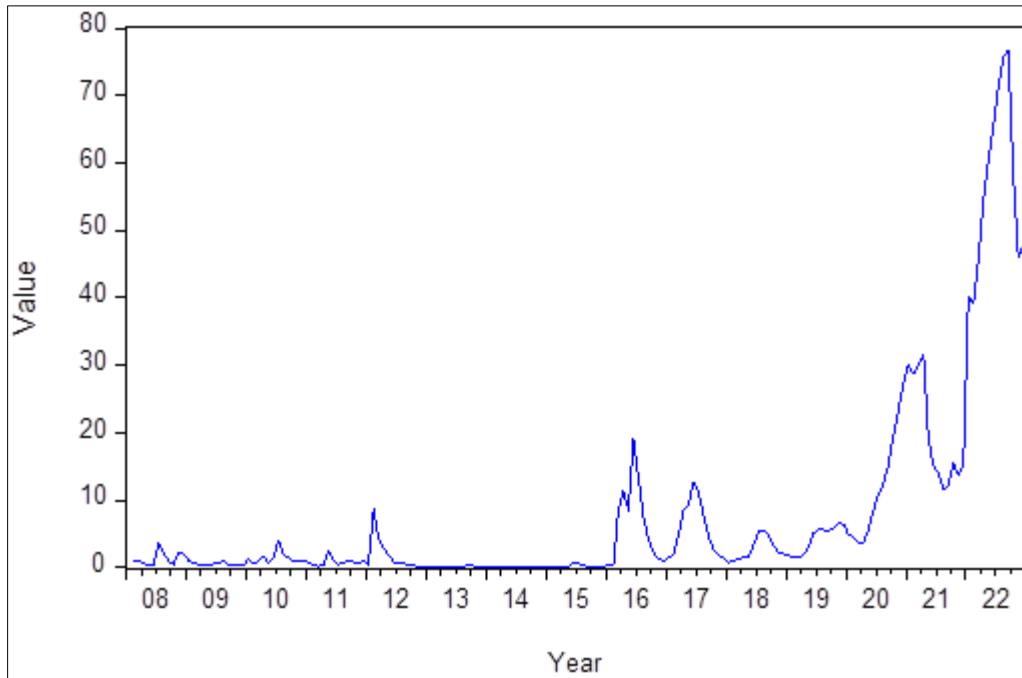
Figure 2 GARCH(1, 1) variance series for inflation

It is observable that inflation is more volatile in the second half of the series for the period under study. The highest scenario of volatility in Nigeria occurred in 2022, followed by the year

Table 5 Estimate of Regression Model specified in Equation 4.

Dependent Variable: INFVOL				
Method: Least Squares				
Date: 05/28/24 Time: 00:04				
Sample (adjusted): 2008M04 2022M12				
Included observations: 175 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.347215	0.295221	1.176117	0.2412
INFVOL(-1)	1.208190	0.074856	16.14013	0.0000
INFVOL(-2)	-0.226719	0.076284	-2.972059	0.0034
D(NCX)	-0.037627	0.312484	-0.120413	0.9043
D(NFX)	-0.012993	0.065986	-0.196901	0.8441
D(NUSX)	0.070128	0.099792	0.702740	0.4832
R-squared	0.949200	Mean dependent var		7.786829
Adjusted R-squared	0.947697	S.D. dependent var		15.11584
S.E. of regression	3.456966	Akaike info criterion		5.352344
Sum squared resid	2019.654	Schwarz criterion		5.460851
Log likelihood	-462.3301	Hannan-Quinn criter.		5.396358
F-statistic	631.5555	Durbin-Watson stat		2.005976
Prob(F-statistic)	0.000000			

The regression result in Table 5 above shows that the bi-lateral exchange rates; NCX, NFX and NUSX have no effect on inflation volatility in Nigeria. Inflation volatility is significantly influence by its previous one(at lag1) and two(at lag2) months values, significant under 5% level respectively. The R-squared indicates that about 82.3% variations in the inflation is explained by the regressor variables. The D-W statistic is (2.006) indicating absence of serial correlation in the residuals of the model and this agrees with the result of serial correlation test in Table6 as shown below.

Table6. Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.048491	Prob. F(2,167)	0.9527
Obs*R-squared	0.101569	Prob. Chi-Square(2)	0.9505
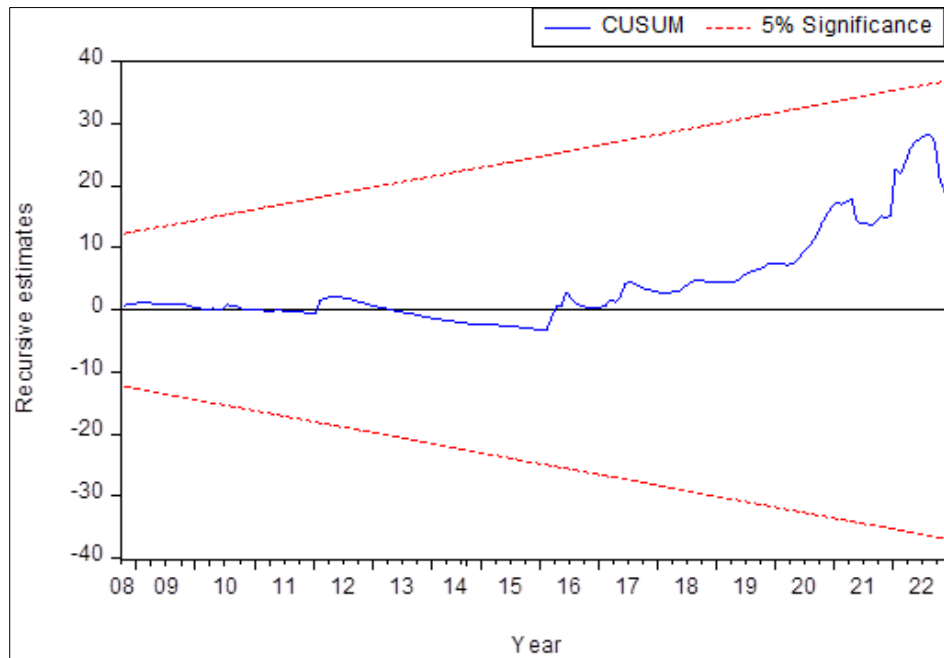
Figure 3 CUSUM test of parameter stability

The recursive estimates in Figure3 specifies that the parameters of the model are stable. Therefore, the model is properly specified and adequate.

4   Discussion

The results of this study as presented in Table2 and Table4 indicate that NCX (Nigerian naira/1 Chinese yuan), NFX (Nigerian naira/1 France franc) and NUSX(Nigerian naira/1 US dollar) have no influence on both inflation and its volatility in Nigeria. This implies that changes in exchange rates is not explaining the sudden increase in the prices of goods and services in Nigeria. This findings agrees with that of [10] who examined the impact of exchange rate depreciation on inflation in Nigeria and found that although Naira depreciation is relevant in ensuring an improvement in the production of exportable commodity, but it must not be relied upon as a potent measure for controlling inflation in Nigeria. However, the finding is contrary to [18] who observed that the rate of inflation and exchange rate explained each other in Kenya.

5   Conclusion

We conclude that despite the depreciation of Nigerian naira relative to Chinese yuan, France franc and US dollar, these exchange rates have no significant influence in inflation dynamics in Nigeria. Therefore, the government should look beyond exchange rates in finding solution to rising inflation phenomenon in Nigeria's economic space.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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