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A Var Approach to Exchange Rate and Consumer Price Index Shocks on Economic Growth in Nigeria

Sani Abdullahi[1]* and Hassan Nuhu Wali[2]

[1]Aminu Kano College of Islamic and Legal Studies, Kano, Nigeria; sabdullahi067@gmail.com
[2]Sule Lamido University, Jigawa State, Nigeria

Abstract

This paper attempt to assess the influence of exchange rate on economic growth in Nigeria using time series analysis from 1981-2021. Vector Autoregressive Method (VAR) was utilized as a method of analysis. The World Bank repository provides the data for this study. Real Gross Domestic Product was the dependent variable, while exchange rate and consumer price index were the independent variables. The result of the unit root test shows that all the variables are stationary at first difference. That enabled the researchers to use VAR to estimate the long run relationship among the variables. It was further revealed that the current value of the variables is explained by their past value. Exchange rate was found to be the most important determinant for growth in Nigeria, and that the Nigerian economy is sensitive to exchange rate shocks.

Keywords: Consumer Price Index, Economic Shocks, Exchange Rate, GDP, VAR

JEL Code: E5, E6

1. Introduction

Exchange rate is an important macroeconomic variable that enables the exchange of goods and services between different countries, and it plays a crucial role in determining the consumer price index, import and export levels, and overall economic balance. As noted by Islam *et al.*, 2007), the exchange rate is a key price in the financial world and is subject to frequent fluctuations that can occur any time, whether it be daily, monthly, or annually.

Exchange rate is therefore referring to as the price at which one country's currency is exchanged for that of another country. The status of a country's economic wellbeing is reflected by the real exchange rate (Okonkwo *et al.*, 2017). In general, if a country experiences an increase in its domestic income, it is likely that its currency will decrease in value. On the other hand, if the country's foreign exchange earnings increase, its currency is likely to appreciate. Furthermore, if there is high demand for domestic goods and services, the country's currency is to appreciate, while a demand for foreign goods and services is likely result in a depreciation of the currency (Arize *et al.*, 2000).

The CBN (2019) has reported that the movement of Nigeria's exchange rate over the past few decades has shown a direct cause-and-effect relationship between exchange rate movement and GDP. The consistent decline in the exchange rate has been closely linked to changes in GDP in Nigeria. During the 1990s, exchange rate movements were closely related to economic growth. However, exchange rate volatility is attributed to fluctuations in growth rate. For instance, Nigeria's exchange rate in 1990 was N9.30k for 1 USD, which rose to N22.05k for 1 USD in 1993. The GDP growth rate declined from 11.36% to 1.56% in 1990 and 1993 respectively. Similarly, when the exchange rate rose from N21.86 in 1995 to N92.69 and

*Author for correspondence

N192.11 in 1999 and 2000 respectively, and later increased to N133.5 in 2004, and averaged N198.74 between 2005-2019, economic growth followed a similar pattern (CBN, 2019).

There is a clear relationship between exchange rate appreciation and imports, and between exchange rate depreciation and exports. Appreciation of the exchange rate leads to a rise in imports and decrease exports and vice versa. Moreover, exchange rate depreciation causes a change in demand from goods produced outside the country to the goods produced within the country. This will consequently lead to a shift in terms of trade that diverts income from importing countries to exporting countries, affecting balance of trade and economic growth of both countries (Aliyu, 2011). Empirical evidences show that Nigeria has been suffering from exchange rate volatility, despite the series of exchange rate policies and reform embarked by successive Nigerian governments. The crucial question to ask is to what extent such policies have been effective in acceleration of economic growth in the country?

This paper is therefore designed using appropriate VAR framework to achieve the following objective: firstly, to examine the influence of exchange rate shock on economic growth in Nigeria, and secondly, to determine the level of response of the Nigerian economy to a shock from the exchange rate. The rest part of this paper is organized as follows. The next section provides theoretical and empirical literature review, while section three deals with research methodology. Section four presents and discuss the results, and section five concludes the paper.

2. Literature Review

This section of the paper provides us with reviews of literature that are relevant to the topic of the paper. It is made up of two aspects: review of theory of exchange rate and review of empirical works on impact of exchange rate on economic growth.

Theoretically, authors provided a theoretical explanation of exchange rate as one of the important macroeconomic variables. As stated earlier, the exchange rate is the value of one country's currency in comparison to another country's currency. Therefore, the exchange rate is a determinant of the price of domestic and foreign goods. Optimum Currency Area (OCA) theory is a theory of exchange rate policy which originated from the work of Mundell and McKinnon respectively (Ishiyama, 1975). The focal point of the theory is the extent to which macroeconomic policy can be effective in an open economy. External shock can decrease the demand for a country's exports; in this case interest rates must be cut to stimulate investment. Nevertheless, this may result in capital outflow and consequently adverse condition of balance of payment. The theory is on the view that fixed exchange rate regime can accelerate trade and output growth by providing certainty in exchange rate as well as reducing the cost of hedging. It can also encourage investment by lowering currency premium from interest rates (Akpan *et al.*, 2011). Although, fixed exchange regime may slow necessary relative price adjustment process, which hampers trade and output growth. Developing countries, including Nigeria often choose fixed regime due to fear of floating. Therefore, this research work uses the OAC theory as a framework as it explains the nature of exchange rate policies of developing countries and how it affects their economy.

In terms of empirical literature, several studies have examined the use of VAR approach in analyzing the relationship between two or more macroeconomic variables. Similarly, much research was conducted on the impact of exchange rate and consumer price index on economic growth. For the studies conducted in Nigeria, Yusuf *et al.,* (2019) investigated the effects of exchange rate and interest rate on economic growth of Nigeria using time series quarterly data for seventeen-year time prime (from 2000-2017). The authors used Cointegration and Error Correction Model (ECM) as a method of analysis. The findings of their research reveal that there is a long run relationship among the variables of the research. It was also found that the relationship between real GDP, CPI and real exchange rate is negative and statistically significant. However, it shows that there is a positive relationship between real GDP and interest rate. In the same vein, Omojuyigbe *et al.,* (2021) studied the effects of exchange rate movement on economic growth in Nigeria. The result of vector auto regression reveals that real exchange rate and real income are strongly cointegrated. On the contrast, Areghan *et al.,* (2022) used VAR to examine the impact of consumer price index on economic growth in Nigeria. The result reveals that there is a short run relationship between consumer price index and economic growth, and CPI doesn't have a long run causal effect to GDP. Additionally, Vasani *et al.,* (2019)

used VAR to investigate the long run relationship between exchange rate fluctuation and oil and gas performance in Nigeria. The result reveals that there was a positive significant relationship between the exchange rate and oil export.

Moreover, the studies conducted outside Nigeria provided evidence for the use of VAR or the relationship among exchange rate, consumer price index and GDP. For instance, McPherson *et al.,* (2000) investigated the relationship between real exchange rate and economic growth in India. Johansen cointegration and Granger causality test were utilized for the analysis. The study found that, there was a long run relationship between real exchange rate and economic growth in India. Similarly, the study conducted by Ahmad *et al.* (2013) in Kenya using VAR approach, confirm a positive long run relationship between changes in exchange rate and GDP growth rate. Moreover, the study carried out in Pakistan by Khan (2021) used OLS to investigate relationship between exchange rate and economic growth. The result reveals that, exchange rate and inflation has a strong negative relationship with Pakistani GDP. Similarly, Maddala (1992) studied the impact of exchange rate on economic growth in Bangladesh using OLS method. A strong positive relationship between the exchange rate and GDP was found.

The literature reviewed above provides empirical evidence of the relationship between exchange rates and economic growth. And some of them provide evidence of using VAR to access relationships among macroeconomic variables. Only the study conducted by McPherson *et al.,* (2000) in India and Ahmad *et al.* (2013) in Kenya use VAR to examine the relationship between exchange rate and economic growth. However, many of the studies conducted in Nigeria examine the relationship between exchange rate and growth using ECM Method, thus warranting research using the VAR method.

3. Methodology

The research employed an analytical research design where an econometrics procedure was adopted. The procedure is an effective technique for testing and validating economic theories (Nachrowi *et al.*, 2006).

3.1 Model Specification

Following the established practice in the background, and in tandem with the research objectives of the study, the model for the study is expressed in mathematical functional relation form as:

$$RGDP = f(EXRT, CPI \quad i$$

To make equation *i* fit for computation, we present it in econometric form as;

$$RGDP = \alpha_0 + \alpha_1 EXRT + \alpha_2 CPI + \mu \quad ii$$

where,

RGDP = Real Gross domestic product

EXRT = Exchange rate

CPI = Consumer price index

α_0 is the constant term; α_1 and α_2 are the coefficient of *EXRT and CPI,* respectively. Furthermore, the expected signs of the coefficients of the research model is such that $\alpha_1 < 0$ *while* $\alpha_2 > 0$.

Given that the research intends to interpret the coefficients as elasticity, the model is re-specified by taking their natural logarithm thus:

$$\ln RGDP = \alpha_0 + \alpha_1 EXRT + \alpha_2 CPI + \mu \quad iii$$

where,

ln stands for the natural logarithm of the variables.

3.2 Estimation Procedure

This research employs an econometric method of time series analysis to evaluate the objectives of the study captured by the model. The starting point of the estimation is the unit root test to confirm the stationarity state of the variables. In this regard, Augumented Dickey Fuller (ADF) test is used. Following the test for stationarity is the optimal lag selection using AIC and SIC. Similarly, the Vector Autoregressive (VAR), Impulse Response Function and Variance Decomposition were used to determine the dynamic relationship between the variables.

3.3 Stationarity Test

As a prerequisite to the econometrics model for time series data, the level of stationarity of the variables is determined. A stationary time series data is stable data in which its mean, variance and autocovariance at different lags remain the same at any time the data is used. If the data used in the model is not stationary, the results derived from the data have no meaningful relationship and interpretation, and this is called spurious regression. The Augmented Dickey-Fuller (ADF) test, developed by David Dickey and Wayne Fuller, is a widely used method to determine the stationarity of data. The hypotheses for this test are such that H_0: $\delta = 0$ (unit root) and H_1: $\delta \neq 0$.

According to Sims (1980), the ADF test may be conduct using various models either with no intercept, with intercept or with intercept and trend:

ΔYt = β1 + β2t + δYt-1 + ut (intercept with time trend) *iv*

Δ= first difference of the variables used, t = trend variable

3.4 Optimal Lag Selection Test

Determining an optimal lag length is an important and integral part of the VAR model. If the optimal lag used is too short, the dynamics of the model may not be fully captured. While selecting a lag that is too long may lead to inefficient estimation, particularly in a model with limited samples and degrees of freedom. Consequently, determining the appropriate optimum lag prior to performing VAR estimation is essential.

3.5 Vector Autoregressive (VAR) Analysis

The Vector Autoregressive (VAR) model is commonly utilized to examine the relationship among the time-based variables and to evaluate the effects of disruptive factors present in the variable system. Sims (1980) popularized the use of the VAR model in economics, as they are one of the most successful, flexible, and user-friendly models for multivariate time series analysis. VAR models have proven to be highly valuable in characterizing the dynamic patterns of economic and financial time series, as well as in forecasting future trends.

The general form of the Vector Autoregressive model VAR(P) can be represented as

$$y_t = A + \sum_{-=1}^{p} B_i Y_{t-1} + u_t \qquad v$$

where,

$$y_t = \begin{bmatrix} y_t \\ y_{t-1} \\ \vdots \\ y_{t-p} \end{bmatrix}, A = \begin{bmatrix} A \\ 0 \\ \vdots \\ 0 \end{bmatrix} X = \begin{bmatrix} X_1 X_2 & \cdots & X_{p-1} \\ 1 \quad 0 & & 0 \\ \vdots \quad \vdots & \ddots & \vdots \\ 0 \quad 1 & \cdots & 1 \end{bmatrix} u_t = \begin{bmatrix} u_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

y_t is a (3×1) random vector of endogenous variables being considered as real GDP, exchange rate, and consumer price index, the B_i are fixed coefficient matrix, A is a fixed (3×1) vector of intercept terms. μ_t is a 3-dimensional white noise and p is the lag order.

However, the structural unrestricted VAR model for this study is specified as

$$lnRGDP_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \, lnRGDP_{t-1} + \sum_{i=1}^{p} \delta_i \, EXRT_{t-1} + \sum_{i=1}^{p} \theta_i \, CPI_{t-1} + u_{1t} \qquad vi$$

$$EXRT_t = \vartheta_0 + \sum_{i=1}^{p} \beta_i \, lnRGDP_{t-1} + \sum_{i=1}^{p} \delta_i \, EXRT_{t-1} + \sum_{i=1}^{p} \theta_i \, CPI_{t-1} + u_{2t} \qquad vii$$

$$CPI_t = \varphi_0 + \sum_{i=1}^{p} \beta_i \, lnRGDP_{t-1} + \sum_{i=1}^{p} \delta_i \, EXRT_{t-1} + \sum_{i=1}^{p} \theta_i \, CPI_{t-1} + u_{3t} \qquad viii$$

where,

$\beta_i, \delta_i \; and \; \theta_i$ are the unknown parameters to be estimated, $\alpha_0, \vartheta_0 \; and \; \varphi_0$ are the constant or intercept, u's are the stochastic error terms, *p* is the number of lags, and RGDP is the natural log of real GDP proxied as economic growth, EXRT is the USD/NGN exchange rate and CPI is the consumer price index.

More specifically, our interest is in equation *vi* that is the economic growth equation

$$lnRGDP_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \, lnRGDP_{t-1} + \sum_{i=1}^{p} \delta_i \, EXRT_{t-1} + \sum_{i=1}^{p} \theta_i \, CPI_{t-1} + u_{1t}$$

3.6 Impulse Response Function

A VAR analysis technique called the impulse response function is used to evaluate how variables in a system react to shocks in other variables. This strategy assumes that each variable's innovations are uncorrelated, allowing for direct distribution of a shock's impact. A graphical representation of the reaction of one variable to a shock in another over several periods is produced by the impulse response function. The effects of the shock will eventually fade, and shock won't have a long-lasting effect on the variable if the response moves closer to a convergence point or returns to the previous equilibrium.

3.7 Variance Decomposition

The variation of one endogenous variable in a VAR system is decomposed using the variance decomposition technique into the shock component of other endogenous variables. This variance composition shows how much of a series movement is caused by the shock of the variable in question as opposed to shock from other variables. The variable yt can be regarded as exogenous if the shock component is unable to adequately describe the variance of the forecast error. As a result, variable yt is unrelated to both variable zt and the impact component. On the other hand, the variable yt is regarded as endogenous if the shock component can explain the prediction error variance.

3.8 Residual Diagnostic Tests

To test the "white-noise" properties of the estimated residuals, this study uses multivariate LM Tests for Autocorrelations for residual serial correlation, White Heteroskedasticity test for detecting heteroskedasticity and Dynamically-stable Model Test for the stability of the model.

4. Result and Discussion

This section provides a presentation of the econometric results and analysis of the data. It also involves diagnostic tests and estimations of the parameters among other things.

4.1 Data Description

Secondary data from 1981 to 2021 was used in this research. The data was obtained from World Development Indicators (WDI) 2023. The RGDP stands for economic growth in this study. The price of the Nigerian Naira in terms of US dollars is represented by the Exchange Rate (EXRT), and the Consumer Price Index (CPI) is also used. Due to the heterogeneous nature of the data, the natural log of the RGDP was taken. However, the natural logarithm of EXRT and CPI were not taken because they are homogenous and need no further transformation. Eview (version 10.0) software was used to analyze the model.

4.2 Empirical Results

To apply the Vector Autoregression (VAR) model, it is important to check if the variables of interest are stationary or not. To do this a unit root test was conducted using Augmented Dickey-Fuller (ADF) Test. The result of the test is summarized in Table 1.

The result of the ADF unit root test at a 5% critical level revealed that the null hypothesis of the unit root for each series was not rejected at its level form. However, it was rejected when the data was differenced once (fist difference). In other words, at a 5% level of significance, the test indicates that all the series are stationary at first difference indicating that the variables are integrated of Order 1 expressed as I(1). This result suggests evidence of co-integration and possible VAR model estimation for a long-run relationship.

4.3 Optimal Lag Selection

In choosing the optimal lag for the series, the lag length selection criteria were performed. The Akaike Information Criteria (AIC) and Schwarz Information Criterion (SIC) results were all in support of 1 lag. Therefore the model for the study is a VAR(1) model.

Table 1. ADF unit root test result

VARIABLES	ADF test at Level			ADF test at First Difference		
	ADF test	Critical Value at 5%	Order of integration	ADF test	Critical Value at 5%	Order of integration
LRGDP	-1.036	-2.943	NON STATIONARY	-3.778	-2.941	STATIONARY
EXRT	-0.127	-2.957	"	-5.307	-2.960	"
CPI	-2.310	-2.941	"	-5.788	-2.945	"

Source: Authors' E-views Computation.

4.4 Vector Autoregression (VAR) Estimates

Table 2 provides a summary of the analysis of the results an one-lag VAR model was employed based on the optimal lag selection criteria. This was done to avoid the issues of multicollinearity and loss of degree of freedom and to select the best order that would yield manageable outcomes.

Table 2 displayed the findings of the analysis, which reveals that the previous value of economic growth, as an endogenous variable, has a significant impact on its current value (0.901%). More so, the past value of the explanatory variable, an exchange rate (0.001%), has a significant effect on the current level of economic growth in Nigeria. However, the lag value of the consumer price index (CPI) (0.002%) was found to have no significant positive impact on determining the present level of economic growth in Nigeria.

The result further shows that past level of economic growth seems to have the highest impact, while exchange rate and consumer price index do not have much impact, taking into account the level of the coefficient. Furthermore, the Durbin-Watson (DW) test statistic (d*) shows the presence of a weak positive serial correlation between the error terms in the model, and that 99% of variation in the dependent variable is accounted by changes in the independent variable.

4.5 Dynamically-Stable Model Test

The calculations of impulse response and variance decomposition will only be correct if the VAR model is

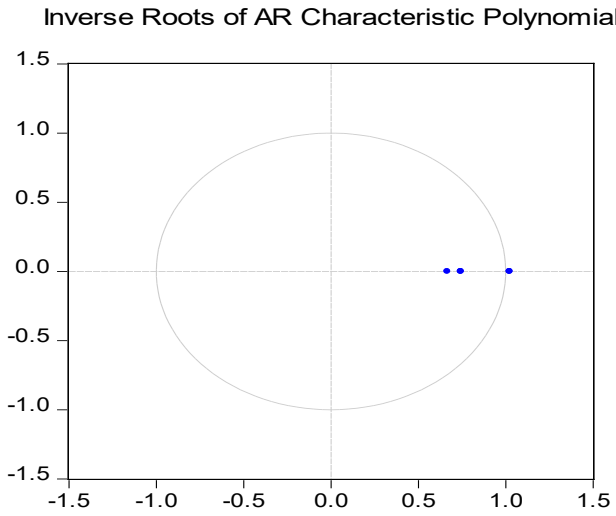

Figure 1. Test for VAR model stability.

Table 2. VAR estimation result

VARIABLES	COEFFICIENT	STD. ERROR	P>value
RGDP(-1)	0.901	0.0557	0.0000
EXRT(-1)	0.001	0.0003	0.0031
CPI(-1)	0.002	0.0033	0.6186
C	2.507	0.056	0.0689

R-squared	0.991
Adj. R-squared	0.990
F-statistic	1071.18
Resid covariance (dof adj.)	1.209
Number of coefficient	12

Source: Authors' E-views Computation.

found to be stable. Therefore, the stability of the VAR model would be tested using the AR Root Eigenvalues. Using the graph, if all the eigenvalues lie inside the unit circle, the VAR model is said to satisfy the stability condition.

The Figure 1 below indicates visually that the eigenvalues are well inside the unit circle, although only one is found outside which can be ignored and consider the model as a stable VAR model. The results are the basis for assessing the impact of the exchange rate and consumer price index on economic growth in Nigeria over the period from 1981 to 2021.

4.6 Impulse Response Function (IRF)

An IRF is a VAR method that traces the effect of a one-time shock on one of the innovations on the current and future values of the endogenous variables. Thus, in Table 3, the result of the impulse response for the level of economic growth is presented.

Table 3. Impulse response function result

Response of LRGDP:			
Period	**LRGDP**	**EXRT**	**CPI**
1	0.041594	0.000000	0.000000
	(0.00520)	(0.00000)	(0.00000)
2	0.038356	0.013856	0.003354
	(0.00578)	(0.00496)	(0.00639)
3	0.035757	0.025348	0.007305
	(0.00741)	(0.00874)	(0.00998)
4	0.033749	0.034829	0.011280
	(0.00926)	(0.01199)	(0.01254)
5	0.032261	0.042646	0.014992
	(0.01112)	(0.01503)	(0.01488)
6	0.031214	0.049118	0.018324
	(0.01295)	(0.01801)	(0.01719)
7	0.030533	0.054520	0.021249
	(0.01476)	(0.02094)	(0.01945)
8	0.030150	0.059083	0.023792
	(0.01654)	(0.02378)	(0.02157)
9	0.030009	0.062997	0.025998
	(0.01830)	(0.02648)	(0.02351)
10	0.030062	0.066414	0.027919
	(0.02005)	(0.02902)	(0.02526)

Source: Authors' E-views Computation.

The IRF results in Table 3 show how economic growth reacts to its past value and exogenous impulses or shocks of other independent variables over time. The results reveal that present economic growth is influenced at the same time by the shocks from its past and from other variables depicted in column one to three of Table 3. The information presented in the first column of the table refers to current economic growth rates, which is influenced by past economic growth. The second column of the table demonstrates how current economic growth rate responds to an exchange rate shock, while the third column indicates the response of current economic growth rate to a consumer price index shock. The results revealed that, the past value of economic growth is positively significantly explaining its current value, although the impact decreases toward the long run. Furthermore, the economic growth response to structural one innovation appears to be greater in exchange rate than the other variables in the long run, specifically from the 3rd to 10th horizon. Therefore, one innovation in exchange rate shows large percentages of economic growth response. This shows that monetary policies that affect exchange rate innovations play an important role in the variation of economic growth in long run than they do in the short run. Similarly, innovations in consumer price index explain relatively small proportions of economic growth response though the effects are becoming larger after the 8th year's horizon into the future.

4.7 Variance Decomposition

While an IRF provides information on the size of exchange rate and consumer price index shock effects on economic growth, a variance decomposition shows the extent to which these shocks are responsible for the volatility of the variables or the prediction errors observed in the last ten years. The result of the variance decomposition for this study is depicted in Table 4.

The results of the variance decomposition analysis indicate that external factors are the primary determinants of economic growth fluctuations in Nigeria. Specifically, economic growth shocks contribute significantly to short-term volatility, with their impact diminishing over time until the tenth period. However, exchange rate shocks have an increasingly important effect on economic growth variation, starting from the seventh period and

Table 4. Variance decomposition result

Variance Decomposition of LRGDP:				
Period	**S.E.**	**LRGDP**	**EXRT**	**CPI**
1	0.041594	100.0000	0.000000	0.000000
2	0.058348	94.03053	5.639009	0.330464
3	0.073341	83.28429	15.51437	1.201330
4	0.088646	71.50226	26.05625	2.441490
5	0.104606	60.85984	35.33272	3.807440
6	0.121100	52.05450	42.81503	5.130461
7	0.137918	45.03410	48.63661	6.329293
8	0.154878	39.50064	53.12056	7.378806
9	0.171849	35.13330	56.58474	8.281960
10	0.188749	31.66029	59.28648	9.053235

Source: Authors' E-views Computation.

continuing into the future. In addition to exchange rates, consumer price index shocks also have some influence on economic growth variability, albeit to a lesser extent, accounting for 7% of variation after the eighth period.

4.8 Diagnostic Tests Result

The result for Serial Correlation with a probability value greater than 0.05 (that is 0.107) implies that we cannot reject the null hypothesis, and therefore concludes that there is no serial autocorrelation in the model. However, there exists a problem of heteroschedasticity given that the p>value is less than 0.05, though it could be resolved using the robust standard error.

5. Conclusion and Policy Implication

This paper assesses the influence of exchange rate and CPI shocks in determining economic growth in Nigeria. Findings from the study reveal that the exchange rate is a key macroeconomic variable to be considered by policies formulators in the country so as to achieve economic growth. The principal finding of the study revealed that the shock from exchange rate significantly influences the economic growth more than the shock from other macroeconomic variables. It also determines the changes in the Nigerian economy than other variable especially in the long run.

The outcome of the analysis is significant for policy makers in comprehending the impact of inappropriate monetary policies related to exchange rates and consumer price index on economic growth. Therefore, the study provides valuable insights into the measures that can be taken to avoid its hindrances and poster growth. Therefore, this paper recommends the following:

Regulatory bodies, particularly the Central Bank, should make an effort to stabilize exchange rate fluctuations in the country. This is necessary to reduce inflationary pressure and promote confidence, which can attract investment into the economy.

Given that, past economic growth has a significant impact on current economic growth in the short run. Therefore, efforts should be put in place to achieve stable economic growth by encouraging growth in investment, employment, and output in the long run.

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