CAUSALITY BETWEEN KEY MACROECONOMIC FACTORS AND NIGERIA'S ECONOMIC GROWTH

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Abstract

Globally, macroeconomic factors or variables such as interest rates, inflation rates, exchange rates, export of goods and services, consumer price index, etc. play fundamental roles on the economic performance of any country, especially the developing countries. This work therefore investigates the causal dynamics between the Nigeria's economy growth proxy as Gross Domestic Product (GDP) and some vital macroeconomic factors such as Exchange Rate (EXR), Consumer Price Index (CPI) and Export of Goods and Services (EGS) using the unrestricted Vector Autoregressive (VAR) modeling techniques. Pre-examinations of the time series variables using the Augmented Dickey-Fuller (ADF) and cointegration tests confirmed that the series are not only difference stationary series of order ones {I(1)s} but are also not cointegrated; which means that the VAR (p) model is appropriate for analyzing the series. However, the Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC) and Hann-Quinn Information Criteria (HQC) selected the optimal order p to be 5 (i.e. p = 5). This means VAR (5) will be fitted to the datasets. Model stability diagnosis of the VAR (5) model revealed that: all inverse roots of characteristic AR polynomial have modulus less than one and lie inside the circle; majority of the spikes of the residual correlogram are laying inside two standard error bounds, and there is no serial correlation in the residuals of the fitted model. In other words, VAR (5) is stable. Findings from the study established that there is no causation or prediction running from the EXR, EGS and CPI to GDP. Conversely, there are unilateral causalities running from the GDP to EXR, EGS to EXR while bilateral causality exists between CPI and EXR. Finally, there is no causation or prediction running from GDP to EGS, EXR to EGS, CPI to EGS, GDP to CPI, and EGS to CPI.

Keywords: EXR, EGS, CPI, GDP, Causality

1. Introduction

The exchange rate is the price at which one currency can be exchanged for another, effectively reflecting the value of one currency in terms of another (Jhingan, 2005). It represents the price of a unit of foreign currency in terms of domestic currency. For decades, there has been an ongoing debate over what factors determine the choice of exchange rate regimes. Friedman (1953) argued that in the presence of sticky prices, floating exchange rates could provide better insulation from foreign stocks by allowing faster adjustment of relative prices. He suggested that, in the long run, the exchange rate system has minimal real economic impact, as it is ultimately a choice of monetary regime. While monetary policy might not significantly affect real economic quantities in the long run, it does have short-run effects. Conversely, Mundell (1963) posited that in a world with capital mobility, the optimal choice of exchange rate regime depends on the type of economic shocks: real shocks would favor a floating exchange rate, while monetary shocks would call for a fixed exchange rate.

In emerging markets like Nigeria, the degree of exchange rate volatility is heavily influenced by the United States dollar, a key trading currency. Over the last two decades, exchange rate fluctuations have been considerable, often unrelated to economic fundamentals. This has led monetary authorities in many developing countries to intervene in the market regularly to stabilize the exchange rate. However, such interventions are often made without a clear sense of a sustainable equilibrium and tend to occur with delays, sometimes failing to prevent severe exchange rate misalignment and volatility. These imbalances can lead to economic fluctuations, protectionist trade pressures, and sharp policy reversals in exchange rate management. The exchange rate instability experienced in Nigeria between 2015 and 2017 highlighted these challenges (Nkwede, 2017).

Economic activities in Nigeria heavily depend on imported inputs, and the average consumer strongly prefers foreign goods due to perceived quality differences. On the export side, Nigeria's main export commodity, oil, is subject to international market fluctuations and quota allocations, which has moderated the flow of foreign exchange and contributed to high exchange rate volatility over the years. This volatility poses significant risks for both the government and domestic investors engaged in foreign trade, making the extent of exchange rate volatility a crucial concern for policymakers and investors alike (Nkwede, 2017).

A close examination of foreign exchange rate developments in Nigeria from 2010 to late 2014 reveals that both official and unofficial markets experienced significant shocks due to excessive demand pressure and speculative activities, which contributed to market volatility. The persistent high exchange rate instability observed in Nigeria following the sharp decline in oil prices highlighted the importance of the unofficial market to the economy. The inability of the official market to manage the high demand for foreign exchange led to the growth of the unofficial foreign exchange market. Understanding the dynamics of both markets is essential for effective policy formulation. Additionally, demand pressure intensified in 2015, prior to the introduction of a more liberalized exchange rate regime. Comparing the persistence and level of volatility in these markets could provide valuable insights into the challenges facing the foreign exchange markets and help guide investor decision-making, particularly in terms of portfolio diversification. Moreover, the issue of asymmetry in these markets, where the domestic currency's movements against foreign currencies create uncertainty, warrants attention. The Central Bank's reliance on external reserves has also contributed to this asymmetry. Therefore, an asymmetric conditional volatility model is explored to estimate the variations in exchange rates and compare the degree of asymmetry between the two markets, providing detailed insights for better understanding and policy formulation (Isenah and Olubusoye, 2016).

It is noteworthy that major foreign currencies such as the British Pound Sterling (GBP) and the European Euro (EUR) typically hold higher value than the United States Dollar (USD) in the foreign exchange market (Investing.com, 2022). Consequently, one might assume that the strongest economies will have the most significant global currencies, while the USD remains the vehicle currency that drives all other global currencies in the foreign exchange market (Investopedia, 2022). The dollar often acts as a "vehicle currency," meaning that agents in non-dollar economies typically engage in currency trade indirectly using the U.S. dollar rather than engaging in direct bilateral trade among their currencies (Devereux & Shi, 2013). When a large proportion of international exchanges involve a single currency on one side of the transaction, which currency is referred to as a vehicle currency (Bank of International Settlements, 2010). There are two types of currencies in international trade pricing: vehicle currencies and non-vehicle currencies. The former involves the use of a third currency, while the latter involves the use of the exporter’s or importer’s currency (Magee and Rao, 1980). The top ten most tradable vehicle currencies globally, in order, are USD, EUR, Japanese Yen (JPY), GBP, Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), Chinese Renminbi, Swedish Krona, and New Zealand Dollar (Remitr, 2022).

Traditional econometric models are appropriate for analyzing financial time series measured at low frequencies, such as monthly, quarterly, or yearly intervals (Gujarati and Porter, 2009). For example, annual exchange rate series can be analyzed using univariate or multivariate time series models. In univariate models, the objective is to forecast the future based on past periods (Box and Jenkins, 1976; Yaffee and McGee, 2000; Gujarati, 2009). The univariate time series approach is suitable when there is only one time series variable under investigation, provided the series is measured at low frequencies. The best possible model for a univariate time series dataset could be AR(p), MA(q), ARMA(p, q), or ARIMA(p, d, q), depending on the values of the orders p, q, and the level of differencing d of the series. If p is non-zero and d and q are zeros, an AR(p) model is appropriate. If p and d are zeros but q is non-zero, an MA(q) model is used. However, if p and q are non-zero but d is zero, an ARMA(p, q) model is suitable. Lastly, if p, d, and q are non-zero, then an ARIMA(p, d, q) model is appropriate. In contrast, multivariate time series models involve more than one time-dependent variable, where each variable depends not only on its past values but also on other variables. The goal in multivariate models is to determine the predictability of one variable by another (Yaffee and McGee, 2000). When analyzing multiple time series variables in a study, the multivariate time series approach is the best modeling technique to adopt, allowing for a holistic consideration of the variables (Garba et al., 2020). If the time series in the study are difference-stationary series of order one (I(1)s) and satisfy the conditions for cointegration, the system should be specified as a Vector Error Correction Model (VECM); otherwise, a Vector Autoregressive (VAR) system, developed by Sims in 1980, should be used (Engle and Granger, 1987). Akanni et al. (2021) also noted that the Autoregressive Distributed Lag (ARDL) model, developed by Pesaran et al. (2001), can be used to analyze the I(1) series, depending on the study's objective.

On the other hand, volatility models are generally the best for forecasting financial assets or asset prices such as oil, stocks, exchange rates, gold, etc. This is because financial assets or asset prices are typically sampled at high frequencies, such as daily or intraday. Therefore, forecasting daily exchange rates series such as USD-Naira (UN), British Pound Sterling-Naira (PN), and Euro-Naira (EN) using traditional econometric models is expected to yield misleading results due to the phenomenon of volatility clustering, first identified by Mandelbrot in 1963. Financial time series often exhibit a behavior known as volatility clustering, where significant price changes tend to cluster together, leading to persistent price change amplitudes (Mandelbrot, 1963). To address volatility clustering, Engle (1982) first proposed the Autoregressive Conditional Heteroscedasticity (ARCH) model, which Bollerslev later extended to the Generalized ARCH (GARCH) model in 1986.

Choudhury (2005) investigated the impact of exchange rate volatility on U.S. real exports to Canada and Japan using both nominal and real exchange rates between the United States dollar and the currencies of Canada and Japan. The study, which used aggregate monthly data from January 1974 to December 1998, employed the conditional variance from the GARCH (1, 1) model as a measure of exchange rate volatility and found significant and mostly negative effects of exchange rate volatility on real exports. Similarly, Sukar and Hassan (2001) explored the relationship between U.S. trade volume and exchange rate volatility using cointegration and error-correction models. Their study, which used quarterly aggregate data from 1975Q1 to 1993Q2 and a GARCH model to measure exchange rate volatility, found evidence of a significantly negative relationship between U.S. export volume and exchange rate volatility. However, unlike other studies, they found that the short-run dynamics of the exchange rate volatility-trade relationship were insignificant. They attributed this result to the availability of avenues for hedging against exchange risks, which could neutralize the negative impact of exchange rate volatility. Other scholars suggest that this short-run insignificant relationship may be due to the use of aggregate data, which ignores sectoral differences—where one sector may exhibit a negative relationship, another may exhibit an equal but opposite effect, offsetting each other.

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Most of the previously published works on the impacts of some macroeconomic factors on Nigeria's economic growth were mostly based on Ordinary Least Squares (OLS), Autoregressive Distributed-Lag (ARDL), or Error Correction Model (ECM). For example, Danmola(2013) employed Ordinary Least Squares (OLS) and Granger causality tests to show that exchange rate volatility has a positive influence on Gross Domestic Product (GDP), Foreign Direct Investment (FDI), and Trade Openness, with negative influence on the inflationary rate in the country.

In a study, Oudat et al (2020) investigated the nexus between macroeconomic variables and portfolio investment in Bahrain using an Autoregressive Distributed-Lag (ARDL) model. Their findings revealed that there was a long-run relationship between portfolio and macroeconomic factors. They also discovered that the variable can cause portfolio investment only for the consumer price index and gross domestic product in the long run whereas consumer price index has a significant on the portfolio in the short run.

Again, Brownson et al (2012) examined the relationship between agricultural productivity and macroeconomic fluctuation in Nigeria using the VECM. Their findings established that in the short and long-run periods, the coefficients of real total exports, external reserves, inflation rate, and external debt have a significant negative relationship with the agricultural productivity in the country while the industry's capacity utilization rate and nominal exchange rate have positive association with agricultural productivity in both periods.

Adebayo et al (2021) studied the impact of major macroeconomic variables on foreign direct investment in Nigeria using the Autoregressive Distribute-Lag (ARDL) model and wavelet coherence technique. They found that ARDL's long-run estimate reveals that exports and trade openness exerts positive impact on FDI inflows. However, their further findings from the wavelet coherence-based causality and wavelet correlation techniques further provide supportive evidence to the ARDL technique.

Furthermore, Innocent et al (2018) examine the effects of macroeconomic variables on stock market performance in Rwanda. They concluded that GDP, inflation, and exchange rate have negative effects on stock market performance while is insignificant in the model.

However, Amassoma (2016) examined the nexus between exchange rate variation and economic growth in Nigeria using the Error Correction Model (ECM). His findings exhibited that there exists a positive but insignificant impact of exchange rate fluctuation on Nigerian economic growth in both the long and short run. Hence, to formulate better policies that will stimulate the country's growth, it is imperative to test Granger causality between some vital macroeconomic factors and Nigeria's GDP.

Amin et al (2018) examined the exchange rate overshooting hypothesis in Bangladesh using both cointegration and causal analyses techniques. Their results revealed that GDP and INT are effective in influencing NER in the long run while MS and INF are found to be ineffective. Thus, in the long run, macroeconomic variables are partially effective in simulating exchange rate movements in Bangladesh. They also found that monetary policy is ineffective in influencing NER movements in the short run.

Arthur-Aidoo (2018) studied exploratory factor analysis on drivers of firm's growth among construction SMEs in Ghana. Findings from his study ranked stakeholder involvement (SKI) as the most important factor in the growth of construction SMEs and the business environment of a firm (BEF) as the least important.

Olokoyo et al (2019) examined the macroeconomic determinants of bank performance in Nigeria using the Autoregressive Distributed-Lag (ARDL) model. Their findings established that growth, trade, and interest rates are important determinants of bank performance in Nigeria.

Ismaila & Imoughele (2015) examine the macroeconomic determinants of economic growth in Nigeria using cointegration techniques. They concluded that gross fixed capital formation, foreign direct investment, and total government expenditure are the main determinants of Nigeria's economic output under a stable inflationary rate.

2. Research Methodology

This study employed the Unrestricted VAR (p) model to examine the causality dynamics among the Gross Domestic Product (GDP), Exchange Rate (EXR), Export of Goods and Services (EGS) and Consumer Price Index (CPI).

2.2 Model Specification

Unlike the univariate time series models which use only one variable for its analyses, VAR (p) model generalizes the univariate autoregressive models by allowing multivariate time series. The VAR (p) model is developed by Sims (1980). In VAR (p) techniques, the structural modelling is conducted in such a way that each endogenous variable is treated as a function of the lagged values of all the endogenous variables in the system. The general form of VAR (p) model is of the form:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + BX_t + e_t \qquad (1.0)$$

Where: y_t is a k vector of endogenous variables, X_t is a d vector of exogenous variables, A_1 to A_p and B are matrices of coefficients to be estimated, $e_t^{'}$ is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right hand side variables.

Since we are considering four (4) variables (i.e. GDP, EXR, EGS and CPI) in the study, we specify four equation-models for the study such that each endogenous variable has its exogenous variables on the right-hand side. However, for appropriate estimation of the four equation-models for the VAR (p) model, the natural log of each variable was taken and specified as equations (1.1), (1.2), (1.3) and (1.4) below:

$$\mathrm{lnGDP_t} = \alpha_{10} + \sum_{i=1}^{p} \emptyset_{1i}\mathrm{lnGDP_{t-i}} + \sum_{i=1}^{p} \beta_{1i}\mathrm{lnEXR_{t-i}} + \sum_{i=1}^{p} \delta_{1i}\mathrm{lnEGS_{t-i}} + \sum_{i=1}^{p} \Upsilon_{1i}\mathrm{lnCPI_{t-i}} + e_{1t} \quad (1.1)$$

$$\mathrm{lnEXR_t} = \alpha_{20} + \sum_{i=1}^{p} \emptyset_{2i}\mathrm{lnGDP_{t-i}} + \sum_{i=1}^{p} \beta_{2i}\mathrm{lnEXR_{t-i}} + \sum_{i=1}^{p} \delta_{2i}\mathrm{lnEGS_{t-i}} + \sum_{i=1}^{p} \Upsilon_{2i}\mathrm{lnCPI_{t-i}} + e_{2t} \quad (1.2)$$

$$\mathrm{lnEGS_t} = \alpha_{30} + \sum_{i=1}^{p} \emptyset_{3i}\mathrm{lnGDP_{t-i}} + \sum_{i=1}^{p} \beta_{3i}\mathrm{lnEXR_{t-i}} + \sum_{i=1}^{p} \delta_{3i}\mathrm{lnEGS_{t-i}} + \sum_{i=1}^{p} \Upsilon_{3i}\mathrm{lnCPI_{t-i}} + e_{3t} \quad (1.3)$$

$$lnCPI_t = \alpha_{40} + \sum_{i=1}^{p} \emptyset_{4i}lnGDP_{t-i} + \sum_{i=1}^{p} \beta_{4i}lnEXR_{t-i} + \sum_{i=1}^{p} \delta_{4i}lnEGS_{t-i} + \sum_{i=1}^{p} \Upsilon_{4i}lnCPI_{t-i} + e_{4t} \quad (1.4)$$

Basically, there are six basic steps or procedures of VAR (p) model which include: unit root analysis, cointegration testing, optimal lag selection, estimation of appropriate VAR model, Granger causality and impulse response graphs.

3. Data Analysis and Results

This section presents the results of analyses conducted on the GDP, EXR, CPI and EGS series using EViews 9.0.

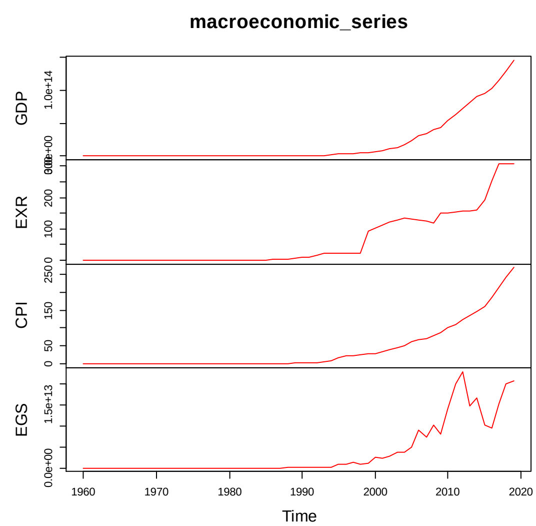


Figure 1: GDP, EXR, CPI and EGS series, (1960-2019) yearly

The time series plots of the GDP, EXR, CPI and EGS series in Figure 1 revealed that the series are not only suggested to be different stationary series of order some order *d*. As a result, the series need to be different once {I(1)} or twice {I(2)} in order to attain stationarity. For proper determination of the order of integration of individual series, each series was subjected to unit root tests and results of the unit root tests are presented in Tables 1a, 1b, 1c, 1d, 1e, 1f, 1g and 1h below.

Table 1a: Unit root tests for lnGDP at level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.206787	0.4770
Test critical values:	1% level	-4.121303	
	5% level	-3.487845	
	10% level	-3.172314	

*MacKinnon (1996) one-sided p-values.

Table 1b: Unit root tests for lnGDP after first difference

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.290687	<**0.0001**
Test critical values:	1% level	-4.124265	
	5% level	-3.489228	
	10% level	-3.173114	

*MacKinnon (1996) one-sided p-values.

Table 1c: Unit root tests for lnEXR at level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.378540	0.9804
Test critical values:	1% level	-3.546099	
	5% level	-2.911730	
	10% level	-2.593551	

*MacKinnon (1996) one-sided p-values.

Table 1d: Unit root tests for lnEXR after first difference

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.981890	<**0.0001**
Test critical values:	1% level	-3.548208	
	5% level	-2.912631	
	10% level	-2.594027	

*MacKinnon (1996) one-sided p-values.

Table 1e: Unit root tests for lnEGS at level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.010227	0.5837
Test critical values:	1% level	-4.121303	

	5% level	-3.487845	
	10% level	-3.172314	

*MacKinnon (1996) one-sided p-values.

Table 1f: Unit root tests for lnEGS after first difference

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.690019	<**0.0001**
Test critical values:	1% level	-4.124265	
	5% level	-3.489228	
	10% level	-3.173114	

*MacKinnon (1996) one-sided p-values.

Table 1g: Unit root tests for lnCPI at level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.083068	0.9617
Test critical values:	1% level	-3.550396	
	5% level	-2.913549	
	10% level	-2.594521	

*MacKinnon (1996) one-sided p-values.

Table 1h: Unit root tests for lnCPI after first difference

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.092323	**0.0021**
Test critical values:	1% level	-3.550396	
	5% level	-2.913549	
	10% level	-2.594521	

*MacKinnon (1996) one-sided p-values.

Results of unit root analyses reported in Tables 1a, 1c, 1e and 1g revealed that we fail to reject the null hypotheses of non-stationarity for the GDP, EXR, EGS and CPI at level.
However, further results reported in Tables 4.1b, 4.1d, 4.1f and 4.1h later confirmed that the null hypotheses have been rejected for the GDP, EXR, EGS and CPI series after first differences. In other words, GDP, EXR, EGS and CPI are all I(1)s.
Hence, since these series have been confirmed to be I(1)s, the system will therefore be subjected to cointegration tests in order to determine whether the VAR or VECM is desirable for examining the macroeconomic series.

Table 2: Cointegration tests

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**

None	0.271865	35.11711	47.85613	0.4419
At most 1	0.156358	16.71551	29.79707	0.6610
At most 2	0.105186	6.853977	15.49471	0.5947
At most 3	0.007008	0.407918	3.841466	0.5230

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.271865	18.40159	27.58434	0.4621
At most 1	0.156358	9.861535	21.13162	0.7575
At most 2	0.105186	6.446059	14.26460	0.5566
At most 3	0.007008	0.407918	3.841466	0.5230

Max-eigenvalue test indicates no cointegration at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Cointegration tests results in From 2 established that both the trace and maximum eigenvalue test results indicate no co-integration. This implies that there is no long-run relationship among the GDP, EXR, EGS and CPI series. As a result, the VAR model is suitable for the series since there is no evidence of cointegration relationship among these series (Engle and Granger; 1987).

Table 3: Lag length criteria for the macroeconomic series

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-217.6298	NA	0.037171	8.059266	8.205254	8.115721
1	59.04373	503.0428	2.85e-06	-1.419772	-0.689833*	-1.137499
2	82.48785	39.21561	2.19e-06	-1.690467	-0.376576	-1.182375*
3	95.12733	19.30394	2.54e-06	-1.568267	0.329576	-0.834356
4	113.2423	25.03162	2.47e-06	-1.645175	0.836618	-0.685446
5	140.0949	**33.19952***	**1.80e-06***	**-2.039814***	1.025932	-0.854265

From Table 3, majority of the selection criteria such as LR, FPE and AIC selects lag 5 as optimal lag. This means that the optimal lag p = 5 in the system. In other words, we will be estimating VAR (5) model for the whole system.

Table 4: VAR (5) model estimates

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.882059	0.204617	4.310775	<**0.0001**
C(2)	-0.031366	0.253861	-0.123556	0.9018
C(3)	-0.285272	0.240526	-1.186034	0.2377

C(4)	0.314795	0.247804	1.270339	0.2061
C(5)	-0.082691	0.188017	-0.439806	0.6608
C(6)	0.090783	0.133008	0.682543	0.4961
C(7)	-0.106030	0.188172	-0.563476	0.5740
C(8)	0.182359	0.178462	1.021835	0.3087
C(9)	-0.100405	0.192331	-0.522042	0.6025
C(10)	-0.062400	0.131808	-0.473419	0.6367
C(11)	0.090135	0.089833	1.003361	0.3175
C(12)	-0.019141	0.103548	-0.184854	0.8536
C(13)	0.015024	0.108398	0.138601	0.8900
C(14)	0.119050	0.107222	1.110316	0.2688
C(15)	0.034623	0.106588	0.324834	0.7458
C(16)	0.436394	0.426309	1.023658	0.3078
C(17)	-1.031238	0.714367	-1.443569	0.1512
C(18)	1.209240	0.759540	1.592069	0.1137
C(19)	-0.853554	0.703668	-1.213007	0.2272
C(20)	0.156760	0.413359	0.379235	0.7051
C(21)	-0.303118	3.500842	-0.086584	0.9311
C(22)	0.096688	0.196857	0.491158	0.6241
C(23)	-0.103362	0.244233	-0.423210	0.6728
C(24)	-0.203922	0.231404	-0.881236	0.3797
C(25)	0.249323	0.238406	1.045792	0.2975
C(26)	0.251604	0.180886	1.390956	0.1665
C(27)	0.756450	0.127963	5.911465	<**0.0001**
C(28)	0.174541	0.181035	0.964127	0.3367
C(29)	-0.005486	0.171694	-0.031953	0.9746
C(30)	-0.156196	0.185037	-0.844138	0.4001
C(31)	-0.019880	0.126809	-0.156774	0.8757
C(32)	-0.292893	0.086426	-3.388956	**0.0009**
C(33)	0.112083	0.099621	1.125090	0.2625
C(34)	0.113015	0.104287	1.083695	0.2804
C(35)	0.040096	0.103156	0.388696	0.6981
C(36)	-0.443081	0.102546	-4.320820	<**0.0001**
C(37)	0.556009	0.410141	1.355654	0.1775
C(38)	-0.856867	0.687274	-1.246762	0.2146
C(39)	0.673454	0.730734	0.921612	0.3584
C(40)	0.856106	0.676981	1.264594	0.2082
C(41)	-0.742754	0.397682	-1.867708	0.0640
C(42)	4.065007	3.368071	1.206925	0.2296
C(43)	0.312065	0.409058	0.762886	0.4469
C(44)	-0.425063	0.507503	-0.837558	0.4037
C(45)	0.286811	0.480845	0.596471	0.5519
C(46)	0.670172	0.495395	1.352805	0.1784
C(47)	-0.562391	0.375871	-1.496233	0.1369
C(48)	0.572733	0.265901	2.153935	**0.0330**
C(49)	-0.269790	0.376182	-0.717180	0.4745
C(50)	-0.017059	0.356770	-0.047816	0.9619

C(51)	-0.183157	0.384496	-0.476356	0.6346
C(52)	0.143533	0.263502	0.544713	0.5868
C(53)	0.519481	0.179588	2.892626	**0.0045**
C(54)	0.351790	0.207008	1.699405	0.0915
C(55)	-0.011299	0.216702	-0.052140	0.9585
C(56)	-0.074793	0.214352	-0.348926	0.7277
C(57)	-0.069002	0.213084	-0.323824	0.7466
C(58)	0.745675	0.852250	0.874949	0.3831
C(59)	-0.953261	1.428119	-0.667494	0.5056
C(60)	0.663332	1.518426	0.436855	0.6629
C(61)	-0.928055	1.406730	-0.659725	0.5105
C(62)	0.268232	0.826362	0.324594	0.7460
C(63)	-0.808796	6.998669	-0.115564	0.9082
C(64)	0.100956	0.087049	1.159770	0.2482
C(65)	0.063528	0.107998	0.588235	0.5573
C(66)	-0.098159	0.102325	-0.959285	0.3391
C(67)	0.011371	0.105421	0.107867	0.9143
C(68)	0.071212	0.079986	0.890302	0.3749
C(69)	0.097842	0.056584	1.729141	0.0861
C(70)	0.163353	0.080052	2.040574	**0.0432**
C(71)	-0.100694	0.075922	-1.326285	0.1870
C(72)	-0.067522	0.081822	-0.825234	0.4107
C(73)	0.035631	0.056074	0.635434	0.5262
C(74)	-0.026220	0.038217	-0.686095	0.4938
C(75)	-0.025786	0.044052	-0.585349	0.5593
C(76)	0.053881	0.046115	1.168405	0.2447
C(77)	0.084022	0.045615	1.841991	0.0677
C(78)	-0.022373	0.045345	-0.493400	0.6225
C(79)	1.344138	0.181361	7.411396	<**0.0001**
C(80)	-0.806988	0.303907	-2.655376	**0.0089**
C(81)	0.435613	0.323125	1.348126	0.1799
C(82)	-0.021337	0.299356	-0.071278	0.9433
C(83)	-0.337644	0.175852	-1.920049	0.0569
C(84)	-5.449871	1.489334	-3.659268	**0.0004**
Determinant residual covariance	7.21E-08			

$$\mathrm{lnGDP_t} = 0.882059\mathrm{lnGDP_{t-1}} - 0.031366\mathrm{lnGDP_{t-2}} - 0.285272\mathrm{lnGDP_{t-3}} + 0.314795\mathrm{lnGDP_{t-4}} - 0.082691\mathrm{lnGDP_{t-5}} + 0.090783\mathrm{lnEXR_{t-1}} - 0.106030\mathrm{lnEXR_{t-2}} + 0.182359\mathrm{lnEXR_{t-3}} - 0.100405\mathrm{lnEXR_{t-4}} - 0.062400\mathrm{lnEXR_{t-5}} + 0.090135\mathrm{lnEGS_{t-1}} - 0.019141\mathrm{lnEGS_{t-2}} + 0.015024\mathrm{lnEGS_{t-3}} + 0.119050\mathrm{lnEGS_{t-4}} + 0.034623\mathrm{lnEGS_{t-5}} + 0.436394\mathrm{lnCPI_{t-1}} - 1.031238\mathrm{lnCPI_{t-2}} + 1.209240\mathrm{lnCPI_{t-3}} - 0.853554\mathrm{lnCPI_{t-4}} + 0.156760\mathrm{lnCPI_{t-5}} - 0.303118 \quad (3.11)$$

$R^2 = 0.998259$, Adjusted $R^2 = 0.997235$, $\text{Durbin} - \text{Watson Stat} = 1.989244$

$$\begin{aligned}\ln EXR_t = {} & 0.096688 \ln GDP_{t-1} - 0.103362 \ln GDP_{t-2} - 0.203922 \ln GDP_{t-3} + \\ & 0.249323 \ln GDP_{t-4} + 0.251604 \ln GDP_{t-5} + 0.756450 \ln EXR_{t-1} + 0.174541 \ln EXR_{t-2} - \\ & 0.005486 \ln EXR_{t-3} - 0.156196 \ln EXR_{t-4} - 0.019880 \ln EXR_{t-5} - 0.292893 \ln EGS_{t-1} + \\ & 0.112083 \ln EGS_{t-2} + 0.113015 \ln EGS_{t-3} + 0.040096 \ln EGS_{t-4} - 0.443081 \ln EGS_{t-5} + \\ & 0.556009 \ln CPI_{t-1} - 0.856867 \ln CPI_{t-2} + 0.673454 \ln CPI_{t-3} + 0.856106 \ln CPI_{t-4} - \\ & 0.742754 \ln CPI_{t-5} + 4.065007 \qquad (3.12)\end{aligned}$$

$R^2 = 0.996753$, Adjusted $R^2 = 0.994842$, Durbin − Watson Stat = 2.257099

$$\begin{aligned}\ln EGS_t = {} & 0.312065 \ln GDP_{t-1} - 0.425063 \ln GDP_{t-2} + 0.286811 \ln GDP_{t-3} + \\ & 0.670172 \ln GDP_{t-4} - 0.562391 \ln GDP_{t-5} + 0.572733 \ln EXR_{t-1} - 0.269790 \ln EXR_{t-2} - \\ & 0.017059 \ln EXR_{t-3} - 0.183157 \ln EXR_{t-4} + 0.143533 \ln EXR_{t-5} + 0.519481 \ln EGS_{t-1} + \\ & 0.351790 \ln EGS_{t-2} - 0.011299 \ln EGS_{t-3} - 0.074793 \ln EGS_{t-4} - 0.069002 \ln EGS_{t-5} + \\ & 0.745675 \ln CPI_{t-1} - 0.953261 \ln CPI_{t-2} + 0.663332 \ln CPI_{t-3} - 0.928055 \ln CPI_{t-4} + \\ & 0.268232 \ln CPI_{t-5} - 0.808796 \qquad (3.13)\end{aligned}$$

$R^2 = 0.993853$, Adjusted $R^2 = 0.990238$, Durbin − Watson Stat = 1.980515

$$\begin{aligned}\ln CPI_t = {} & 0.100956 \ln GDP_{t-1} + 0.063528 \ln GDP_{t-2} - 0.098159 \ln GDP_{t-3} + 0.011371 \ln GDP_{t-4} \\ & + 0.071212 \ln GDP_{t-5} + 0.097842 \ln EXR_{t-1} + 0.163353 \ln EXR_{t-2} \\ & - 0.100694 \ln EXR_{t-3} - 0.067522 \ln EXR_{t-4} + 0.035631 \ln EXR_{t-5} \\ & - 0.026220 \ln EGS_{t-1} - 0.025786 \ln EGS_{t-2} + 0.053881 \ln EGS_{t-3} \\ & + 0.084022 \ln EGS_{t-4} - 0.022373 \ln EGS_{t-5} + 1.344138 \ln CPI_{t-1} \\ & - 0.806988 \ln CPI_{t-2} + 0.435613 \ln CPI_{t-3} \\ & - 0.021337 \ln CPI_{t-4} - 0.337644 \ln CPI_{t-5} - 5.449871 \qquad (3.14)\end{aligned}$$

$R^2 = 0.999519$, Adjusted $R^2 = 0.999235$, Durbin − Watson Stat = 2.169021

POST-ESTIMATION TESTS: Model stability
Stability diagnosis

Table 4a: AR table for fitted VAR (5) model

Root	Modulus
0.984075	0.984075
0.878798 - 0.253560i	0.914647
0.878798 + 0.253560i	0.914647
0.303353 - 0.828021i	0.881840
0.303353 + 0.828021i	0.881840
0.817917 - 0.313334i	0.875880
0.817917 + 0.313334i	0.875880
0.865459	0.865459
0.665121 - 0.540137i	0.856816
0.665121 + 0.540137i	0.856816
-0.255466 + 0.772678i	0.813815

-0.255466 - 0.772678i	0.813815
-0.732016 + 0.258054i	0.776170
-0.732016 - 0.258054i	0.776170
0.097951 + 0.746806i	0.753202
0.097951 - 0.746806i	0.753202
-0.535163 - 0.484326i	0.721784
-0.535163 + 0.484326i	0.721784
-0.619474	0.619474
-0.208922	0.208922

No root lies outside the unit circle.
VAR satisfies the stability condition.

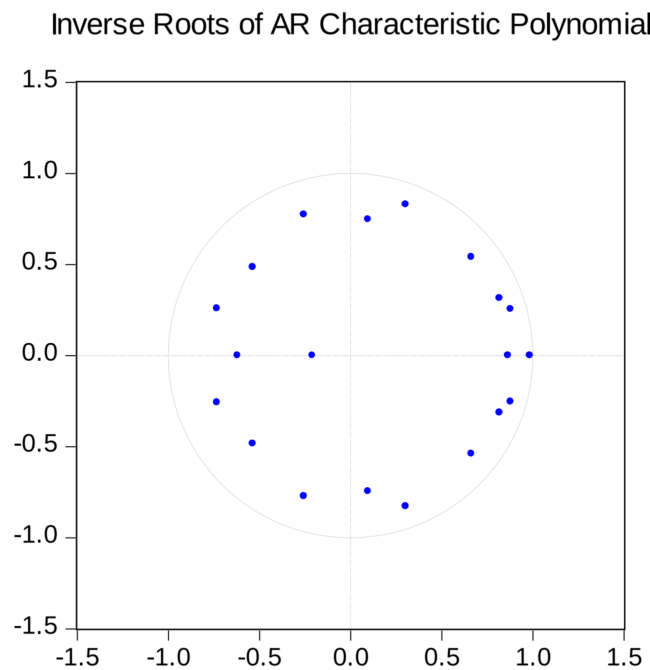
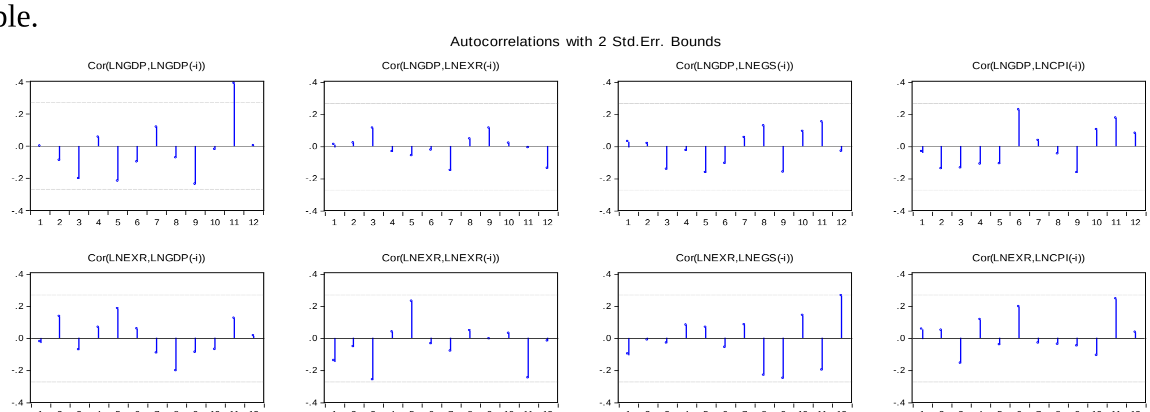


Figure 2a: Autoregressive root graph for the fitted VAR (5) model

Results emanating from Table 4a and Figure 2a revealed that all inverse roots of characteristic AR polynomial have modulus less than one and lie inside the circle. Hence, the estimated VAR (5) is stable.



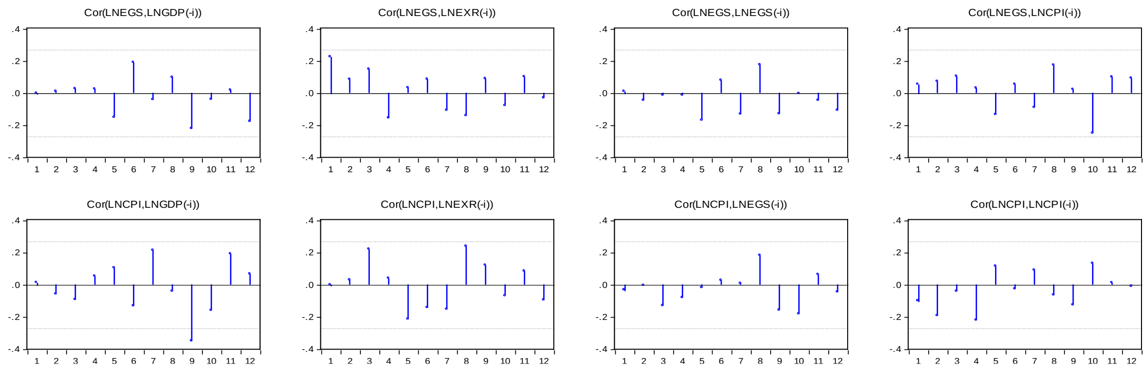


Figure 4a: Residual correlogram obtained from VAR (5) model

Visualizations from Figure 4a showed that largely all the spikes are laying inside two standard error bounds; which means that the VAR (5) model is also stable.

Table 5: VAR residual serial correlation LM tests

Lags	LM-Stat	Prob
1	20.35821	0.2045
2	18.46795	0.2972
3	34.16786	**0.0052**
4	19.47286	0.2449
5	25.83509	0.0564

Probs from chi-square with 16 df.

Based on the results reported in Table 5, the p-value of the selected lag 5 is not statistically significant (i.e. p-value (=0.0564) > 0.05). That is, the hypothesis of no serial correlation has been accepted; which means that there is no serial correlation in the residual of the estimated VAR (5) model estimates.

Table 6: Results of Granger causality tests obtained on lnGDP, lnEXR, lnEGS and lnCPI series

Null hypothesis				
Dependent variable: lnGDP	**Chi-sq**	**Df**	**P-value**	**Direction of causality**
lnEXR does not Granger cause lnGDP	2.720132	5	0.7430	No causation
lnEGS does not Granger cause lnGDP	6.034782	5	0.3028	No causation
lnCPI does not Granger cause lnGDP	4.063763	5	0.5403	No causation
Dependent variable: lnEXR				
lnGDP does not Granger cause lnEXR	11.88707	5	**0.0364**	lnGDP→lnEXR
lnEGS does not Granger cause lnEXR	29.40921	5	**<0.0001**	lnEGS→lnEXR
lnCPI does not Granger cause lnEXR	24.82882	5	**0.0002**	lnCPI→lnEXR
Dependent variable: lnEGS				
lnGDP does not Granger cause lnEGS	4.723922	5	0.4505	No causation
lnEXR does not Granger cause lnEGS	5.858477	5	0.3202	No causation
lnCPI does not Granger cause lnEGS	2.858496	5	0.7218	No causation

Dependent variable: lnCPI				
lnGDP does not Granger cause lnCPI	7.940697	5	0.1595	No causation
lnEXR does not Granger cause lnCPI	22.01966	5	**0.0005**	lnEXR→lnCPI
lnEGS does not Granger cause lnCPI	8.424556	5	0.1343	No causation

Summarized results of Granger causality tests in Table 4.6 indicate that there is no causation running from the EXR, EGS and CPI to GDP.

However, there are unilateral causalities running from the GDP to EXR, EGS to EXR while bilateral causality exists between CPI and EXR. In other words, GDP predicts EXR, EGS predicts EXR whereas CPI predicts EXR and EXR predicts CPI.
Lastly, no causation running from GDP to EGS, EXR to EGS, CPI to EGS, GDP to CPI, and EGS to CPI.

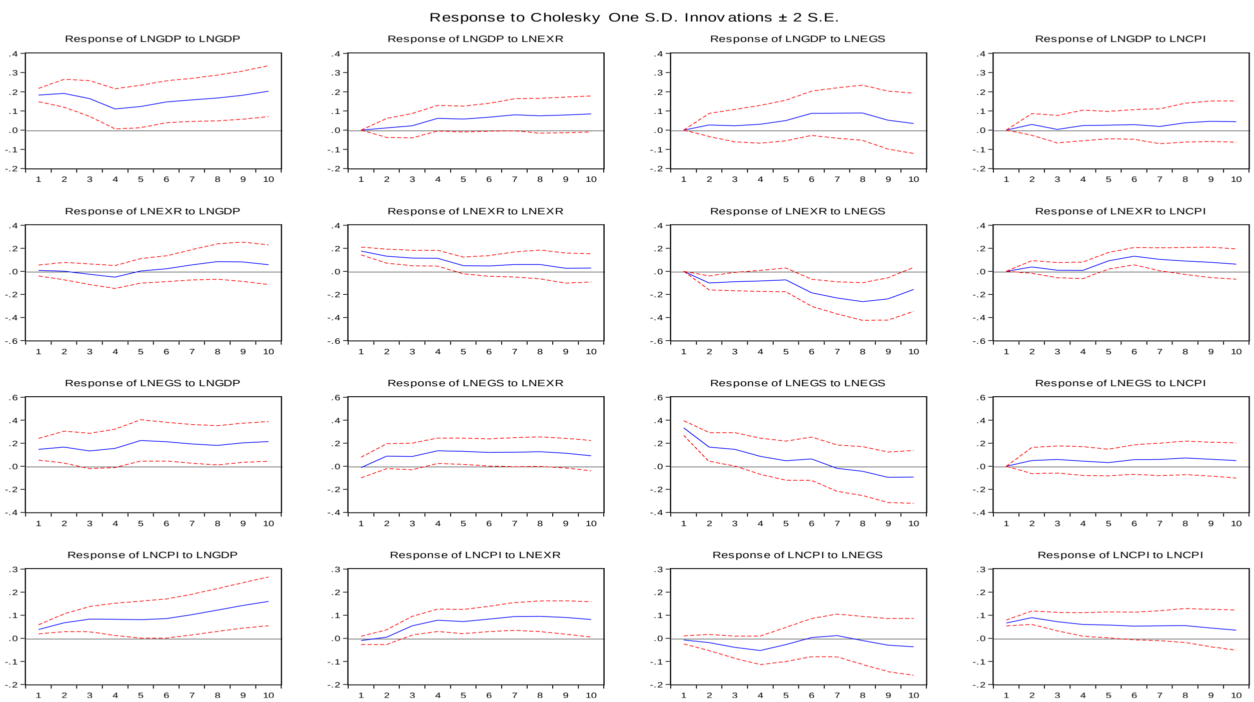


Figure 5: Impulse response function graphs

Also, the impulse response graph of Figure 5 supports the Granger Causality results reported in Table 4.6.

5. Summary of Findings

This study aimed at determining the direction of causalities among some vital macroeconomic variables such as Gross Domestic Product (GDP), Exchange Rate (EXR), Export of Goods and

Services (EGS) and Consumer Price Index (CPI) using low (annual) frequency time series data spans 1960 to 2019.

Pre-tests results of the GDP, EXR, EGS and CPI series presented in Tables 1a, 1b, 1c, 1d, 1e, 1f, 1g and 1h, 2 and 3 revealed that the series are I(1)s; not cointegrated, has optimal lag of five (5). As a result, VAR (5) model is appropriate for examining the causality dynamics of the series. Furthermore, post-estimation evaluations results of Table 4a and Figure 2a, the VAR (5) model estimates that all inverse roots of characteristic AR polynomial have modulus less than one and lie inside the circle. Hence, the estimated VAR (5) is stable. Also, further stability tests results in Figure 4a showed that largely all the spikes of the residual correlogram are laying inside two standard error bounds. This is also an indication that the VAR (5) model is stable. Further VAR residual serial correlation LM tests reported in Table 5 revealed that the p-value of the selected lag 5 is not statistically significant (i.e. p-value(= 0.0564) > 0.05). That is, the hypothesis of no serial correlation has been accepted; which means that there is no serial correlation in the residual of the estimated VAR (5) model estimates.

Summarized results of Granger causality tests in Table 6 indicate that there is no causation running from the EXR, EGS and CPI to GDP. However, there are unilateral causalities running from the GDP to EXR, EGS to EXR while bilateral causality exists between CPI and EXR. In other words, GDP predicts EXR, EGS predicts EXR whereas CPI predicts EXR and EXR predicts CPI. Finally, no causation running from GDP to EGS, EXR to EGS, CPI to EGS, GDP to CPI, and EGS to CPI.

6. Conclusion

This study has contributed its quota to the growing literature on the nexus between some selected vital macroeconomic factors such as Exchange Rate (EXR), Export of Goods and Services (EGS) and Consumer Price Index (CPI) and Nigeria's economic growth proxy as Gross Domestic Product (GDP). Evidence from the results of analysis and summary of findings established that there is no causation or prediction running from the EXR, EGS and CPI to GDP. Conversely, there are unilateral causalities running from the GDP to EXR, EGS to EXR while bilateral causality exists between CPI and EXR. Finally, no causation or prediction running from GDP to EGS, EXR to EGS, CPI to EGS, GDP to CPI, and EGS to CPI. The findings of this work therefore recommend that the exchange rate be boosted through exportation of our locally produced items or goods which will have positive feedback on the country's GDP and CPI through earning of major foreign currencies such as United States Dollar, British Pound Sterling, European Euro, etc.

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