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Examining Interconnected Macroeconomic Trends: A Panel Vector Autoregressive (PVAR) Model for Nigeria, Ghana, and Cameroon

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Abstract

This study employs a comprehensive panel vector autoregressive (VAR) model to investigate the dynamic multivariate interactions among key macroeconomic variables, including exchange rates, foreign reserves, and gross domestic product (GDP), in Nigeria, Ghana, and Cameroon from 1960 to 2022. The research findings unveil that variations in GDP per capita and foreign reserves collectively account for 99.8% of the fluctuations observed in foreign exchange rates over the study period. However, the study concludes that GDP per capita and foreign reserves exhibit no significant influence on foreign exchange rates at specific lags, with nuanced effects observed in various lag scenarios. Notably, the first lag of GDP per capita, foreign reserves, and the second lag of foreign exchange rates display negative effects on foreign exchange, while other lags demonstrate positive effects. The absence of a cointegrating relationship among variables suggests the suitability of the panel VAR model for the dataset, further validated by unit root tests establishing stationarity. Impulse response analysis is conducted to trace the transmission of shocks within the system, highlighting the model's capabilities. The study estimates random and fixed effects components, with the Hausman Test favoring the fixed effect model. Hypothesis testing reveals joint significance between foreign exchange rates (both lags) and GDP per capita, while foreign reserves (both lags) do not have a joint significant effect on GDP per capita. Similarly, GDP per capita (both lags) demonstrates joint significance on foreign exchange rates, whereas foreign reserves (both lags) do not have a joint significant effect. The study concludes that foreign exchange rates (both lags) do not exhibit a joint significant effect on foreign reserves, providing valuable insights into the intricate macroeconomic dynamics within the studied countries.

Keywords: *Macroeconomic Interaction, PVAR, Foreign Exchange Rates, GDP per Capita, Variance Decomposition*

1. Introduction

Panel data, also referred to as longitudinal or cross-sectional time-series data, constitutes a dataset wherein the behavior of entities is observed across different points in time (t). Panel analysis, a statistical method extensively employed in social science, epidemiology, and econometrics, serves to analyze two-dimensional panel data, typically encompassing cross-sectional and longitudinal dimensions. This approach involves collecting data over time from the same individuals and subsequently running regressions across these two dimensions. Panel data regression models have emerged as widely applied statistical tools in various research fields, including social, behavioral, environmental sciences, and econometrics.

A panel dataset, defined as a cross-sectional time-series dataset, ideally captures repeated measurements of specific variables over a duration on observed units like individuals, households, firms, cities, and states. In contrast, a cross-sectional dataset comprises observations on variables at a specific point in time, while a time-series dataset encompasses observations on a variable or several variables over multiple periods. A panel dataset visualizes as a three-dimensional structure for each variable, with time represented vertically and multiple observations for each variable horizontally.

The number of repeated measurements on the same variables for the same population or sample in a panel dataset can be as low as two, particularly evident in "one-shot" experiments (Campbell and Stanley, 1966). Panel data is conceptually a balanced panel dataset when observations in the samples are consistent across all periods; however, in some instances, such as random surveys, the observations in samples from one period may differ from those in another, leading to an unbalanced panel dataset. Examples of panel data abound in diverse disciplines, including economics, social sciences, medicine, epidemiology, finance, and the physical sciences (Campbell & Stanley, 1966).

An alternative strategy for addressing interdependent economies involves constructing a panel VAR model. This model dispenses with much of the explicit microstructure inherent in DSGE models and, like its VAR counterparts, aims to capture the dynamic interdependencies within the data using a minimal set of constraints. By employing shock identification, these reduced-form models can be transformed into structural models, facilitating the execution of common exercises, such as impulse response analyses, in a relatively straightforward manner. It is important to note that structural panel VAR models are susceptible to the standard criticisms leveled at structural VAR models (see, for instance, Cooley and Le Roy, 1983; Faust and Leeper, 1997; Cooley and Dweyer, 1998; Canova and Pina, 2005; Chari et al., 2008) and, as such, require careful consideration. Nonetheless, the insights they yield can effectively complement analyses conducted with DSGE models, pinpoint areas where these models may fall short, and offer stylized facts and predictions that enhance the realism of the DSGE model.

Several authors have applied VAR modelling in studying some macroeconomic variable. For instance, Akpan (2019) investigates the impact of external shocks on Nigeria's output performance from 1981 to 2015, emphasizing the need to consider these shocks in policy design. Using multivariate VAR and VECM frameworks, the study finds that both external shocks and domestic policies have short-term effects on Nigeria's output. The unrestricted VAR model outperforms

VECM. Results highlight the Nigerian economy's vulnerability to external shocks, explaining over half of the variance in output performance with varying effects. The dynamic response to shock variables is rapid, contrasting with a moderate response to domestic economic factors. Variance decomposition identifies international crude oil prices, terms of trade, capital inflows, and monetary policy as significant contributors to output variability. The study underscores the importance of addressing external shocks for effective economic policies in Nigeria.

David (2019) explores the causal-effect relationship between telecommunication infrastructures, economic growth, and development in selected African countries, examining a panel of forty-six nations from 2000 to 2015. Using real gross domestic product as a proxy for economic growth, the Human Development Index for economic development, and a composite index derived from mobile, fixed line, and internet access penetration via principal component analysis (PCA) for telecommunication infrastructures, the study estimates the trivariate impacts in the region. The empirical findings indicate a bidirectional long-run relationship between telecommunication infrastructures, economic growth, and development. Causality tests reveal feedback causality, suggesting that telecommunication infrastructures promote economic growth and development in Africa and vice versa. The study underscores the importance of inclusive policies to enhance digital provision, economic growth, and development concurrently in Africa. It concludes that increasing telecommunication infrastructures can positively influence aggregate output and the standard of living in the region.

Ay *et al.*, (2017) investigated the link between remittances and economic growth in 23 selected African countries from 1985 to 2015, utilizing panel data. The Panel Fixed/Random Effects model was employed to analyze the relationship between personal remittances, gross fixed capital, and GDP per capita. Additionally, a panel cointegration test was conducted to assess long-term cointegration. The results from the panel fixed/random effects estimation revealed a negative and significant relationship between remittances and economic growth, consistent with findings from other studies (Louise & Clovis, 2012; Deisting et al., 2015; Chami et al., 2003; Coiffard, 2011; Ahoure, 2008). Conversely, a positive link was observed between capital formation and economic growth. The panel cointegration result indicated a significant long-term cointegration relationship between remittances and economic growth. In essence, the study suggested that remittances did not contribute positively to the development of the 23 African countries examined. The authors recommended that each country's government should implement investment policies to benefit domestic labor and investors.

2. Methodology

The Panel Vector Autoregressive (VAR) Model

Consider a k-variate homogeneous panel VAR of order p with panel-specific fixed effects represented by the following system of linear equations, we have

$$Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + Y_{it-3}A_3 + \cdots + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + X_{it}B + \mu_t + e_{it} \qquad (2.1)$$
$$i \in \{1,2,\ldots.N\}, t \in \{1,2,\ldots T_i\}$$

Where $Y_{it}$is a (1×k) vector of dependent variables, X_{it} is a (1×l) vector of exogenous covariates, and μ_t and e_{it} are (1 × k) vectors of dependent variable-specific panel fixed effects and idiosyncratic errors, respectively. The (k×k) matrices A_1, A_2,..., A_{p-1}, A_p and the (l×k) matrix B are parameters to be estimated.

Similar to Shahbaz et al., (2020), we assume that the cross-sectional units share the same underlying data generating process, with the reduced-form parameters A_1, A_2,..., A_{p-1}, A_p, and B to be common among them. Systematic cross-sectional heterogeneity is modeled as panel-specific fixed effects. This setup contrasts with time-series VAR, where by construction, the parameters are specific to the unit being studied, or with random-coefficient panel VAR, where the parameters are estimated as a distribution.

Panel VARs have the same structure as VAR models, in the sense that all variables are assumed to be endogenous and interdependent, but a cross sectional dimension is added to the representation. In a way, a panel VAR is similar to large scale VARs where dynamic and static interdependencies are allowed for. It differs because cross sectional heterogeneity imposes a structure on the covariance matrix of the error terms. A detailed comparison with large scale VARs and with other approaches designed to handle multi-unit dynamics

Model Specification

$$GDPPC_{it} = K_1 + GDPPC_{t-1} + GDPPC_{t-2} + EXR_{t-1} + EXR_{t-2} + FR_{t-1} + FR_{t-2} + U_{i1t} \quad (2.2)$$

$$EXR_{it} = K_2 + GDPPC_{t-1} + GDPPC_{t-2} + EXR_{t-1} + EXR_{t-2} + FR_{t-1} + FR_{t-2} + U_{i2t} \quad (2.3)$$

$$FR_{it} = K_3 + GDPPC_{t-1} + GDPPC_{t-2} + EXR_{t-1} + EXR_{t-2} + FR_{t-1} + FR_{t-2} + U_{i3t} \quad (2.4)$$

Where

U_{it} = Random disturbances

$GDPPC_{it}$ = Gross Domestic Product Per Capita

EXR_{it} = Foreign Exchange Rate

FR_{it} = Foreign Reserve

t-1 = Lag 1

t-2 = Lag 2

3. Results

Statistics	Nigeria GDP_PC	Ghana GDP_PC	Cameroon GDP_PC	Nigeria EXR	Ghana EXR	Cameroon EXR	Nigeria FR	Ghana FR	Cameroon FR	Pooled GDP_PC	Pooled FR	Pooled EXR
Mean	265680.7	3077.5	733969.6	74.394	0.976	404.547	13,500,000,000	1,840,000,000	940,000,000	334,242.60	5,410,000,000	159.97
Median	250500.9	2845.9	747889	9.909	0.037	381.066	4,680,000,000	437,000,000	80,796,978	250,500.90	636,000,000	9.91
Maximum	379251.6	5331.8	1091113	358.811	8.272	732.398	53,000,000,000	9,920,000,000	3,680,000,000	1,091,113.00	53,000,000,000	732.4
Minimum	173173	1858.9	512049.8	0.547	0.000	211.280	112,000,000	42,579,200	9,555,391	1,858.90	9,555,391	0
Std. Dev.	61261.23	925.71	142717.7	103.126	1.790	155.944	16,800,000,000	2,620,000,000	1,380,000,000	315,951.80	11,300,000,000	206.15
Skewness	0.356	1.129	0.448	1.314	2.219	0.299	1.014	1.482	1.074	0.55	2.7	1.05
Kurtosis	1.670	3.238	2.544	3.639	7.408	1.669	2.398	3.818	2.301	2.03	9.14	2.85
Jarque-Bera	5.978338	13.522	2.651521	19.2	102.7	5.586888	11.74048	24.80716	13.39758	17.07	526.03	34.88
Probability	0.050329	0.0012	0.265601	7E-05	0	0.06121	0.002822	0.000004	0.001232	0.000	0.000	0.000
Sum	16737887	193882	46240086				8.48E+11	1.16E+11	5.92E+10	63,171,855	1.E+12	
Sum Sq. Dev.	2.33E+11	5E+07	1.26E+12	659367	198.6	1507749	1.75E+22	4.25E+20	1.18E+20	2.00E+13	2.00E+22	7.9E+6
Observations	63	63	63	63	63	63	63	63	63	189	189	189

Table 3.1 Summary of Descriptive Statistics of All Variables

Source: Researcher’s computation with Eviews 13.0

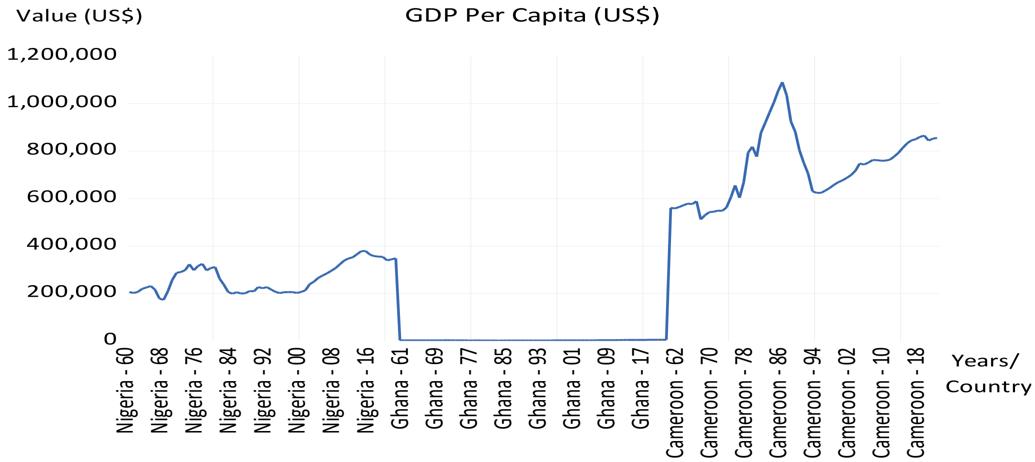


Figure 3.1 Time Plot of Gross Domestic Product Per Capita

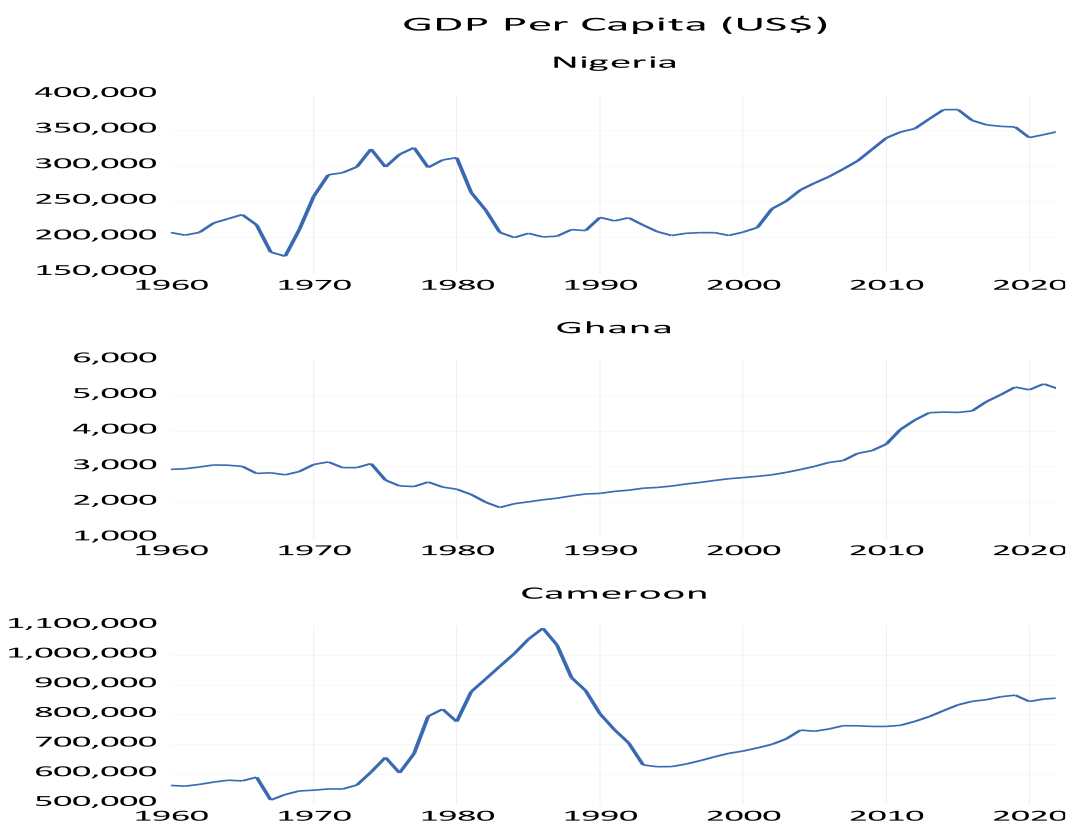
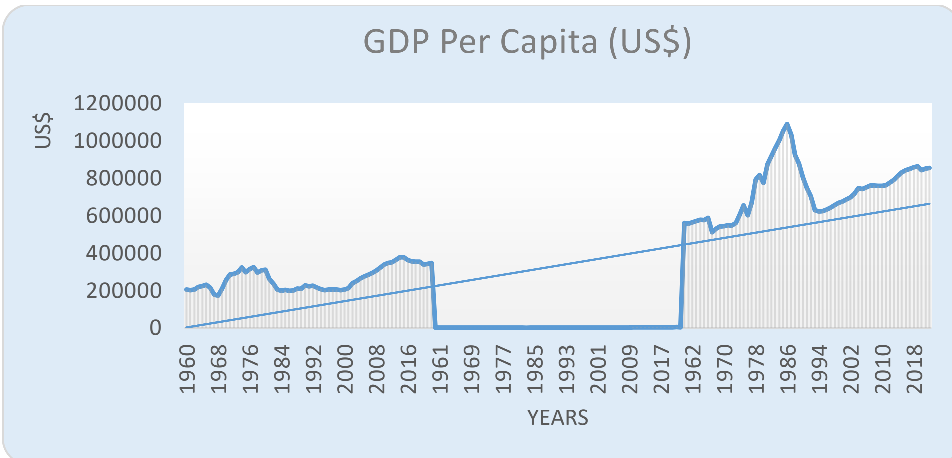


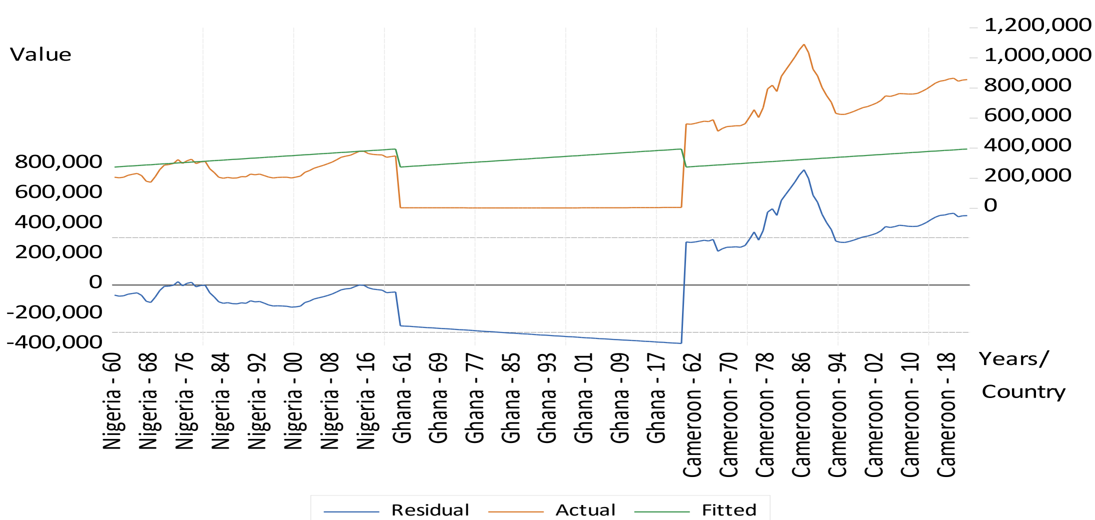
Figure 3.2 Individual Time Plot of Gross Domestic Product Per Capita

Trend Analysis of Gross Domestic Product Per Capita



GDP_PC = -3515643.4 + 1933.64*T

Figure 3.3 Trend Plot of Gross Domestic Product Per Capita



GDP_PC = -3515643.4 + 1933.64*T

Figure 4.4 Actual, Fitted and Residual Plot of Gross Domestic Product Per Capita

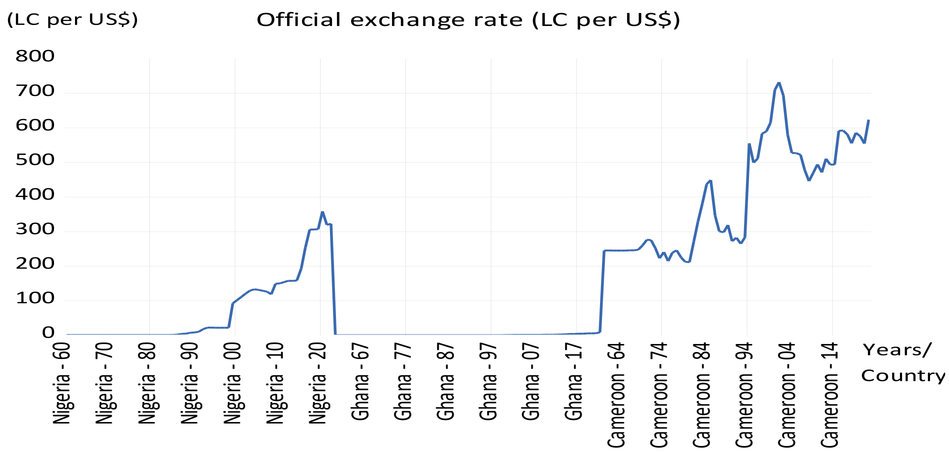


Figure 3.5 Time Plot of Foreign Exchange Rate

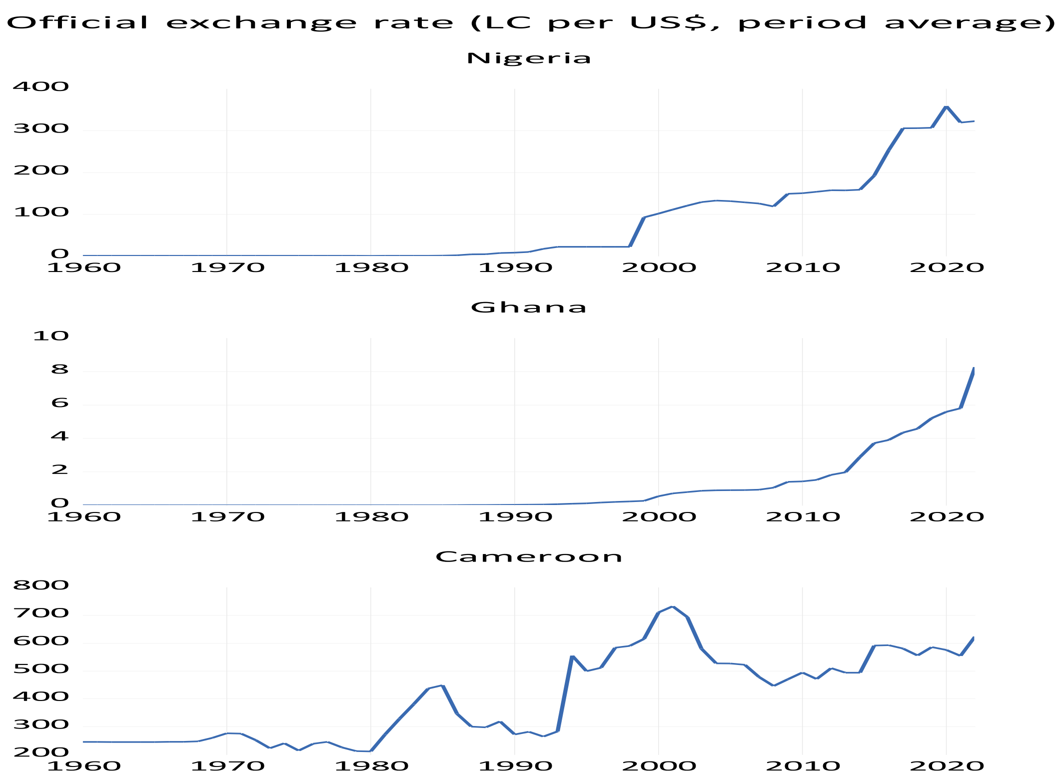
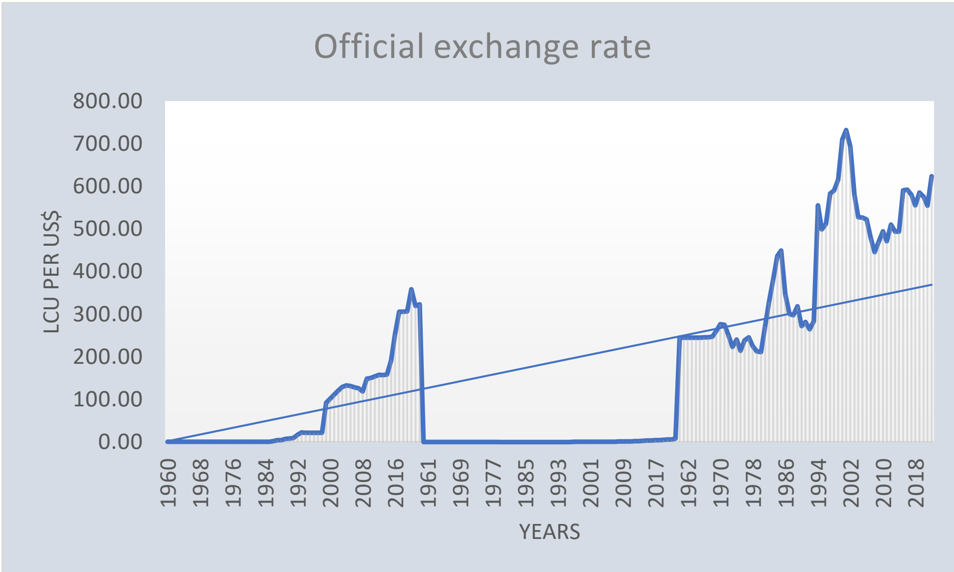


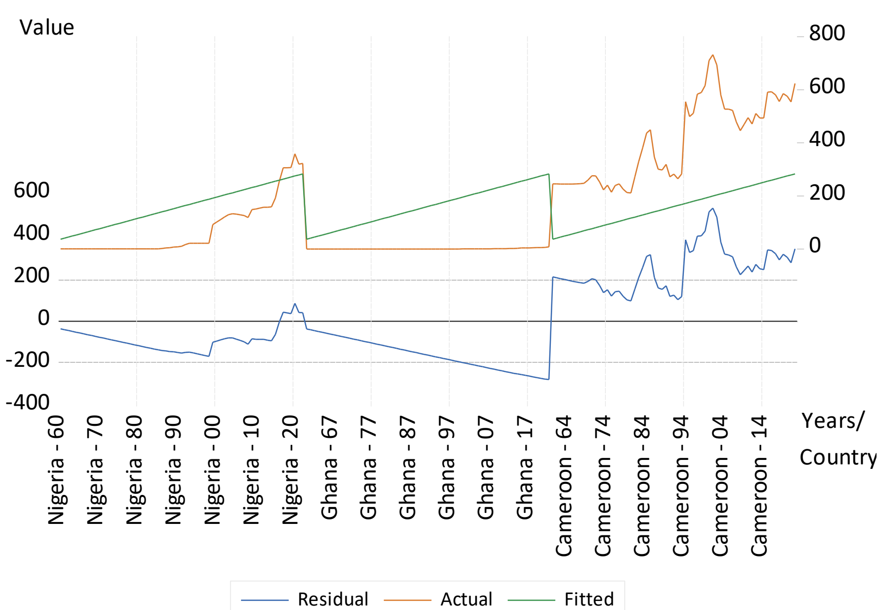
Figure 3.6 Individual Time Plot of Foreign Exchange Rate

4.2.1.2 Trend Analysis of Foreign Exchange Rate



EXR = -7748.71 + 3.97*T

Figure 3.7 Trend Plot of Foreign Exchange Rate



EXR = -7748.71 + 3.97*T

Figure 3.8 Actual, Fitted and Residual Plot of Foreign Exchange Rate

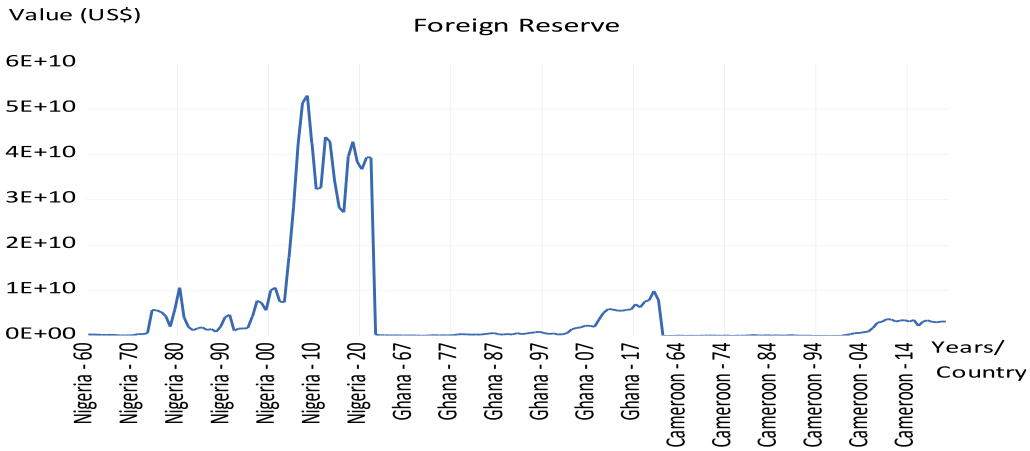


Figure 3.9 Time Plot of Foreign Reserve

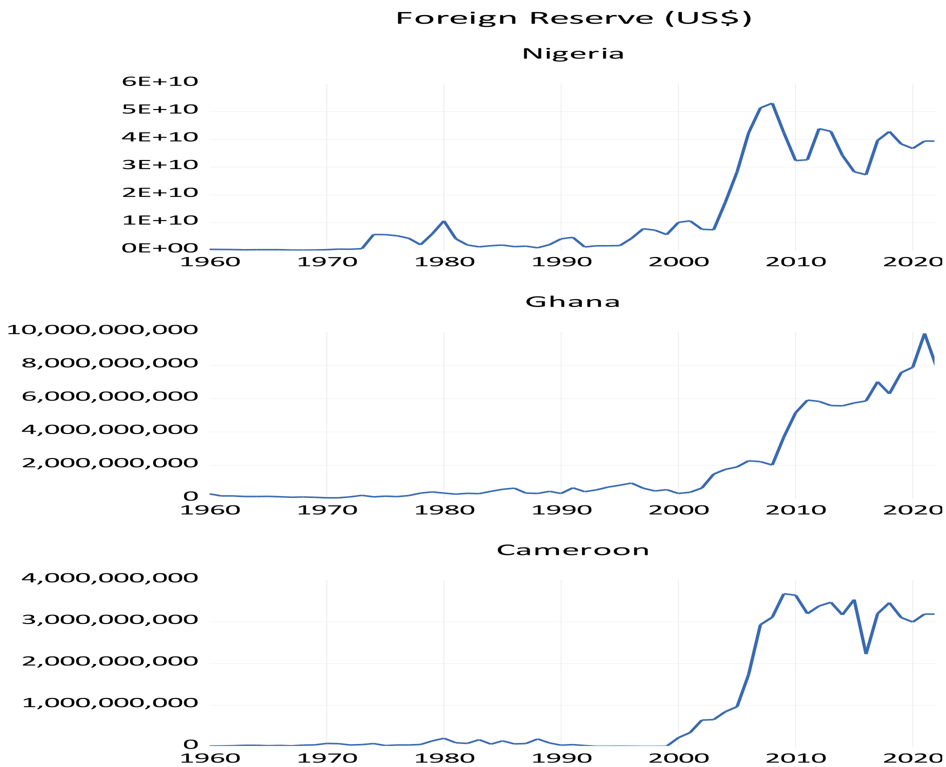
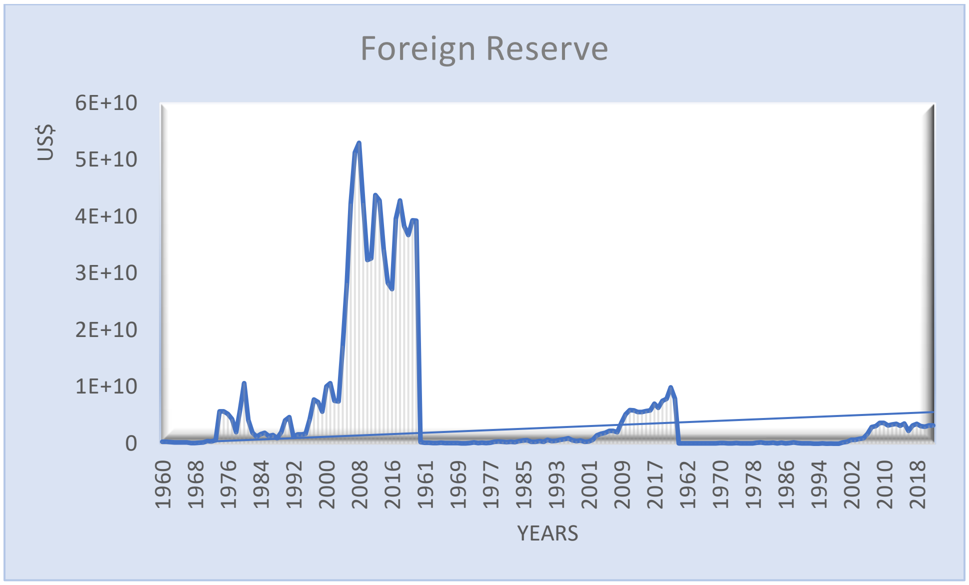


Figure 3.9 Individual Time Plot of Foreign Reserve

Trend Analysis of Foreign Reserve



FR = -605,959,287,005 + 307067840.12*T

Figure 3.10 Trend Plot of Foreign Reserve

Table 3.3: VAR Lag Order Selection for Panel VAR Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1131.011	NA	187.1587	13.74559	13.80206	13.76851
1	146.4304	2492.946	3.93e-05	-1.629459	-1.403572	-1.537763
2	170.9155	46.89285	3.26e-05*	-1.817158*	-1.421856*	-1.656691*
3	173.2254	4.339765	3.54e-05	-1.736066	-1.171348	-1.506827
4	178.0310	8.853880	3.72e-05	-1.685224	-0.951091	-1.387214
5	184.7114	12.06532	3.83e-05	-1.657108	-0.753561	-1.290327
6	191.2357	11.54598	3.96e-05	-1.627100	-0.554137	-1.191547
7	199.3613	14.08435	4.01e-05	-1.616501	-0.374122	-1.112176
8	209.7759	17.67323*	3.95e-05	-1.633647	-0.221854	-1.060551

Table 3.4 Summary of Panel VAR Model (Fixed Effect) showing the Effects of Foreign Exchange Rates and Foreign Reserve on Gross Domestic Product Per Capita

Variable	Coefficient	t-Statistic	Prob.
C	0.569426	2.518457	0.0127
$LNGDPPC_{t-1}$	1.305972	18.24165	0.0000
$LNGDPPC_{t-2}$	-0.355348	-4.968444	0.0000
$LNEXR_{t-1}$	0.014815	0.823366	0.4114
$LNEXR_{t-2}$	-0.010203	-0.560243	0.5760
$LNFR_{t-1}$	0.006964	0.884095	0.3779
$LNFR_{t-2}$	-0.007625	-0.959098	0.3388

Effects Specification

Cross-section fixed (dummy variables)

Root MSE	0.048917	R-squared	0.999585
Mean dependent var	11.32035	Adjusted R-squared	0.999566
S.D. dependent var	2.407647	S.E. of regression	0.050166
Akaike info criterion	-3.099027	Sum squared resid	0.437894
Schwarz criterion	-2.941184	Log-likelihood	292.5610
Hannan-Quinn criteria.	-3.035046	F-statistic	52380.23
Durbin-Watson stat	1.978280	Prob(F-statistic)	0.000000

$$LNGDPPC = 0.569 + 1.306*LNGDPPC_{t-1} - 0.355*LNGDPPC_{t-2} + 0.015*LNEXR_{t-1} - 0.010*LNEXR_{t-2} + 0.007*LNFR_{t-1} - 0.008*LNFR_{t-2} \quad (3.1)$$

Similarly we have

Summary of Panel VAR Model (Fixed Effect) showing the Effects of Gross Domestic Product Per Capita and Foreign Reserve on Foreign Exchange Rates

$$LNEXR = 2.946 - 0.4781*LNGDPPC_{t-1} + 0.182*LNGDPPC_{t-2} + 1.252*LNEXR_{t-1} - 0.252*LNEXR_{t-2} - 0.028*LNFR_{t-1} + 0.052*LNFR_{t-2} \quad (3.2)$$

Summary of Panel VAR Model (Fixed Effect) showing the Effects of Gross Domestic Product Per Capita and Foreign Exchange Rates on Foreign Reserve

$$LNFR = 0.924 + 1.079*LNGDPPC_{t-1} - 1.031*LNGDPPC_{t-2} + 0.070*LNEXR_{t-1} - 0.041*LNEXR_{t-2} + 0.972*LNFR_{t-1} - 0.042*LNFR_{t-2} \quad (3.3)$$

The Model Specification

The models can be represented explicitly thus for the Panel Vector Autoregressive Model;

$$\begin{bmatrix} GDPPC_{it} \\ EXR_{It} \\ FR_{it} \end{bmatrix} = \begin{bmatrix} 0.569 \\ 2.946 \\ 0.924 \end{bmatrix} + \begin{bmatrix} 1.306 & 0.015 & 0.007 \\ -0.478 & 1.252 & -0.028 \\ 1.079 & 0.070 & 0.972 \end{bmatrix} \begin{bmatrix} GDPPC_{it-1} \\ EXR_{It-1} \\ FR_{it-1} \end{bmatrix} + \begin{bmatrix} -0.355 & -0.010 & -0.008 \\ 0.182 & -0.252 & 0.052 \\ 1.031 & -0.041 & -0.042 \end{bmatrix} \begin{bmatrix} GDPPC_{it-2} \\ EXR_{It-2} \\ FR_{it-2} \end{bmatrix} \quad (3.4)$$

Impulse Response

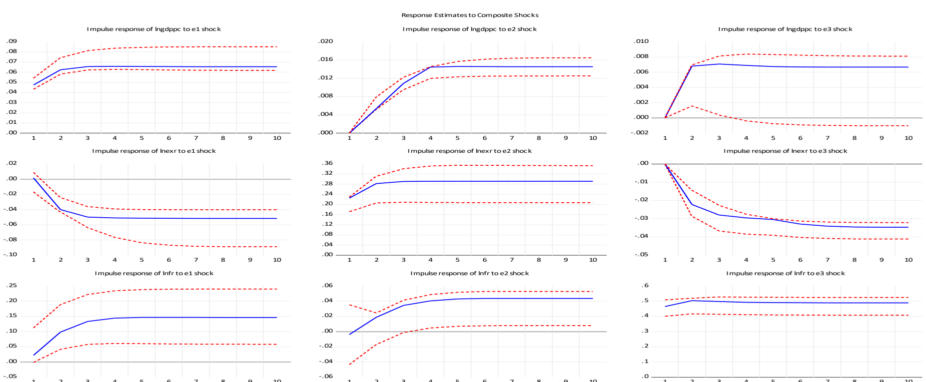


Figure 3.11: Plots of Impulse Response due to composite shock

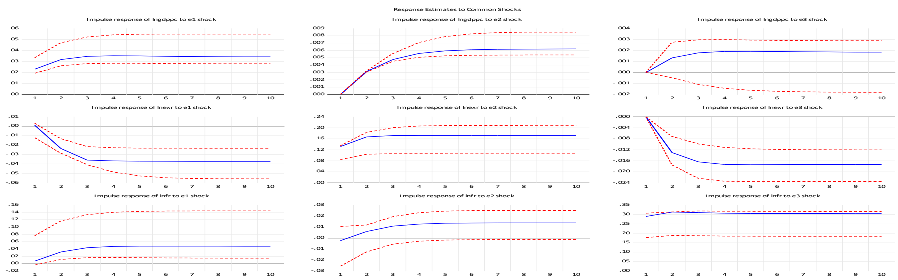


Figure 3.12: Plots of Impulse Response due to common shock

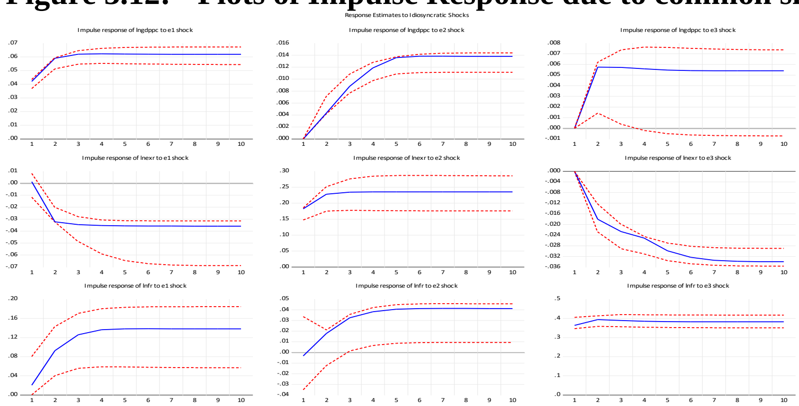


Figure 3.13: Plots of Impulse Response due to idiosyncratic

Variance Decomposition

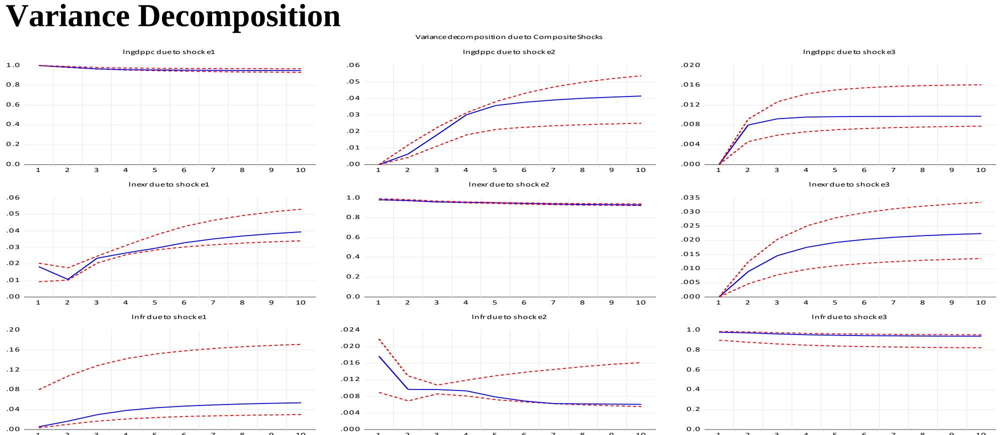


Figure 3.14: Plots of Variance Decomposition due to composite shock

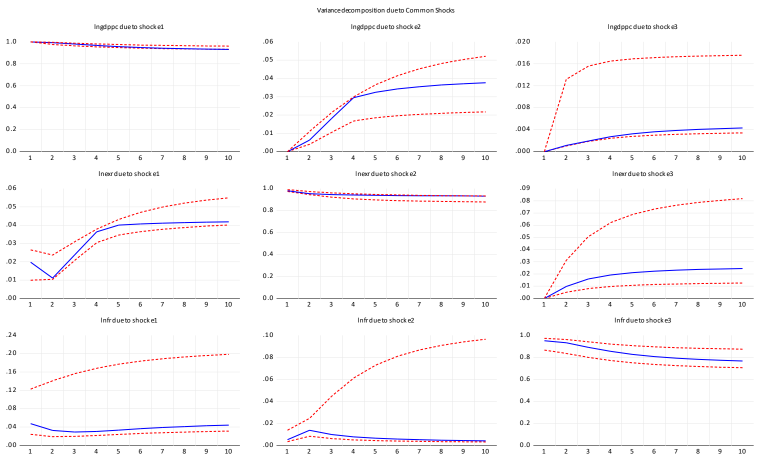


Figure 3.15: Plots of Variance Decomposition due to a common shock

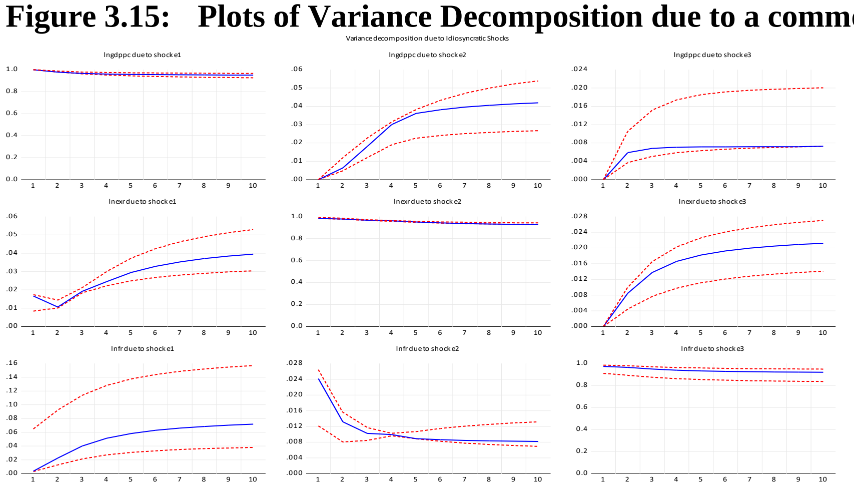


Figure 3.16: Plots of Variance Decomposition due to idiosyncratic shock

4. Discussion

The result of the cointegration analysis indicated no cointegration among the variables, and essentially because of the panel nature of the study data, the panel VAR was the most appropriate as explained in the methodology. However, it was also necessary to select the lag length through lag length selection criteria. The lag length selection result shown in Table 4.4 showed that the lag length of 2 was chosen by all information criteria, however, the researcher adopted the Akaike Information Criteria which selected lag length 2, consequently, model estimation was done using 2 lags. The panel VAR was estimated for the period 1960 to 2022. The period showed a fairly lengthy time dimension and as such there was sufficient information for parameter estimation. Both Random and fixed effects were estimated and the Hausman Test rejected the random effect model for the fixed effect model in each case, therefore the fixed effect model was estimated.

4.4.1 Discussion on the Effects of Foreign Exchange Rates and Foreign Reserve on Gross Domestic Product Per Capita

$$LNGDPPC = 0.569 + 1.306*LNGDPPC_{t-1} - 0.355*LNGDPPC_{t-2} + 0.015*LNEXR_{t-1} - 0.010*LNEXR_{t-2} + 0.007*LNFR_{t-1} - 0.008*LNFR_{t-2} \quad (4.1)$$

The above result as also presented in Table 4.5 shows an adjusted coefficient of determination($\bar{R}^2$) of 0.99. This implied that a 99% variation in GDP per capita is explained by variations in the foreign exchange rate and foreign reserve. The result showed that GDP per capita at lag 1 and lag 2 significantly influenced GDP per capita. Both lags of foreign exchange rate and also both lags of foreign reserve were not significant, the first lag of both variables showed positive effects while the second lag showed negative effects.

4.4.1.1 The Test of Joint Significance of Lags of Foreign Exchange Rate on GDP Per Capita

HO_1: Foreign exchange rates (both lags) do not jointly cause GDP per capita

The Wald test result conducted on joint causality of foreign exchange rate on GDP per capita, summarized and presented in Table 4.6 showed that F-statistics =3.867, Pv = 0.022 < 0.05) consequently, the null hypothesis is rejected and it is concluded that foreign exchange rate (both lags) had joint significance on GDP per capita

5.4.1.2 The Test of Joint Significance of Lags of Foreign Reserve on GDP Per Capita

HO_2: Foreign reserves (both lags) do not jointly cause GDP per capita

The result of the Wald test in Table 4.7 on the joint significance of foreign reserve on GDP per capita showed that F-statistics = 0.460, Pv = 0.632 > 0.05) therefore, the null hypothesis cannot be rejected. It is thus concluded that foreign reserves (both lags) do not have a joint significant effect on GDP per capita.

4.4.2 Discussion on the Effects of Gross Domestic Product Per Capita and Foreign Reserve on Foreign Exchange Rates

$$LNEXR = 2.946 - 0.4781*LNGDPPC_{t-1} + 0.182*LNGDPPC_{t-2} + 1.252*LNEXR_{t-1} - 0.252*LNEXR_{t-2} - 0.028*LNFR_{t-1} + 0.052*LNFR_{t-2} \quad (4.2)$$

The results of this study, as presented in Table 4.7, reveal a remarkably high adjusted coefficient of determination (R^2) of 0.998, indicating that 99.8% of the variation in foreign exchange rates can be attributed to variations in GDP per capita and foreign reserves. This aligns with recent studies emphasizing the significance of economic indicators in explaining fluctuations in foreign exchange rates (Ausloos et al., 2019; Haseeb et al., , 2019). However, the study's finding that GDP per capita at lag 1 and lag 2, as well as both lags of foreign reserves, were not significant in influencing foreign exchange rates diverges from some recent literature (Gajurel, 2022). The observed significance of both lags in foreign exchange rates is consistent with research highlighting the impact of historical exchange rate movements on the current rates (Bussière et al., 2014). Moreover, the negative effects identified for the first lag of GDP per capita, foreign reserves, and the second lag of foreign exchange rates, contrasted with the positive effects of other lags, contribute nuanced insights to the ongoing discourse on the multifaceted influences on foreign exchange dynamics (Lal, 2023). This study's results, while aligning with some recent research, introduce unique nuances that warrant further exploration and comparative analysis within the context of evolving global economic dynamics.

4.4.2.1 The Test of Joint Significance of Lags of GDP Per Capita on Foreign Exchange Rate

HO_3: GDP per capita (both lags) do not jointly cause the foreign exchange rate

The Wald test result conducted on joint causality of GDP per capita on the foreign exchange rate, summarized and presented in Table 4.8 showed that F-statistics = 6.128, Pv = 0.003 < 0.05 consequently, the null hypothesis is rejected and it is concluded that GDP per capita (both lags) had joint significance on the foreign exchange rate

4.4.2.2 The Test of Joint Significance of Lags of Foreign Reserve on Foreign Exchange Rate

HO_4: Foreign reserves (both lags) do not jointly cause the foreign exchange rate

The result of the Wald test in Table 4.9 on the joint significance of foreign reserve on foreign exchange rate showed that F-statistics = 2.493, Pv = 0.086 > 0.05) therefore, the null hypothesis cannot be rejected and it is concluded that foreign reserve (both lags) do not have a joint significant effect on foreign exchange rate.

4.4.3 Effects of Gross Domestic Product Per Capita and Foreign Exchange Rates on Foreign Reserve

$$LNFR = 0.924 + 1.079*LNGDPPC_{t-1} - 1.031*LNGDPPC_{t-2} + 0.070*LNEXR_{t-1} - 0.041*LNEXR_{t-2} + 0.972*LNFR_{t-1} - 0.042*LNFR_{t-2} \quad (4.3)$$

The result summary on the effects of gross domestic product per capita and foreign exchange rate on foreign reserve presented in Table 4.10 and summarized in the equation above shows that the adjusted coefficient of determination($\bar{R}^2$) of 0.952. This inferred that the 95.2% variation in foreign reserve is explained by variations in GDP per capita and foreign exchange rate. Detailed analysis showed that only foreign exchange lag 1 had a significant effect on foreign reserves.

4.4.3.1 The Test of Joint Significance of Lags of GDP Per Capita on Foreign Reserve

HO_5: GDP per capita (both lags) do not jointly cause foreign reserve

The Wald test result conducted on joint causality of GDP per capita on foreign reserve, summarized and presented in Table 4.12 showed that F-statistics = 1.213, Pv = 0.299 > 0.05) consequently, the null hypothesis cannot be rejected and it is concluded that GDP per capita (both lags) had no joint significance on foreign reserve.

4.4.3.2 The Test of Joint Significance of Lags of Foreign Exchange Rate on Foreign Reserve

HO_6: Foreign exchange rate (both lags) do not jointly cause foreign reserve

The result of the Wald test in Table 4.13 on the joint significance of foreign exchange rate on foreign reserve showed that F-statistics = 1.599, Pv = 0.205 > 0.05) therefore, the null hypothesis cannot be rejected. It is thus concluded that foreign exchange rates (both lags) do not have a joint significant effect on foreign reserves.

4.5 **The Impulse Response Function**

In the study's exploration of the panel VAR model, it is revealed that shocks to endogenous variables not only have a direct impact but also influence other variables through the dynamic structure of the VAR model. To understand the consequences of a one-time shock on present and future values of endogenous variables, the impulse response function is employed. Three key innovations are identified: a shock to GDP per capita, a shock to the foreign exchange rate, and a shock to foreign reserves, each represented by one standard deviation. The associated figures illustrate the impulse response due to composite, common, and idiosyncratic shocks, depicting the reactions of GDP per capita, foreign exchange rate, and foreign reserves.

4.6 **Variance Decomposition**

Another analytical tool employed is variance decomposition, offering insights into the dynamic interaction among variables by isolating the variance in an endogenous variable attributed to system shocks. The variance decomposition analysis, illustrated in Figures 3.18 to 3.20, delineates the comparative significance of each random innovation on the system's variables. The top row of each graph displays the variance decomposition of GDP per capita, foreign exchange rate, and foreign reserves due to shocks to GDP per capita, foreign exchange rate, and foreign reserves, respectively. This method provides a comprehensive understanding of how shocks impact different variables within the system.

5. Conclusion

The study employs a panel vector autoregressive (VAR) model to analyze the macroeconomic interactions in Nigeria, Ghana, and Cameroon, focusing on economic variables such as exchange rates, foreign reserves, and gross domestic product (GDP) from 1960 to 2022. The findings reveal that variations in GDP per capita and foreign reserves explain 99.8% of the fluctuations in foreign exchange rates during the study period. However, the study concludes that GDP per capita and foreign reserves did not significantly influence foreign exchange rates at certain lags. Specifically, the first lag of GDP per capita, foreign reserve, and the second lag of foreign exchange rates exhibited negative effects on foreign exchange, while others showed positive effects. The absence of a cointegrating relationship among variables suggests that the panel VAR model is suitable for the dataset. Unit root tests were conducted to ensure stationarity, with the rejection of the null hypothesis indicating stationary series. The study also conducts impulse response analysis, emphasizing the model's capability to trace the transmission of shocks within the system. The random and fixed effects components were estimated, with the Hausman Test favoring the fixed effect model. Hypothesis testing indicates joint significance between foreign exchange rates (both lags) and GDP per capita, while foreign reserves (both lags) do not have a joint significant effect on GDP per capita. Similarly, GDP per capita (both lags) has joint significance on foreign exchange rates, whereas foreign reserves (both lags) do not have a joint significant effect. The study concludes that foreign exchange rates (both lags) do not have a joint significant effect on foreign reserves.

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