MODELLING SHORT-RUN DYNAMICS OF MACROECONOMIC VARAIBLES ON GDP IN ECOWAS COUNTRIES USING PANEL VECTOR AUTOREGRESSION MODEL

Abstract

This study implemented Panel Vector Autoregression (PVAR) Model to examine short-run dynamic relationships between inflation rate, population and unemployment rate as function of Gross Domestic Product (GDP) for Economic Community of West Africa States (ECOWAS) counties. To achieve this, secondary data was sourced for Population, Inflation rate, Unemployment rate and GDP from National Bureau of Statistics, Nigeria and ECOWAS office Nigeria covering from 1991 to 2020. The study implemented PVAR (1) and PVAR (2) models but only PVAR (2) model fulfilled the stability condition. Results from the analysis PVAR (2) model for GDP shows that GDP, population, inflation rate and unemployment rate at lag 1 are all positively related to GDP but only GDP and population at lag 1 are significant (P<0.05). While at lag 2 for GDP model, inflation rate and unemployment rate are negatively related to GDP though only GDP and population were significant (P<0.05). This study therefore concluded and recommended that in the short run, previous GDP and population data are significant in determining current GDP in ECOWAS countries

Keywords: PVAR, ECOWAS, GDP, Inflation, unemployment, population.

1.0 Introduction

Autoregression is a time series model that uses observation from previous time steps as input to a regression equation to predict the value at the next time step. It is a very simple concept that can result in accurate forecasts on a range of time series problems. The Vector Autoregression model is useful instrument for describing the dynamic behavior of economic, financial time series, climate time series, etc. and for predicting the future. It always provides superior forecast to univariate time series model and expand theory based linear equation models. (Abdelhadi, 2013, Adenomon, et al, 2012, Adenomon, et al, 2013). Vector Autoregression (VAR) models are used for multivariate time series. The design is that each variable is a linear function of the past lags of itself and past lags of the other variables. Vector autoregression models are used to analyze macroeconomics time series where we have many of the observation. The Vector Autoregression models (VAR) methodology was derived in the macro econometrics literature as another method to multivariate simultaneous equation model (Sims 1980, John 2005, Dimitris 2015). All variable in VAR system are usually served as endogenous, although identifying restriction based on theoretical model or on statistical procedures may be imposed to disentangle the impact of exogenous change onto the system (Holtz-Eakin, Neway, and Rosen 1988). Therefore, Vector Autoregression (VAR) is a statistical model used to explain the correlation between multiple variable as they change over time. Vector Autoregression (VAR) is used to express short – run correlation between the variables and can be extended to Panel Vector Autoregression (PVAR) Model. Therefore Panel Vector Autoregression (PVAR) is a statistical model used to analyze the relationships among multiple time series variables. It is a combination of Vector Autoregression model (VAR) and panel data model. PVAR allows for individual variation in the coefficients and error covariance matrices across entities, as well as for dynamic interactions among the variables over time. (Michael and Robert 2018)

The following previous studies examined macroeconomic variables in ECOWAS countries and aim is to model macroeconomic using PVAR model and performances. Guilherme and Marcelo (2016) explored the dynamic relationship between economic growth and several measures of governance quality across a wide sample of countries and a panel VAR approach were used to account for time invariant characteristics intrinsic to each country. The study revealed that governance quality exert a positive and significant impact on economic growth, which can be sustained for more than ten years after the initial shock. The study further revealed that as much as 33% of the variation in GDP were explained by variations in governance.

Abdulsalam and Abdullahi (2016) examined the Impact of Unemployment and inflation on Economic Growth in Nigeria. The Ordinary Least Square (OLS) technique was adopted with various test to determine how fit are the data for the analysis. The result of test indicates that data for the analysis are stationary at level and there are cointegrating equation implying that there exist long-run relationship between RGDP, Unemployment and inflation. The results indicated that unemployment and inflation are positively related to economic growth.

Adenomon and Tela (2017) investigated the relationship between GDP and unemployment rate in Nigeria as it regards Okun's law using annual data from 1972 to 2014. The study revealed a positive relationship between unemployment rate and GDP in Nigeria though not significant.

Ndoricimpa (2017) examined the impact of inflation rate on economic growth in Africa using dynamic panel threshold regression. The study suggested that low inflation is growth-enhancing for the sub Saharan countries while high inflation rate could have detrimental effects on the economic growth of the sub-Saharan African countries.

Iyoha and Okin (2017) investigated the impact of exports, exchange rate, investment, human capital, inflation and population growth on GDP in ECOWAS countries using pooled OLS, fixed effects model, random effect model and dynamic panel regression model. Results revealed that the dynamic panel regression model was preferred and that exports, exchange rate and investment were significant determinants of GDP in ECOWAS countries.

Janifar et al (2020) studied the Impact of GDP, Inflation, Population Growth and FDI on Unemployment in Bangladesh Economy. Gross Domestic Product (GDP) and Inflation, FDI are stationary on level and intercept while unemployment is stationary on first difference. The study observed that long run relationship existed among the factors and unemployment in Bangladesh. Economic factors like GDP and FDI have significant influence on unemployment rate in Bangladesh.

Fikirte (2012) examined Economic Growth and Inflation using panel data that includes 13 Sub –Saharan African countries from 1969 to 2009. The result indicates that there is a negative relationship between economic growth and inflation. The study also examined the causality relationship between economic growth and inflation by using Panel Granger causality test which shown that inflation Granger causes economic growth for all countries in the sample, while economic growth Granger causes inflation for two countries (i.e. Congo, Dep. Rep and Zimbabwe).

Abada et al (2021) examined the impact of unemployment, inflation and household consumption on economic growth for 1960 to 2018. OLS estimation technique was adopted. From the analysis, unemployment, inflation and household’s consumption have impacted economic growth. But it was observed that inflation (INF) significantly influence economic growth in Nigeria

Akintunde et al (2013) examined the effect of population dynamics (mortality and fertility) on economic growth in sub-Saharan Africa using data covering from 1970 to 2005. The study used pooled OLS and dynamic panel data analysis and the results revealed that population of fertility rate had a negative impact on economic growth while by expecting at birth had a positive impact on economic growth

Tessema (2022) investigated population growth on the economic growth of sub-Saharan African counties using panel data analysis. The study used data coving 1990 to 2019 and found out that there is a positive relationship between population growth and economic growth

Ofori et al. (2022) investigated the key drivers of economic growth in Sub-Saharan Africa (SSA) using machine learning techniques which includes the standard lasso, the adaptive lasso, the minimum schwarz Bayesian information criterion lasso and the ElasticNet on data set containing 113 covariates for variables affecting growth in SSA. The study provided the following as the key drivers affecting economic growth in Africa: manufacturing (value addition), population, financial development, government spending, macroeconomic management, globalization and social inclusion.

Adenomon and Oduwole (2022) examined the dynamic interrelationships among inflation, interest and exchange rates with the effects of money supply and GDP in Nigeria using Bayesian Vector Autoregression with Exogenous variables (BVARX) models. The study used data spanning the period of 2010Q1-2020Q4. The study revealed high positive correlation between inflation and GDP in Nigeria (r=0.7801). Six (6) versions of BVARX models with lag 2 using Normal-Wishart, Normal Flat and Flat-Flat priors were implemented and the results revealed superior BVARX models with Flat-Flat prior using Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) as means of model selection. finally, evidenced from Bivariate Granger causality testing reveals that the past lag values of inflation rate help in predicting exchange rate in Nigeria

2.0 Materials and Methods

The data used for the study is a secondary data collected from National Bureau of Statistics Headquarter Abuja, Nigeria and ECOWAS office Nigeria. The sample consists of 30 years data from 1991 to 2020. The data on Gross Domestic product (GDP) and Population (POP) are valued in million while Unemployment rate and inflation rate are valued in percent. The identified model has four variables which hypothesize that Gross Domestic product (GDP) is a function of Inflation rate, Unemployment rate and Population

$$GDP_t = F(INF_t, UNE_t, POP_t)$$

Where GDP represents Gross Domestic Product, INF represents Inflation rate, UNE represents Unemployment rate, Pop represents population and represents time index

3.1 Model Specification and Description

3.1.1 Panel Vector Autoregresssion (PVAM) Model

We consider K- variate homogeneous panel vector autoregression of order P with panel specific fixed effects represented by the following system of linear equations

$$Y_{it} = Y_{it-1}A_1 + Y_{it-1}A_2 + Y_{it-3}A_3 + ... + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + U_i + e_{it} \qquad 3.1$$

$$\mathcal{E}\{1, 2, ..., N\}, t\mathcal{E}\{1, 2, .. ., T_i\}$$

Then equation 2 can be rewritten as:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ \vdots \\ . \\ y_{Nt} \end{bmatrix} = \begin{bmatrix} Y_{1t-1} \\ Y_{2t-1} \\ \vdots \\ . \\ Y_{Nt-1} \end{bmatrix} A_1 + \begin{bmatrix} Y_{1t-2} \\ Y_{2t-2} \\ \vdots \\ . \\ Y_{Nt-2} \end{bmatrix} A_2 + \begin{bmatrix} Y_{1t-3} \\ Y_{2t-3} \\ \vdots \\ . \\ Y_{Nt-3} \end{bmatrix} A_3 + \ldots + \begin{bmatrix} Y_{1t-P} \\ Y_{2t-P} \\ \vdots \\ . \\ Y_{Nt-P} \end{bmatrix} A_{p-1} + \begin{bmatrix} Y_{1t-P} \\ Y_{2t-P} \\ \vdots \\ . \\ Y_{Nt-P} \end{bmatrix} A_p +$$

$$\begin{bmatrix} B_{11} & B_{12} & \ldots & B_{1N} \\ B_{21} & B_{22} & \ldots & B_{2N} \\ \vdots & \vdots & & \\ B_{N1} & B_{1N} & \ldots & B_{NN} \end{bmatrix} \begin{bmatrix} X_{1t} \\ X_{2t} \\ \vdots \\ . \\ X_{Nt} \end{bmatrix} + \begin{bmatrix} U_{1t} \\ U_{2t} \\ \vdots \\ . \\ U_{Nt} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ \vdots \\ . \\ e_{Nt} \end{bmatrix}$$

Where Y_{it} is a (1×k) Vector of dependent variables, X_{it} is a (1×i) Vector of exogenous covariates, and U_i and e_{it} are (1×k) Vectors of dependent variable specific panel fixed – effects and idiosyncratic errors, respectively. The (k×k) matrices $A_{1,}$ $A_{2,} \ldots$ $A_{p-1,}$ A_p and the (l×k) matrix B are parameters to be estimated. We assume that the innovations have the following characteristics:$(e_{it}) = 0$, $E(e_{it}{}^1 e_{it}) = \sum$, and $E(e_{it}{}^1 e_{it}) = 0$, for $t > s$ (Michael and Inessa 2016)

The first vector autoregressive panel model (PVAR) was introduced by Holtz-Eakin et al. (1988). Binder et al. (2005) extended their equation-by-equation estimator for a PVAR model with only endogenous variables that are lagged by one period. They further improve this model by Sigmund and Ferstl (2017) to allow for p lags of m endogenous variables, k predetermined variables and n strictly exogenous variables. Therefore, we consider the following stationary PVAR with fixed effects.

$$y_{i,t} = \mu_i + \sum_{i=1}^{p} A_i y_{i,t-1} + Bx_{i,t} + Cs_{i,t} + \epsilon_{i,t}$$

I_m Denotes an $m \times m$ identity matrix. Let $y_{i,t} \epsilon R^m$ be a $m \times 1$ vector of endogenous variables for the ith cross-sectional unit at time t. Let $y_{i,t-l} \epsilon R^m$ be a $m \times 1$ vector of lagged endogenous variables. Let Let $x_{i,t} \epsilon R^k$ be a $k \times 1$ vector of predetermined variables that are potentially correlated with past errors. Let $s_{i,t} \epsilon R^n$ be a $n \times 1$ vector of strictly exogenous variables that neither depend on ϵ_t nor on ϵ_{t-s} for $s = 1 \ldots T$.

The idiosyncratic error vector $\epsilon_{i,t} \epsilon R^m$ is assumed to be well behaved and independent from both the regressors $x_{i,t}$ and $s_{i,t}$ and the individual error component μ_i . Stationarity requires that all unit roots of the PVAR model fall inside the unit circle, which therefore places some constraints on the fixed effect μ_i . The cross section i and the time section t are defined as follows: i = 1, 2, ..., N and t = 1, 2, ..., T. In this specification we assume parameter homogeneity for $A_{l(m\times m)}$, $B_{(m\times k)}$, and $C_{(m\times m)}$, for all i. A PVAR model is hence a combination of a single equation dynamic panel model (DPM) and a vector autoregressive model (VAR). First difference and system GMM estimators for single equation dynamic panel data models have been implemented in the STATA package xtabond by Roodman (2009) and some of the features are also available in the R package plm. There they define the first difference moment conditions (Holtz-Eakin et al., 1988; Arellano and Bond, 1991), formalize the ideas to reduce the number of moment conditions by linear transformations of the instrument matrix and define the one- and two-step GMM estimator. Furthermore, we setup the system moment conditions as defined in Blundell and Bond (1998) and present the extended GMM estimator. In addition to the GMM-estimators we contribute to the literature by providing specification tests (Hansen over identification test, lag selection criterion and stability test of the PVAR polynomial) and classical structural analysis for PVAR models such as orthogonal and generalized impulse response functions, bootstrapped confidence intervals for impulse response analysis and forecast error variance decompositions. Finally, we implement the first difference and the forward orthogonal transformation to remove the fixed effects

4. Results and Discussion

The analysis of the data used in this study was done in R environment using Panelvar package (Sigmund and Ferstl 2021)

Table 1: Fixed Effect OLS Panel VAR (1) estimation

Number of obs = 450, Number of groups = 15, Obs per group: min = 30, avg = 30, max = 30

	DEMEANED LNGDP	DEMEANED LNPOP	DEMEANED LNINF	DEMEANED LNUNEMP
demeaned_lag1_lngdp	0.7364 *** (0.0312)	-0.0000 (0.0026)	-0.0183 (0.0563)	0.0156 (0.0322)
demeaned_lag1_lnpop	0.6090 *** (0.0754)	1.0018 *** (0.0062)	-0.1888 (0.1361)	-0.0156 (0.0778)
demeaned_lag1_lninf	0.0183 (0.0213)	0.0000 (0.0018)	0.4409 *** (0.0384)	0.0156 (0.0219)
demeaned_lag1_lnunemp	0.0160 (0.0319)	0.0014 (0.0026)	0.0376 (0.0575)	0.7453 *** (0.0329)

Note *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$ denotes Significance at 1%, 10% and 5%, level, respectively

The estimated model for PVAR (1) as presented in table 1 above is given as:

$$LNGDP_t = 0.7364 LNGDP_{t-1} + 0.6090 LNPOP_{t-1} + 0.0213 LNINF_{t-1} + 0.0160 LNIUNEMP_{t-1} + \varepsilon_{t-1} \quad 1$$

$$LNPOP_t = 1.0018 LNPOP_{t-1} + 0.0014 LNUNEMP_{t-1} + \varepsilon_{t-1} \quad 2$$

$$LNINF_t = 0.4409 LNINF_{t-1} - 0.0183 LNGDP_{t-1} + 0.1888 LNPOP_{t-1} + 0.0376 LNUNEMP_{t-1+} \varepsilon_{t-1} \quad 3$$

$$LNUNEMP_t = 0.7453 LNUNEMP_{t-1} + 0.0156 LNGDP_{t-1} - 0.0156 LNPOP_{t-1} + 0.0156 LNINF_{t-1} + \varepsilon_{t-1} \quad 4$$

In the table 1 above, the estimated model in equation 1 revealed that GDP at lag 1 and population at lag 1 are significant and positively related to GDP in ECOWAS countries. Furthermore, a unit increase in GDP at lag 1 causes GDP to increase by 0.7364 per unit increase in GDP at lag 1 while a unit increase in population at lag1 causes GDP to increase by 0.6090 per unit increase in population at lag 1. Lastly inflation rate at lag 1 and unemployment rate at lag 1 are positively related to GDP in ECOWAS countries though not significant (P>0.05) which is line with the studies of Adenomon and Tela, (2017); Adenomon and Oduwole (2022).

In equation 2 above, the estimated model revealed that population, unemployment and inflation at lag 1 are positively related to population while GDP at lag 1 is negatively related to population but only population was significant in ECOWAS countries ($p<0.05$). Furthermore, a unit increase in population at lag 1 cause population to increase by 1.0018 per unit increase in population at lag 1 while a unit increase in unemployment at lag1 causes population to increase by 0.0014 per unit increase in unemployment rate at lag 1.

In equation 3 above, the estimated model revealed that inflation at lag 1 and unemployment at lag are positively related to inflation rate while GDP and population at lag 1 are negatively related to inflation rate but only inflation at lag 1 is significant ($p<0.05$).

In equation 4 above, the estimated model revealed that GPD, inflation and unemployment at lag 1 are positively related to unemployment but population at lag 1 is negatively related to unemployment but only unemployment rate at lag 1 is significant ($p<0.05$).

Table 2: Forecast Error Variance Decomposition for GDP in PVAR (1) Model

	LNGDP	LNPOP	LNINF	LNUNEMP
[1,]	1.0000000	0.000000000	0.0000000000	0.0000000000
[2,]	0.9974783	0.001656743	0.0006892607	0.0001756477
[3,]	0.9926591	0.005451480	0.0013808773	0.0005085326
[4,]	0.9859557	0.011258605	0.0018656600	0.0009200429
[5,]	0.9776684	0.018824136	0.0021608636	0.0013466065
[6,]	0.9681045	0.027824724	0.0023240976	0.0017466722
[7,]	0.9575726	0.037924058	0.0024045734	0.0020987666
[8,]	0.9463559	0.048812388	0.0024357853	0.0023959364
[9,]	0.9346946	0.060226812	0.0024385535	0.0026399919
[10,]	0.9227809	0.071956738	0.0024252562	0.0028370614

Table 2 above shows that 92.3% of variation in GDP was caused by GDP while POP, INF and UNEMP causes variation in GDP by 7.2%, 0.24% and 0.28% respectively

Table 3: Forecast Error Variance Decomposition for Population in PVAR (1) Model

	LNGDP	LNPOP	LNINF	LNUNEMP
[1,]	0.02564480	0.9743552	0.000000e+00	0.0000000000
[2,]	0.02565281	0.9741994	6.452882e-09	0.0001477531
[3,]	0.02568187	0.9739197	2.319625e-08	0.0003983628
[4,]	0.02572397	0.9735863	1.401594e-07	0.0006895655
[5,]	0.02577343	0.9732392	3.720161e-07	0.0009870434
[6,]	0.02582629	0.9729003	6.917583e-07	0.0012727632
[7,]	0.02587990	0.9725809	1.063855e-06	0.0015380894
[8,]	0.02593248	0.9722863	1.458198e-06	0.0017797160
[9,]	0.02598292	0.9720180	1.853323e-06	0.0019972684
[10,]	0.02603060	0.9717753	2.235517e-06	0.0021919007

Table 3 above shows that 97.2% of variation in POP was caused by POP while GDP, INF and UNEMP causes variation in POP by 2.6%, 0.0002%, and 0.22% respectively

Table 4: Forecast Error Variance Decomposition for Inflation in PVAR (1) Model

	LNGDP	LNPOP	LNINF	LNUNEMP
[1,]	0.0006413501	0.0009091222	0.9984495	0.0000000000
[2,]	0.0009623616	0.0007802017	0.9978715	0.0003859323
[3,]	0.0012084497	0.0007946152	0.9971101	0.0008867966
[4,]	0.0013729002	0.0009152195	0.9964229	0.0012890125
[5,]	0.0014772015	0.0011006837	0.9958692	0.0015529383
[6,]	0.0015433096	0.0013234431	0.9954247	0.0017085165
[7,]	0.0015864517	0.0015678325	0.9950515	0.0017942213
[8,]	0.0016159403	0.0018252929	0.9947198	0.0018389570
[9,]	0.0016372378	0.0020910821	0.9944107	0.0018610195
[10,]	0.0016535311	0.0023624722	0.9941129	0.0018710819

Table 4 above shows that 99.4% of variation in INF was caused by INF while GDP, POP and UNEMP causes variation in INF by 0.17%, 0.24%, and 0.19% respectively

Table 5: Forecast Error Variance Decomposition for Unemployment in PVAR(1) Model

	LNGDP	LNPOP	LNINF	LNUNEMP
[1,]	5.181233e-05	7.483984e-06	0.0001619093	0.9997788
[2,]	2.807930e-04	6.505170e-06	0.0003090839	0.9994036
[3,]	5.709681e-04	5.827695e-06	0.0006158056	0.9988074
[4,]	8.637761e-04	5.473154e-06	0.0008738285	0.9982569
[5,]	1.125768e-03	5.360683e-06	0.0010530294	0.9978158
[6,]	1.342534e-03	5.492113e-06	0.0011681676	0.9974838
[7,]	1.512103e-03	5.964501e-06	0.0012393506	0.9972426
[8,]	1.639303e-03	6.917508e-06	0.0012824435	0.9970713
[9,]	1.731721e-03	8.480215e-06	0.0013082137	0.9969516
[10,]	1.797259e-03	1.074022e-05	0.0013235090	0.9968685

Table 5 above shows that 99.7% of variation in UNEMP was caused by UNEMP while GDP, POP and INF causes variation in UNEMP by 0.18%, 0.007%, and 0.13% respectively

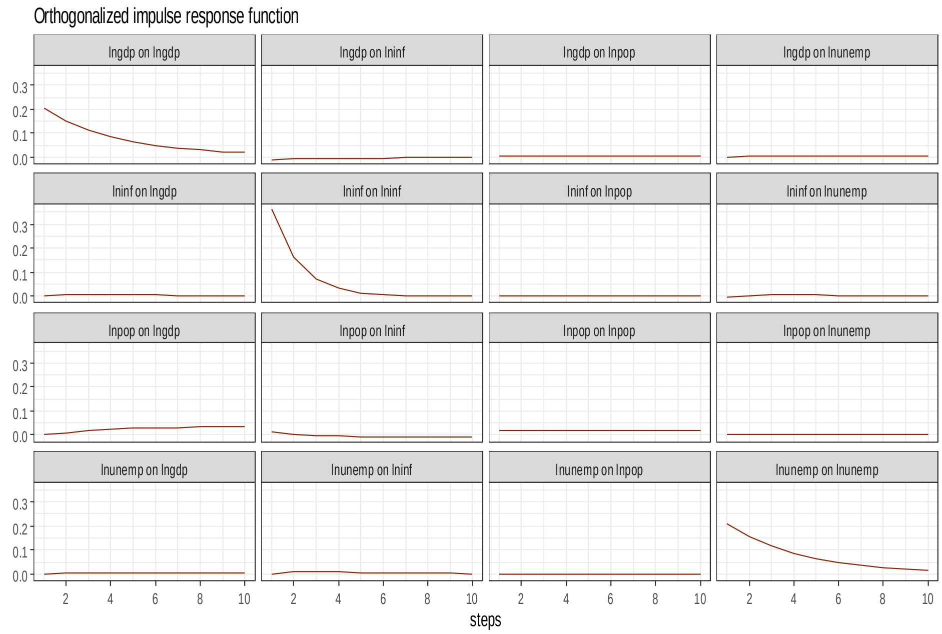

Fig 1 Orthogonal impulse response function of the estimated PVAR (1)

Fig 1 above shows the orthogonal impulse response function of the estimated PVAR (1) Model. The fig1 shows that each macroeconomic variables are well explain by itself

Table 6: Eigenvalue stability condition for PVAR (1):

	Eigenvalue	Modulus
1	1.0018353	1.0018353
2	0.7572829	0.7572829
3	0.7251327	0.7251327
4	0.4401187	0.4401187

From Table 6. above, since not all the modulus in Eigenvalue are less than one (1) therefore PVAR (1) does not satisfies the stability condition therefore there is need to estimate PVAR (2) model

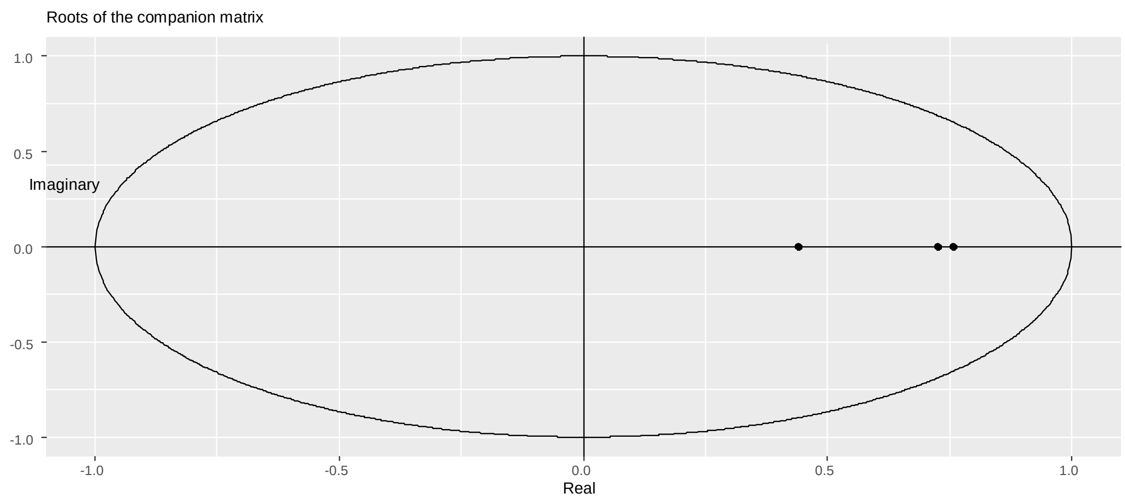

Fig 2 Stability condition test of PVAR(1) model

Fig 2 above shown that the PVAR(1) model do not satisfies stability conditions since not all the root points lie inside the unit circle. Then, there is need for Panel VAR (2) estimation

Table 7. Fixed Effects OLS Panel VAR (2) estimation

Number of obs = 450, Number of groups = 15, Obs per group: min = 30, avg = 30, max = 30

	DEMEANED LNGDP	DEMEANED LNPOP	DEMEANED LNINF	DEMEANED LNUNEMP
demeaned_lag1_lngdp	0.6168 *** (0.0481)	-0.0009 (0.0022)	-0.1592 (0.0844)	0.0074 (0.0507)
demeaned_lag1_lnpop	2.5445 *** (0.5871)	1.8442 *** (0.0265)	0.7422 (1.0300)	-0.1043 (0.6189)
demeaned_lag1_lninf	0.0275 (0.0266)	-0.0000 (0.0012)	0.4697 *** (0.0467)	0.0370 (0.0281)
demeaned_lag1_lnunemp	0.0029 (0.0462)	0.0017 (0.0021)	-0.0073 (0.0810)	0.6136 *** (0.0487)
demeaned_lag2_lngdp	0.1180 * (0.0469)	-0.0006 (0.0021)	0.2008 * (0.0822)	0.0028 (0.0494)
demeaned_lag2_lnpop	-1.9076 ** (0.5897)	-0.8429 *** (0.0266)	-1.0860 (1.0345)	0.0986 (0.6216)
demeaned_lag2_lninf	0.0143 (0.0243)	-0.0004 (0.0011)	-0.0477 (0.0426)	-0.0298 (0.0256)
demeaned_lag2_lnunemp	0.0107 (0.0471)	-0.0019 (0.0021)	0.0132 (0.0825)	0.1779 (0.0496)

Note *** p < 0.001; ** p < 0.01; * p < 0.05 denotes Significance at 1%, 10% and 5%, level, respectively

The estimated model for PVAR (2) as presented in table 7. above is given as:

$$LNGDP_t = 0.6168LNGDP_{t-1} + 2.5445LNPOP_{t-1} + 0.0275LNINF_{t-1} + 0.0029LNIUNEMP_{t-1} + 0.1180LNGDP_{t-2} - 1.9076LNPOP_{t-2} + 0.0143LNINF_{t-2} + 0.0107LNIUNEMP_{t-2} + \varepsilon_t \quad 1$$

$$LNPOP_t = -0.0009LNGDP_{t-1} + 1.8442LNPOP_{t-1} + 0.0017LNIUNEMP_{t-1} - 0.0006LNGDP_{t-2} - 0.8429LNPOP_{t-2} - 0.0004LNINF_{t-2} - 0.0019LNIUNEMP_{t-2} + \varepsilon_t \quad 2$$

$$LNINF_t = -0.1592LNGDP_{t-1} + 0.7422LNPOP_{t-1} + 0.4697LNINF_{t-1} - 0.0073LNIUNEMP_{t-1} + 0.2008LNGDP_{t-2} - 1.0860LNPOP_{t-2} - 0.0477LNINF_{t-2} + 0.0132LNIUNEMP_{t-2} + \varepsilon_t \quad 3$$

$$LNUNEMP_t = 0.0074LNGDP_{t-1} - 1.1043LNPOP_{t-1} + 0.0370LNINF_{t-1} + 0.6136LNIUNEMP_{t-1} + 0.0028LNGDP_{t-2} + 0.0986LNPOP_{t-2} - 0.0298LNINF_{t-2} + 0.1779LNIUNEMP_{t-2} + \varepsilon_t \quad 4$$

In the table 7. above for equation 1, the estimated PVAR (2) model for GDP shows that GDP, POP, INF and UNEMP at lag 1 are all positively related to GDP but only GDP and POP at lag 1 is significant ($P<0.05$). While at lag 2, GDP, INF and UNEMP are positively related to GDP and POP is negatively related to GDP though only GDP and POP are significant ($P<0.05$). This result is similar to Adenomon and Tela (2017); Adenomon and Oduwole (2022) while the result on population is similar to the work of Akintunde et al (2013).

For equation 2, the estimated PVAR (2) model for POP shows that POP and UNEMP at lag 1 are positively to POP also GDP and INF are negatively related, but only POP at lag 1 is significant ($P<0.05$) while at lag 2 GDP, INF, POP and UNEMP are all negatively related but only GDP is significant ($P<0.05$)

For equation 3, the estimated PVAR (2) model for INF shows that POP and INF at lag 1 are positively related to INF and GDP and UNEMP are negatively related to INF at lag 1 but only INF at lag 1 is significant ($P<0.05$) while at lag 2 GDP and UNEMP are positively related to INF also INF and POP are negatively related though only GDP is significant ($P<0.05$)

For equation 4, the estimated PVAR (2) model for UNEMP shows that GDP, INF and UNEMP are positively related to UNEMP and POP is negatively related to UNEMP but only UNEMP at lag 1 is significant ($P<0.05$) while at lag 2 GDP, INF and UNEMP are positively related to UNEMP and INF is negatively related.

Table 8: Forecast Error Variance Decomposition for GDP in PVAR(2) Model

	LNGDP	LNPOP	LNINF	LNUNEMP
[1,]	1.0000000	0.000000000	0.000000000	0.000000e+00
[2,]	0.9888308	0.009507424	0.001655073	6.699102e-06
[3,]	0.9636945	0.031193098	0.004883500	2.289187e-04
[4,]	0.9261918	0.066293831	0.007016391	4.979955e-04
[5,]	0.8785749	0.112735690	0.007891174	7.982495e-04
[6,]	0.8237743	0.167210352	0.007960494	1.054897e-03
[7,]	0.7652978	0.225852372	0.007609832	1.239966e-03
[8,]	0.7064270	0.285144787	0.007082463	1.345717e-03
[9,]	0.6496999	0.342404245	0.006514234	1.381613e-03
[10,]	0.5967592	0.395902314	0.005974100	1.364391e-03

Table 8 above shows that 59.7% of variation in GDP was caused by GDP while POP, INF and UNEMP causes variation in GDP by 40%, 0.59%, and 0.13% respectively

Table 9 : Forecast Error Variance Decomposition for Population in PVAR (2) Model

	LNGDP	LNPOP	LNINF	LNUNEMP
[1,]	0.0006524920	0.9993475	0.000000e+00	0.0000000000
[2,]	0.0003269723	0.9993071	8.048326e-07	0.0003651084
[3,]	0.0001353087	0.9994240	2.890696e-05	0.0004117513
[4,]	0.0001074393	0.9994028	1.023106e-04	0.0003874499
[5,]	0.0002071390	0.9992578	2.017584e-04	0.0003333154
[6,]	0.0004045258	0.9990107	3.112926e-04	0.0002734582
[7,]	0.0006740413	0.9986861	4.216634e-04	0.0002182265
[8,]	0.0009942169	0.9983053	5.283455e-04	0.0001721478
[9,]	0.0013474544	0.9978865	6.292653e-04	0.0001367695
[10,]	0.0017197565	0.9974445	7.235949e-04	0.0001121225

Table 9 above shows that 99.7% of variation in POP was caused by POP while GDP, INF and UNEMP causes variation in POP by 0.17%, 0.07%, and 0.01% respectively

Table 10: Forecast Error Variance Decomposition for Inflation in PVAR (2) Model

	LNGDP	LNPOP	LNINF	LNUNEMP
[1,]	0.001215946	0.0001293676	0.9986547	0.000000e+00
[2,]	0.010218556	0.0005851874	0.9891806	1.570572e-05
[3,]	0.010063546	0.0006203855	0.9892900	2.606322e-05
[4,]	0.010991957	0.0006380085	0.9883375	3.250912e-05
[5,]	0.012102831	0.0008344830	0.9870216	4.111169e-05
[6,]	0.012909262	0.0013115499	0.9857309	4.832715e-05
[7,]	0.013431574	0.0021123360	0.9844015	5.458428e-05
[8,]	0.013759853	0.0032440256	0.9829363	5.985147e-05
[9,]	0.013965820	0.0046918653	0.9812780	6.431795e-05

[10,]	0.014095305	0.0064281368	0.9794084	6.814403e-05

Table 10 above shows that 97.9% of variation in INF was caused by INF while GDP, POP and UNEMP causes variation in INF by 0.14%, 0.64%, and 0.006% respectively

Table 11: Forecast Error Variance Decomposition for Unemployment in PVAR(2) Model

	LNGDP	LNPOP	LNINF	LNUNEMP
[1,]	6.957311e-06	0.0003265472	0.0009630269	0.9987035
[2,]	3.462300e-05	0.0002759950	0.0020116819	0.9976777
[3,]	5.383354e-05	0.0002434034	0.0016455963	0.9980572
[4,]	1.885002e-04	0.0002194589	0.0014801196	0.9981119
[5,]	3.167510e-04	0.0002044708	0.0014007902	0.9980780
[6,]	4.399854e-04	0.0001951961	0.0013530983	0.9980117
[7,]	5.456627e-04	0.0001893258	0.0013217737	0.9979432
[8,]	6.343186e-04	0.0001858926	0.0013002575	0.9978795
[9,]	7.067543e-04	0.0001850383	0.0012853123	0.9978229
[10,]	7.647456e-04	0.0001876596	0.0012748982	0.9977727

Table 11 above shows that 99.8% of variation in UNEMP was caused by UNEMP while GDP, POP and INF causes variation in UNEMP by 0.07%, 0.019%, and 0.13% respectively

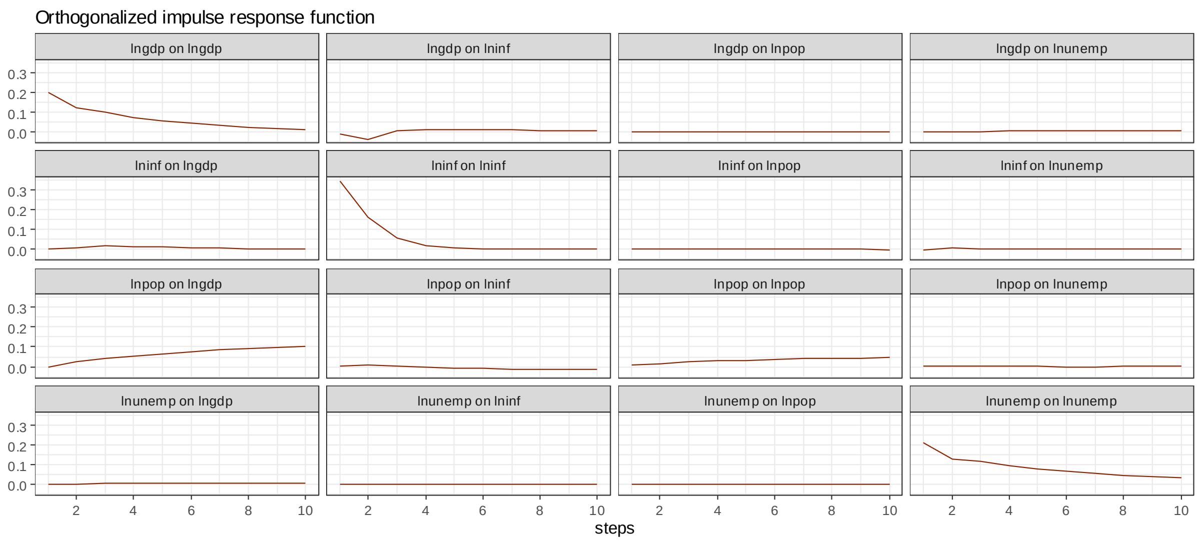

Fig 3: Orthogonal Impulse Response Function for the Macroeconomic variables in PVAR (2) Model

Fig 3 above shows the orthogonal impulse response function of the estimated PVAR (2) Model. The fig 3 shows that each macroeconomic variables are well explain by itself.

Table 12: Eigenvalue stability condition for PVAR (2) :

	Eigenvalue	Modulus
1	0.9870740+0.0000000i	0.9870740
2	0.8631802+0.0000000i	0.8631802
3	0.8248189+0.0000000i	0.8248189
4	0.7775670+0.0000000i	0.7775670
5	0.2384938+0.0909043i	0.2552310
6	0.2384938-0.0909043i	0.2552310
7	-0.1926435+0.0160458i	0.1933106
8	-0.1926435-0.0160458i	0.1933106

From Table 12 above, since all the modulus value in Eigenvalue are less than one (1), therefore PVAR(2) satisfies stability condition

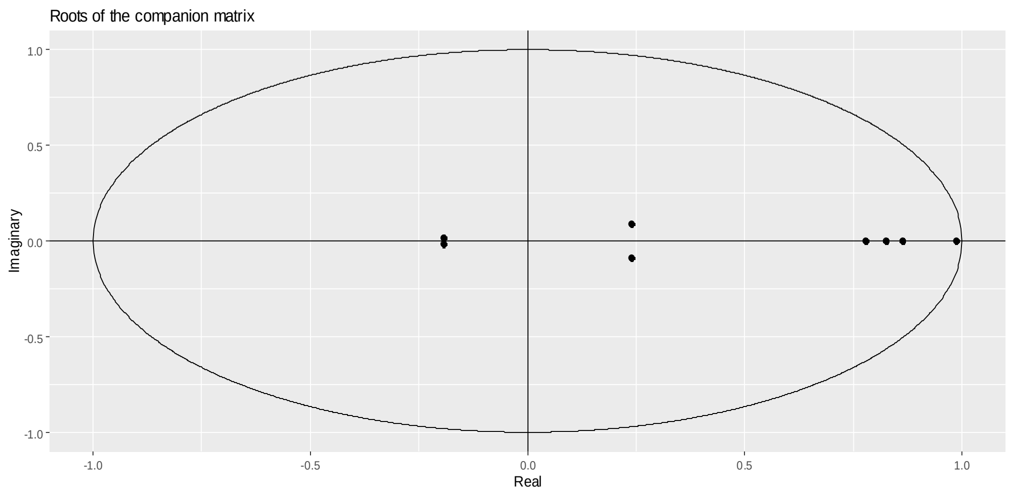

Fig 4 Stability condition test PVAR (2) model

Fig 4 above showed that the PVAR (2) model satisfies stability conditions since all the root points lie inside the unit circle.

Conclusion

This study was carried out to empirically examine the relationship of unemployment rate, inflation rate, and population on GDP in ECOWAS from 1991 to 2020. Four variables are used in this paper which are Unemployment Rate, Inflation Rate, Population and GDP. Results from the analysis PVAR (2) model for GDP shows that GDP, population, inflation rate and unemployment rate at lag 1 are all positively related to GDP but only GDP and population at lag 1 are significant ($P<0.05$). While at lag 2, GDP, inflation rate and unemployment rate is negatively related to GDP though only GDP and population are significant ($P<0.05$). This study therefore concluded and recommended in the short run, previous GDP and population data are significant in determining current GDP in ECOWAS countries.

References

Abdelhadi Y (2013): A Panel analysis of economic shock and loan portfolio quality, International monetary fund Middle East Center for economics and finance

Abdulsalam S.A and Abdullahi B (2016): The Impact of Unemployment and inflation on Economic Growth in Nigeria (1981–2014), International Journal of Business and Economic Sciences Applied Research 9(1):47-55, http://ijbesar.teiemt.gr

Adenomon, M. O. and Oduwole, H. K. (2022): Dynamics of Inflation, Interest and Exchange Rates with the Effects of Money Supply and GDP in Nigeria: Evidence from BVARX Models. Asian Journal of Probability and Statistics, 20(3): 122-131. DOI: 10.9734/AJPAS/2022/v20i3431

Adenomon, M. O. & Tela, M. N. (2017): Application of Okun's Law to Developing Economies: A Case Study of Nigeria. Nasara Scientifique Journal of Natural and Applied Sciences. 5(2):12-20.

Adenomon, M.O., Oyejola,B.A and Adenomon C.A, (2012): On the relationship between Savings and investment in Nigeria; A Vector Autoregressive Analysis Approach. Journal of the Nigeria Statistical Association 24: 45-58

Adenomon, M.O., Ojehomon V.E.T. and Oyejola,B.A (2013): Modelling the dynamic Relationship between Rainfall and Temperature Time Series in Niger State Nigeria. Mathematical Theory and modelling, 3(4): 53-70

Akintunde, T.S., Olomola, P.A. and Oladeji, S.I (2013): Population Dynamics and Economic Growth in Sub – Saharan Africa J. Econs and fns. Dev, 4(13): 148-157

Arellano, M. and Bond, S., (1991): Some tests of Speciation for Panel data: Monte Carlo evidence and an Application to Employment Equations, Review of Economic Studies, 58, 277-297.

Binder, M., C. Hsiao and Pesaran M. (2005): "Estimation and Inference in Short Panel Vector Autoregressions with Unit Roots and Cointegration," working paper, University of Cambridge

Abada F., Charles M., Ogochukwu O., Nnenna G. N., Ngozi M. N., Shammah E. S. and Oluseun P. (2021): Impact of Unemployment, Inflation and Households Consumption on Economic Growth International Journal of Business and Economics Research 2021; 10(6): 258-266

Fikirte T. M (2012): Economic Growth and Inflation, A Panel data analysis, Sodertorns University, Department of Social Sciences Economics

Guilherme A. and Marcelo E. A. S.(2016): Governance and Growth: A Panel VAR Approach, Department of Economics, Universidade Federal de Pernambuco, Brazil Department of Economics and PIMES/UFPE, Universidade Federal de Pernambuco, Brazil

Holtz –Eakin D, Newey W. and Rosen H.S (1988): Estimating Vector Autoregression with Panel Data Econometrica 56: 1371 -1395

Iyoha, M. and Okim, A. (2017): The Impact of Trade on Economic Growth in ECOWAS countries: Evidence from Panel Data. CBN Journal of Applied Statistics, 8(1):23-49.

Janifar A, Quazi N A, and Md. T H (2020): Impact of GDP, Inflation, Population Growth and FDI on Unemployment: A Study On Bangladesh Economy, African Journal of Economics and Sustainable Development ISSN: 2689-5080 3(3), 2020, 67-79

Newey, W., and McFadden D. (1994): Large Sample Estimation and Hypothesis Testing," in Hand - book of Econometrics, Vol. 4, ed. by R. Engle, and D. McFadden, North Holland, 2111–2245

Ndoricimpa, A. (2017): Threshold Effects of Inflation on Economic Growth in Africa: Evidence from a Dynamic Panel Threshold Regression Approach. Working Paper Series No. 249, African Development Bank, Adidjan, Cote d'Ivoire

Ofori, I. K.; Obeng, C. K. and Asongu, S. A. (2022): What Really Drives Economic Growth in Sub-Saharan Africa? Evidence from the Lasso Regularization and Inferential Techniques. J. Knowl. Econ, 2022:1-36

Roodman, D. (2009): An Introduction to Difference and System GMM in Stata. The Stata Journal L986-136. https://doi.org/10.1177/1536867X0900900106

Sims, C.A (1988): Macroeconomics and reality. Econometrica, 48:1-48.

Sigmund, M.and Ferstl, R. (2017) Panel Vector Autoregression in R with the Package Panelvar *Available at SSRN:* https://ssrn.com/abstract=2896087

Sigmund, M.and Ferstl, R. (2021): Package 'Panelvar'.CRAN

Tessema, H.F (2022): The effect of the population growth on the Economic growth of 43 Sub-Saharan Africa countries. Panel Data Analysis (1990-2019). Master Thesis, KDI School of Public Policy and Management. archives.kdschool.ac.kr