

MODELLING SHORT-RUN DYNAMICS OF MACROECONOMIC VARIABLES 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) countries. 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.

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 covering 1990 to 2019 and found out that there is a positive relationship between population growth and economic growth

## 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 Autoregression (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

$$Y_{it} = Y_{it-1}A_1 + Y_{it-2}A_2 + Y_{it-3}A_3 + \dots + Y_{it-p+1}A_{p-1} + Y_{it-p}A_p + U_i + e_{it} \quad 3.1$$

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

Then equation 2 can be rewritten as:

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

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

Where  $Y_{it}$  is a  $(1 \times k)$  Vector of dependent variables,  $X_{it}$  is a  $(1 \times i)$  Vector of exogenous covariates, and  $U_i$  and  $e_{it}$  are  $(1 \times k)$  Vectors of dependent variable specific panel fixed – effects and idiosyncratic errors, respectively. The  $(k \times k)$  matrices  $A_1, A_2, \dots, A_{p-1}, A_p$  and the  $(1 \times k)$  matrix  $B$  are parameters to be estimated. We assume that the innovations have the following characteristics:  $E(e_{it}) = 0$ ,  $E(e_{it}^1 e_{it}) = \Sigma$ , 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.

$$y_{i,t} = \mu_i + \sum_{i=1}^p A_i y_{i,t-1} + B x_{i,t} + C s_{i,t} + \epsilon_{i,t}$$

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

The idiosyncratic error vector  $\epsilon_{i,t} \in R^m$  is assumed to be well behaved and independent from both the regressors  $x_{i,t}$  and  $s_{i,t}$  and the individual error component  $\mu_i$ . Stationarity requires that all unit roots of the PVAR model fall inside the unit circle, which therefore places some constraints on the fixed effect  $\mu_i$ . The cross section  $i$  and the time section  $t$  are defined as follows:  $i = 1, 2, \dots, N$  and  $t = 1, 2, \dots, T$ . 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 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) for GDP as presented in table 1 above is given as:

$$LN\text{GDP}_t = 0.7364LN\text{GDP}_{t-1} + 0.6090LN\text{POP}_{t-1} + 0.0213LN\text{INF}_{t-1} + 0.0160LN\text{UNEMP}_{t-1} + \varepsilon_{t-1} \quad 1$$

$$LN\text{POP}_t = 1.0018LN\text{POP}_{t-1} + 0.0014LN\text{UNEMP}_{t-1} + \varepsilon_{t-1} \quad 2$$

$$LN\text{INF}_t = 0.4409LN\text{INF}_{t-1} - 0.0183LN\text{GDP}_{t-1} + 0.1888LN\text{POP}_{t-1} + 0.0376LN\text{UNEMP}_{t-1} + \varepsilon_{t-1} \quad 3$$

$$LN\text{UNEMP}_t = 0.7453LN\text{UNEMP}_{t-1} + 0.0156LN\text{GDP}_{t-1} - 0.0156LN\text{POP}_{t-1} + 0.0156LN\text{INF}_{t-1} + \varepsilon_{t-1} \quad 4$$

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 ( $P>0.05$ )

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	0.000000000	0.000000000
[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
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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**

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	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

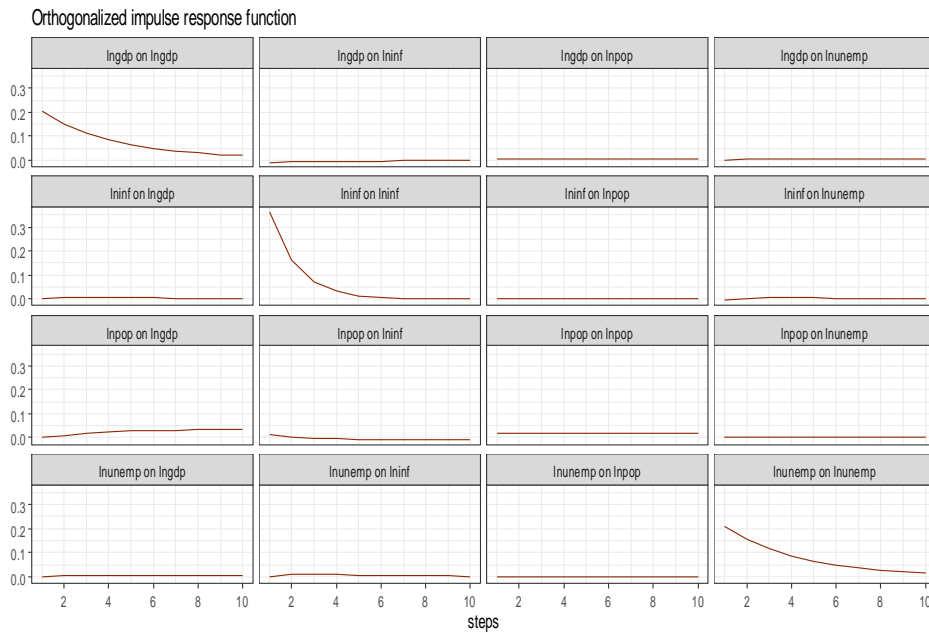


Fig 1 above shows the orthogonal impulse response function of the estimated PVAR (1) Model. The fig 1 shows that each macroeconomic variables are well explain by itself

**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

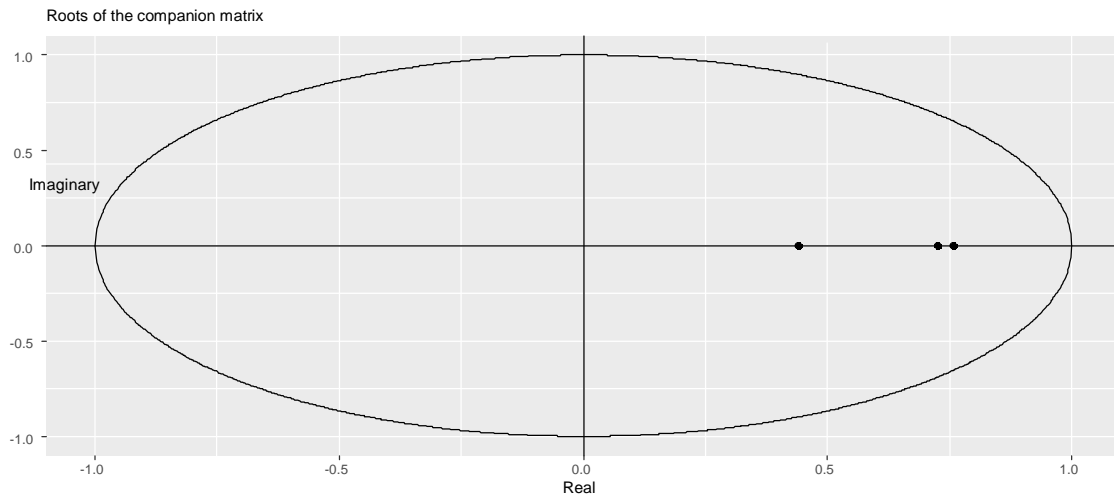


Fig 2 above shown that the PVAR(1) model do not satisfies stability conditions since not all the root points lie inside the unit circle. Then, there is need for Panel VAR (2) estimation

**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 (1) for GDP as presented in table 7 above is given as:

$$\begin{aligned}
 \text{LN}GDP_t &= 0.6168\text{LN}GDP_{t-1} + 2.5445\text{LN}POP_{t-1} + 0.0275\text{LN}INF_{t-1} + 0.0029\text{LN}UNEMP_{t-1} + \\
 &0.1180\text{LN}GDP_{t-2} - 1.9076\text{LN}POP_{t-2} + 0.0143\text{LN}INF_{t-2} + 0.0107\text{LN}UNEMP_{t-2} + \varepsilon_t \quad 1 \\
 \text{LN}POP_t &= -0.0009\text{LN}GDP_{t-1} + 1.8442\text{LN}POP_{t-1} + 0.0017\text{LN}UNEMP_{t-1} - 0.0006\text{LN}GDP_{t-2} - \\
 &0.8429\text{LN}POP_{t-2} - 0.0004\text{LN}INF_{t-2} - 0.0019\text{LN}UNEMP_{t-2} + \varepsilon_t \quad 2 \\
 \text{LN}INF_t &= -0.1592\text{LN}GDP_{t-1} + 0.7422\text{LN}POP_{t-1} + 0.4697\text{LN}INF_{t-1} - 0.0073\text{LN}UNEMP_{t-1} + \\
 &0.2008\text{LN}GDP_{t-2} - 1.0860\text{LN}POP_{t-2} - 0.0477\text{LN}INF_{t-2} + 0.0132\text{LN}UNEMP_{t-2} + \varepsilon_t \quad 3
 \end{aligned}$$

$$LNUNEMP_t = 0.0074LN\text{GDP}_{t-1} - 1.1043LN\text{POP}_{t-1} + 0.0370LN\text{INF}_{t-1} + 0.6136LN\text{IUNEMP}_{t-1} + 0.0028LN\text{GDP}_{t-2} + 0.0986LN\text{POP}_{t-2} - 0.0298LN\text{INF}_{t-2} + 0.1779LN\text{IUNEMP}_{t-2} + \varepsilon_t \quad 4$$

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 are 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)

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

	LN\GDP	LN\POP	LN\INF	LN\UNEMP
[1, ]	1.00000000	0.0000000000	0.0000000000	0.0000000e+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
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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

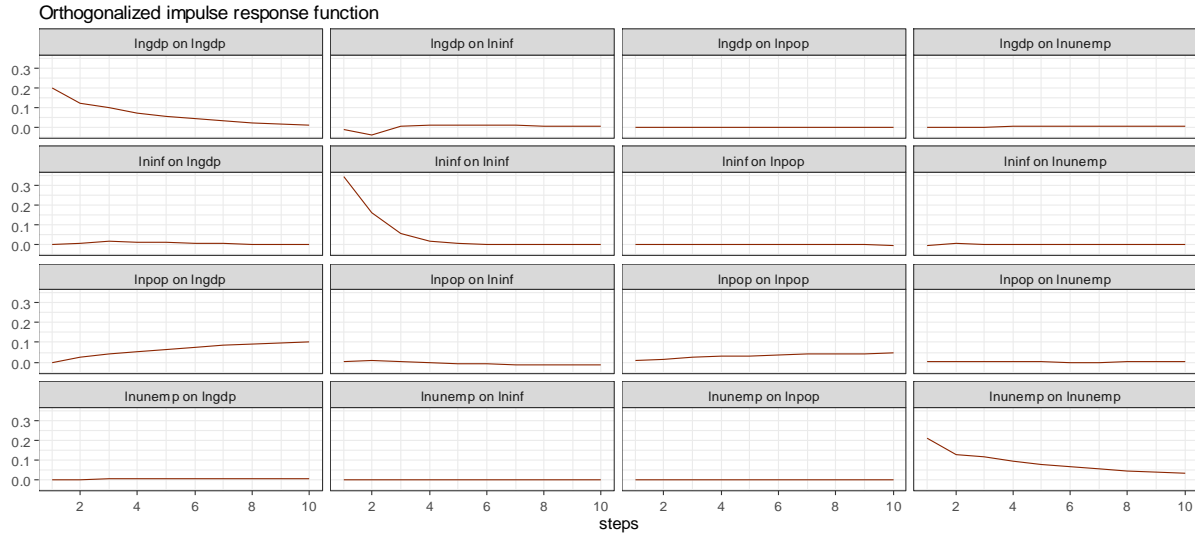


Fig 3: Orthogonal Impulse Response Function for the Macroeconomic variables in PVAR (2) Model

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

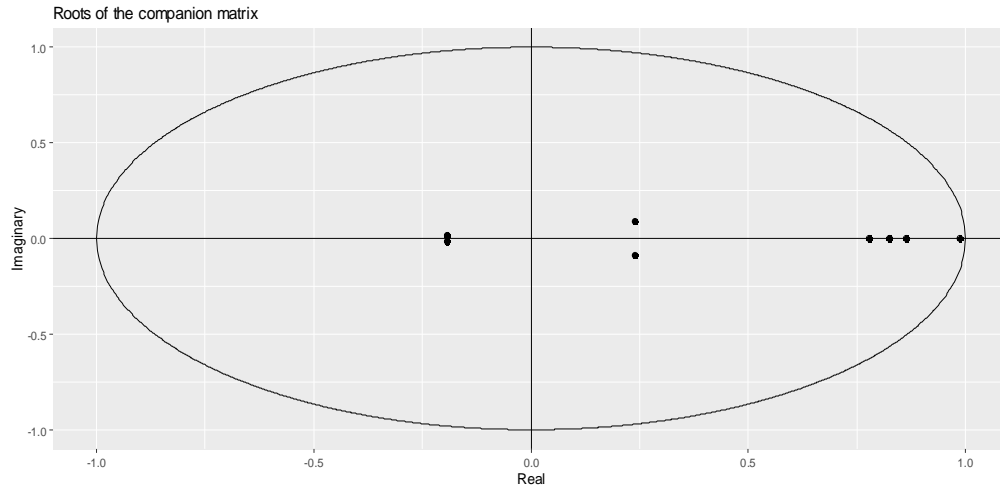


Fig 4 above showed that the PVAR (2) model satisfies stability conditions since all the root points lie inside the unit circle.

## 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 that, there is the short run, previous GDP and population data are significant in determining current GDP in ECOWAS countries

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