Analysis of Asymmetry between Population Growth and Food Production in Nigeria

Ifetolase Dorcas Ojeniyi and Oluwatosin Olusola Adesina

Lead City University, Ibadan, Oyo state, Nigeria
E-mail: *regensoul@yahoo.ca*

Abstract

Nigeria faces a critical challenge of diminishing food production amidst rapid population growth, projected to exceed 400 million by 2050. This study analyses the asymmetric relationship between population growth and food production in Nigeria between 1981 and 2021, integrating Malthusian theory with empirical evidence. Employing a Vector Autoregression (VAR) model and the Toda-Yamamoto causality test, findings indicate that positive population growth stimulates increased food production, and conversely, enhanced food production supports further population growth. The analysis also shows that negative population growth shocks influence food production, and that labour force participation in agriculture is a key positive driver of output. These results challenge simplistic Malthusian predictions and underscore the role of human capital in agricultural productivity. The study concludes that population growth and food production are dynamically interlinked. Thus, the study recommends integrated policymaking that simultaneously promotes agricultural investment, technological adoption, and human development through improved healthcare, education, and family planning to harness demographic trends for sustainable food security.

Keywords: Population growth, food production, food security, Malthusian theory, Nigeria

1. Introduction

Food production and population dynamics represent intertwined phenomena central to Nigeria's socio-economic framework. Fundamental to human survival, the production of food relies heavily on agricultural outputs within society. Globally, the imperative to augment agricultural yields by an estimated 70 percent by 2050 underscores the urgency in fortifying food production systems. However, Nigeria, despite its status as a prominent agricultural producer, grapples with diminishing food production levels, propelled by a myriad of factors such as climate variability, infrastructural inadequacies, suboptimal storage facilities, and inadequate financial support for the agricultural sector. Despite sporadic upswings in food production, typified by a notable 29% increase in cereal output from 2014 to 2018, the nation's capacity to satisfy its populace's nutritional needs remains tenuous. With Nigeria's population surpassing 206 million in 2021 and projected to exceed 400 million by 2050, the strain on the country's food production infrastructure intensifies. This rapid demographic expansion, outstripping agricultural output, has precipitated a state of food insecurity, exacerbating malnutrition prevalence across various demographic segments.

Endowed with diverse ecological zones and abundant natural resources, Nigeria possesses the potential to sustain substantial livestock populations and cultivate various crops. However, the nuances of regional ecological variations and precipitation trends dictate agricultural practices, dietary preferences, and resource utilization strategies. Agriculture assumes a pivotal role in Nigeria’s economic landscape, engaging approximately 70 percent of its labour force and contributing significantly to its GDP. Despite its agricultural prowess, Nigeria grapples with myriad challenges in food production, distribution, accessibility, and the attainment of food security. In 2018, an estimated 22.2 million Nigerians confronted food insecurity, constituting 11 percent of the population. The trajectory of Nigeria's population growth, doubling every two decades, accentuates rural-urban migration trends, exacerbating the strain on the nation's food production capacities.

Notably, the seminal work of British economist Thomas Malthus delineating the nexus between population expansion and food production has catalysed scholarly discourse exploring these intricate relationships unrest (Malthus, 1798, Thornton, Wichern, & Herroro, 2018, Moro and Igben, 2020). As the global populace burgeons, the demand for food escalates, placing mounting pressure on agricultural systems worldwide. The discourse surrounding this interplay has been thoroughly examined through diverse theoretical lenses and empirical investigations. Initially introduced by Thomas Robert Malthus in the late 18th century, the Malthusian theory postulates a scenario where population expansion surpasses the rate of food production, potentially leading to crises marked by famine, disease, and social unrest (Malthus, 1798). Malthus argues that unless population growth is curtailed through preventive measures such as delayed marriage and self-control, or through positive checks like epidemics and famines, an imbalance between population and food supply will ensue, resulting in catastrophic consequences (Thornton, Wichern, & Herroro, 2018).

Critics of the Malthusian theory contend that historical trends have often contradicted its dire predictions. Contrary to Malthus's forecasts, technological advancements have propelled agricultural productivity, often outpacing population growth in regions such as Western Europe and the United States. Moreover, globalization has facilitated the exchange of goods, mitigating the constraints posed by limited arable land (Okunola, Nathaniel, and Festus, 2018). Thus, the notion of an inevitable population-food production imbalance as postulated by Malthus has been challenged by empirical realities.

The discourse on population growth and food production intersects with broader issues of economic development, agricultural sustainability, and social welfare. Empirical studies suggest a complex relationship between population dynamics and agricultural output, with population growth exerting adverse effects on food security (Hyacinth, 2020; Osu, 2017). For instance, research indicates that rapid population growth strains agricultural resources, leading to unsustainable land use practices and diminishing productivity (FAO, 2020). This phenomenon underscores the imperative for effective population management strategies to ensure both short-term food security and long-term agricultural sustainability. Moreover, the nexus between population growth and food production in Nigeria is compounded by structural challenges such as overreliance on oil revenue, which has led to neglect of the agricultural sector. The resulting decline in food production exacerbates food insecurity, contributing to social instability and economic fragility (Ajibade, Onimisi, Yusuf, and Achor, 2022).

Consequently, there is a pressing need for comprehensive policy interventions aimed at diversifying the economy, enhancing agricultural productivity, and addressing the root causes of food insecurity. Furthermore, the discourse extends beyond mere agricultural considerations to encompass broader socio-economic dimensions. Studies reveal correlations between population growth, poverty, and social welfare indicators, highlighting the multifaceted nature of the population-food production nexus (Peters, n.d.; Amen, 2015). As such, effective policy responses must adopt a holistic approach, addressing not only agricultural productivity but also socio-economic inequalities and demographic challenges.

For instance, the Malthusian Population Theory was examined for Nigeria from 1982 to 2012 by Hyacinth (2020), who found that while population growth had no significant impact on economic development, it correlated with increased poverty and social problems. A study by UNDP (2012) on population growth and food security in Nigeria, using regression analysis, concluded that population growth negatively affected agricultural output, worsening food insecurity. Peters (n.d.) explored the relationship between population dynamics, savings, and agricultural output, noting the adverse impact of population dynamics on savings and investment in the agricultural sector. Ajibade, Onimisi, Yusuf, and Achor (2022) addressed the role of oil resource management in exacerbating food insecurity in Nigeria, emphasizing the neglect of the agricultural sector due to overreliance on oil revenue.

Further, Omotayo (2018) conducted research on food security in sub-Saharan Africa, highlighting the pervasive challenges of poverty and malnutrition, and emphasizing the need for comprehensive strategies to address food insecurity and promote sustainable development. Amen (2015) examined the socio-economic characteristics and food security status of farming households in Nigeria, revealing high levels of food insecurity among respondents. FAO's (2020) study focused on agricultural land use and population growth in Nigeria, revealing significant positive correlations between population and agricultural land variables, and the unsustainable expansion of agricultural land due to population pressure. Osu's (2017) study, using the cointegration approach, found that population growth adversely affected food security in Nigeria, emphasizing the importance of ensuring food self-sufficiency and security to prevent social unrest.

Thus, the analysis of asymmetry between population growth and food production in Nigeria necessitates a nuanced understanding that integrates theoretical insights with empirical evidence. While the Malthusian framework offers valuable insights into the potential risks of unchecked population growth, contemporary realities underscore the need for adaptive policy responses that address the complex interplay of socio-economic factors. By embracing a comprehensive approach that prioritizes sustainable agricultural development, poverty alleviation, and demographic management, Nigeria can navigate the challenges posed by population growth while fostering inclusive and resilient food systems. However, this discourse on population growth and food production intersects with broader issues of economic development, agricultural sustainability, and social welfare. Empirical studies suggest a complex relationship between population dynamics and agricultural output, with population growth exerting adverse effects on food security (Hyacinth, 2020; Osu, 2017). For instance, research indicates that rapid population growth strains agricultural resources, leading to unsustainable land use practices and diminishing productivity (FAO, 2020). This phenomenon underscores the imperative for effective population management strategies to ensure both short-term food security and long-term agricultural sustainability. Nigeria's agricultural landscape, grappling with these dynamics, confronts the dual imperative of enhancing production to meet escalating demand and curbing reliance on external food sources (Osu, 2017; Okunola, Nathaniel, and Festus, 2018; FAO, 2020).

Against the backdrop of Nigeria's evolving socio-economic landscape, a scholarly exploration of the dynamics between population growth and food production assumes paramount significance. This research endeavors to unravel the intricate nexus between population growth and food production in Nigeria. By dissecting these relationships, this research aspires to inform strategic interventions aimed at enhancing agricultural productivity, mitigating demographic pressures, and ensuring food security for Nigeria's burgeoning population. As such, nonlinear Granger causality, was employed which revealed that population growth and food production in Nigeria exhibit a significant bi-directional causal relationship. Positive and negative population growth both revealed a one-way causality on food production. To proceed to the analysis of this study, section two sets the method of analysis while section three presents the analysis that achieves the objective and section four concludes the study.

2. Methods of Analysis

The framework of this study is founded on the Malthusian theory of population. The theory stated that the growth of population is higher than that of the growth of food production. This was explained further that while population grows at a geometrical rate, food production grows at an arithmetical or subsistence level. The theory is therefore based on the inability of the growth of food production to satisfy the needs of a growing population. However, the growth of food production is determined by the population of the economy. This relationship can therefore be expressed as:

$$FP = f(POPG) \quad (1)$$

Where, FP = food production, and POP = Population growth.

Food production (FP) is measured by agricultural GDP (AGDP), while POPG is the growth of population. In addition, there are other macroeconomic variables identified by scholars which determine food production such as commercial bank loan to agriculture, government expenditure on agriculture, labour, inflation and exchange rate. Integrating these into the model, it can be re-expressed statistically as:

$$AGDP_t = \alpha_0 + \alpha_1 POPG_t + \alpha_2 DCA_t + \alpha_3 GEA + \alpha_4 LFP_t + \alpha_5 EXR_t + \alpha_6 INF_t + \varepsilon_t \quad (2)$$

Where, AGDP is agricultural output as a percentage of GDP, POPG is the growth of population, DCA is the deposit money bank credit to agriculture, LFP is the labour force participation rate, EXR is the exchange rate, INF is the inflation rate, α_0 is the intercept, $\alpha_{1\text{-}6}$ are the coefficient of the independent variables, ε is the error term.

To estimate the asymmetric causal relationship between population growth (POPG) and food production in Nigeria (AGDP), the data will be filtered through the VAR model to obtain the residual series, and then the residual series will be used for the nonlinear Granger causality analysis. In this study, the nonlinear Granger causality test proposed by Diks and Panchenko is used. In determining the asymmetric causality, if the past and present values of $POPG_t$ contain the additional information about the future value of GDP_t, then $POPG_t$ can strictly Granger cause $AGDP_t$. Let $F_{X,t}$ and $F_{Y,t}$ denote the set of past observations that contain $POPG_t$ and $AGDP_t$ before time t + 1, respectively. Let ~represent the equivalence of the distribution. The time series $POPG_t$ can strictly Granger cause $AGDP_t$ when the following conditions are met:

$$(AGDP_{t+1}, \ldots, AGDP_{t+k})j(F_{X,t}, F_{Y,t}) \sim (AGDP_{t+1}, \ldots, AGDP_{t+k})|F_{X,t}$$

where $k \geq 1$ represents the boundary of the predict, and at the time k = 1, the conditional distribution of Y_t is compared with and without the past and present values of X_t. Suppose the lag vector matrices $POPG_t^{L_x} = (POPG_{t-L_x+1}, \ldots, POPG_t)$ and $AGDP_t^{L_y} = (AGDP_{t-L_y+1}, \ldots, AGDP_t)$

The null hypothesis assumes that $X_t^{L_x}$does not contain any information that can predict the value of $LGDP_t^{L_y}$as follows:

$$H_0 : AGDP(t+1)|\,(AGDP_t^{L_y};AGDP_t^{L_y}) \sim Y(t+1)|AGDP_t^{L_y}$$

For a strictly stationary bivariate time series, Equation (3.5) means that the distribution of the (Lx + Ly + 1) dimensional vector $W_t = (POPG_t^{L_y}, AGDP_t^{L_y}, Z_t)$ will remain constant, where $Z_t = AGDP_{t+1}$. To keep the presentation compact and easy to discuss, the time subscript is removed, and Lx = Ly = 1 is assumed. Then, under these assumptions, the conditional distribution of Z, given (POPG, AGDP) = (x,y), is the same as that of Z given AGDP = y. Thus, Equation (3.5) can be re-expressed by the joint probability density function, as follows:

$$\frac{fx,y,z(x,y,z)}{f\gamma(y)} = \frac{fx,y(x,y)}{f\gamma(y)}, \frac{f\gamma,z(y,z)}{f\gamma(y)}$$

POPG and Z are conditional and independent of AGDP = y for each fixed y value, so the modified null hypothesis H_0 indicates that the following relation is established:

$$Q \equiv E[fx,y,z(x,y,z)f\gamma(y) - fx,y(x,y)f\gamma,z(y,z)] = 0$$

Let $\hat{f}_w(W_i)$ denotes the local density function estimated value of the random vector W at W_i, as follows:

$$\hat{f}_w(W_i) = \frac{(2\varepsilon_n)^{-dw}}{(n-1)} \sum_{j,j\neq i} I_{ij}^{W}$$

where I_{ij}^{W}= I(||W_i -W_j || <ε_n), I(·) is the index function, and ε_n is the bandwidth parameter associated with the number of samples (n). When a local density function is given an estimation, the following test statistic is constructed:

$$Tn(\varepsilon n) = \frac{n-1}{n(n*2)} \cdot \sum_i (\hat{f}x,y,z(POPG_i, AGDP_i, Z_i)\hat{f}\gamma(AGDP_i) \;\; \hat{f}x,y(POPG_i, AGDP_i)\hat{f}\gamma,z(POPG_i, Z_i)$$

For Lx = Ly = 1, when $\varepsilon_n = Cn^{-\beta}(C > 0, \frac{1}{4} < \beta < \frac{1}{3})$, the statistic $T_n(\varepsilon_n)$ satisfies the following condition:

$$\sqrt{n}\frac{(T_n(\varepsilon_n)-q)}{S_n} \xrightarrow{D} N(0,1)$$

where $\xrightarrow{D}$ denotes the distribution convergence, and S_n denotes the estimated value of the asymptotic variance of $T_n(\cdot)$.

For this study, time series (annual) data were obtained from the CBN Statistical Bulletin and the World Bank World Development Indicators from 1981 to 2021. The variables used and their measurement are defined in the table below.

Table 1: Description measurement of the variables

Variable	**Indicator**	**Description**
Food Production (AGDP)	Agriculture, forestry, and fishing, value added (% of GDP)	This is an economic indicator that measures the contribution of these sectors to the overall economic output of a country. It represents the value of goods and services produced by the

		agriculture, forestry, and fishing industries, after deducting the cost of inputs such as seeds, fertilizers, and other materials.
Population Growth (POPG)	Population growth (annual %)	This indicator that measures the rate at which a population is increasing or decreasing over a period of one year. It is expressed as a percentage, and is calculated as the difference between the number of births and deaths in a population, plus the net migration rate (the number of immigrants minus the number of emigrants), divided by the total population, multiplied by 100.
Labour Force Participation (LFP)	Labor force participation rate, total (% of total population ages 15+) (modelled ILO estimate)	This is a measure of the percentage of the working-age population (those aged 15 years and older) who are either employed or actively seeking employment. This indicator is based on a modelled estimate by the International Labour Organization (ILO).
Inflation (INF)	Inflation, Consumer Prices (Annual %)	Inflation measured by consumer price index (CPI) is described as the change in the prices of a basket of goods and services that are typically purchased by specific groups of households.
Government Expenditure (GE)	Government Expenditure (% of GDP)	This is an economic indicator that measures the total amount of money a government spends on goods and services, expressed as a percentage of the country's Gross Domestic Product (GDP).
Exchange Rate (EXR)	Official Exchange Rate (LCU	Exchange rate is the price of one currency in terms of another currency.

	Per US$, Period Average)	
Bank Credit to Agriculture (DCA)	Deposit Money Bank Credit to Agriculture (% of GDP)	This is an economic indicator that measures the extent to which deposit money banks (DMBs) are providing credit to the agricultural sector of an economy. It represents the total value of loans disbursed by DMBs to the agricultural sector, as a percentage of the country's Gross Domestic Product (GDP).

Note: Authors' compilation (2023)

In order to achieve the objectives of this study using the specified model, the variables will be subjected to the test of stationarity using the Augmented Dickey-Fuller test which uses non-parametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms. The objective of this study which is to estimate the asymmetry causality relationship between population growth and food production in Nigeria will be accessed using the asymmetry causality based on Toda Yamamoto test. This utilizes a modified Wald test for restrictions on the parameters of a VAR (k) model (where k is the lag length in the system). Toda and Yamamoto proved that this test has an asymptotic $\chi 2$ distribution when a VAR (k+ d max) model is estimated (where d max is the maximal order of integration suspected to occur in the system). The advantage of this procedure is that it does not require knowledge of cointegration properties of the system. This test can be done even if there is no cointegration and/or the stability and rank conditions are not satisfied.

3. Analysis and Discussion of Results

The appropriateness of the method to be used for the empirical analysis in this study is based on the results, some pre-estimation test that were carried out to determine the correlation, stationarity and the cointegration of the variables.

Table 2 presents the correlation analysis result among the variables of this study. It shows the degree of association between agricultural output and population growth as well as other macroeconomic variables between 1981 and 2021.

Table 2: Correlation matrix

	AGDP	**POPG**	**LFP**	**DCA**	**GE**	**INF**	**EXR**
AGDP	1						
POPG	-0.1520	1					
LFP	0.6627	-0.0067	1				
DCA	-0.1463	-0.4248	0.0831	1			
GE	0.2521	-0.0559	0.5695	0.3731	1		
INF	0.0500	-0.2082	0.2449	0.5195	0.2216	1	
EXR	0.1792	-0.2093	-0.3190	-0.5112	-0.4276	-0.3418	1

Source: Authors' computation (2023).

The results as shown in Table 2 indicates that the Agricultural Output as a Percentage of GDP (AGDP) has a correlation coefficient of -0.1520 with POPG, indicating a weak negative correlation between agricultural output and population growth. This suggests that as the population grows, there is a slight tendency for agricultural output as a percentage of GDP to decrease. AGDP has a strong positive correlation of 0.6627 with Labour Force Participation Rate (LFP). This imply that a higher participation rate in the labour force is associated with a greater agricultural output as a percentage of GDP. This makes intuitive sense, as increased labour force participation can contribute to higher agricultural productivity. On the other hand, AGDP has a weak negative correlation of -0.1463 with DCA (Deposit Money Bank Credit to Agriculture), indicating that as bank credit to the agricultural sector increases, there is a slight tendency for agricultural output as a percentage of GDP to decrease.

There is also found a moderate positive correlation of 0.2521 between AGDP and GE (Government Expenditure as a Percentage of GDP). The implication of this is that higher government expenditure as a percentage of GDP is associated with a greater agricultural output. Increased government investment in agriculture can enhance productivity and stimulate growth in the sector. There is a weak positive correlation of 0.0500 between AGDP and INF (Inflation Rate) which indicate that as the inflation rate increases, there is a slight tendency for agricultural output as a percentage of GDP to increase. Similarly, AGDP has a weak positive correlation of 0.1792 with EXR (Exchange Rate). This implies that as the exchange rate increases, there is a slight tendency for agricultural output as a percentage of GDP to increase.

Thus, the correlation matrix provides insights into the relationships between the variables. It shows that labour force participation rate and government expenditure as a percentage of GDP are positively correlated with agricultural output as a percentage of GDP in Nigeria. While, population growth, bank credit to agriculture, inflation rate, and exchange rate show weak correlations, indicating that other factors may have a more significant influence on agricultural output.

The pre-estimation technique used examine the stationarity level of individual variables is the Augmented Dickey Fuller (ADF). It indicates whether the variables are stationary or non-stationary. This permits this study to determine the stationary level of the variable under study in order to suggest the appropriate technique to estimate the parameter coefficients. Intercept model is used to statistically find the significance of the variables at 1%, 5% and 10% critical point at levels and first difference. Furthermore, it should be noted that the lag length for ascertaining this stationarity level of our variables as well as unit-root test is automatic and optimally chosen by the Schwarz-Bayesian Information Criterion (SIC). The results of the unit root tests for the variables are summarized in Table 3.

Table 3: Summary of the ADF test

Variables	**At Levels**		**At First Difference**		**Order of Integration**
	ADF Test Statistics	**Test Critical Values**	**ADF Test Statistics**	**Test Critical Values**	
Agricultural Output as a Percentage of GDP (AGDP)	-2.562	-3.616	-6.965	-3.616***	I(1)
Deposit Money Bank Credit to Agriculture (DCA)	-1.490	-3.606	-6.088	-3.610***	I(1)
Growth of Population (POPG)	-1.311	-3.646	-4.759	-3.621***	I(1)

Labour Force Participation (LFP)	1.708	-3.610	-3.278	-2.939**	I(1)
Government Expenditure as a Percentage of GDP (GE)	-1.865	-3.610	-10.233	-3.610***	I(1)
Inflation (INF)	3.009	-2.937**			I(0)
Exchange Rate (EXR)	2.169	-3.610	-4.121	-3.616***	I(1)

Note: ***1%, ** 5%, level of significance. Calculated at trend and intercept and lag lengths selected automatically using the Schwarz Info Criterion. See results in appendix I for details
Source: Authors, 2023

The stationarity test results summarized in Table 3 shows that only INF was stationary at levels at 5% level of significance which suggest that at levels, the statistic of the variables is stationary and integrated of order zero, which imply that the variable converges to its long-run equilibrium or true mean at levels. While for other variables (AGDP, POPG. LFP, GE, DCA and EXR), as a result of their non stationarity at levels, they were subjected to further test at first difference where they were found to be stationary. Where AGDP, DCA, POPG, GE and EXR are stationary at 1% level of significance, LFP is stationary at 5% level of significance. The implication of this is that the statistic of the variable were stationary and integrated of the first order, hence a long-run equilibrium convergence.

To analyse the asymmetry causal relationship that exist between population growth and food production in Nigeria. The variables for this study were observed to be a mixture of I(0) and I(1), as a result, the asymmetry causality will be tested based on the Toda-Yamamoto (TY) causality test. The TY causality estimation requires an optimum lag length which in this study was obtained based on Akaike's Information Criterion (AIC) after running a VAR (2) model for the variables. From the VAR (2) result, the lag length criteria test was carried out. Based on the AIC, lag 7 was chosen as the optimal lag length as shown in table 4.4.

It is important to note here that this optimal lag length was obtained using three independent variables which are the positive change in population growth (POPG_POS), negative change in population growth

(POPG_NEG) and labour force participation (LFP). This is because the estimates when all the independent variables are included is unreliable as a result of the presence of serial correlation which violates the assumption of independence of errors. The result of this estimate is reported in the appendix IIa. Therefore, this study proceeds to estimate the asymmetry causality relationship between population growth and food production in Nigeria with food production measured by agricultural contribution to GDP (AGDP) as the dependent variable while the positive and negative change in population growth (POPG_POS and POPG_NEG) and Labour force participation are the independent variables.

Table 4: Lag order selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-12.60578	NA	3.22e-05	1.006411	1.187806	1.067445
1	138.1877	255.8920	9.19e-09	-7.162891	-6.255917	-6.857722
2	159.9792	31.69667	6.78e-09	-7.513889	-5.881335	-6.964584
3	180.4192	24.77577	5.86e-09	-7.782980	-5.424847	-6.989540
4	200.2398	19.22003	6.01e-09	-8.014535	-4.930823	-6.976960
5	239.4595	28.52343	2.40e-09	-9.421791	-5.612499	-8.140080
6	294.3396	26.60850	5.81e-10	-11.77816	-7.243285	-10.25231
7	445.4236	36.62643*	1.28e-12*	-19.9651*	-14.7046*	-18.19509*

Source: Authors' computation (2023).

The model was further tested for serial correlation among the variables of study before proceeding to carry out the causality test. The diagnostic autocorrelation LM Test was carried out to test for serial correlation. The result as presented in table in Table 5 the test statistic is not statistically significant, which provides evidence that the residuals are not autocorrelated.

Table 5: Autocorrelation LM test

Lag	LRE* stat	Df	Prob.	Rao F-stat	df	Prob.
1	24.35973	16	0.0819	2.058932	(16, 6.7)	0.1738
2	29.94339	16	0.0183	3.301820	(16, 6.7)	0.0612
3	11.52948	16	0.7757	0.553834	(16, 6.7)	0.8434
4	27.79857	16	0.0334	2.763945	(16, 6.7)	0.0929
5	7.435279	16	0.9639	0.302570	(16, 6.7)	0.9766
6	15.29423	16	0.5032	0.861148	(16, 6.7)	0.6241
7	19.21664	16	0.2576	1.284729	(16, 6.7)	0.3893

Source: Authors' computation (2023).

Having established the appropriateness of the estimation method, the asymmetry causality test based in the TY procedure was reported in the Table 6 below which depict the asymmetric causal relationship between population growth and food production in Nigeria.

Table 6: Asymmetric causality results based on TY procedure

Dependent Variables	Independent Variables					Direction of Causality
	AGDP	**POPG_POS**	**POPG_NEG**	**LFP**	**All**	
AGDP		26.950**	12.501***	24.497***	40.023***	POPG_POS, POPG_NEG, LFP→ AGDP (one-way causality)
POPG_POS	17.366***		42.700***	34.017***	125.137***	AGDP, POPG_NEG, LFP → POP_POS (one-way causality)
POPG_NEG	8.18581	8.77497		68.909***	127.747***	LFP→ POPG_NEG (one-way causality)
LFP	6.7007	1.5772	6.100		8.767	No Causality

Note: ***1%, ** 5% and * 10% level of significance
Source: Authors' computation (2023).

From the results presented in table 6, it can be seen that the analysis indicates a significant bi-directional causal relationship between positive population growth and food production in Nigeria. This means that an increase in the population growth rate has a direct impact on food production, leading to higher levels of production. It suggests that population growth can be considered a driving force behind increased food production in Nigeria. However, as a result of the return causality, food production also leads to an expansion in population growth. Hence, policies aimed at increasing food production can contribute to population growth in Nigeria.

Meanwhile, there was found a significant one-way causality from negative population growth to food production in Nigeria. This result implies that a decline in population growth rate can cause changes in food production in Nigeria. It suggests that a decrease in population growth could potentially have significant effects on food production in Nigeria.

Labour force participation rate (LFP) on the other hand was found to also exhibit a one-way causality to food production in Nigeria. This implies that a larger labour force actively engaged in the agricultural sector leads to higher productivity and, consequently, increased agricultural output.

Furthermore, negative population growth (POPG_NEG) was found to have a one-way causal relationship with positive population growth (POPG_POS). This means that changes in negative population growth can influence subsequent changes in positive population growth.

It was also found a significant positive one-way causality from the labour force participation rate to positive population growth (POPG_POS) and negative population growth (POPG_NEG). This indicates that an increase in labour force participation positively influences both positive and negative population growth. A larger labour force actively participating in economic activities contributes to population dynamics in Nigeria.

Meanwhile, none of the independent variables (AGDP, POPG_POS, POPG_NEG) have a significant causal effect on the labour force participation rate (LFP). This indicate that changes in agricultural output or population growth do not significantly influence the labour force participation rate in the agricultural sector. It is important to note that the coefficient for LFP is not statistically significant, indicating no causal relationship. This implies that there are other factors responsible for changes in LFP which may include wages and salaries. Hence, policies aimed at increasing agricultural output or population growth may not directly impact the labour force participation rate in Nigeria.

The stability of the model is further tested using the inverse roots of the AR characteristic polynomial which provide insights into the persistence or decay of autocorrelation in the time series.

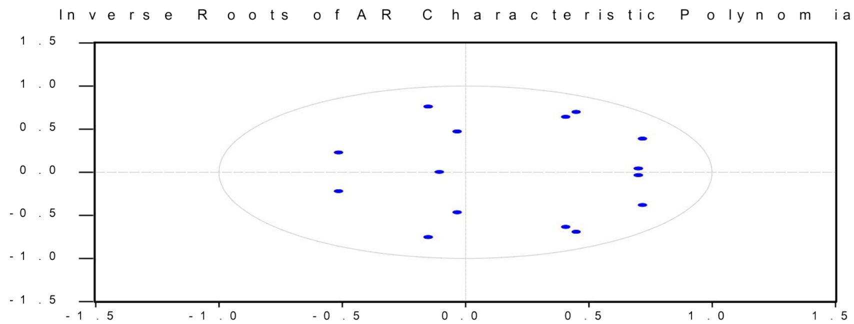

Figure 1: Stability test graph
Source: Authors' computation (2023)

Findings from the analysis revealed several important findings regarding the relationship between population growth, food production, and labour force participation in Nigeria. Firstly, there is a significant bi-directional causality between positive population growth and food production, indicating that population growth has a direct impact on food production, and vice versa. Additionally, negative population growth has a one-way causal relationship with food production, suggesting that a decline in population growth can affect food production in Nigeria. Furthermore, the labour force participation rate exhibits a one-way causal relationship with food production, indicating that a larger labour force engaged in agriculture leads to higher productivity and increased agricultural output. Moreover, negative population growth influences subsequent changes in positive population growth, and an increase in labour force participation positively affects both positive and negative population growth. However, changes in agricultural output or population growth do not significantly influence the labour force participation rate, suggesting that other factors, such as wages and salaries, play a more significant role in determining labour force participation in the agricultural sector. Therefore, policies aimed at increasing agricultural output or population growth may not directly impact the labour force participation rate in Nigeria.

These findings are in line past studied that also examine the relationship between population growth, food production, and labour force participation in Nigeria. Firstly, a study found a significant bi-directional relationship between population growth and food production, emphasizing the positive impact of population growth on agricultural output (Doering and Sorensen, 2018). Similarly, another study identified a strong positive association between population growth and agricultural productivity in Nigeria, highlighting the role of population dynamics in driving food production (Kousar, Ahmed, Pervaiz, and Bojnec, 2021) Furthermore, other scholars have also demonstrated the positive impact of labour force participation on agricultural output, affirming the notion that an increased labour force in the agricultural sector leads to higher productivity and improved food production (FAO, 2020).

In contrast, there are also studies that present opposing perspectives. One of such found no significant relationship between population growth and agricultural productivity in Nigeria. The study suggests that population growth alone does not directly translate into increased food production, indicating that other factors such as technology, infrastructure, and access to resources play a crucial role. Similarly, another study argued that the impact of population growth on agricultural productivity is contingent on various socio-economic factors, such as education, access to credit, and agricultural policies (Megan, 2018) The study highlighted the need for comprehensive and targeted interventions to maximize the potential benefits of population growth on food production. Additionally, scholars also found that labour force participation does not significantly influence agricultural output in Nigeria, contradicting the notion of a strong positive relationship between the two variables (Shaibu, 2023).

4. Conclusion

The study analysed the relationship between population growth and food production in Nigeria, emphasizing the country's challenges and potential solutions. Despite Nigeria's agricultural prowess, it faces diminishing food production levels due to various factors like climate variability and infrastructural inadequacies. With its population projected to exceed 400 million by 2050, the strain on food production infrastructure intensifies, leading to food insecurity and exacerbating malnutrition prevalence. The study integrates theoretical frameworks like the Malthusian theory with empirical evidence to examine the complex interplay between population dynamics and agricultural output. While the Malthusian theory suggests a potential imbalance between population growth and food production, empirical realities challenge this notion, emphasizing technological advancements and globalization's role in enhancing agricultural productivity.

The analysis employs econometric methods like the VAR model and Toda-Yamamoto causality test to examine the asymmetric causal relationship between population growth and food production in Nigeria. Findings reveal significant bi-directional causality between positive population growth and food production, indicating that population growth drives increased food production, and vice versa. Negative population growth also influences food production, suggesting that a decline in population growth can affect food production. Additionally, labour force participation positively impacts agricultural output, contributing to increased productivity and food production. These findings align with past studies but also highlight opposing perspectives, emphasizing the need for comprehensive interventions tailored to Nigeria's socio-economic context to maximize the potential benefits of population growth on food production.

It is therefore recommended that, given the significant bi-directional causality between population growth and food production, policymakers should implement strategies that promote agricultural output and maintain stable population growth. This can include initiatives to improve healthcare, education, and family planning services, which can contribute to a sustainable and well-supported labour force for the agricultural sector.

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