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EFFECTS OF POPULATION DYNAMICS ON AGRICULTURAL PRODUCTIVITY IN NIGERIA

OGUNNIYI LAUDIA TITILOLA
Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Email: ltogunniyi@lautech.com

TOROMADE ADEKUNLE STEPHEN*
Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
University of Nottingham, United Kingdom. *Corresponding Author Email: toromadeadekunle@gmail.com

ILORI ANUOLUWA LEAH
Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

ADEBAMBO MICHAEL AKANMU
Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Email: ademiposimichael1789@gmail.com

DAMILOLA TOBILOBA ADERETI
Augustana University, Sioux Falls, USA. Email: damilolatobiloba@gmail.com

Abstract

This paper examines how population change and agricultural output relate in Nigeria since 1980 and 2022. The aim of the research was to determine the trends in the fertility rates, mortality rates, net migration, and agricultural productivity; to determine both the short and the long-run determinants of agricultural productivity, and to determine the cause-effect relationship between agricultural productivity and its determinants. The results obtained with the help of various techniques such as descriptive statistics, unit root tests, the Autoregressive Distributed Lag (ARDL) model, cointegration tests, the Error Correction Model (ECM), and Granger causality tests showed that the average Agricultural Total Factor Productivity (AgTFP) was 93.76, the fertility rate was 6.11 births per woman, and the life expectancy was 48.6 years. The net migration was 63,369.58, primary school enrolment was 90% of gross enrolment and rural population constituted 62.99% of the total population. The cointegrating test proved the presence of long-term relationship between the variables. The analysis over the long term showed that net migration had a positive impact on AgTFP, whereas the effect of the rural population and the openness of the economy to trade was negative. In the short term, the result of AgTFP and fertility rate of last year influenced negatively the present AgTFP, and so did the present rural population and the past year openness of the trade. The ECM showed that it had an adjustment rate of 75.6% per annum to the long-term equilibrium. The Granger causality tests indicated that AgTFP Granger-causes fertility rates. The results highlight the complexity of the relationship between population dynamics and agricultural productivity, and therefore the need to have combined policy intervention to ensure the promotion of sustainable agricultural development in Nigeria.

Keywords: Population, Agricultural Productivity, Dynamic, Fertility Rate, Food Security.

INTRODUCTION

As the most populated country in Africa, Nigeria is faced with immense problems in attaining food security in the face of growing population. The strain on the agricultural sector to sustain the food demand of the growing population is now more than ever, given the forecasts of a population of about 400 million in 2050 (Gabriel et al., 2023; Wudil et al., 2023).

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Agricultural sector which is the source of around 42.05 per cent of Gross Domestic Product (GDP) in the country and employs more than two-thirds of the labour forces are subjected to enormous challenges in order to keep up with these demographic changes (Obayelu et al., 2017). Nigeria is a country with dire concerns in its agricultural output due to the pressures of population increase, determined by high fertility and mortality rates and changes in migration patterns.

In the past, fertility rates in Nigeria were high and averaged 5.3 births per woman in recent years (World Bank, 2021), thus putting a burden on the agricultural resources; family sizes increased, thus putting pressure on land, water, and financial resources (Awa et al., 2021). At the same time, there is the tendency of rural-urban migration, young and able-bodied people migrate to urban regions to get better economically, thus reducing the number of people doing agricultural work, and this results in the reduction of productivity in the rural regions (Okpala et al., 2021). The current reduction in the productivity of agricultural production causes serious and alarming concerns about food security, worsening the poverty and unemployment issues the entire country (Fasoyiro & Taiwo, 2012; Ikuemonisan et al., 2022; Toromade et al 2024).

Although there has been a lot of literature regarding the form of interrelationship between population dynamics and agricultural productivity, a lot of gaps are still present in how to relate agricultural productivity with population dynamics within the context of Nigeria. In the past, scholars concentrate mostly on single elements of the demographics without an overall systemic interaction between fertility, mortality, migration, human capital, and farm productivity (Adeyemi et al., 2021; Mbah et al., 2020). Furthermore, empirical evidence on the dynamics of the determinants of agricultural productivity in Nigeria is limited (both in the short-run & the long-run). This study is important because it enables policymakers to come up with comprehensive approaches to tackle food insecurity besides encouraging agricultural sustainability.

In order to fill the above gaps, the research tries to analyse the relationship that exists between population dynamics and agricultural productivity in Nigeria by undertaking an in-depth study. The main research question that will be used to conduct this study is the following: what is the impact of population dynamics (fertility rates, mortality rates, & migration) on agricultural productivity in Nigeria? Based on this general question, the main objectives of the study can be summarised as follows: to examine the trends in the fertility rates, mortality rates, net migration, and agricultural productivity in Nigeria between 1980 and 2022, identify the short-run and long-run determinants of agricultural productivity in the country, and analyse how agriculture products relate to the determinants of agricultural productivity with particular focus on the effect of population dynamics. The results of this study would add to the literature already available in the field by giving a clear understanding of the complex relationship between population dynamics and agricultural productivity thus acting as a guideline to stakeholders and policymakers in Nigeria.

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The study also seeks to enlighten the targeted policy interventions that can be used to meet the food security needs as well as the economic growth of agricultural operations by identifying the dimensions of the population dynamics that have a great impact on agricultural productivity.

To put the discussion into context, the frameworks that support this research are based to a large extent by the Malthusian theory, the demographic transition theory (DTT), and the dependency theory. The theory of Malthusian assumes that uncontrolled increase in population will eventually surpass the food production capacities, resulting in the depletion of resources (Kucher et al., 2020). This is a relevant view considering the historical dynamics of a high fertility rate in Nigeria and a stagnant agricultural production dimension that is likely to trigger an outbreak of food insecurity in the event that no modernity practices are implemented.

On the other hand, the demographic transition theory proposes that with industrialization, there are shifts between high mortality and fertility rates and low rates, which is demonstrated in developed economies (Nkwede & Ugwoke, 2020). Most importantly though, in Nigeria, the anticipated fertility decline has not followed through with population growth implying that it will not be following the normal DTT curves. This contrast emphasizes the peculiar socio-economic issues that Nigeria has to deal with, which is the reason why this research is relevant. And, finally, dependency theory focuses on the effect of the migration process on agricultural productivity, especially in economies dependent on agriculture to support economic stability (Oyinloye et al., 2021). Rural-urban migration causes agricultural labour shortages, which explains how demographic changes can impair agricultural production and destabilize socio-economic balance.

Considering this theoretical framework, it is clear that the extent of study on individual components of population dynamics is quite extensive, but limited on the level of empirical research that concurrently studies the impact of fertility, mortality, migration, and agricultural productivity on each other is limited in Nigeria. The state-of-the-art literature largely overlooks the complex associations between these variables and tends to treat them outside of the greater context of growth and societal socio-economic contexts that underpin the development of the agricultural sector in Nigeria (Adewale et al., 2024).

Moreover, even though previous studies have managed to identify major demographic influences on agricultural productivity, research studies that identify the variances in productivity outcomes in a holistic way based on panel approaches is limited. Such interconnections are important to understand the challenges that the agricultural sector of Nigeria is currently facing and how to deal with the challenges needing urgent attention due to rapid demographic changes.

Empirical studies have also been conducted on the implication of population dynamics in relation to the agricultural productivity showing that there exists the complex interrelationship, which is different in contexts. Researchers in Nigeria have reported that fertility rates may negatively affect agricultural productivity because they cause strain on

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resources and decrease in investment in agricultural development (Awa et al., 2021). As an example, the same analysis by Adeyemo et al. (2022) found that productivity indices are lower in regions with higher fertility rates and attributed the decrease to the fact that resources are allocated to more and more dependents.

The role of migration should not be underrated as well. Research has shown that the long-term net migration patterns have serious implications on the agricultural productivity. Indicatively, Banjo et al. (2020) established that skilled migration has the capacity to boost agricultural production through improved access to skilled labour and diversification of the workforce with a range of skills that can support the introduction of modernisation in the farming industry. According to their findings, migrant remittances are also contributory towards agricultural investments on the household level, hence increasing productivity.

In the meantime, Mbaha et al. (2020) performed an extensive work examining how the rural population dynamics affect agricultural performance. Their findings revealed that with the increase in the rural population, the strain on the available land resources increases and this results in decreasing returns. This is in accordance with the idea that an increased rural population may offer more labour force in the short run, but in the long-term will impose pressure which contributes to a decline in agricultural productivity (Adeyemi et al., 2021).

Additionally, researchers have investigated the impact of socio-economic aspects including education, resource availability on farm output. As an example, Umo (2021) emphasised the fact that the higher the number of students who enrol in primary school, the more efficient the agricultural performance, which may be due to the fact that education increases skills and knowledge of farmers, making them able to use more effective farming methods and increase yields. This highlights the importance of human capital development in supporting agricultural development in dynamic population dynamics.

Another critical sphere of inquiry in literature is the effect of the openness of trade. Trade policy which allows free entry to the market may significantly influence the productivity of agriculture by bringing competition and encouraging the import of new agricultural technology. In some instances, Onwe et al. (2021) discovered that trade openness shows adverse correlation with agricultural productivity, which is mainly because of the rise in dependence of imported food that can weaken local production capabilities.

Moreover, different econometric models have been used to study these relationships in empirical studies. The popularity of autoregressive Distributed Lag (ARDL) models in conducting this task is because they are powerful tools that can be used to test relationships between non-stationary variables over a long period (Nkoro & Uko, 2016). As applied to Nigeria, the ARDL models have helped to get insights into the dynamic characteristics of agricultural productivity and its determinants over the long and short run, including migration, fertility rates, and rural population (Ezeabu et al., 2022).

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METHODOLOGY

The given study is devoted to Nigeria, a country in West Africa, which borders Benin, Niger, Chad, and Cameroon, and its south borders the Gulf of Guinea (Adewale et al., 2024).

Nigeria with a size of 923,768km^2 is characterized by different ecological regions such as semi deserts in the north and tropical rainforests in the south. The nation is a federal constitutional republic that is subdivided into 36 states and its Federal Capital Territory, Abuja.

The population of Nigeria has increased very fast and can be considered the most populous country in Africa as it was 88.9 million in the year 1991 and 193.4 million in the year 2017 (Gabriel et al., 2023).

The agricultural production activity is done by around 70% of the population but the sector has shifted to both a net exporter to a net importer of food mainly because of the demands of the rapid demographic changes (Li et al., 2023).

Data Collection

In this study, the secondary data was used, including the time series observations between 1980 and 2022. The data sources are Agricultural Total Factor Productivity (AgTFP): The data was taken out of the Central Bank of Nigeria Statistical Bulletin, AgTFP is a ratio of the agricultural output in the country and agricultural input, which indicates the level of productivity in this sector.

Fertility Rate (FR): Sourced in the same World Development Indicators (WDI) database, fertility rate is measured as a number of live births to every 1000 women between the ages 15-49 years.

Life Expectancy (LE): The life expectancy is also a data provided by WDI, and it is the average number of years during which a newborn can expect to live. Net Migration (NM): This variable is the annual net movement of the population of the country following migration and it was sourced at the United Nations Department of Economic and Social Affairs (UN DESA).

Primary School Enrolment (PSE): This indicator is used to indicate the educational access, and this could affect the agricultural productivity because of the percentage of gross enrolment which is based on UNESCO Institute of Statistics.

Gross Capital Formation (GCF): According to WDI percentage of gross capital formations, the percentage of GDP that is invested in the economy is shown. Trade Openness (TROP): TROP is an indicator that is measured on the basis of exports and imports as a ratio to the GDP and it delivers the information about the integration of the country with the international markets.

Rural Population (RPOP): This is a percentage of the entire population in the rural regions obtained through the WDI.

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Variables and Model Specification

All variables have been measured very carefully and were relevant and consistent to be analysed: AgTFP was measured using the ratio of total output index to the total input index. Calculation of Fertility rate took the crude birth rate. The life expectancy was a value in years, Net Migration was a numerical figure, and GCF was a percentage of GDP. Primary School Enrolment was expressed as a percentage of the gross enrolment; Trade Openness was expressed as a ratio and Rural Population was expressed as a percentage of the total population.

The main aim of the study was to measure the impacts of population dynamics in agricultural productivity in Nigeria. To examine such a relationship, the econometric model was as follows:

$$LNAgTFPt = \alpha + \beta_1 LNFRt + \beta_2 LNLEt + \beta_3 LNNMt + \beta_4 LNPSEt + \beta_5 LNGCFt + \beta_6 LNTROPt + \beta_7 LNRPOPt + \varepsilon t$$

In this model, LNAgTFP represents the natural logarithm of Agricultural Total Factor Productivity, LNFR denotes the Fertility Rate, LNLE is Life Expectancy, LNNM stands for Net Migration, LNPSE signifies Primary School Enrolment, LNGCF indicates Gross Capital Formation, LNTROP refers to Trade Openness, LNRPOP represents Rural Population, and εt is the error term.

Data Analysis Techniques

Descriptive and Graphical Analysis: Descriptive statistics were initially calculated by each variable, in order to summarize the basic features of each variable (mean, median, standard deviation, etc.). Time series plots demonstrated the trend of variables by plotting the data over the period of study including AgTFP, fertility rate, life expectancy, net migration and others.

Unit Root Testing: In order to test the stationarity of the time series data, the Augmented Dickey-Fuller (ADF) test was used. This test has a null hypothesis that the underlying time series is non-stationary, meaning that it has a unit root (Sinha et al., 2021). The test is appropriate to determine the higher-order correlations of time series data (Lin et al., 2018).

Autoregressive Distributed Lag (ARDL) Model: Since the integration of the various variables varied, the ARDL modelling methodology was used to examine the long and short-run relationships. The model is popular due to its flexibility and the possibility to find dynamic relations between variables (Natsiopoulos & Tzeremes, 2022).

Test of Cointegration Testing: A Bounds Test of Cointegration, was done after estimation of ARDL estimation was done to determine the existence of long-run relationships between the variables (Pesaran et al., 2001). The determination of cointegration is a sign of a long-term stable equilibrium relationship.

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Error Correction Model (ECM): After detecting the cointegration, the ECM was used to portray the short-run dynamics and approximate the process of adjustments to the long-run equilibrium. A short-term imbalance that exists among the variables can be corrected using the ECM (Engle & Granger, 1987).

Post-Estimation Diagnostic Tests A collection of diagnostic tests was conducted to measure model estimate reliability. They were: The Breusch-Godfrey LM test of serial correlation, Breusch-Pagan test of heteroscedasticity to test whether the error variance has been constant, Jarque-Braun test of the correctness of specifications, Ramsey RESET test of specification correctness, CUSUM test of stabilization of parameter estimates (Akewugberu et al., 2024).

Granger Causality Tests: To further discuss causal relationships between variables, Granger Causality Tests were used. This test will determine how the past values of one variable can be used to predict the future values of another variable with the feedback relationship that was considered.

Ethical Considerations

The research paper takes advantage of the secondary data collected using the publicly available databases hence adhering to the ethical research practices. No personalized or recognizable data were gathered and all the data collection and analysis were undertaken in an open manner.

RESULTS AND DISCUSSION

Descriptive Statistics

As the first descriptive statistics, summarized in Table 1, would help to see the core features and distributions of the variables being studied. The first observation is the large range between the minimum and maximum values of all the variables used in this study.

The average Agricultural Total Factor Productivity in Nigeria is 93.76 and the average fertility rate is found to be 6.11 births per woman. The average life expectancy at birth during the period is 48.6 years. The mean value of net migration is 63369.58 which is an inflow or outflow of people. There is high enrolment in primary education with the averages of primary school enrolment being 90% of gross enrolment. It has a rural population of 62.99 as a percentage of the total population thus indicating that the rural population is quite significant in the country. The percentage of gross capital formation to GDP is 15.31 on average which indicates the amount of investment in the economy. Finally, the average of openness to trade is 16.61.

The additional calculation on skewness shows that the five variables life expectancy of the variable, net migration, primary school enrolment, gross capital formation and trade openness has positive or right skewness. On the other hand, the Agricultural Total Factor Productivity, fertility rates and rural population are skewed negatively which means that the tail of the distributions is long on the left-hand side.

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Table 1: Descriptive statistics

	AGTFP	FR	LE	NM	PSE	GCF	RPOP	TROP
Mean	93.75897	6.110419	48.61240	63369.58	90.99301	15.30858	62.98902	16.61649
Median	96.47519	6.116000	47.61900	43504.00	89.27564	15.13986	64.33100	13.80143
Maximum	110.2584	6.847000	52.91000	507539.0	113.1457	27.49712	78.03000	49.63853
Minimum	71.89253	5.237000	45.48700	4194.000	76.46310	10.21161	46.47900	4.957568
Std. Dev	11.78950	0.440589	2.676244	78426.32	9.340298	4.268010	9.333595	11.22025
Skewness	-0.670845	-0.301515	0.358196	4.430775	0.769025	1.140492	-0.171348	1.496538
Kurtosis	2.191164	2.379590	1.498721	25.29924	2.918270	4.008303	1.857884	4.652906
Jarque-Bera	4.397370	1.341158	4.957643	1031.612	4.250625	11.14339	2.547517	20.94567
Probability	0.110949	0.511412	0.083842	0.000000	0.119396	0.003804	0.279778	0.000028
Sum	4031.636	262.7480	2090.333	27.24892	3912.699	658.2691	2708.528	714.5092
Sum of Sq-Dev	5837.679	8.152982	300.8158	2.58E+11	3664.129	765.0681	3658.872	5287.551
Observation	43	43	43	43	43	43	43	43

Testing for Unit Roots

Graphical Analysis

Visual trend analysis provides initial information related to the time behaviour of the variables. As Figure 1 shows, the trend of Agricultural Total Factor Productivity is fluctuated with time.

It started with a lower value, traversed a constant rise, especially in the 15-year mark, with a rising and falling trend until some 35 years mark and then notably rose. The trend suggests that there is inefficiency in agricultural production, and as a whole, it has an upward trend in the long run.

Figure 1: Trend of Agricultural Total Factor Productivity

Figure 2 of the fertility rate shows a steady decrease in the fertility rate throughout the period of study, with a high of 7.2, and a low of less than 5.6 at the end of the graph. This implies a declining mean childbearing. The cause of this trend might be associated with the availability of education, family planning campaigns, or urbanization (Geng, 2024; Okoye & Pongou, 2023).

Figure 2: Trend of Fertility Rate

In Figure 3, the life expectancy depicts evident pattern of increase starting at approximately 50 years, gradually increasing to over 70, and finally, oscillating at approximately 75 years. It shows that the average lifespan has increased over the years, which is probably possible because of modernization in healthcare and sanitation, as well as in living conditions in Nigeria (Chen et al., 2023).

Figure 3: Trend of Life Expectancy

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The trend of net migration as in Figure 4 is negative. Beginning with the high point at about 25 (which was presumably thousands or tens of thousands), it suddenly falls to less than -25, and then oscillates around -20. This implies that the population outflow in the region is always higher compared to the inflow. This adverse net migration may have an economic, security-related, or better opportunities abroad (Mbaha et al., 2016).

Figure 4: Trend of Net Migration

The trend in the enrolment to primary school as shown in Figure 5 is fluctuating. It started towards the top with a steep fall to an approximate of 85, after which it goes up to an approximate of 105 then follows a downward trend with slight rise and finally ends slightly above 80. These variations may reflect the alterations in policy or economic changes or the different degrees to access education between the years (Chen et al., 2023).

Figure 5: Trend of Primary School Enrolment

In Figure 6, gross capital formation is also showing a trend of fluctuation. It began low, then modified slightly, and then undergoes a number of rises and falls before taking a sharp rise after the 30-year mark of the X-axis. It starts to decrease after reaching the 37 years point. The economic policies, confidence of investors, and the economic conditions affecting Nigeria can be attributed to this volatility in capital formation (Adewale et al., 2024).

Figure 6: Trend of Gross Capital formation

The openness to trade indicated in Figure 7 depicts that the extent of openness has decreased over the years between the 0 and the 15-year segments between a high of approximately 50 to a low of close to 10. After that, it increases slightly to reach a peak of about 25 years old and then goes up and down showing a negative direction. Alterations in the openness to trade may be an indication of changing national trade policies, international trade agreements, or national economic priorities (Onwe et al., 2024).

Figure 7: Trend of Trade Openness

And, finally, rural population trend, which Figure 8 shows, shows a gradual decrease with time, beginning with some 80 per cent and gradually falling below 55 per cent as we proceed on the X-axis. This implies that the ratio of the citizens living in rural regions is steadily declining. This is a typical situation in developing nations, which can be explained by the rural to urban migration in the pursuit of improved economic prospects and social resources (Ayinde et al., 2014; Mbah et al., 2016).

Figure 8: Trend of Rural population

Unit Root Test

The formal unit root tests, detailed in Table 2, provide a statistical basis for assessing the stationarity of the time series variables.

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Table 2: Unit Root Test Results

Variable	t-statistic	test statistics		Critical		Order of integration
	Levels	1st diff.	1%	5%	10%	
AgTFP	0.572 (0.835)	-2.572* (0.011)	-2.637	-1.951	-1.611	I (1)
FR	-2.868 (0.184)	-3.579* (0.045)	-4.244	-3.544	-3.204	I (1)
LE	-2.810 (0.203)	-1.120 (0.912)	-4.244	-3.544	-3.204	I (2)
NM	-5.361* (0.000)	-6.106* (0.000)	-4.199	-3.524	-3.193	I (0)
PSE	-4.148* (0.012)	-4.879* (0.002)	-4.244	-.544	-3.204	I (0)
GCF	-3.043 (0.133)	-6.077* (0.000)	-4.192	-3.520	-3.192	I (1)
RPOP	-1.167 (0.904)	-7.854* (0.000)	-4.199	-3.524	-3.193	I (1)
TROP	-1.506 (0.812)	-5.558* (0.000)	-4.198	-3.524	-3.193	I (1)

Source: Researcher's computation, 2024

*Notes: Probability values are shown in parenthesis, * represents statistical significance at 5%*

The results indicate that Agricultural Total Factor Productivity, fertility rate, gross capital formation, rural population, and trade openness are not statistically significant at the 0.05 level when tested at their levels. This implies that their probabilities are greater than 0.05, leading to the conclusion that these variables are non-stationary at levels. These variables were found to be stationary after first differencing, thus being integrated of order I (I).

Net migration and primary school enrolment, however, emerge as stationary at levels (I). Life expectancy presents a unique case, as it is found to be neither stationary at levels nor at first difference, but rather stationary at second difference, i.e., integrated of order I. Consequently, life expectancy cannot be utilized for further analysis within the ARDL framework, which typically accommodates variables integrated of order I or I (Nkoro & Uko, 2016).

This finding implies that life expectancy exhibits a more complex non-stationary behaviour, requiring different econometric approaches if it were to be directly included in an ARDL model.

Cointegration Tests

Optimum Lags Selection

The initial step in applying the Autoregressive Distributed Lag model involves selecting an appropriate lag length for the model. As detailed in Table 3, various criteria from the Vector Autoregression model were considered for lag selection. Specifically, the Sequential Modified LR test statistics, Final Prediction Error, and Akaike Information Criterion all suggest an optimum lag of two.

In contrast, the Schwarz Information Criterion and Hannan-Quinn Information Criterion indicate an optimum lag of one. Given that most of the criteria recommend two lags, and considering the underlying time series comprises 40 observations, a lag length of two was selected as the appropriate optimum for this study.

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This choice aims to avoid under-parameterization and ensure the robustness of the model, which is a critical consideration in ARDL modelling (Kripfganz & Schneider, 2023; Natsiopoulos & Tzeremes, 2022).

Table 3: VAR Lag Order Selection

Lag	LogL	LR	FPE	AIC
0	193.8419	NA	2.07e-13	-9.342097
1	552.4419	573.7600	4.07e-20	-24.82210
2	615.7238	79.10240*	2.51e_20*	-25.42312*
3	662.4625	42.06477	5.59e-20	-25.42312
* Indicates lag order selected by the criterion				
LR: sequential modified LR test statistics (each test at 5% level)				
FPE: Final prediction error				
AIC: Akaike information criterion				
SC: Schwarz information criterion				
HQ: Hannan-Quinn information criterion				

ARDL Model

The application of the ARDL model proceeded with the estimation of both long-run and short-run relationships, along with diagnostic tests to ensure model validity.

Bound Test

The Bound Test for Cointegration was conducted to ascertain the presence of a long-run equilibrium relationship among the variables. As presented in Table 4, the F-statistic generated from the test is 3.921. This value exceeds the upper bound critical value of 3.61 at the 5% significance level. This result leads to the rejection of the null hypothesis of no cointegration between the dependent variable and the independent variables.

Consequently, the alternative hypothesis of cointegration is accepted, indicating that fertility rate, net migration, primary school enrolment, gross capital formation, rural population, and trade openness are indeed bound together in a long-run relationship with agricultural total factor productivity. This confirms the existence of a long-term equilibrium among these crucial demographic and economic factors and agricultural output (Engle & Granger, 1987).

Table 4: ARDL Bound Test for Cointegration

Null Hypothesis: No Levels Relationship

Test Statistics	Test values	10% I (0)	Critical I (1)	5% I (0)	Critical I (1)	1% I (0)	Critical I (1)
F-statistics	3.921	2.12	3.23	2.45	3.61	3.15	4.43

Source: Researcher's computation, 2024

Long-Run ARDL Estimate Model

The results of ARDL regression of the study in the long run, estimated by using unrestricted constant and no trend are showed in Table 5.

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The results show that the net migration has a positive and significant impact on agricultural total factor productivity at 5% level of significance. It means that an increase in net migration by one unit leads to an increase in agricultural total factor productivity by 0.02 units in the long term. Such positive association may imply that migration especially when it introduces skilled labour or occupies labour gaps may lead to agricultural output (Mbah et al., 2016).

On the other hand, rural population has negative and statistically significant impact on agricultural TFP at 10% level of significance in the long run. With other things held constant, an increase in the rural population of one unit is linked to a corresponding reduction in agricultural TFP of about 1.08 units in the long run. This rural population negative effect on agricultural TFP may reflect a push on many rural land resources and agricultural infrastructures, which results in reducing returns (Eririogu et al., 2020; Obayelu et al., 2017).

In addition, it is noted that there is a negative and significant correlation between trade openness and agricultural total factor productivity. This means that a one unit rise in trade openness is related to the drop in agricultural total factor productivity in the long run by 0.18 units. The difference may be explained by the competition of imported agricultural products or a change in the domestic production of some crops because of the international market influence (Onwe et al., 2024). All other independent variables that were added to the model were not statistically significant even at 10% degree.

Table 5: Long run ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNFR	0.453	1.110	0.408	0.687
LNNM	0.023	0.009	2.460**	0.021
LNPSE	0.141	0.101	1.398	0.174
LNGCF	-0.105	0.066	-1.608	0.120
LNRPOP	-1.080	0.602	-1.794*	0.085
LNTROP	-0.176	0.021	-8.465***	0.000
=EC = LNAGTFP- (0.4529*LNFR+0.0230*LNNM+ 0.1413*LNPSE -0.1053 *LNGCF – 1.0801*LNRPOP -0.176*LNTROP)				

Source: Researcher's computation, 2024

*** means significant at 1%, ** means significant at 5%, * means significant at 10%

Akaike Information Criterion

The ARDL model that was chosen had the best information in terms of AIC. In particular, Agricultural Total Factor Productivity was chosen to have two lags, fertility rate to have two lags, net migration to have zero lags, primary school enrolment to have one lag, gross capital formation to have zero lags, rural population to have one lag and trade openness to have two lags, according to the AIC. The lag form is essential in identifying the dynamic associations among the model variables correctly (Kripfganz & Schneider, 2023; Natsiopoulos & Tzeremes, 2022).

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Short-Run

According to Table 6, the short-run ARDL estimation findings have shown that there is a negative and significant relationship between the agricultural TFP of the last year and the present year AgTFP in Nigeria at the 10% level of significance. This means that, holding other things constant, an increase in the past year AgTFP by one unit will cause a short-run reduction of 0.23 units in the AgTFP of the present year.

This may indicate the short-term cyclical impacts, or a sluggish adjustment process in agricultural output. Also, fertility rate in the preceding year also shows a negative and significant effect on agricultural total factor productivity at the 1 per cent level.

This indicates that an extra birth per woman in the previous year will lead to a decline in the agricultural total factor productivity of 3.74 units.

This observation adds to the idea that an increased fertility level in the short run can put household resources under pressure and shift labour off productive agricultural production, thereby affecting the productivity negatively (Geng, 2024).

On the other hand, the rural population this year has direct and significant effect on Agricultural TFP at 100% significant in the short run where an increase in rural population by one unit will increase the agricultural total factor productivity in Nigeria by 11.77 units.

This short-run, when contrasted with the long-run, counter-intuitive outcome, perhaps represents an immediate supply of labour in rural locations that can be utilised in agricultural activities despite the negative impact of increased rural population in long-run on resources.

This may also underscore the difficulty of measuring the short-term effect of such a variable as rural population that is frequently related to the long-term demographic changes.

Besides, the correlation between agricultural total factor productivity and trade openness last year is positive and statistically significant at the 5% level, which means that the increase in a unit of trade openness in the past year will increase agricultural total factor productivity by 0.06 units in the short run.

This gives an indication that within a short period, higher levels of openness to trade may spur agricultural production due to availability of new markets or factors of production.

The negative coefficient of the error correction term, that is less than one and statistically significant at 5% level indicates the rate of returning back to the long-run equilibrium. Its negative value of -0.756 means that the whole system can adjust itself to eliminate its disequilibrium and be back to the long-run equilibrium at the speed of 75.6% per annum.

The high and statistically significant error correcting term shows that the probability to restore the variables to their long-run equilibrium once there are any short-term shocks is high (Engle & Granger, 1987).

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Table 6: ARDL Short Run

ARDL Error Correction Regression

Dependent variable: D(LNAGTFP)

Variable	Coefficient	Std. Error	t-Statistics	Prob.
Constant	6.229	1.064	5.854	0.000
D (LNAGTFP (-1))	-0.233	0.121	-1.911*	0.067
D (LNFR)	1.956	1.311	1.492	0.148
D (LNFR (-1))	-3.744	1.329	-2.816***	0.009
D (LNPSE)	-0.056	0.081	-0.692	0.495
D (LNRPOP)	11.766	2.161	5.445***	0.000
D (LNTROP)	-0.026	0.029	-0.886	0.384
D (LNTROP (-1))	0.066	0.030	2.198**	0.037
CointEq (-1) *	-0.756	0.130	-5.812***	0.000

R- Squared	0.682307	**Mean depend. Var**	0.009758
Adjusted R- Squared	0.602884	S.D depend. Var	0.047445
S.E. of regression	0.029898	Akaike info criterion	-3.990841
Sum squared resid	0.028605	Schwarz criterion	-3.614191
Log likelihood	90.81225	Hannan-Quinn Criter	-3.853868
F-Statistics	8.590775	Durbin-Watson stat	1.726003
Prob (F- Statistics)	0.000004		

Source: Researcher's computation, 2024

*** means significant at 1%, ** means significant at 5%, * means significant at 10%

Post-Estimation Diagnostic Tests for ECM

To ensure the reliability and validity of the estimates derived from the error correction model, several post-estimation diagnostic tests were conducted.

Serial Correlation

The Breusch-Godfrey LM test was employed to detect the presence of serial correlation in the model. As indicated by the results in Table 7, the probabilities associated with the F-statistic and the Obs*R-squared are greater than 0.05. This leads to the failure to reject the null hypothesis, which states that there is no serial correlation. Consequently, it is confirmed that autocorrelation is absent in the model, ensuring the unbiasedness and efficiency of the estimated coefficients, a fundamental assumption for reliable econometric inference.

Table 7: Breusch-Godfrey LM Test

Null hypothesis: No	Serial correlation		
F-statistic	1.865099	Prob. F (2,24)	0.1766
Obs*R-squared	5.515218	Prob. Chi-Square (2)	0.0634

Source: Researcher's computation, 2024

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Heteroscedasticity Test

Assuming that the homoscedasticity is maintained, meaning that the error term variance is the same in every observation is a key assumption to the validity of regression findings (Clar, 2023). The test used to test the heteroscedasticity was the Breusch-Pagan-Godfrey test. Table 8 indicates that the probability of F-statistic and the observed R-squared are both above 0.05. The implication of this result is that there is no heteroscedasticity in the model, and the null hypothesis of homoscedasticity cannot be rejected.

Thus, the mistakes of the Error Correction Model are considered homoscedastic. This lack of heteroscedasticity is significant since in the case of its violation, the standard errors of regression parameters may be biased and inconsistent and consequently, failure to infer correctly as a result of such significance tests and confidence intervals (Hayes & Cai, 2007; Long & Ervin, 2000; Rosopa et al., 2013).

Table 8: Heteroskedasticity test: Breusch-Pagan

Null hypothesis:	**Homoskedasticity**		
F-statistic	0.767698	Prob. F (14,26)	0.6920
Orbs*R-squared	11.99144	Prob. Chi-Square (14)	0.6070
Scaled explanation	3.523989	Prob Chi -square (14)	0.9977

Source: Researcher’s computation, 2024

Normality Test

The Jarque-Bra test was done to ascertain whether the residuals are normally distributed. The findings indicate that the probability value exceeds 10% meaning that the residuals are normally distributed. This meets a significant assumption of a variety of econometric analyses, especially inference and hypothesis testing.

Stability Test

CUSUM Test

CUSUM residual test was conducted to check the stability of the model and it was either suitable to make long-run decisions. The CUSUM plot of model is within the 5% critical limits. This aesthetic validation represents that the parameters of the model do not experience any structural imbalance throughout the study period. That is to say, all of the coefficients in the error correction model are consistent, which gives credence to the long-run inferences which are made using the model, and validates that it is robust in terms of policy analysis.

Linearity Test

Ramsey Reset Test was performed to determine whether the model was linear and perfectly specified. According to Table 9, the t-statistic, F-statistic and Likelihood ratio are not statistically significant (the p-values are larger than the widely used values of significance). This implies that the null hypothesis which states that the coefficients of the powers of the fitted values of the regression are equal to zero meaning that the model is

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correctly specified cannot be rejected. Thus, the model can be viewed as being linear and properly specified, which helps to support the validity of the functional form that was used in the analysis.

Table 9: Ramsey Reset Test

	Value	Df	Probability
t-statistic	0.210108	25	0.8353
F-statistic	0.044146	(1, 25)	0.8353
Likelihood	0.072335	1	0.7880

F-test summary	Sum of Sq	Df	Mean square
Test SSR	5.04E-05	1	5.04E-05
Restricted SSR	0.028605	26	0.001100
Unrestricted SSR	0.028555	25	0.001142

LR test summary	Value
Restricted LogL	90.81225
Unrestricted LogL	90.84841

Source: Researcher’s computation, 2024

Granger Causality Test

When there is a cointegration relationship, as it was previously established, the application of Granger causality tests will be essential in establishing the direction of causality relationships between the variables (Granger, 1969).

The Pairwise Granger Causality Tests were conducted to test the causal nexus of the independent variables to the agricultural productivity in Nigeria and Table 10 presents the results. One of the results is that the null hypothesis of no Granger-causality of agricultural total factor productivity on fertility rates is rejected at the 5% level of significance.

The findings reveal that agricultural TFP brings about fertility levels. It indicates that there is a strong causal correlation in which agricultural productivity can have an impact on demographics, in multiple ways such as economic, educational, or resource access, which could subsequently influence fertility behaviour (Geng, 2024; Okoye & Pongou, 2023). But, in the case of other relationships, the null hypotheses of no Granger causality were usually not rejected. To give an example, the findings indicate that net migration is not Granger caused by AgTFP and vice versa.

On the same note, primary school enrolment, gross capital formation, rural population, and trade openness do not seem to Granger cause AgTFP and vice versa at the traditional levels of significance of most of the pairs except the correlation between AgTFP and fertility rate. These results are subtle indications of the multifaceted nature of connections and indicate that some of them are direct, whereas others are indirect or mediated by other factors not directly measured in the pairwise tests.

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Table 10: Pairwise Granger Causality Test

Null Hypothesis	Obs	F-Statistics	Prob
LNFR does not Ganger Cause LNAGTFP	41	1.27930	0.2906
LNAGFP does not Ganger Cause LNFR	41	3.78530	0.0322
LNNM does not Ganger Cause LNAGTFP	41	2.19173	0.1264
LNAGTFP does not Ganger Cause LNNM	41	1.39521	0.2609
LNPSE does not Ganger Cause LNAGTFP	41	1.89469	0.1651
LNAGTFP does not Ganger Cause LNPSE	41	0.36345	0.6978
LNGCF does not Ganger Cause LNAGTFP	41	0.75836	0.4758
LNAGTFP does not Ganger Cause LNGCF	41	0.92990	0.4039
LNRPOP does not Ganger Cause AGTFP	41	2.14615	0.1317
LNAGTFP does not Ganger Cause LNRPOP	41	0.45740	0.6366
LNTROP does not Ganger Cause LNAGTFP	41	1.30205	0.2845
LNAGFP does not Ganger Cause LNTROP	41	1.06962	0.3538

DISCUSSION

The analysis shows that the net migration has a positive, statistically significant impact on the Agricultural Total Factor Productivity (AgTFP) in the long-run. In particular, a one unit rise in net migration correlates with a 0.02 unit rise in AgTFP. This implies that migration can either supply skilled labour or assist in bridging labour gaps hence contributing positively to agricultural output. Although the relationship in the long-run is proved to be beneficial, short-run processes are also examined. Nonetheless, information on the short-term impacts of net migration was not provided in the results in detail. It emphasizes the complexity of these dynamics, which implies changes in the effects across the time spans.

The Granger causality tests as well failed to show evidence to the effect that the net migration Granger-causes the AgTFP, or the other way around. It means that although migration can be beneficial in terms of farm productivity, the causation process might not be direct and have a direct impact on the productivity in the short run.

Economic implications of such findings are high. With Nigeria struggling with the issue of agricultural productivity, the correlation between net migration and AgTFP is positive, which gives emphasis on the role that migration has in promoting agricultural growth. Migration can also increase innovation, transfer of knowledge, and adoption of modern agriculture methods by recruiting talented people.

In addition, these lessons indicate that migration should be a crucial part of the agricultural development policies, which must be taken into account by policymakers. Assistance in the adaptation of migrants to the agricultural labour force might aid in the productivity growth, rise in food security, and rural development.

Thus, detailed policies that embrace the integration of migrants and maximize labour productivity in agriculture can greatly help Nigeria to develop economically and be able to withstand challenges as the agricultural industry continues to face numerous adversities.

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CONCLUSION

This paper has comprehensively addressed the complex correlation between population growth and agricultural output in Nigeria between 1980 and 2022. The results suggest that though population growth affects many factors of agricultural productivity, effects are multidimensional and multi-faceted. The analysis indicated that net migration has a positive impact on Agricultural Total Factor Productivity (AgTFP), on a long-term basis, which provides argument that migration would alleviate part of the adverse impacts of accelerated population growth by introducing more labour and skills.

Nevertheless, rural population size and trade openness were also found to be negatively affecting the AgTFP over the long run and making the current issues in agricultural sustainability and food security worse (Gabriel et al., 2023; Wudil et al., 2023). Also, the short-run dynamics showed that the AgTFP and the fertility rates of the previous years had a negative effect on the current productivity rates, which implies the necessity of specific interventions.

Error Correction Model (ECM) brought out a major adjustment process towards long-run equilibrium, which indicated that although it is not possible to avoid short-term fluctuations, a way in which productivity levels were regained existed. Generally, these findings highlight the urgency of combined policies that do not solely focus on the solutions to the problems associated with the population but encourage the development of agriculture.

Recommendations

This research consequently advised that advocacy of family planning programmes due to the adverse effect of high population rate on agricultural productivity, it is important that the Nigerian government should strengthen family planning programmes. With awareness campaigns and availability of reproductive health services, the families will be empowered to make informed decisions, which may lead to a decrease in the fertility level and pressure on agricultural resources (Okoye & Pongou, 2023).

In addition, the provision of better educational facilities and access in the rural setting can be used to increase human capital which will lead to productivity in the agricultural industry. Developing secondary and tertiary education can provide the rural labour force with skills and knowledge required to engage in the modern agricultural practices (Umar et al., 2022).

Also, consolidating Agricultural Policy Frameworks that emphasize on sustainability and productivity. Agricultural output can be enhanced by instituting policies that promote the use of technology, better methods of irrigation, and sustainable land use practices in response to the population pressures (Ikuemonisan et al., 2022). In addition, it would deter young people immigrating to cities by focusing on Urban-Rural migration to generate employment opportunities in the rural areas. The government can encourage young people to invest in agriculture by popularizing rural entrepreneurship and providing them with access to credit facilities (Okpala et al., 2021).

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Policy Implications

The implications of this research are based on the development of effective and integrated policies that should take into account the population life and the productivity of agriculture. The policymakers must be aware of the interdependence of the food systems and demographic trends to the stakes in case of the booming population of Nigeria. The results of the present study led to the following policy implications: Informed Policy Making: The research results an evidence-based policy should be developed by the informed policy makers and applied in the formulation of evidence-based policies to tackle the issue of population dynamics as well as agricultural productivity (Andam et al., 2023). The revision of current policies can be done through continuous research and analysis that will make these policies achieve developmental objectives.

Also, agricultural policies should be comprehensive and combine different inputs, such as education, health and economic development. The government can provide synergies that encourage sustainable agricultural development by encouraging the interaction between sectors (Ukwe, 2025). Furthermore, the negative impact of population growth on natural resources can be reduced by focusing on sustainable agricultural practices in the policy-making process. The policies would aim at better farming methods, decreased reliance on chemicals, and maintenance of ecological balance (Adeosun & Popogbe, 2020). Moreover, Agri-planning and monitoring and evaluation systems should be implemented to measure the efficiency of the agricultural policies under the population dynamics.

Feedback can be used to make changes on time in order to maximize the impact of the policy (Fasoyiro & Taiwo 2012). Lastly, to tackle the issue of population dynamics and the way it affects agricultural productivity, a multi-stakeholder strategy, which includes government agencies, the commercial sector, non-governmental organizations, and rural population, is necessary. The synergies can be improved through the joint efforts to resource distribution and program implementation (Obayelu et al., 2017).

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