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PUBLIC AGRICULTURAL EXPENDITURE, AGRICULTURAL PRODUCTIVITY, AND ECONOMIC GROWTH IN NIGERIA: THE INTERACTIVE EFFECT OF HUMAN CAPITAL AND TECHNOLOGY

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ABSTRACT

This study examined the interactive effects of public agricultural expenditure and selected components of agricultural productivity, human capital, and technology on economic growth in Nigeria over the period 1986–2024. The Fully Modified Ordinary Least Squares (FMOLS) technique was employed to address endogeneity and serial correlation issues associated with time-series data. The findings show that the interaction between public agricultural expenditure and human capital has a significant positive effect on economic growth, indicating that government spending becomes more growth-enhancing when supported by skilled labour, training, and capacity development. Conversely, the interaction between public agricultural expenditure and technology reveals a positive but statistically insignificant relationship, suggesting that inconsistent adoption may limit its long-term impact. The study recommends restructuring public agricultural expenditure toward productive investments in education and technology to enhance farmers' capacity, improve productivity, and promote sustainable economic growth.

Keywords: Public Agricultural Expenditure, Agricultural Productivity, Economic growth, Human capital, Technology, Nigeria.

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1. Introduction

Economic growth has attracted sustained attention in both theoretical and empirical literature for decades (Solow, 1956; Easterly & Levine, 2001; Shobowale et al., 2022). This attention stems from the premise that a nation's economic growth depends largely on the performance of several interdependent sectors within its economic system. Beyond the mobilisation of financial resources, however, a critical concern in growth planning lies in how available funds are allocated and channelled across these sectors. Given the interdependence among sectors, funds directed to one sector inevitably generate spillover effects on others, particularly those with strong structural linkages.

The linkage between the agricultural sector and economic growth is evident in the multifaceted roles the sector plays within the economy (Chiekezie et al., 2020). Johnston and Mellor (1961), as cited in Okoh et al. (2019), identified five key inter-sectoral linkages of agriculture: food supply, labour transfer, market expansion, domestic savings mobilisation, and foreign exchange earnings. These linkages underscore the strategic importance of agriculture in driving structural transformation and sustained economic development.

Despite its significance, the sector's contribution to national income has experienced a downward trend over time. Agriculture accounted for approximately 60% of national income in the 1960s, but this declined to about 18% by 1986 and remained below 25% in subsequent years, with few exceptions. Notable increases occurred in 2002 (36.965%), 2003 (33.827%), 2004 (27.23%), and 2009 (26.749%). However, the contribution stood at 22.7% in 2023 and further declined to 20.4% in 2024 (World Development Indicators [WDI], 2024). In response to this persistent decline, the Nigerian government has introduced several ad hoc programmes and initiatives aimed at improving agricultural productivity. These include Operation Feed the Nation (OFN) in 1976, the Green Revolution (GR) in 1980, the National Economic and Empowerment Development Strategy (NEEDS) in 2003, the Agricultural Promotion Policy (APP) in 2016, the President's Economic Diversification Initiative (PEDI) in 2017, various credit facilities for farmers, and the Structural Adjustment Programme (SAP) in 1986 (FAO, 2022; Mahmud, 2023).

Public expenditure on agriculture represents government allocation of financial resources to enhance productivity within the sector, with the ultimate aim of fostering economic growth (Agbana & Lubo, 2022). At the continental level, the Malabo Declaration of 2003 committed African nations to allocate at least 10% of their annual budgets to agriculture in order to achieve a minimum annual growth rate of 6% and reduce poverty by 2025 (Sikwese et al., 2024).

Notwithstanding these efforts, existing studies have largely overlooked the interactive effect of public agricultural expenditure with key components of agricultural productivity, particularly human capital and technology, on economic growth. The underlying premise of this interaction is that technological advancement in agriculture enhances economic resilience and supports sustainable growth. However, the effective utilisation of technology depends significantly on the availability of skilled and educated human capital. A major challenge facing the agricultural sector in Nigeria is the predominance of poorly trained and less-educated farmers. Only educated and skilled farmers can efficiently utilise available resources, maximise returns on government investment, improve productivity, increase farm income, and ultimately enhance government revenue and economic growth. This study, therefore, addresses this identified lacuna.

Research Question

What is the interactive effect of public agricultural expenditure and each of the two components of agricultural productivity (human capital and technology) on economic growth in Nigeria over the study period?

Objective of the Study

The specific objective of this study is to investigate the interactive effect of public agricultural expenditure and each of the two components of agricultural productivity, human capital, and technology on economic growth in Nigeria over the study period.

2. Literature Review

2.1 Conceptual Literature

Public expenditure refers to expenditure on government. Public expenditure is well known as government expenditure or spending by Adolf Wagner, a noted German fiscal theorist of the 19th century. The law stated that government expenditures tend to rise as the economy improves (Ugochukwu & Oruta, 2021). In most developing countries like Nigeria, adopting public expenditure as the most important policy instrument for promoting growth. It is widely acknowledged in the sense that public expenditure is used to improve technology, human capital, and infrastructure development necessary for growth. Also provides the incentives and enabling environment to promote private sector investments in order to further growth (Okere et al., 2019). Therefore, Public agricultural expenditure involves the financial resources allocated and spent by governments on various agricultural projects, programs, and initiatives. These expenditures

aim to strengthen agricultural development, enhance productivity, advance rural livelihoods, and address various challenges encountered by the agricultural sector (Ukpong et al., 2022).

According to Huang and Wang (2024), asserted that one of the main forces behind economic growth is agricultural productivity. Therefore, Alabi and Abu (2023) defined agricultural productivity as the ratio of agricultural outputs to inputs; a higher ratio is linked to better agricultural performance. Furthermore, agricultural productivity catalyzes overall economic growth by influencing rural incomes and providing resources for structural transformation (Dkhar & De, 2018). In addition, several key factors influence agricultural productivity, which include raw materials availability, socioeconomic factors, capital intensity, technology, and human capital.

Human capital directly influences agricultural productivity by affecting the way in which inputs are used and combined by farmers. Improvements in human capital affect acquisition, assimilation, and implementation of information and technology (Ukpong, 2021). Also, human capital creates the ability to absorb new technologies. Hence, human capital (health and education) is vital to economic growth and human development (Ofem et al., 2023).

On the other hand, Technology has a significant role in increasing agricultural productivity. The application of agricultural technology innovation has been proven to increase the productivity of agricultural businesses, which in turn can improve the welfare of farmers and the food security of farming households (Fatchiya et al., 2016; Novitasari, 2024). One important aspect in increasing agricultural productivity is agricultural mechanization, which aims to increase labour productivity, land and reduce production costs (Baiti et al., 2023). Also, Research increases the available technology; hence, public agricultural R & D expenditures are used as a proxy for agricultural technological change (Ukpong, 2021). Public agricultural R & D expenditure is a government-funded investment that is aimed at generating scientific knowledge, technologies, and innovations to increase agricultural productivity, sustainability, and food security (Ojukwu et al., 2025).

Economic growth is generally agreed as a necessity or a prerequisite for the achievement of economic development; it is a macroeconomic goal that every government strives to achieve and sustain (Megbowon et al., 2022). Thus, economic growth is the change in output of a nation over time. It reflects how healthy or vulnerable to shocks an economy is, as well as the size and productive capacity of a country (Shobowale et al., 2022). According to Nelson et al. (2025), economic growth is a fundamental concept in economics, reflecting an economy's capacity to produce goods and services that enhance the well-being of its population, particularly in the face of increasing numbers and diversity. Also, it can be viewed from the perspective of economic transformation, which connotes a move away from low-productivity to high-productivity growth (Oguwuiké, 2018). Thus, investing in agriculture is one of the most effective ways of promoting agricultural productivity, raising real incomes, reducing poverty and food insecurity, and enhancing environmental sustainability (Asmau, 2020).

2.2 Theoretical Literature

The Endogenous Growth Model

The study is centered on the endogenous growth model developed by Romer (1986) and Lucas (1988), which focused on the role of human capital from the outset as an independent source of increasing returns and divergence in growth rates between developing and developed countries. The endogenous growth theory model represents a significant advancement in economic thought, addressing limitations observed in traditional models such as the neoclassical growth theory. Unlike conventional viewpoints that attribute growth solely to external factors, the model redirects attention towards internal elements within an economy, particularly emphasising the significance of human capital, innovation, and knowledge in propelling long-term growth (Romer 1990; Adeyemo et al., 2024).

It places vital importance on human capital: the skills, knowledge, and expertise possessed by individuals. Thereby arguing that investments in education and training play a pivotal role in fostering economic growth by enhancing productivity. Subsequently, human capital augmented endogenous growth theory further established the role of human capital accumulation in driving long-term economic growth. This was developed by Lucas (1988), Romer (1990), and others. The theory postulates that investments in education, training, and skills development can enhance labour productivity, technological innovation, and overall economic performance. The mathematical representation of this theory can be depicted by the following production function:

$$Y = A(K, H) f(L, E) \quad 2.2$$

where Y represents output, A signifies total factor productivity (TFP), which captures technological progress and efficiency, K denotes physical capital, H represents human capital, L denotes labour input, E represents the level of technology, and F is the production function indicating the relationship between inputs and output. However, the inclusion of human capital (H) as a determinant of output reflects the key tenet of human capital augmented endogenous growth theory, emphasising the importance of education and knowledge accumulation in fostering economic growth.

Consequently, the critics of the endogenous model often target its reliance on the assumption of increasing returns to scale, commonly utilized in models like that of Romer (1990) and Lucas (1988) to generate sustained endogenous growth. They argued that this assumption may lack empirical support in many industries and could lead to unrealistic predictions about the long-term behavior of the economy. Furthermore, the presence of increasing returns to scale might exacerbate income inequality and market distortions, undermining market efficiency and potentially impeding economic growth. Therefore, the

model provides a comprehensive framework for understanding economic growth patterns, particularly within agriculture, highlighting the role of technology and human capital.

2.3 Empirical Literature

The empirical literature is saddled with copious studies on the impact of public agricultural expenditure and economic growth, and mixed findings were uncovered. According to Agbana and Lubo (2022) examined the impact of Nigeria's agricultural expenditure proxy by the agricultural credit guarantee scheme fund and government expenditure on agriculture and economic growth proxy by real GDP using secondary data from the CBN Statistical Bulletin from 1981 to 2021. The study adopted the ordinary least squares regression method to analyse the data.

Their results found that the agricultural credit guarantee scheme fund and government expenditure on agriculture have a positive and significant impact on economic growth. It revealed that the coefficient of determination, the adjusted R^2 , was 0.712875, and it measured the proportion of the variation in economic growth. These implied that 71.3% of the growth of the Nigerian economy resulted from an increase in the agricultural credit guarantee scheme fund and government expenditure on agriculture, as stated in the model, while the other 28.7% is accountable for other factors not included in the study. They recommended that the government should evolve policies toward diversifying the economy and encourage the campaign for improvements in the non-oil sectors of the economy, especially spending more on the agricultural sector.

In a recent study by Hemat et al. (2025), the effect of government expenditure on the agricultural sector and economic growth in Afghanistan during the period 2006 to 2020. The study employed the Augmented Dickey-Fuller (ADF) test, the Johansen co-integration test, and the Ordinary Least Squares (OLS) method. They established that to support economic growth and long-term development, government expenditure should focus on engendering an enabling environment for private sector expansion and addressing market inefficiencies.

The result showed that a 1% increase in government agricultural expenditure, holding other factors constant, will result in a 0.58% rise in real gross domestic product. This confirmed a positive relationship between RGDP growth and government investment in agriculture. Hence, the study recommended that the Afghan government should increase investment in the agriculture sector and ensure the efficient and transparent use of financial resources. These studies exhibited a positive relationship between public agricultural expenditure and economic growth.

While studies like Megbowon et al. (2022) revealed a negative and significant nexus between government agricultural expenditure and economic growth in the Kingdom of Lesotho. They employed descriptive statistics and inferential econometric techniques (ARDL, DOLS, and VEC Granger causality) over time-series data for the period 1982-2019. The study identified the agricultural sector as a productive sector that

is central to the achievement of the economic growth goal and development plan in Lesotho. Therefore, they recommended that countries, including Lesotho, should prioritise sustained increases in domestic investment, since domestic investment appears to be a stimulant of the desired economic prosperity.

Also, a study by Kareem et al. (2022) analysed the impact of federal government agricultural financing on economic growth in Nigeria from 1981 to 2017 and used the augmented Dickey-Fuller unit root test and Granger causality test to analyse the data. They revealed that federal government agricultural financing has a negative contribution to economic growth in Nigeria and was statistically insignificant. Hence, the study concluded that federal government agricultural financing has no significant impact on economic growth in Nigeria. Therefore, the study recommended that the federal government should increase funding to the agricultural sector to be able to impact on the economic growth of Nigeria.

Discussing the nexus between public agricultural expenditure and agricultural productivity, Dada et al. (2023) tested the explanatory power of government agricultural expenditures with particular interest in finding out whether past expenditures matter in explaining agricultural productivity and food security in Nigeria. The finite distributed lagged models were employed using the OLS method, having confirmed the variables to be level at stationarity.

The study revealed that government agricultural expenditures have a positive impact on agricultural productivity and food security in Nigeria. They recommended that there is a need for sustained funding of the agricultural sector to boost the rate of agricultural investment. Considering the rate of unemployment as well as population growth in the country, expanding investment in the agricultural sector through funding will open many job opportunities and solve the problem of hunger that results from insufficient food supply.

Finally, Sikwese et al. (2024) examined the contribution of public expenditure to the growth of the agricultural sector in Tanzania from 2004 to 2018 using the error correction and autoregressive distributed lag. The results of the study revealed a positive relationship between agricultural recurrent expenditure and sector growth, with a 1% increase in the recurrent expenditure budget ratio leading to a 0.3326% increase in the growth rate. On the other hand, a 1% increase in agricultural development investment expenditure corresponds to a 0.1034% decrease in the growth rate, indicating a negative long-run relationship. Therefore, they recommended that the government should formulate macroeconomic policies that allocate the budget based on the sector's contribution to GDP, thereby financing agricultural sector expenditure and fostering growth.

From the empirical findings above, the study deduced that a key flaw in these studies is that, aside from being inconclusive, their findings have limited relevance to real-world situations. This is because the studies failed to recognise the importance of technology, which is an essential component of agricultural productivity to achieve the necessary growth, as well as human capital, which was mentioned in the theoretical framework but not included in the model specification as an exogenous factor that can induce

growth and productivity. However, the majority of the studies focused on the causal relationship between the factors rather than comprehending the variables' interactive effects on each other.

3. Methodology

Sources of Data

The study used secondary data from national and international authorities' official websites/databases, such as the World Development Indicators (WDI), Agricultural Science and Technology Indicators (ASTI), and the International Labour Organisation (ILO) 2024. The selection of time series data for this study is based on its capacity to yield further insights into the variables under analysis across time. Researchers and policymakers make use of time series data for conducting economic analysis, forecasting, and decision-making. Also, Nigeria is selected as a case study since agriculture is regarded as the primary source of income for more than 60% of the people (FAO, 2020). The sample size for this study is 39 years, based on an annual time series dataset spanning 1986 to 2024. Thus, the justification for selecting the research period is based on the availability of data for all of the variables used.

Econometric Model

The model employed the Fully Modified Ordinary Least Squares (FMOLS) to investigate the interactive effect of public agricultural expenditure and each of the agricultural productivity components, such as human capital and technology, on economic growth in Nigeria. Phillips and Hansen (1990), however, stated that the FMOLS has an advantage over the Ordinary Least Squares (OLS) method. In the sense that the method provides an asymptotically unbiased and fully efficient estimate of regressors, thereby accounting for serial correlation and endogeneity caused by co-integrating relationships.

Model Equation

The analysis utilised Romer's endogenous model by incorporating human capital in the Cobb-Douglas production framework as proposed by Alabi and Abu (2020). The framework emphasises labour, capital, and human capital as the main factors of production, to examine the impacts of other variables such as public agricultural expenditure, inflation, interest rate, as well as population on economic growth. The general form of the function linking output in period t with inputs is specified in equation (1) as:

$$Y_t = f(L_t, K_t, H_t, A_t) \quad (1)$$

Which is further written in Cobb-Douglas form in equation (2) as:

$$Y_t = A_t K_t^\alpha L_t^\beta H_t^\eta \quad (2)$$

where Y_t denotes economic growth at time t , while A_t , K_t , L_t , and H_t also represent the Total Factor Productivity (TFP), capital stock, stock of labour, and stock of human capital at time t , respectively.

According to Udoh (2011), Lipsey (2001), Barro (1990), and Alabi and Abu (2020), the effect of public agricultural expenditure on growth possibly operates through the total factor productivity (A). They assumed that TFP is a function of Public Agricultural Expenditure (PAE), Technology (T), and other exogenous factors. Thus, the TFP can be modelled as:

$$A_t = f(\text{PAE}_t, T_t, \text{IFN}_t, \text{IN}_t, \text{PO}_t) \quad (3)$$

Equation (3) can be written explicitly as:

$$A_t = \text{PAE}_t^\phi T_t^\lambda \text{IFN}_t^\sigma \text{IN}_t^\psi \text{PO}_t^\partial \quad (4)$$

Combining equations (2) and (4) will yield equation (5) below:

$$Y_t = C_t K_t^\alpha L_t^\beta H_t^\eta \text{PAE}_t^\phi T_t^\lambda \text{IFN}_t^\sigma \text{IN}_t^\psi \text{PO}_t^\partial \quad (5)$$

Furthermore, log-linearising equation (5) and adding the error term (ε_t) will lead to equation (6)

$$\ln Y_t = C_0 + \alpha \ln K_t + \beta \ln L_t + \eta \ln H_t + \phi \ln \text{PAE}_t + \lambda \ln T_t + \sigma \ln \text{IFN}_t + \psi \ln \text{IN}_t + \partial \ln \text{PO}_t + \varepsilon_t \quad (6)$$

where: $\ln Y_t$ = Economic growth (proxy by Real Gross Domestic Product growth), $\ln K_t$ = stock of capital growth (proxy by Gross Capital Formation in relation to GDP), $\ln L_t$ = Labour stock growth, $\ln H_t$ = stock of human capital growth (proxy by school enrollment, primary (% gross)), $\ln \text{PAE}_t$ = public agricultural expenditure, $\ln T_t$ = Technology growth (proxy by public agricultural research and development expenditures), $\ln \text{IFN}_t$ = Inflation rate, $\ln \text{IN}_t$ = Interest rate, $\ln \text{PO}_t$ = Population growth and ε_t = Error term.

Thus, to capture the interactive effect of public agricultural expenditure and each of the two components of agricultural productivity on economic growth in Nigeria, equation (7) will be stated as:

$$\ln Y_t = C_0 + \alpha \ln K_t + \beta \ln L_t + \eta \ln H_t + \phi \ln \text{PAE}_t + \lambda \ln T_t + \theta_1 \text{PAE}_t * H_t + \theta_2 \text{PAE}_t * T_t + \sigma \ln \text{IFN}_t + \psi \ln \text{IN}_t + \partial \ln \text{PO}_t + \varepsilon_t$$

(8)

4. Results and Discussion

Results Presentation

Table 1: Descriptive Analysis of Variables

Statistics	CG	GDP	HC	IFN	INT	LFG	PAE	PG	TG
Mean	31.172	4.1101	88.823	19.914	2.3470	70609	23.785	2.5851	2554.0

Median	29.430	3.6471	87.949	13.006	4.3102	669261	23.371	2.6501	2079.4
Maximum	54.950	15.329	100.18	72.835	18.180	1.13E+08	36.965	2.8027	5383.0
Minimum	14.900	-2.0351	76.463	5.3880	-31.452	441821	18.020	2.0829	950.77
Std. Dev.	12.030	3.7587	6.0928	17.029	9.5738	201792	3.6699	0.2271	1583.0
Skewness	0.3132	0.5671	0.3149	1.6881	-1.1873	0.5211	1.6001	-1.2942	0.6223
Kurtosis	2.0610	3.6484	2.2567	4.7176	5.4949	2.1282	6.461	3.2890	1.8263
JB Prob	0.3551	0.2498	0.4624	0.1001	0.1001	0.2230	0.1001	0.1040	0.0927

Source: Author's compilation (2025)

This section presents the descriptive statistical analysis of key economic indicators, economic growth (GDP), public agricultural expenditure (PAE), technology growth (TG), human capital (HC), labour force growth (LFG), interest rate (INT), inflation rate (IFN), and population growth (PG). The results of the measures of central tendency reveal contrasting mean and median values and also demonstrate different skews. For instance, LFG shows irregularity with a mean (70,609) much lower than the median (669,261) with positive skewness (0.5211). IFN displays a strong positive skewness with a mean (19.914) higher than the median (13.006). TG shows positive skewness as well (2,554.0 mean vs. 2,079.4 median), INT presents a strong negative skewness with a mean (2.347) suggestively below the median (4.310) and a negative skewness of -1.1873. Then, for GDP, CG, HC, and PAE, their means are slightly greater than medians, suggesting a mild positive skewness, while PG has a mean (2.585) slightly less than the median (2.650), representing an insignificant negative skewness.

Also, the analysis of the measures of dispersion indicates that LFG exhibits the highest volatility with a standard deviation of 112,558,179 and a broad range. TG shows significant upward trends with a standard deviation of 1,583.0, while IFN has high variability due to extreme positive values. INT also shows high dispersion influenced by both extreme positive and negative values. Among the variables: GDP, CG, HC,

PAE, CG is the most variable with a standard deviation of approximately 12.03, while GDP has a significant range due to its negative minimum. PG is the most stable variable with the lowest dispersion and tight clustering around its mean of 2.585.

Again, the variable distributions show a range of skewness and kurtosis characteristics. For instance, PAE shows highly positive skewness and high leptokurtosis, signifying clustering around the mean with frequent large positive extremities. IFN also follows with high positive skewness and leptokurtosis, supporting extreme positive values. INT exhibits considerable negative skewness and is the most leptokurtic, and this is an indication of an extreme negative outcome. PG is characterized by negative skewness and low dispersion, while GDP has moderate positive skewness and leptokurtosis, being closer to a normal distribution than PAE or INT. CG, HC, TG, and the LFG show slight skewness and platykurtosis, with high JB probabilities indicating their proximity to normality.

Correlation Analysis

In an effort to determine the existence or otherwise of multicollinearity among the variables used in the study, a correlation analysis was performed, and the results are presented in Table 4.2.

Table 2: Correlation Analysis Results

	CG	GDP	HC	IFN	INT	LFG	PAE	PG	TG
CG	1								
GDP	-0.1963	1							
HC	0.1169	0.2319	1						
IFN	0.3863	-0.3178	-0.0497	1					
INT	-0.3652	0.3167	-0.1704	-0.7808	1				
LFG	-0.6561	-0.0969	-0.3069	-0.2732	0.2737	1			
PAE	-0.0568	0.4509	0.4098	-0.0126	0.0336	-0.1826	1		

PG	0.0488	0.4168	0.3683	-0.0491	0.0300	-0.7375	0.2519	1	
TG	-0.6287	-0.1812	-0.3957	-0.2672	0.2720	0.9690	-0.2683	-0.7609	1

Source: Author's compilation (2025)

The results in Table 2 show that technology growth (TG) and labour force growth (LFG) have a near-perfect positive correlation of 0.9690, demonstrating that the two variables share similar features and that higher technology growth leads to labour force growth. Conversely, there appears to be a strong inverse relationship between interest rate (INT) and inflation rate (IFN) as shown by a correlation of -0.7808, signifying that higher interest rates correspond with lower inflation, and this implies counter-cyclical monetary policy. Moreover, population growth (PG) reveals a significant inverse correlation with LFG (-0.7375) and TG (-0.7609), representing that as the TG grows and LFG increases, the population growth rate tends to decline.

The results also reveal the existence of positive relationships with a correlation value of 0.4509 between GDP Growth and public agricultural expenditure (PAE), signifying augmented government spending during economic booms, and a 0.4168 correlation between GDP growth and population growth. PAE also displays a 0.4098 correlation with human capital (HC), and this shows that spending rises with the utilization of human capital. The results also show a negative correlation between capital growth (CG) and technology growth (TG) as well as with labour force growth (LFG) (-0.6287 and -0.6561 respectively). This implies reduced capital investment as technology growth widens. Furthermore, GDP Growth negatively correlates with IFN at -0.3178, and by implication, high growth may imply lower inflation, while HC has a -0.3957 correlation with the technology growth, suggesting lower human capital metrics with wider technology growth. By and large, the results of correlation analysis imply that the variables are either positively or negatively correlated and that there is no evidence of multicollinearity.

Unit Roots Test

The results of unit root tests are reported in Table 3. The study employed two distinct unit root tests in order to have a robust analysis. From the results of Augmented Dickey-Fuller (ADF) test, it was revealed that economic growth (GDP), inflation rate (IFN) and population growth (PG) were stationary at levels while public agricultural expenditure (PAE), technology (TG), human capital (HC), capital growth (CG), labour force growth (LFG) and interest rate (INT) were stationary at first difference.

Table 3: Unit Root Tests Results

Variable	ADF Test (with Constant only)			PP Test (with Constant only)		
	At Level	At First Difference	Order	At Level	At First Difference	Order
CG	-2.0790 (0.2539)	-5.3907*** (0.0001)	I(1)	-5.0047*** (0.0002)	-13.103*** (0.0000)	I(0)
GDP	-4.1410*** (0.0025)	-10.972*** (0.0000)	I(0)	-3.3679** (0.0179)	-12.235*** (0.0000)	I(0)
HC	-2.4063 (0.1468)	-5.9673*** (0.0000)	I(1)	-1.8448 (0.3544)	-7.0059*** (0.0000)	I(1)
IFN	-1.3089** (0.0120)	-5.3881*** (0.0001)	I(0)	-1.9054 (0.3267)	-6.3537*** (0.0000)	I(1)
INT	-2.3831 (0.1536)	-5.1118*** (0.0002)	I(1)	-1.9054 (0.3267)	-6.3537*** (0.0000)	I(1)
LFG	3.2022 (1.0000)	-2.0778*** (0.0043)	I(1)	-2.6075* (0.0995)	-8.5754*** (0.0000)	I(0)
PAE	-1.7732 (0.3873)	-6.9793*** (0.0000)	I(1)	-1.3020 (0.6199)	-8.2983*** (0.0000)	I(1)
PG	--2.4199** (0.0434)	-6.5689*** (0.0000)	I(0)	-3.2336** (0.0249)	-12.1138*** (0.0000)	I(0)
TG	0.5540 (0.9864)	-5.1623*** (0.0001)	I(1)	-3.2870** (0.0219)	-5.5081*** (0.0001)	I(0)

Source: Author's compilation (2025)

Similarly, the results of Philips-Peron (PP) unit root test showed that capital growth (CG), economic growth (GDP), labour force growth (LFG), population growth (PG) and technology (TG) were stationary at levels and at different levels of significance while human capital (HC), inflation rate (IFN), interest rate (INT) and public agricultural expenditure (PAE) were stationary at first difference and at 1% level of significance.

The Interactive Effect of Public Agricultural Expenditure and Each of the Two Components of Agricultural Productivity on Economic Growth in Nigeria

In an attempt to investigate the interactive effect of public agricultural expenditure and each of technology growth and human capital growth on economic growth in Nigeria over the study period, a technique of Fully-modified Ordinary Least Squares (FMOLS), which is a long-run model, was employed.

Table 4: Fully Modified OLS Results

Dependent Variable: GDP**Method: Fully Modified Ordinary Least Squares (FMOLS)**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CG	0.1166	0.1215	0.9601	0.3455
HC	-1.3246	0.5775	-2.2935	0.0298
IFN	-0.0243	0.0350	-0.6964	0.4921
INT	0.0581	0.0637	0.9115	0.3701
LFG	2.84E-07	7.96E-08	3.5708	0.0014
PAE	-4.9405	2.4217	-2.0400	0.0512
PG	13.009	7.1306	1.8244	0.0792
TG	-0.0073	0.0048	-1.5141	0.1416
(PAE*HC)	0.0522	0.0233	2.2359	0.0338
(PAE*TG)	0.0002	0.0001	1.3265	0.1958
C	76.755	77.267	0.9933	0.3293

R-squared	0.8178	Mean dependent var	4.2167
Adjusted R-squared	0.8392	S.D. dependent var	3.7490
S.E. of regression	3.0474	Sum squared resid	250.75
Long-run variance	3.8550		

Source: Author's compilation (2025)

The estimates of the FMOLS model in Table 4 present the long-run relationship between GDP and the various determinants of agricultural productivity. It is shown that capital growth (CG) reveals an insignificant positive relationship with economic growth (with a coefficient = 0.1166, $p = 0.3455$). This implies that growth in physical capital enhances economic growth without a dependable long-run effect, possibly owing to investment ineptitudes and poor capital quality. On the contrary, the results of human capital (HC) depict a significant negative effect on GDP (with coefficient = -1.3246 , $p = 0.0298$). The results may not be unconnected with policy summersault in both education and labour market as lingering skilled workers emigration coupled with rising unemployment among educated individuals is a reflection of structural weaknesses in exploiting the available human resources judiciously.

The coefficient of -0.0243 and p -value of 0.4921 for inflation (IFN) indicate a negative but insignificant

effect on GDP, and by implication, it suggests that inflation does not impose strong long-term economic pressures on economic growth. Similarly, interest rate appears to have an insignificant positive effect on GDP with a coefficient of 0.0581 and p-value of 0.3701, and the results signify that interest rate does not confer a significant influence on GDP in the long run.

The growth in labour force reveals a significant positive impact on GDP with a coefficient of 2.84×10^{-7} and p-value of 0.0014, and this is an indication of an enhanced productive capacity by more workers. Also, public agricultural expenditure (PAE) reveals a marginally significant negative effect (coefficient = -4.9405 , $p = 0.0512$), and this may be due to spending inefficiencies or mismanagement. Population growth maintains a significant positive association with GDP, and technology growth (coefficient = -0.0073 , $p = 0.1416$) shows an insignificant negative relationship with GDP. It is also revealed that labor force growth (LFG) is positively associated with GDP, while population growth (PG) has a positive long-run effect on GDP, linked to demographic dividends and job opportunities, and technology growth (TG) maintains an insignificant negative impact on GDP.

Moreover, there are two interactive terms to achieve in this study. In the first instance, the interactive term (PAE * HC) is significantly positive with a coefficient of 0.0522 and p-value = 0.0338. The results indicate that while PAE and HC have negative individual effects on GDP, their combination results have a significant positive effect on GDP, leading to GDP growth. The findings imply that public agricultural spending becomes more effective when augmented with skilled human capital, as training and capacity development have the potential to improve the efficiency of agricultural investments. Thus, without necessary human capital growth, such agricultural spending could be unproductive. The results also imply that educated farmers make judicious use of resources to enhance the returns on government investments and that effective use of agricultural spending relies on the expertise and education of farmers.

Secondly, the interactive term (PAE * TG) with a coefficient of 0.0002 and p-value of 0.1958 is an interaction between public agricultural expenditure (PAE) and technology growth (TG). The term exhibits an insignificant positive relationship between the two variables. This suggests that technology does augment the benefits of agricultural investment, as its erratic adoption may hamper strong long-term effects, and this calls for rising investment in agricultural technology.

The diagnostic test results reveal that the model is fit, with an R^2 of 0.8178 and an adjusted R^2 of 0.8392, demonstrating that the model explains approximately 82–84% of long-run variations in GDP and efficiently captures most growth dynamics.

4.2. Discussion of Findings

The empirical findings on the interaction between public agricultural expenditure and human capital reveal a significant positive relationship with GDP. The results suggest inefficiencies and mismatches in their separate impacts. However, when combined, they yield a synergistic effect that boosts GDP growth, motivated by the efficacy of public spending and reinforced by a skilled workforce. This interaction emphasises the importance of integrated policies that increase public agricultural investment and human capital development, which can promote sustainable economic growth through education and training initiatives in agriculture. This result is in conformity with the work of Widarni and Bawono (2020) that the role of human capital is very important in economic growth, in the sense that educational development is the key to the success of increasing human capital through public expenditure. This is also supported by the Keynesian theory that government expenditures on education, healthcare, and infrastructure can have a multiplier effect on economic progress.

On the otherhand, the interaction between public agricultural expenditure and technology proxied by public agricultural research and development expenditure exhibited an insignificant positive relationship. This indicates that technology enhances the advantage of agricultural investment; however, inconsistent usage may impede a substantial long-run effect, leading to the need for increased investment in agricultural technology through massive public expenditure. This is in line with the endogenous growth model of Romer (1990), which laid emphasis that government investments in research and development (R&D) with agriculture, are indispensable to increasing productivity through technological advancements as sated in the work of Ojukwu et al., (2025). Hence, the component of human capital and technology as interacted with public agricultural expenditure are shown to be a critical factor necessary to achieve improved productivity and raise the growth rate of any economy.

5. Conclusion and Recommendations

5.1 Conclusion

The study examined the nexus between public agricultural expenditure and agricultural productivity on economic growth in Nigeria, and the findings indicate that human capital appears underperforming, capital growth, inflation, and interest rates exhibit negligible long-run effects, and technology adoption is deficient to sustain GDP growth alongside public agricultural spending. It is evidenced from the findings of this study that economic growth is driven by growing labour supply and effective public agricultural spending supported by a skilled labour force; however, the GDP growth is significantly hindered by poor adoption of technology, low human capital quality, and inefficient public agricultural expenditures. Therefore,

technology does enhance the benefits of agricultural investment, as its erratic adoption may hamper strong long-term effects, and this calls for rising investment in agricultural technology. Again, rising population growth may also imply rising underemployment and resource strain if the rate of labour supply outpaces that of resources available. It is therefore concluded that efficient public agricultural expenditure improves agricultural productivity and enhances economic growth in Nigeria.

5.1 Policy Recommendations

Based on the findings emanated from the study, the following policy recommendations are made:

- a) The government is urged to bolster human capital through the improvement of agricultural training and rural education. This can be partially accomplished by augmenting financial support for agricultural colleges.
- b) Agricultural spending should be reformed by reallocating resources towards productive investments that directly benefit the farmers to improve productivity.
- c) The agricultural process should be digitalised by adopting technology, increasing mechanisation, providing digital training, and partnering with technological firms to improve efficiency in the sector.

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