The Impact of Agricultural Public Expenditure on Agricultural Productivity in Nigeria

Reuben Adeolu Alabi

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The Impact of Agricultural Public Expenditure on Agricultural Productivity in Nigeria

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Contents

List of tables
List of figures
Abstract

1. Introduction 1
2. Literature Review 5
3. Research Methodology 7
4. Results and Discussion 19
5. Summary and Conclusion 32

Notes 35

References 37

Appendix 43

List of tables

1	Average land and labour productivity in cereal production (1981–2019)	3
2	Measurement of relevant variables used in study	15
3	Budget execution rates of agricultural public expenditure in Nigeria	20
4	Structure of agricultural public expenditure in Nigeria, 1981–2014	21
5	IV-2SLS regression results of agricultural capital expenditure impact	22
6	Estimates of long and short-run coefficients of ARDL model (impact of agricultural capital expenditure on agricultural productivity)	24
7	Estimates of long and short-run coefficients of ARDL model (impact of agricultural productivity on agricultural total expenditure)	26
8	Granger causality tests	28
9	Estimates of long and short-run coefficients of ARDL model (impacts of different components of ACE)	29
10	Ranking of components of agricultural public capital expenditure	31
A1	Summary statistics of variables used (logarithm form)	43
A2	Selection of instrument for endogenous variable	44
A3	Lag length selection based on SBIC	44
A4	Augmented Dickey-Fuller (ADF) test for unit root	45
A5	Results from ARDL bounds test for cointegration	45
A6	IV-2SLS regression result of agricultural recurrent expenditure impact	46
A7	IV-2SLS regression result of impact of agricultural total expenditure	46
A8	Estimates of ARDL model (impact of agricultural recurrent and total expenditure on agricultural productivity)	47
A9	Estimates of ARDL model (impact of agricultural productivity on ARE and ACE)	47
A10	Long elasticities of different components of agricultural capital expenditure with respect to ODA and farmers' private capital	48
A11	Diagnostics tests	48

List of figures

1 Agriculture value added per labour, Nigeria and other countries 4

3 Trend of shares of capital and recurrent public agricultural expenditure 21

4 Agricultural public expenditure per farmer in Naira and USD 22

A1 CUSUM square test of stability 48

Abstract

This study analyzes the impact of agricultural public expenditure on agricultural productivity in Nigeria. The relevant time series data for the study were obtained from secondary sources. The data ranged from 1981 to 2014. An instrumental variable two-stage least squares (IV-2SLS) econometric model was employed to investigate the endogeneity of public agricultural expenditure, and the autoregressive distributed lag (ARDL) econometric technique was used to determine the long and short-term effects of public agricultural expenditure on agricultural productivity. The study shows that 20% of agricultural public budgets were not implemented in Nigeria. On average, agricultural public capital expenditure comprised 55% of total agricultural public expenditure in Nigeria, which is lower than the recommended 60% for effective agricultural sector performance. The study also reveals that while public agricultural capital expenditure and agricultural public total expenditure are strong determinants of agricultural productivity, agricultural public recurrent expenditure maintains a weak relationship with agricultural productivity in Nigeria. Finally, the study demonstrates that agricultural public spending on irrigation has the highest impact on agricultural productivity, while agricultural public spending on subsidies has the least impact on agricultural productivity. Among other recommendations, it is suggested that the agricultural public expenditure pattern should be realigned to favour investments in irrigation, research and development, and rural development, which currently attract lower budgetary allocations in Nigerian agricultural budgets.

Key Words: Impact, Public expenditure, Agricultural productivity, Nigeria

1. Introduction

Historically, agriculture was the most important sector in Nigeria, but now accounts for just more than 20% of the country's gross domestic product (GDP) (CBN, 2018). The sector employs more than 48% of the labour force (Odozi et al., 2018), while 60% of those employed in the agricultural sector are women (Action Aid, 2015). The food crop sub-sector contributed about 76% of the share of the agricultural sector in GDP, livestock contributed 10%, with the remainder made up by the forestry and fisheries sub-sectors (CBN, 2018). Prior to the 1970s, agriculture produced adequate food to feed the population. It served as a major foreign exchange earner for the country and was a major source of raw materials for the agro-allied industries (Alabi et al., 2016). In periods immediately following independence, the agricultural sector performed the aforementioned roles to the extent that the regional development and growth cycles witnessed during this time were directly linked to agricultural development (Eluhaiwe, 2010). In recent time, development economists have attributed the economic problem in Nigeria to the poor performance of the agricultural sector (Olomola et al., 2015).

One of the factors that is deemed to have contributed to the poor performance of the agricultural sector in Nigeria is low agricultural budgetary allocation (Islam, 2011; Alabi, 2014). Mogues et al. (2008) and Olomola et al. (2014) indicated that less than 2% of total federal government expenditure was allocated to agriculture in the past two decades in Nigeria. This was lower than the 10% agricultural budgetary allocation recommended in the Maputo Declaration of 2003 for effective agricultural performance (Badiane et al., 2016).

A measure of agricultural sector performance is agricultural productivity (FAO, 2018). Agricultural productivity can be defined as the ratio of agricultural outputs to agricultural inputs; a higher ratio is associated with better agricultural performance. Productivity is a key issue in Nigeria's agricultural sector due to its importance as a strategy for agricultural development and its impact on economic and social development. Improving agricultural productivity is necessary to ensure food security and increased farm income. Productivity growth in agriculture can allow food to become more abundant and cheaper (FAO, 2018).[1] However, the inherent problems in Nigeria's agricultural sector span all types of agricultural productivity. For example, considering single factor productivity such as land productivity,[2] Table 1 reveals that average cereal land productivity (yield) grew only by 2.57% between 1981 and 2019, while the average cereal land productivity in Africa and the world grew by 36.90%

and 56.62%, respectively, over the same period. Likewise, Table 1 indicates further that agricultural labour productivity in cereal production in Nigeria, which grew at 26% between 2011 and 2019, is lower than Africa's and the world's averages of 28% and 34%, respectively, during the period. More importantly, agricultural labour productivity in cereal production in Nigeria, which was estimated at an average of 259kg per farmer between 2011 and 2019, was only 32% of the world average agricultural labour productivity in cereal production, estimated at 822kg per labour during the same period. Further evidence of lower agricultural productivity in Nigeria is revealed in Figure 1, which suggests that agricultural value added per labour ranks among the lowest in the world. In fact, agricultural value added per labour in Nigeria was only 29%, 34% and 43% of that of Algeria, South Africa and Mauritius, respectively. There is also ample evidence that based on total factor productivity (TFP), which is a composite measure of agricultural productivity that takes into accounts all the factors of agricultural production used in the production process, the agricultural productivity growth rate in Nigeria is lower than the global average. For example, the GAP Report (2019) indicates that while the agricultural TFP grew by 1% in a country such as Nigeria, agricultural TFP globally grew at an average of 1.63% in 2019. The decline in agricultural productivity in Nigeria is not nearly adequate for the 6.5% growth rate in the annual demand for food in Nigeria (Action Aid, 2015). This may be one of the reasons for the increase in the rate of food Insecurity in Nigeria[3] and the decline in the agricultural sector contribution to GDP (CBN, 2018).

Kalibata (2010) posited that improved public expenditure in agriculture will help to provide farmers with improved inputs. Well-managed public spending in agriculture can be used to provide rural infrastructure such as roads that will link farmers to markets. Public financial resources will enable farmers to access agribusiness credit and storage facilities to reduce their estimated 50% post-harvest losses (Oguntade, 2014). These resources are important to boost agricultural productivity, which can accelerate economic growth, raise incomes, and improve standards of living. It is expected that the Maputo Declaration of 2003, which targets 10% of public expenditure for agriculture, will boost agricultural productivity in Nigeria. Likewise, following the Maputo Declaration of 2003, the Abuja Declaration of 2006 and the Malabo Declaration of 2013, aimed at increasing farm input use and investment in Nigeria, can ultimately increase agricultural productivity (NEPAD, 2014).

To convince the ministry of agriculture to increase the agricultural budget allocation for the Nigerian agricultural sector, evidence of the impact of this expenditure on agricultural productivity in Nigeria is required.[4] Moreover, the impact of public expenditure on agricultural productivity may differ by type of expenditure (Mogues et al., 2012a; Mogues et al., 2012b). Therefore, an analysis of the heterogeneous impacts of different types of public agricultural investments is imperative. This study pays close attention to these heterogeneous impacts of different types of agricultural public expenditure on agricultural productivity in Nigeria, which could guide agricultural public expenditure policy decisions. Economists have shown that public sector finance alone may not be enough to finance the agricultural sector (Benin, 2017; FAO, 2013).

There is a need for a study of this nature that recognizes the complementary role of official development assistance (ODA) in agricultural public expenditure discourse and analysis.

Some questions continue to dominate recent debates and discussions regarding government spending on agriculture. Some of these questions are: What is the structure of agricultural public expenditure in Nigeria? Is the impact of agricultural public capital expenditure on agricultural productivity relatively greater than that of agricultural public recurrent expenditure in Nigeria? Do the various components of agricultural public capital expenditure have differential impacts on agricultural productivity? This study aims to provide answers to these questions and make recommendations based on the empirical findings.

The broad objective of the study is to analyze the long and short-run impacts of agricultural public expenditure on agricultural productivity in Nigeria. Specifically, the study aims to:

(i) examine the structure of agricultural public expenditure;

(ii) determine the relative impacts of agricultural public capital and recurrent expenditure on agricultural productivity; and

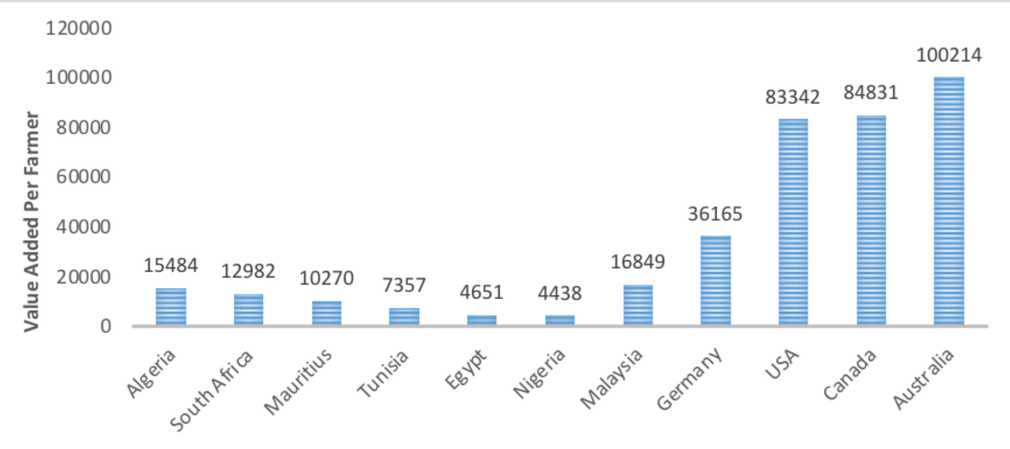
(iii) compare the impacts of different components of agricultural public capital expenditure on agricultural productivity.

Table 1: Average land and labour productivity in cereal production in Nigeria, Africa and the World (1981–2019)

	Land productivity			Labour productivity		
Period	Nigeria (kg/ha)	Africa (kg/ha)	World (kg/ha)	Nigeria (kg/ labour)	Africa (kg/ labour)	World (kg/ labour)
1981–1990	1339.5	1145.5	2489.6	206.1	207.6	613.8
1991–2000	1176.9	1206.8	2895.8	284.8	221.4	628.5
2001–2010	1415.7	1396.9	3329.0	289.4	239.4	686.2
2011–2019	1373.9	1568.2	3899.1	259.2	266.4	822.0
% change (1981–2019)	2.57	36.90	56.62	25.76	28.32	33.92

Source: Computed from FAOSTAT (2019).

Figure 1: Agriculture value added per labour, Nigeria and other countries (US$, 2010 prices)



Source: Computed from FAOSTAT (2021).

2. Literature Review

The *World Development Report* of 2008, titled "Agriculture for Development", explained why the decline in local and international support for agriculture was damaging for agricultural development and poverty reduction in developing countries. The report was useful in that it helped rekindle interest in agricultural expenditure and policy debates (Dethier and Effenberger, 2011). Past studies on the impact of agricultural public expenditure in Nigeria associated public expenditure with economic growth and agricultural output. While some of these studies reported positive and significant impact of agricultural public expenditure on agricultural production (Andrew, 2015; Ibe, 2014; Lawal, 2011 and Itodo et al., 2012), others reported negative or non-significant impacts of agricultural public expenditure in Nigeria (Iganiga and Unemhilin, 2011; Ihugba et al., 2013; Matthew and Mordecai, 2016; Ewubare and Eyitope, 2015 and Ayunku and Etale, 2015). These conflicting reports may be because past studies did not consider the fact that government would spend on public goods and services or spend on areas where the impacts of the spending are likely to be greatest. In other words, public spending decision-making can be endogenous. These past studies are useful for the current study as they emphasized the importance of analyzing the impact of agricultural public expenditure on the agricultural sector. However, they are limited because of endogeneity issues and do not consider the differential impact of agricultural public expenditure.

Enrique et al. (2012), Talknice and Mufaro (2014), Asuamah (2016), Aragie et al. (2016), and Abbas et al. (2016) examined the effect of government spending on agricultural growth in Indonesia, Zimbabwe, Ghana, Ethiopia and Pakistan, respectively. They applied different econometric tools such as: ordinary least squares (OLS) regressions, generalized method of moments (GMM) econometric techniques and vector error correction models (VECM). They concluded that government expenditure on agriculture had a positive but not significant impact on agricultural growth. While these studies are useful and resonate with our study, they fail to appropriately deal with the issue of endogeneity.

Fan et al. (2000) used a simultaneous equation model to estimate the direct and indirect effects of different types of government expenditure on productivity growth in India. Their results showed that if the Indian government were to give highest priority to additional investments in rural roads and agricultural research, these investments would not only have much larger poverty impact than any other government investment, but also generate higher productivity growth. Their study agrees with our study because it recognizes the heterogeneous impact of public expenditure. However, it is different from our study in that they related public expenditure to poverty in India. Fan et al. (2004) further estimated the effects of different types of government expenditure on agricultural growth and rural poverty in Uganda using a seemingly unrelated regression (SURE) approach. Their results revealed that government spending on agricultural research and extension improved agricultural production substantially. Fan et al.'s (2004) study is relevant because it estimated the impact of agriculture public expenditure on agricultural growth and rural poverty in Uganda, but their study differs from ours because it does not compare the impacts of other components of agricultural public expenditure on irrigation, subsidies, rural development and other factors. Using district- and regional-level public expenditure data and household-level production data, Benin et al. (2009) applied simultaneous equations to estimate the agricultural productivity returns on different types of public expenditure in Ghana. Their findings revealed that a 1% increase in agricultural public spending is associated with a 0.15% increase in agricultural labour productivity. Benin et al.'s (2009) study is similar to this study, but these authors only considered the impact of aggregate sectoral expenditure on rural roads, education, health, infrastructure and agriculture on agricultural productivity. They did not analyze the impacts of components of agricultural public expenditure on agricultural productivity.

Udoh (2011) used data from 1970 to 2008 to improve on past studies on the impact of public agricultural spending in Nigeria by controlling for the effect of endogeneity through the application of an autoregressive distributed lag (ARDL) econometric technique. However, Udoh (2011) failed to disaggregate the different impacts of various components of agricultural public expenditure on agricultural productivity. This may have informed his conclusion of non-productivity of agricultural public expenditure as he considered only total agricultural expenditure.

3. Research Methodology

This section presents agricultural production function as the conceptual framework employed in the study. The section also specifies the models as they are related to this study. In addition, how the instrument variable for endogenous variable (agricultural public expenditure) was selected is also explained in this section. The final part of the section focuses data sources, measurement of the variables and estimation strategies.

3.1 Conceptual Framework

It is evident from Figure 2 that agricultural production activities are food webs that are linked in many ways. In an agricultural production setting, land is the factory where other factors of production such as labour, capital and seed interact to sustain agricultural production. In this production process, the natural environment, such as soil (land), rainfall and climate, play important roles. It is not only the natural environment that is vital for agricultural production. The socioeconomic and political environment and institutional arrangements are equally important. Government interventions through agricultural expenditure and non-agricultural expenditure are useful in correcting market failure and ensuring input supply at farm level. Government agricultural expenditures are mainly classified as capital (development) and as recurrent. The capital component of the expenditure can be spent on fertilizer subsidy schemes, which can lead to an increase in fertilizer and other agrochemical use, and can ultimately lead to increased productivity. The capital budget can be spent on rural development such as the construction of feeder roads that link farmers to the market. Rural development will not only lead to an increase in labour productivity, but also increased profitability of farming enterprises in rural areas. Research and development (R&D) expenditure is usually devoted to the R&D of new crops and animals with superior productivity. Cultivating those crops and rearing those animals will increase the productivity on farms. Providing irrigation infrastructure through public expenditure will enable farmers to have access to water regimes that will enable them to farm throughout the year and thereby increase their output and productivity. Overall, public agricultural capital expenditure will affect the quantity and quality of the factors of agricultural production in some way. If well managed, a subsidy scheme can result in an increase in input use. The provision of irrigation will increase the use of water, which can enhance the fertility of the land. The R&D will increase the quality of the seeds being used on the farm, while the provision of rural infrastructure will increase the quality of labour supply and enhance labour productivity.

However, in Nigeria it is evident that critical functional components of agricultural spending in Nigeria were not given due priority (Mogues et al., 2008; Olomola et al., 2014). This also necessitates a study of this nature where the empirical results of differential impacts of different components of public agricultural expenditure can be compared with how the government had been prioritizing agricultural expenditures in the past. This can shed some light on the past misallocation of funds, and at the same time indicate how government should allocate the agricultural budget in the future for better agricultural productivity.

3.2 Model Specification

This study is based on the theory of agricultural production. The production process is where inputs (factors of production) are transformed into goods and services, called output (Olayide and Heady, 1982). In agricultural production, the inputs are usually land, labour, capital, water resources and entrepreneurship. These inputs can be organized into a production unit whose ultimate goal may be output maximization, profit maximization, satisfaction maximization, cost minimization, or a combination of these (Heady and Dillon, 1961). The inputs are allocated as input mix, and managed to produce crop and/ or livestock. Maximum output is attempted with a view to maximizing the goals of output and profit, or minimizing cost. As there are alternative means of attaining these production objectives or goals, the theory of agricultural production presents the theoretical and empirical framework that facilitates a proper selection of alternatives so that any combination can help farmers achieve their objectives (Akinwumi, 1970).

Based on agricultural production theory, the production function expresses the technical relationship between input and outputs in the production exercise. Mathematically, the function is assumed to be continuous and differentiable (Olayide and Ogunfowora, 1969). Its differentiability enables the determination of rates of return (Olayide and Heady, 1982). There are different functional forms that relate inputs with outputs in agricultural production activities. These are linear, power (Cobb-Douglas), quadratic, square root, transcendental, exponential and semi-logarithm. The most applied production functional form is the Cobb-Douglas production function because it has unique characteristics that are useful for empirical analysis (Olayide and Heady, 1982). For example, under the Cobb-Douglas production function, the fact that the parameter coefficients β_i are output elasticities of the inputs used in the production process, their values are constants determined by available technology. Based on the summation of coefficients β_i ($\sum\beta i$) the following returns to scale are obtainable in a typical production function when:

$\sum\beta i=1 \Rightarrow$ constant returns to scale

$\sum\beta i<1 \Rightarrow$ decreasing returns to scale

$\sum\beta i>1 \Rightarrow$ increasing returns to scale

A simple example of a Cobb-Douglas production function is presented in Equation 1 as:

$$Y = AK^{1-\beta}L^{\beta} \tag{1}$$

where Y denotes output, K denotes capital, L denotes labour, and *A* indicates the level of technology. The production function in Equation 1 represents the relative contribution of capital, labour and technology level to output growth (Y). The key parameter is the exponent β on labour in the Cobb-Douglas expression for output. This is because if productivity is to increase, the labour force must continuously be provided with more resources. These resources include physical capital (private and public capital), human capital and knowledge capital (technology). Therefore, governments have been intervening in their economies with the aim of increasing public capital investment.

The Cobb-Douglas production function in Equation 1 is homogeneous of degree 1 with respect to the factors of production, which is consistent with the production function that has constant returns to scale. The Cobb-Douglas production function exhibited diminishing marginal returns for both inputs (capital or labour), while other factors of production can be treated as fixed factors, so the law of diminishing marginal returns can hold. Moreover, it is simple to estimate because both sides of the function could be manipulated into logarithm forms as in Equation 2, where *log* is the logarithms in base 10.

$$Log\,Y = LogA + \beta LogL + (1-\beta)Log\,K \tag{2}$$

In the application of the Cobb-Douglas production function in the agricultural sector, the parameters on the factors of production are allowed to sum to a number greater than 1, allowing for returns to scale of a number greater than 1 (Debertin, 2012). With this modification, Equation 1 becomes:

$$\mathrm{Y} = A\,\mathrm{K}^{\beta_1}\mathrm{L}^{\beta_2} \tag{3}$$

where $\beta_1+\beta_2$ sums to any number greater than 1 (Debertin, 2012).

The second modification made to the original Cobb-Douglas production function in its application to agricultural production was to expand the function in terms of the number of factors of production. For example, for six factors of production to produce Y, the production function will become Equation 4:

$$\mathrm{Y} = \mathrm{f}\left(\mathrm{AK}^{\beta_1}\mathrm{L}^{\beta_2}\mathrm{M}^{\beta_3}\mathrm{N}^{\beta_4}\mathrm{O}^{\beta_5}\mathrm{P}^{\beta_6}\right) \tag{4}$$

The Cobb-Douglas type of production function in Equation 4 is homogeneous of degree $\sum\beta_i$. The returns to scale parameter, or function coefficient, is the sum of the β values on the individual factors of production if all factors of production are treated explicitly as variable. The β values represent the elasticity of production with respect to the corresponding factor of production. This is taken as the measure of the impact of each of the factors of production in the production process.

In this study we assume that agricultural productivity (AGP) is determined by agricultural public expenditure (AEX), farmers' private capital (CA), land (LAN), official development assistance (OD), farm labour supply (LAB) and rainfall (RF). Therefore, if A_t is taken as the level of technology, the agricultural productivity function can be stated in general form as:

$$AGP_t = f(A_t AEX_t CA_t LAN_t OD_t LAB_t RF_t) \quad (5)$$

Linearizing Equation 5 and adding the error term (ε_t), we obtain the estimable econometric model as follows:

$$\log AGP_t = A_t + \alpha_1 \log AEX_t + \alpha_2 \log CA_t + \alpha_3 \log LAN_t + \alpha_4 \log OD_t + \alpha_5 \log LAB_t + \alpha_6 \log RF_t + \varepsilon_t \quad (6)$$

However, the impact of factors of production specified in Equation 6 may not be instantaneous due to lags in the agricultural production cycles. Past agricultural productivity may also have an impact on present agricultural productivity (e.g., last year's glut or drought may affect this year's production). These considerations suggest that lagged values of factors of production ("distributed lag") and lagged values of agricultural productivity ("autoregressive lag") should be added as determinants of current agricultural productivity. Moreover, there are two types of agricultural production function: the first is the short run where the quantities of some factor inputs are kept constant and the quantities of other factor inputs vary, the second is the long run where all factor inputs can be varied (Debertin, 2012). To estimate the long-run and short-run impacts of AEX and other input factors specified previously, Equation 6 can be transformed as:

$$\Delta \log AGP_t = A_0 + C_1 \log AGP_{t-k} + C_2 \log AEX_{t-k} + C_3 \log CA_{t-k} + C_4 \log LAN_{t-k} + C_5 \log OD_{t-k} + C_6 \log LAB_{t-k}$$
$$+ C_7 \log RF_{t-k} + \sum_{k=1}^{p1} a_1 \Delta \log AGP_{t-k} + \sum_{k=1}^{q1} a_2 \Delta \log AEX_{t-k} + \sum_{k=1}^{q2} a_3 \Delta \log CA_{t-k} + \sum_{k=1}^{q3} a_4 \Delta \log LAN_{t-k} + \sum_{k=1}^{q4} a_5 \Delta \log OD_{t-k}$$
$$+ \sum_{k=1}^{q5} a_6 \Delta \log LAB_{t-k} + \sum_{k=1}^{q6} a_7 \Delta \log RF_{t-k} + \xi_t \quad (7)$$

where Δ is the differencing factor and ξ_t is the error term;[5] log and other parameters have been previously defined. As a result of the presence of a lagged AGP and lagged values of factors of production, an ARDL technique is the most appropriate methodology to estimate the short and long-run elasticities of input factors in Equation

7. The ARDL methodology involves estimating the unrestricted error correction model for agricultural productivity in Equation 7. The ARDL methodology for co-integration analysis was developed by Pesaran and Shin (1999), and extended by Pesaran et al. (2001). The methodology is preferred over other methods because it: (i) deals with the problem of reverse causality and endogeneity (Harris and Sollis, 2003); (ii) does not impose an assumption that all variables under investigation must be integrated of the same order;[6] (iii) provides an efficient estimator even when the sample size is not large and when some of the independent variables are endogenous; and (iv) as a form of a dynamic single-equation, it permits the variables to have different optimal lags[7] (Poynter, 2015; Essien et al., 2016).

The first step in applying ARDL is the bounds test for the null hypothesis of no cointegration. Equation 7 is important in testing for the number of co-integration equations between the dependent variable (AGP) and the explanatory variables such as AEX. Where all the variables are expressed in logarithm form, p and q are the lag lengths of dependent and independent variables, respectively, then the long-run multipliers are the c_s, and a_s are the short-run adjustments.

One can test the null and alternative hypotheses of no long-run relationships among the variables specified in Equation 7. The null and alternative hypotheses for Equation 7 can be stated as:

H_0: $c_1 = c_2 = c_3 = c_4 = c_5 = c_6 = c_7 = 0$ (no long-run relationship among the variables)
H_1: $c_1 \neq c_2 \neq c_3 \neq c_4 \neq c_5 \neq c_6 \neq c_7 \neq 0$ (there is a long-run relationship among the variables)
where $c_1, c_2, c_3, c_4, c_5, c_6, c_7$ are the long run-multipliers in Equation 7.

After estimating Equation 7, the bounds testing can be done by testing H_0 against H_1, the calculated F and t-statistics are assessed against the critical values and approximate probability values given by Kripfganz and Schneider (2018) for small sample size estimation. The lower bound critical values assume that the explanatory variables are integrated of order zero, that is 1(0), while the upper critical values assume that the explanatory variables are integrated of order one, that is 1(1). If the calculated F and T values are lower than the lower bounds, the null hypothesis is accepted. If they are greater than the lower bounds but lower than the upper bounds, the decision is inconclusive. Finally, if the F and T values are greater than the upper bounds, the null hypothesis of no cointegration is rejected in favour of the existence of a long-run relationship among the variables. Once the existence of a long-run co-integration relationship is confirmed, the conditional ARDL (p1, q1, q2, q3, q4, q5, q6) long-run equation for AGP can be estimated as:

$$\log AGP_t = \beta_0 + \sum_{k=1}^{p1} \beta_1 \log AGP_{t-k} + \sum_{k=1}^{q1} \beta_2 \log AEX_{t-k} + \sum_{k=1}^{q2} \beta_3 \log CA_{t-k} + \sum_{k=1}^{q3} \beta_4 \log LAN_{t-k} + \sum_{k=1}^{q4} \beta_5 \log OD_{t-k}$$
$$+ \sum_{k=1}^{q5} \beta_6 \log LAB_{t-k} + \sum_{k=1}^{q6} \beta_7 \log RF_{t-k} + \xi_t \quad (8)$$

The short-run dynamic estimates can be obtained by estimating an error correction model associated with the long-run parameters from Equation 9 as:

$$\Delta \log AGP_t = \lambda_0 + \sum_{t=1}^{p1} \lambda_1 \Delta \log AGP_{t-k} + \sum_{k=1}^{q1} \lambda_2 \Delta \log AEX_{t-k} + \sum_{k=1}^{q2} \lambda_3 \Delta \log CA_{t-k} + \sum_{k=1}^{q3} \lambda_4 \Delta \log LAN_{t-k} + \sum_{k=1}^{q4} \lambda_5 \Delta \log OD_{t-k}$$
$$+ \sum_{k=1}^{q5} \lambda_6 \Delta \log LAB_{t-k} + \sum_{k=1}^{q6} \lambda_7 \Delta \log RF_{t-k} + \omega ECM_{t-1} + \xi_t \quad (9)$$

where ECM is the error correction mechanism, ω is the speed of adjustment to equilibrium, β 's and λ s are the long and short-run parameters to be estimated, and other variables are as previously defined.

Although it is expected that agricultural public expenditure can influence agricultural productivity, the same agricultural productivity can also exert a causal effect on agricultural spending through the placement effect, therefore, we also specify an agricultural public expenditure equation, where AEX is the dependent variable and AGP becomes the independent variable. We make the agricultural public expenditure model more robust by replacing the rainfall variable, which may have the least influence on agricultural public budgetary allocation, with a policy variable termed MAP. MAP is a dummy variable to reflect the implementation of the Maputo Declaration that started in 2003, taking a value of 1 since the inception of the Declaration in 2003, and 0 otherwise. Going forward, the number of co-integration relationships in the agricultural public expenditure equation can be tested from Equation 10.

$$\Delta \log AEX_t = d_0 + d_1 \log AEX_{t-k} + d_2 \log AGP_{t-k} + d_3 \log CA_{t-k} + d_4 \log LAB_{t-k}$$
$$+ d_5 \log OD_{t-k} + d_6 \log LAN_{t-k} + d_7 \log RF_{t-k} + \sum_{k=1}^{p1} b_1 \Delta \log AEX_{t-k} + \sum_{k=1}^{q1} b_2 \Delta \log AGP_{t-k}$$
$$+ \sum_{k=1}^{q2} b_3 \Delta \log CA_{t-k} + \sum_{k=1}^{q3} b_4 \Delta \log LAB_{t-k} + \sum_{k=1}^{q4} b_5 \Delta \log OD_{t-k} + \sum_{k=1}^{q5} b_6 \Delta \log LAN_{t-k} + \sum_{k=1}^{q6} b_7 \Delta \log MAP_{t-k} + \psi_t$$

(10)

where all the variables are expressed in logarithm form, p and q are the lag lengths of dependent and independent variables, respectively, long-run multipliers are the *d*s, and *b*s are the short-run adjustments in Equation 10.

One can test null and alternative hypotheses of no long-run relationships among the variables specified in Equation 10. The null and alternative hypotheses in Equation 10 can be stated as:

H_0: $d_1 = d_2 = d_3 = d_4 = d_5 = d_6 = d_7 = 0$ (no long-run relationship among the variables)

H_1: $d_1 \neq d_2 \neq d_3 \neq d_4 \neq d_5 \neq d_6 \neq d_7 \neq 0$ (there is a long-run relationship among the variables) where d_1, d_2, d_3, d_4, d_5, d_6, d_7 are the long-run multipliers in Equation 10.

Once the existence of a long-run co-integration relationship is confirmed, the conditional ARDL (p1, q1, q2, q3, q4, q5, q6) long-run equation for agricultural public expenditure can be estimated as:

$$\log AEX_t = \kappa_0 + \sum_{k=1}^{p1} \kappa_1 \log AEX_{t-k} + \sum_{k=1}^{q1} \kappa_2 \log AGP_{t-k} + \sum_{k=1}^{q2} \kappa_3 \log CA_{t-k} + \sum_{k=1}^{q3} \kappa_4 \log LAN_{t-k} + \sum_{k=1}^{q4} \kappa_5 \log OD_{t-k}$$
$$+ \sum_{k=1}^{q5} \kappa_6 \log LAB_{t-k} + \sum_{k=1}^{q6} \kappa_7 \log MAP_{t-k} + \nu_t \qquad (11)$$

The short-run dynamic estimates can be obtained by estimating an error correction model associated with the long-run parameters from:

$$\Delta \log AEX_t = \varphi_0 + \sum_{k=1}^{p1} \varphi_1 \Delta \log AEX_{t-k} + \sum_{k=1}^{q1} \varphi_2 \Delta \log AGP_{t-k} + \sum_{k=1}^{q2} \varphi_3 \Delta \log CA_{t-k} + \sum_{k=1}^{q3} \varphi_4 \Delta \log LAN_{t-k}$$
$$+ \sum_{k=1}^{q4} \varphi_5 \Delta \log OD_{t-k} + \sum_{k=1}^{q5} \varphi_6 \Delta \log LAB_{t-k} + \sum_{k=1}^{q6} \varphi_7 \Delta \log MAP_{t-k} + \varphi ECM_{t-1} + \nu_t$$

$$(12)$$

where V_t is the error term, all other variables are as previously defined, κ's and φ's are long and short-run elasticity parameters to be estimated, and ϕ is the speed of adjustment to equilibrium. If the long-run cointegration is not established in the agricultural productivity or agricultural public expenditure equation, we can proceed to estimate the restricted ARDL (p1, q1, q2, q3, q4, q5, q6) for any of the equations where co-integration cannot be established.

3.3 Selection of Instrument for Endogenous Variable (Agricultural Public Expenditure)

In the presence of a weak instrument, the bias of the instrumental variable (IV) estimator can be large, and it can even be larger than the bias of the OLS estimator. Therefore, we set out to determine the strength or weakness of the instrument to be used in the study. In determining the relevance condition or weakness of an instrument, Shea (1997) considered multiple regressors and looked at partial R^2. In the case of a single regressor as agricultural public expenditure, Staiger and Stock (1997) considered declaring an instrument to be weak if the first-stage F statistic is less than

10. However, Stock and Yogo (2005) are of the opinion that deciding the strength or weakness of the IV depends on the inferential task to which instruments are applied and how that inference is conducted. In their study, they fixed the largest relative bias of the two-stage least squares estimator (2SLS) relative to OLS that is acceptable. In that sense one can test the null hypothesis that the maximum relative bias due to weak instruments is 10% (or 5%, etc.). The critical values for rejection of the hypothesis depend on the acceptable bias (a lower acceptable bias means that the instrument must achieve a higher first-stage F statistic), the number of endogenous regressors and the number of instruments. Cragg and Donald's (1993) statistic is based simply on the F statistic (first-stage F statistic) for testing the hypothesis that the instrument does not enter the first-stage regression of 2SLS. With one endogenous variable as agricultural public expenditure, the Cragg-Donald test[8] would give a similar result as Stock and Yogo (2005). However, Stock and Yogo's, Cragg-Donald's and Anderson's tests all rely on an independent and identically distributed (iid) assumption on the errors. Kleibergen and Paap's (2006) test is based on heteroscedasticity robust standard errors, therefore it is robust against violations of the iid assumption. It can also work with one endogenous variable and one instrument provided the model is identified.[9] Kleibergen and Paap's (2006) test permits analysts to determine whether the minimal canonical correlation between the endogenous variables and the instruments is statistically different from zero.

In this study we applied Cragg and Donald's (1993), Kleibergen and Paap's (2006), Shea's (1997) and Staiger and Stock's (1997) tests on the instruments we selected for agricultural public expenditure. The instruments considered for agricultural public expenditure are: government revenue,[10] volume of oil export and official exchange rate. The biggest source of the Nigerian government's revenue is oil exports, and the official exchange rate is an important determinant of revenue accrued from oil exports. The most valid instrument was chosen based on the Cragg and Donald (1993), Kleibergen and Paap (2006), Shea (1997) and Staiger and Stock (1997) tests.

3.4 Data Sources and Measurement of Variables

The current analysis utilized the agricultural production function based on the conceptual framework indicated in Figure 2. In the analysis, AGP was proxied by agricultural value added per farmer. Agricultural value added per farmer was derived by dividing agricultural GDP by the number of farmers. The benefit of using agricultural GDP as the measure of agricultural total output is embedded in the fact that the value of all agricultural commodities produced are aggregated in the agricultural GDP. Agricultural GDP is also expressed in monetary terms in order to aggregate different agricultural commodities produced in different forms into a single measure (FAO, 1980). The agricultural value added per farmer as a measure of productivity has been shown to enable the measurement of the returns to factors of production such as land, labour and capital (FAO, 2018). Moreover, according to the FAO (2018), agricultural value added per farmer as an example of a single-factor productivity indicator can easily be interpreted, understood and calculated, due to the fact that both the numerator and denominator can be expressed in terms of physical units. Several studies, for example by Kelly et al. (1996), Prasada (1993) and the FAO (FAO, 2018), have indicated that the lack of accurate agricultural statistics in developing countries will hamper the estimation of TFP, which is a better measure of productivity because it considers all the factors of production used in the production process. Moreover, the measurement of TFP is demanding in terms of data requirements, because disaggregated and specific information on quantities and prices is required for all the outputs and the major inputs included in the production process. The number of farmers considered as denominator in estimating the agricultural value added per farmer is an important unit to be accounted for in measuring agricultural productivity because the number of farmers is the pull from which labour supplies are derived. Labour is an important input in agricultural production, especially in Africa where agriculture remains labour intensive. GSARS (2016) has proved that labour expenses represent about 60% of the total cost of agricultural production if family labour is adequately accounted for in Africa, which also depends on the agricultural products under consideration.

The relevant data for this study are secondary data that range from 1981 to 2014. The agricultural public expenditure is divided into two main categories: capital and recurrent expenditure. Information provided by Mogues et al. (2008) and Olomola et al. (2015) was used to divide agricultural public capital expenditure into different components. Farmers' private capital on the farm is proxied by gross fixed capital formation (GFCF).[11] Farm labour supply is modelled as the ratio of farmers' population to total population in Nigeria.

Agricultural GDP, agricultural public expenditure (recurrent, capital and total) and rainfall were obtained from the Central Bank of Nigeria (CBN) *Statistical Bulletin*. GFCF, arable land per farmer, labour supply and ODA were extracted from the FAOSTAT website (FAOSTAT, 2019). The summary of relevant variables and units of measurement are presented in Table A1, while Table 2 indicates their measurement. All monetary values were deflated (GDP deflator) using 2010 constant prices to exclude the influence of inflation, other temporary monetary and fiscal trends.

Table 2: Measurement of relevant variables used in study

Variables	Measurement
Recurrent agriculture expenditure per farmer	Recurrent agriculture expenditure/number of farmers (number)
Capital agriculture expenditure per farmer	Capital agriculture expenditure/number of farmers (Naira)
Total agriculture expenditure per farmer	Total agriculture expenditure/number of farmers (Naira)
Farmer-population ratio (labour)	Number of farmers/total population (number)

Agricultural GDP	Sum of all agricultural produce in Nigeria expressed in local currency (Naira)
Agricultural value added per farmer	Agricultural GDP/number of f armers(Naira)
Agricultural ODA	Amount of ODA allocated to agriculture (Naira)
Farmers' private investment (depreciated value)	$GFCF_{year}) _X \delta$ (depreciation rate) (Naira)
Arable land per farmer	Arable land/number of farmers (number)

Source: Computed by authors.

3.5 Estimation Procedure

To achieve objective 1 of this study, the share of agricultural public expenditure in total government expenditure in Nigeria was estimated. The share of agricultural public expenditure was compared with the benchmark of 10% envisaged in the Maputo Declaration. Also, the Agriculture Orientation Index (AOI) was determined relating the AEX share in government total spending (% share of AEX) to the share of agricultural GDP in the country's total GDP (% share of AGDP) (Mink, 2016). This supports the priority that the government attaches to the agricultural sector in budgetary allocation in Nigeria. The growth rate of agricultural public expenditure was estimated following Barrett's (2001) procedure. The growth rates of public agricultural capital and recurrent expenditure were estimated separately using Equation 13 as follows:

$$\text{Log (AEX)} = \alpha_o + \psi_1 \text{(Year)} + \ell_{p} \qquad (13)$$

where log is the logarithm in base 10, Year is the period under consideration, where 1981 is 1 and 1982 is 2, and 34 represents 2014. AEX is the agricultural public expenditure, the error term is $_{p}$, ψ_1 is the estimated AEX growth rate when expressed as a percentage. ψ_1 was estimated for agricultural recurrent and capital expenditure to check if there are differences in the growth rates of the two components of AEX in Nigeria. The AEX budget execution rate was determined by calculating the ratio of THE public agricultural budget estimate to its expenditure.[12] If the allocated budget is not fully implemented, it will be difficult for the agriculture ministry to convince the ministry of finance to increase their budgets when the approved budgets seemed not to have been well implemented.

We selected the most valid instruments for agricultural public expenditure out of government revenue, the volume of oil export and official exchange rate as instruments. Government revenue is judged to be the most valid instrument because it has the highest Cragg-Donald (1993) statistic of 35.71, Kleibergen-Paap (2006) statistic[13] of 28.94, partial R^2 (Shea, 1997) value of 0.5694 and first-stage F statistic (Staiger and Stock, 1997; Bound et al., 1995) value of 35.71. These figures are presented in Table A2 in the Appendix. The Durbin score and Wu-Hausman tests were used to test for endogeneity of agricultural public expenditure (Durbin, 1954; Wu, 1974; Hausman, 1978). This was done under the framework of an IV-2SLS approach where AEX was instrumented by government revenue (REV).

The optimal lag length was determined by a Schwarz Information Criterion (SBIC) and is indicated in Table A3 in the Appendix. Proceeding with the ARDL analysis, we performed an augmented Dickey-Fuller test (ADF) test to check for unit roots in order to be sure that none of the variables are in an integration order greater than one. The ADF test shows that all variables of interest were stationary after they were differenced, except the land and rainfall variables, which are stationary without differencing. This means that all the variables are integrated of order one I(1), while the land and rainfall variables are I(0). This is reported in Table A4 in the Appendix.

For objective 2, the dynamic relationship between public agricultural expenditure and agricultural productivity was employed using an ARDL methodology. Cointegration in agricultural productivity and agricultural public expenditure equations was tested, and the ARDL bounds test for cointegration was performed as reported in Table A5 in the Appendix. The results indicate that when agricultural productivity is the dependent variable (agricultural productivity equation), there is 1 (one) cointegrating equation among the variables when agricultural public capital is one of the explanatory variables. In the agricultural public expenditure equation, where agricultural public total expenditure is the dependent variable, there is 1 (one) cointegrating equation among the variables.[14] Hence, an unrestricted error correction ARDL model was estimated for the agricultural productivity and agricultural public expenditure equations for the models where cointegration was established. For the agricultural productivity and agricultural public expenditure equations, where cointegration was not established, restricted ARDL models were estimated. Equations 8 and 9 were estimated to determine the long and short-run impacts of agricultural public capital expenditure on agricultural productivity in Nigeria. Equations 11 and 12 were also estimated for the agricultural public total expenditure (APTE) equation to determine the effect of agricultural productivity on agricultural public total expenditure. In achieving objective 3, the procedure adopted in achieving objective 2 was followed, but now the components of agricultural public expenditure were considered determinants of agricultural productivity.

To authenticate the direction of causality between agricultural productivity and agricultural public expenditure, a Granger causality test was performed. Based on Granger, causality is confirmed when lagged values of agricultural public expenditure have explanatory power in a regression equation of agricultural productivity that contains lagged values of both agricultural productivity and agricultural public expenditure (Essien et al., 2016). For example, if $\Delta logAEX_{t-1}$ fails to Granger cause $\Delta logAGP_t$, the coefficients of the latter in Equation 14, for instance, will be zero. Thus, we tested the null hypothesis (using the standard F-test) that H_0: $\varphi_1 = \varphi_2 = 0$ in Equation 14 against the alternative hypothesis that H_1: at least one of ϕ s is different from 0. If we reject H_0, then we can conclude that agricultural productivity Granger causes agricultural public expenditure. Similarly, in Equation 15 the null hypothesis (H_0: γ_1

= γ_2 = 0) is tested against the alternative (H_1: at least one of γ s is different from 0). If H_0, is rejected, then it is concluded that an increase in public agricultural expenditure Granger causes an increase in agricultural productivity.

$$\Delta \log APG_t = a_0 + \sum_{i=1}^{m} \delta_i \Delta \log AGP_{t-i} + \sum_{j=0}^{m} \phi_j \Delta \log AEX_{t-j} + \chi_{1t} \quad (14)$$

$$\Delta \log AEX_t = b_0 + \sum_{j=0}^{m} \vartheta_i \Delta \log AEX_{t-j} + \sum_{i=1}^{m} \gamma_j \Delta \log AGP_{t-i} + \eta_{2t} \quad (15)$$

While all other variables have been defined previously, χ_{1t} and η_{2t} are the error terms for Equations 14 and 15, respectively.

The diagnostic tests for autocorrelation were performed using Durbin's alternative test and the Breusch-Godfrey LM test. The heteroscedasticity test was done using the Durbin-Watson d-statistic. The results of the various tests, as reported in Table A11 in the Appendix, shows that the analysis did not suffer from autocorrelation and that the equations were homoscedastic. The CUSUM squared test of stability, reported in Figure A1 in the Appendix, reveals that the model is stable as the dotted line lies are within the two bounded lines.

4. Results and Discussion

This section elaborates on the findings from this study and discusses the economic implications of the findings. In detail, it presents and discusses the findings from the structure of public agricultural expenditure in Nigeria. The findings from endogeneity tests are also reported in this part of the report. Similarly, the effects of agricultural public expenditure on agricultural productivity are also reported in this section. The last part of this section presents and discusses findings of the impact of agricultural productivity on agricultural public expenditure.

4.1 Structure of Public Agricultural Expenditure in Nigeria

The mean budget execution rate of agricultural public expenditure is estimated at about 80%, as presented in Table 3. This suggests that about 20% of the agricultural budgets were not implemented in Nigeria. The t-ratio value of 3.1945, which is significant at the 1% level, implies that agricultural public expenditure is significantly lower than had been budgeted over the period under consideration. The discrepancy in budget implementation of an estimated 20% is higher than the 10% discrepancy allowed in the Public Expenditure and Financial Accountability (PEFA) best practice standard for budget execution (World Bank, 2007; 2011). Mogues et al. (2008) reported that the capital budget suffered a lower execution rate (62%) in Nigeria compared to the recurrent budget execution rate (104%), with an overall budget execution rate of 79% between 2000 and 2005 (Mogues et al., 2008). Olomola et al. (2015) indicated that weak executive capacity leads to delays in budget approval at all stages of the budget cycle, and this tends to hinder the budget performance of government at the national level. Table 3 also shows that the coefficients of variation of budget and expenditure are 0.94 and 1.12, respectively. This implies that there is more unpredictability (inconsistency) in expenditure than in budget estimates. The data show that budget execution rates range from as low as 17% in 2002 to as high as 100% in 2018. The unpredictability of the budget execution can limit its impact on agricultural productivity. Mink (2016) reported low budget implementation rates in Africa. He emphasized the need to improve the predictability and consistency of budget releases from ministries of finance.

Table 3: Budget execution rates of agricultural public expenditure in Nigeria

Period	Mean budget (nominal, billion Naira)	Mean expenditure (nominal, billion Naira)	Budget execution rate (%)
1999–2003	10.2551	6.5101	63.48
2004–2008	21.1524	20.3385	96.15
2009–2013	32.2750	25.8573	80.12
2014–2018	47.9941	36.5783	76.21
Grand mean	27.9191	22.3211	79.95
Standard deviation	26.24063	24.8813	25.09
Minimum	10.2551	6.5101	63.48
Maximum	47.9941	36.5783	96.15
Coefficient of variation	0.94	1.12	-
T-ratio	3.1946***		-

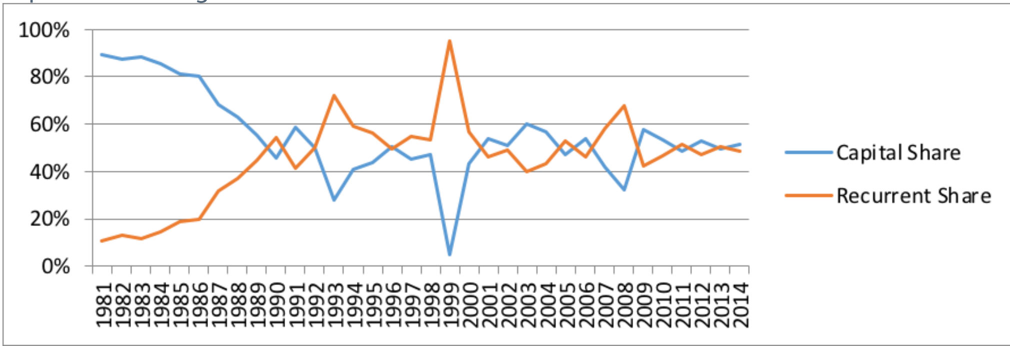
*** Significant at 1%.

Source: Computed by authors; data from Central Bank of Nigeria (2020)

On average, capital expenditure shared 55% of agriculture expenditure between 1981 and 2014 as revealed in Table 4. However, there were a lot of fluctuations in the share of capital expenditure. The share of capital expenditure ranged between 5% and 89%, and consistently fell below the recommended 60% required for effective agricultural performance (Olomola et al., 2015). The evolution in the share of capital and recurrent public agricultural expenditure in Nigeria is portrayed in Figure 3. The figure shows that the highest share of capital expenditure was in 1981 and the lowest in 1999. The share of capital expenditure has not grown to reach the level of 1981. The opposite is true in terms of the share of recurrent public expenditure, as its lowest share was in 1981 and the highest share in 1999. The figure suggests that the shares of capital and recurrent expenditure are negatively correlated. The more shares allocated to recurrent expenditure, the less will be left for capital expenditure.

Table 4 further reveals that recurrent expenditure (10.81%) grew faster than capital expenditure (5.75%), and total public agricultural expenditure grew by 7.35% annually. The estimated share of agricultural public expenditure in total government expenditure in Nigeria is 1.52%, as presented in Table 4, which is far lower than the 4% average for sub-Saharan Africa (SSA) and lower than the 10% recommended in the Maputo Declaration (Benin, 2015). Table 4 also indicates that the share of agricultural expenditure in total government expenditure ranged from 0.65% to 6.58% between 1981 and 2014. The mean AOI is estimated at 7.05%, ranging from 3.32% to 31.41%. This suggests that only 7.05% of agriculture's contribution to the economy was spent on the sector during the period under consideration. Goyal and Nash (2017) revealed that most African countries spend smaller proportions of the public budget on agriculture than the sector's contribution to the economy (GDP). Table 4 further demonstrates that the Nigerian economy (total GDP) grew by about 5% compared with the 6% growth rate in agriculture (agricultural GDP).

Figure 3: Trend of shares of capital and recurrent public agricultural expenditure in Nigeria



Source: Constructed from CBN (2018).

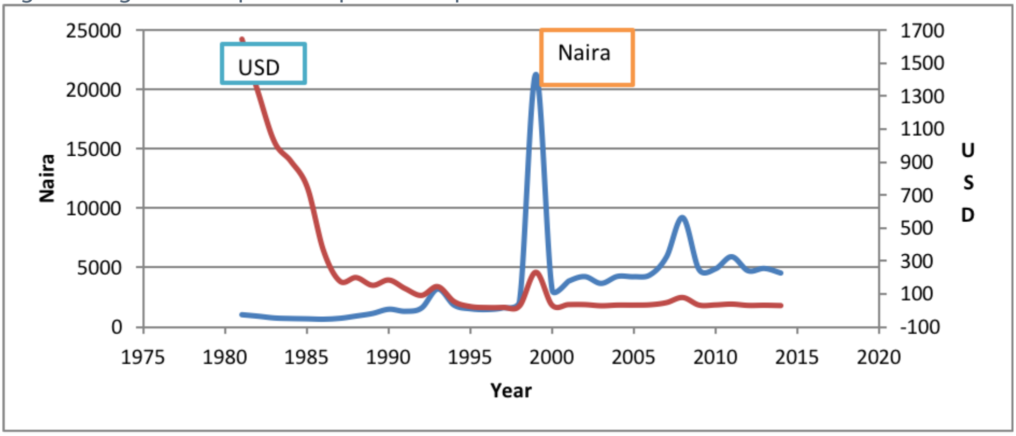
Table 4: Structure of agricultural public expenditure in Nigeria, 1981–2014

Structure of expenditure	Mean	Minimum	Maximum
Share of capital in public agriculture expenditure (%)	54.87	4.93	89.23
Share of recurrent public agriculture expenditure (%)	45.13	10.76	95.07
Growth rate of capital public agriculture expenditure (%)	5.75	-	-
Growth rate of recurrent public agriculture expenditure (%)	10.81	-	-
Growth rate of total public agriculture expenditure (%)	7.35	-	-
Share of total agriculture expenditure in government expenditure (%)	1.52	0.65	6.58
Growth rate of total government expenditure (%)	4.17	-	-
Share of agricultural GDP in total GDP (%)	21.11	15.50	27.00
Agriculture orientation index (%)	7.05	3.32	31.41
Growth rate of agricultural GDP (%)	6.21	-	-
Growth rate of total GDP (%)	4.88	-	-

Source: Computed by authors.

Figure 4 presents agricultural public spending per farmer in Nigeria based on the local currency (Naira) and the US Dollar (USD). Spending per farmer increased sharply in 1999 and declined in 2000, and never again reached the 1999 level. In US dollar terms, spending per farmer was at its peak at more than USD1,500 in 1981 and then declined to less than USD100 per farmer in 2014 (with mean spending per farmer at USD235). Considering only the rural population and based on available data, the spending per rural farmer declined from USD354 in 1981 to USD4 in 2014. The mean spending per rural farmer was USD47, which is higher than the per capita agricultural public expenditure in SSA, which was estimated to be USD28 in 1980/89 and USD19 in 2000/12 (Goyal and Nash, 2017).

Figure 4: Agricultural public expenditure per farmer in Naira and USD



Source: Constructed by authors.

4.2 Test of Endogeneity of Public Agricultural Expenditure in Nigeria

The first-stage regression results of IV-2SLS using REV as an instrumental variable yielded a partial *R*-squared statistic of 0.5694 and an F value of 29.84, as indicated in Table 5. The F value of the first regression is greater than 10 with a high partial R-squared of 0.5694, which supports the fact that REV might not be a weak instrument for agricultural capital expenditure (ACE) (Wooldridge, 2013). We then estimated the IV-2SLS using REV as instrumental variable. The Durbin score of 16.1159 and Wu-Hausman score of 23.4294 are significant at 1%. This suggests that ACE is endogenous.

The reported IV-2SLS estimates in Table 5 reveal that the positive determinants of agricultural productivity are agricultural public capital expenditure, farmers' private capital and rainfall. The labour regression coefficient is negative but significant at 1%. Land and ODA are not significant determinants of agricultural productivity in the model. The IV-2SLS result estimates of the impact of recurrent and total agricultural expenditure (ARE and APTE) on agricultural productivity are shown in Tables A6 and A7, respectively, in the Appendix. While Table A7 conveys essentially the same message as Table 5, Table A6 shows that REV is a weak instrument for ARE, which may also suggest that ARE is not a significant determinant of agricultural productivity in Nigeria.

Table 5: IV-2SLS regression results of agricultural capital expenditure impact

First-stage regression			Second-stage regression		
	F(1, 27)	29.84		F(6, 27)	890.73
	Prob > F	0.0000		Prob > F	0.0000
	R^2	0.9219		Centered R^2	0.9913
	Adjusted R^2	0.9045			
	Partial R^2	0.5694			
Agric capital expenditure (ACE)	Coefficient	P>|t|	Agric productivity	Coefficient	P>|t|

Continued on page 23

Private capital	0. 11039*	0.110	ACE	0.2427***	0.000
Land	-0. 7082	0.300	Private capital	0. 1452***	0.000
ODA	0. 0012	0.972	Land	-0.1321	0.627
Labour	-0. 0703	0.903	ODA	0. 0069	0.487
Rainfall	-0. 0845	0.742	Labour	-1.5573 ***	0.000
Government revenue	0. 0968***	0.000	Rainfall	0. 1491**	0.050
Constant	4.8365**	0.032	Constant	6.8839***	0.000
			H_0: Capital agric expenditure is exogenous		
			Durbin (score) Chi^2	16.1159 ***	0.000
			Wu-Hausman F	23.4294 ***	0.000

(*), (**) and (***) express 10%, 5% and 1% significance level, respectively.

Source: Computed by authors.

4.3 Effect of Agricultural Public Expenditure on Agricultural Productivity in Nigeria

Having established cointegration in the agricultural productivity equation where agricultural public capital expenditure is an independent variable, the estimated long and short-run impacts of ACE on agricultural productivity are reported in Table 6. The error correction mechanism (ECM) estimated in Table 6 is -0.8138 and is significant at 1%, which confirms that there is cointegration among the variables specified in the model. The ECM value of -0.8138 implies that the previous year's deviation from the long-run equilibrium in the estimated equation in Table 6 is corrected at a rate of 81.38% in the current year.[15] In the long run, the table indicates that past agricultural public capital expenditure, farmers' private capital and rainfall are the positive determinants of agricultural productivity. Labour is a negative determinant, while land and ODA are not significant determinants of agricultural productivity in Nigeria in the long run. This agrees with our IV-2SLS estimates reported in Table 5. However, in the short run, the positive determinants are farmers' private capital and rainfall, while labour maintains a negative but significant relationship with agricultural productivity. Table 6 also demonstrates a weak negative relationship between agricultural public capital expenditure and agricultural productivity in the short run. The weak negative relationship[16] between agricultural public capital expenditure and agricultural productivity in the short run justifies the need to estimate the long-run relationship between agricultural public capital expenditure and agricultural productivity. If the long-run elasticity of agricultural public capital expenditure with respect to agricultural productivity was not estimated, we would have concluded a negative relationship between agricultural public capital expenditure and agricultural productivity. This may be attributed to a negative relationship between public investment and agricultural sector productivity in Ghana, as reported by Asuamah (2016). In their static model estimation, Matthew and Mordecai (2016) also concluded that public agricultural expenditure had a significant but negative impact on agricultural output in Nigeria.

Table 6 demonstrates that the regression coefficient of lagged public capital expenditure is 0.1566 in the long run. This implies that if past government agricultural capital expenditure had increased by 100%, agricultural productivity would have increased by 15.66%. The coefficient of 0.1566 that was estimated compares favourably with the estimated elasticity of 0.17 in Alene and Coulibaly (2009), but is lower than the 0.36 in Thirtle et al. (2003). Alene and Coulibaly (2009) and Thirtle et al. (2003) used simultaneous equation systems in their estimations. However, the estimated public capital expenditure elasticity of 0.1566 presented in Table 6 falls within the range of 0.10–0.30 of the average for Africa found by Goyal and Nash (2017) and Benin (2015). The elasticity of farmers' private capital in the long run is 0.1283. This suggests that if in the past farmers' private capital had doubled, agricultural productivity would also have increased by 12.83%. The estimated elasticity of farmers' private capital of 0.1283 is close to the 0.12 estimated impact of private farm investment on the value of household total agricultural output per capita in Ghana (Benin et al., 2009). The elasticities of labour supply in the long and short run are -1.7103 and -1.3919. The fact that the elasticities of labour are negative and significant in the long and short-run models is confirmation of the declined agricultural labour productivity in Nigeria. Other scholars have also reported low and declining labour productivity in Africa. The FAO (2001) showed that labour productivity fell by an average of one per cent per year in SSA agriculture, while it increased by 1.9% and 2.5% per year, respectively, in South Asia and Latin America. McCullough (2017) revealed that workers in SSA countries are 3.4 times as productive outside of agriculture as in the sector. This finding is consistent with that of Gollin et al. (2014).

Table 6: Estimates of long and short-run coefficients of ARDL model (impact of agricultural capital expenditure on agricultural productivity)

	Long run			Short run	
	R^2	0.7926			
	Adj R^2	0.7235			
Agric GDP per farmer	Coefficient	P>|t|	ΔAgric GDP per farmer	Coefficient	P>|t|
Capital agric expenditure$_{(t-1)}$	0.1566***	0.008	ΔCapital agric expenditure	-0.1175*	0.088
Private capital$_{(t-1)}$	0.1283***	0.000	ΔPrivate capital	0.1044***	0.000
Land$_{(t-1)}$	0.1277	0.648	ΔLand	-0.1039	0.642
ODA$_{(t-1)}$	0.0122	0.243	ΔODA	0.0099	0.256
Labour$_{(t-1)}$	-1.7103***	0.000	ΔLabour	-1.3919***	0. 000
Rainfall$_{(t-1)}$	0.2470***	0.006	ΔRainfall	0.2010***	0.000
Constant	5.1890***	0.000	ECM	-0. 8138***	0.000
	Log likelihood	63.4993			

(*), (**) and (***) express 10%, 5% and 1% significance level, respectively; Δ = differencing factor.

Source: Authors' computation.

It should be noted that in the short and long run, rainfall has a significant and positive relationship with agricultural productivity, as seen in Table 6. This reinforces the importance of the water regime in agricultural production activities. Benin (2015) also reported the relevance of rainfall in improving agricultural productivity and highlighted that the importance of rainfall in impacting agricultural productivity depends on the crops under consideration. Another variable that has a positive and significant impact on agricultural productivity in the long and short run is farmers' private capital. The FAO (2001) emphasized the importance of farmers' private capital investment in improving agricultural productivity.

The estimated restricted ARDL results of agricultural productivity equations where ARE and APTE are the explanatory variables are presented in Table A8 in the Appendix. Table A8 shows that ARE maintains a weak relationship with agricultural productivity in Nigeria (significant at a 10% level of significance), while APTE is a strong determinant of agricultural productivity in Nigeria (significant at a 1% level of significance). This supports the fact that the interaction of agricultural public capital expenditure with agricultural public recurrent expenditure increases the productivity of agricultural total public expenditure (Benin, 2015). Labour and land have negative but significant relationships with agricultural productivity at the 1% and 10% levels of significance, respectively (in column 5 in Table A8). The case of declined labour productivity in Nigerian agriculture may be the reason for low labour participation in the agricultural sector in Nigeria since 2001 (Odozi et al., 2018). The negative relationship between land and agricultural productivity implies declined land productivity in Nigerian agriculture. Phillip et al. (2019) also reported declining land productivity in Nigeria, which they attributed to bush burning, land tenure constraints and other negative traditional practices.

4.4 Impact of Agricultural Productivity on Public Agricultural Expenditure in Nigeria

The estimated impact of agricultural productivity on agricultural public total expenditure is presented in Table 7. The ECM estimated in the total agricultural public expenditure model is -0.8104 and is significant at 1%. This confirms that there is cointegration among the variables specified in the model. The coefficient of ECM in the model of -0.8104 indicates that the previous year's deviation from the long-run equilibrium in the estimated equation is corrected in 81.04% of cases, at a rate of 1.19(1/0.84) years.[17] Table 7 reveals that the determinants of total agricultural expenditure in Nigeria are past agricultural productivity and farmers' private capital in the long and short runs. More specifically, the table shows that agricultural productivity elasticity with respect to agricultural total expenditure in the long run is significantly equal to 4.0745 at 1%.

Table 7: Estimates of long and short-run coefficients of ARDL model (impact of agricultural productivity on agricultural total expenditure)

	Long run			Short run	
	R^2	0.7250			
	Adj R^2	0.6334			
Agric total expenditure	Coefficient	P>|t|	ΔAgric total expenditure	Coefficient	P>|t|
Agric GDP per farmer$_{(t-1)}$	4.0745**	0.022	ΔGDP per farmer	3.3020***	0.011
Private capital$_{(t-1)}$	-0. 7091***	0.008	ΔPrivate capital	-1.0150***	0.000
Land$_{(t-1)}$	1.7436	0.373	ΔLand	1.4130	0.345
ODA$_{(t-1)}$	-0. 0767	0.297	ΔODA	-0.0622	0.328
Labour$_{(t-1)}$	4.1935	0.210	ΔLabour	3.3984	0.159
Maputo	-0. 7403	0.223	Maputo	-0.5999	0.169
Constant	-28.5766***	0.011	ECM	-0.8104 ***	0.010

(*), (**) and (***) express a 10%, 5% and 1% significance level, respectively; Δ = differencing factor.

Source: Authors' computation.

A cointegrating test of agricultural capital and recurrent equations where agricultural productivity is the independent variable indicates an absence of cointegration. The estimated restricted ARDL models for agricultural capital and recurrent equations are reported in Table A9 in the Appendix. The table shows that agricultural productivity has a positive and significant relationship with recurrent expenditure (at a 10% level of significance). The positive and significant relationship between agricultural productivity and agricultural recurrent expenditure in agricultural expenditure reinforces the notion of reverse causality between agricultural public recurrent expenditure and agricultural productivity.

The positive relationship between lagged agricultural productivity and total agricultural public expenditure suggests that agricultural products that are highly productive in Nigeria attract more government spending intervention. This is the case in a crop such as cassava, which attracted a lot of government attention because the country had a comparative advantage in its production (IITA, 2012). In Table 7, the elasticity of farmers' private capital with respect to total agricultural public expenditure in the long run is -0.7091, which is significant at 1%. This reflects the possible "crowding out" effect of total agricultural public expenditure on farmers' private capital investment (Mbaku and Kimenyi, 1997). The crowding out effect of public expenditure can manifest when governments are spending on projects or schemes that do not encourage private enterprise from taking place in the same area of the market by making it undesirable or even unprofitable (Investopedia, 2020). The pattern of agricultural public expenditure may also explain its crowding out effect in the Nigerian agriculture sector, as about 97% of agricultural public capital expenditure was directed to support the crops subsector, and only 3% went to supporting the livestock and fisheries subsectors combined (Mogues et al., 2008). Mogues et al. (2008) also reported a remarkable concentration of public resources in the agricultural subsidy scheme in Nigeria.

While Table 7 shows that ODA does not have a significant relationship with APTE, Table A9 in the Appendix reveals that ODA has a positive and significant relationship with agricultural public capital expenditure. This suggests that an increase in ODA induces more agricultural public capital expenditure. This may be because some of the ODA-related agricultural projects in Nigeria are being funded with government counterpart funding. The finding of a positive relationship between agricultural public capital expenditure and ODA aligns with Reisen et al.'s (2004) study, which reported a complementary role between ODA and public expenditure in developing countries. ODA has been proven to tackle the savings and trade balance (foreign exchange) constraints to agricultural production and growth because it helps bridge the gaps of limited domestic capital in developing countries such as Nigeria (Verter, 2017).

Comparing the crowding out effect of farmers' private capital with different components of agricultural public capital expenditure in Table A10 in the Appendix demonstrates that the crowding out effect of agricultural public expenditure is higher regarding subsidy expenditure than any other component of agricultural public capital expenditure. This supports the notion that public spending may be unproductive or crowding out private capital when government sometimes spends on things other than public goods (Goyal and Nash, 2017). Empirical evidence has shown that government spending on public goods has typically been much more productive than public spending on private goods (López and Galinato, 2007). Fan et al. (2007) indicated that subsidy programmes crowded out more productive government spending in agricultural R&D, rural roads and education in India.

Moreover, Table A10 in the Appendix indicates that ODA crowds in more rural development expenditure than any other components of agricultural public capital expenditure. Realizing the importance of ODA for promoting rural development, Ssozi et al. (2019) called for more research on the nexus between ODA for agricultural and rural development. The finding of crowding in of agricultural public capital expenditure by ODA suggests that although ODA may not have an impact on agricultural productivity directly (as reflected in Table 6), its impact may be transmitted through its inducement of agricultural public capital expenditure which, in turn, will increase agricultural productivity.

It is worth noting that the coefficient of the Maputo variable is not significant in all relevant equations that were estimated. This is an indication that the Maputo Declaration of 2003 has not significantly increased agricultural public expenditure in Nigeria. It is evident because the share of government expenditure in the agricultural sector in Nigeria was estimated at 1.52%, which is far from the 10% envisaged in the Maputo Declaration. Generally, only about 20% of African countries have increased their budgetary allocations to agriculture based on the Maputo Declaration, and Nigeria is not among those countries (Badiane et al., 2016).

The causality test between agricultural public expenditure and agricultural productivity is presented in Table 8. The table shows a lack of causality between agricultural ARE and agricultural productivity. However, there is bidirectional causality between public ACE and agricultural productivity. The bidirectional causality between public agricultural capital expenditure and agricultural productivity further supports the endogeneity of agricultural public capital expenditure, which ARDL and IV-2SLS analyses have established. The table reveals further that there is a unidirectional causality between APTE and agricultural productivity, and the direction is from agricultural productivity to agricultural public total expenditure.

Table 8: Granger causality tests

Hypotheses	F statistics	Probability
ACE does not cause agricultural productivity	4.1141	0.0515**
Agricultural productivity does not cause ACE	4.1269	0.0511**
ARE does not cause agricultural productivity	0.3102	0.5817
Agricultural productivity does not cause ARE	2.8606	0.1011
APTE does not cause agricultural productivity	0.3865	0.5388
Agricultural productivity does not cause APTE	7.4071	0.0107**

**Significant at 5%.

Source: Authors' computation.

The estimates presented in Table 9 reveal that the elasticities of subsidy, irrigation, R&D and rural development expenditures are 0.1556, 0.1570, 0.1557, and 0.1561, respectively. This is an indication that if a lagged subsidy, irrigation, R&D and rural development expenditures had increased by 100%, agricultural productivity would have increased by 15.56%, 15.70%, 15.57% and 15.61%, respectively. This shows that an increase in irrigation expenditure will have the greatest influence (15.70%) on agricultural productivity, while an increase in subsidy expenditure will have the least effect (15.56%) on agricultural productivity. As the differences in the estimated elasticities in Table 9 may not be significant, we proceeded to estimate marginal returns to the subsidy, irrigation, R&D and rural development expenditures in Table 10. The table demonstrates that marginal returns to subsidy, irrigation, R&D and rural development expenditures are 0.18, 6.53, 2.18 and 0.82, respectively. This finding reinforces the fact that expenditure in irrigation facilities will have a greater effect on agricultural productivity (6.53) in Nigeria than public investment on agricultural subsidy schemes and programmes (0.18). Other scholars have reported a positive impact of irrigation expenditure not only on agricultural productivity but also on its ability to induce more private investment in agricultural production activities (Fan et al., 2000). According to Rosegrant et al. (2009), SSA has significant unexploited potential to develop both large and small-scale irrigation, but economic returns depend on keeping costs down.

Table 9: Estimates of long and short-run coefficients of ARDL model (impacts of different components of ACE)

	Subsidy		R&D		Rural dev		Irrigation	
	Long run							
	R^2	0.7934	R^2	0.7950	R^2	0.8249	R^2	0.7939
	Adj R^2	0.7245	Adj R^2	0.7266	Adj R^2	0.7052	Adj R^2	0.7252
	Long Run		Long Run		Long Run		Long Run	
Agric GDP per farmer	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|
Component of expenditure$_{(t-1)}$	0. 1556***	0. 008	0.1561***	0.008	0. 1557***	0.008	0. 1570***	0.000
Private capital$_{(t-1)}$	0. 12855 ***	0.000	0.1286***	0.000	0.1283***	0.000	0.1283***	0.000
Land$_{(t-1)}$	0. 1254	0. 653	0. 1254	0.653	0. 1325	0.633	0.1310	0.639
ODA$_{(t-1)}$	0. 01213	0.243	0. 0122	0.238	0. 0123	0.235	0.0122	0.239
Labour$_{(t-1)}$	-1.7122***	0.000	-1.7114***	0.000	-1.7111***	0.000	-1.70931***	0.000
Rainfall$_{(t-1)}$	0. 2473***	0.005	0. 2473***	0.005	0. 2479***	0.005	0.2476***	0.005
Short run								
Agric GDP per farmer	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|
ΔComponent of expenditure	-0. 1177*	0.085	-0.1195*	0.080	-0. 1216*	0.075	-0. 1188*	0.084
ΔPrivate capital	0. 1048***	0.000	0. 1045***	0.000	0.1045***	0.000	0.1046***	0.000
ΔLand	0.1022	0.647	-0. 1054	0.635	0. 1079	0.626	0. 1069	0.632
ΔODA	0. 0099	0.256	0. 0099	0.250	0. 0099	0.247	0.0099	0.252
ΔLabour	-1.3952***	0.000	-1.3949***	0.000	-1.3944***	0.000	-1.3943***	0.000
ΔRainfall	0.2015***	0.005	0. 2016***	0.005	0. 2020***	0.005	0. 2020***	0.005
Constant	5.3162***	0.000	5.6594***	0.000	5.5057***	0.000	5.7638***	0.000
ECM	-0. 8149***	0.000	-0. 8151***	0.000	-0.8149***	0.000	-0. 8157***	0.000
	Log likelihood	66.027975	Log likelihood	66.221771	Log likelihood	66.2948	Log likelihood	66.04489

(*), (**) and (***) express 10%, 5% and 1% significance level, respectively; Δ = differencing factor.

Kripfganz and Schneider (2018) critical values and approximate p-values, Pesaran, et al. (2001) bounds test.

Source: Authors' computation.

The marginal returns to each of the components of agricultural public expenditure was estimated by multiplying the elasticity of each of the components of capital agricultural public expenditure (subsidy, irrigation, R&D and rural development expenditures) with their respective ratio of average agricultural GDP to each of the components of capital agricultural public expenditure (Fan et al., 2008; Benin et al., 2009). The marginal returns, estimated as ratios, can provide the information necessary for comparing the relative benefits of an additional unit of spending on subsidy, irrigation, R&D and rural development expenditures. The information can be used to rank spending on subsidy, irrigation, R&D and rural development expenditures.

The ranking of the components of agricultural public expenditure in Table 10 reflects a misallocation of agricultural public capital expenditure as the allocation is not aligned with the estimated impacts of the components of agricultural public expenditure. The table implies that government investments in irrigation, R&D and rural development will increase agricultural productivity more than investments in subsidy programmes. The importance of public expenditure on irrigation to bring much-needed agricultural productivity and economic development has also been established by Gemmell et al. (2012). Irrigation systems can help tackle the problem of aridity in Nigeria, which is face with increasing desertification in large parts of the country. Changes in the climatic conditions in many parts of the country, with incessant changes and alteration in the rainfall pattern and periods, resulted in many parts becoming more arid (Amissah-Arthur, 2005). While an FAO report has indicated that Nigeria is a country where the population has already exceeded the carrying capacity of developed land and labour resources when cultivated at low levels of technology, the potential can be increased through irrigation development to increase agricultural productivity by three to seven times (FAO, 1995). While irrigation potential estimates in Nigeria vary from 1.5 to 3.2 million hectares, available information reveals that less than 1% of this potential is utilized in Nigeria (FAO, 2005; Alabi, 2014). Fan and Saurkar (2006) also indicated that spending on agricultural research is a crucial type of expenditure for increasing agricultural productivity. Table A10 in the Appendix indicates that the crowding out effect of agricultural public expenditure is lower regarding R&D expenditure than subsidy expenditure. Other studies have also proven that expenditure on R&D is more beneficial than input subsidies (Seck et al., 2013; Stads and Beintema, 2015; Asare and Essegbey, 2016).

Table 10: Ranking of components of agricultural public capital expenditure

Component of capital expenditure	Amount capital expenditure	Elasticity	Average agricultural GDP (AGDP)	Ratio of AGDP to component of capital expenditure	Marginal returns (MR)	Ranking according to MR	Ranking according to % of expenditure
Subsidy	5638.86	0. 1556	6224.69	1.103892	0.171766	4	1
R&D	445.17	0.1561	6224.69	13.98263	2.175697	2	3
Rural development	1187.13	0. 1557	6224.69	5.243487	0.815887	3	2
Irrigation	148.39	0. 1570	6224.69	41.94789	6.527092	1	4

Source: Authors' computation.

5. Summary and Conclusion

This study analyzed the short and long-run impacts of agricultural public expenditure on agricultural productivity in Nigeria. Initial findings show that about 20% of agricultural budgets were not implemented in Nigeria. On average, agricultural public capital expenditure constituted a share of 55% of total agricultural public expenditure in Nigeria, which is lower than the recommended 60% for the agricultural sector to perform effectively. The estimated share of agricultural public expenditure in total government expenditure in Nigeria is 1.52%, which is far lower than the 10% recommended in the Maputo Declaration. The study shows that, in the long run, if past public agricultural capital expenditure and farmers' private capital had increased by 100%, agricultural productivity would have increased by 15.66% and 12.83%, respectively. The estimated negative elasticity for labour supply in the long and short runs, one of the findings from the study, is a confirmation of declined agricultural labour productivity in Nigeria. The estimates also reveal that rainfall has a significant and positive relationship with agricultural productivity in the short and long runs. This reinforces the importance of water provision for agricultural production activities. The study also indicates that while public agricultural capital expenditure and agricultural public total expenditure are strong determinants of agricultural productivity, agricultural public recurrent expenditure maintains a weak relationship with agricultural productivity in Nigeria. In the agricultural productivity equation, where agricultural public total expenditure is the explanatory variable, significant declined land productivity was revealed.

The elasticity of farmers' private capital with respect to agricultural public total expenditure in the long run, which is estimated to be -0.709,[1] is a reflection of the possible "crowding out" effect of total agricultural public expenditure on farmers' private capital investment. By comparing the crowding out effect of farmers' private capital with different components of agricultural public capital expenditure, it is revealed that the crowding out effect is higher regarding subsidy expenditure than any other component of agricultural public capital expenditure. The study reveals that ODA has a positive and significant relationship to agricultural public capital expenditure. Relating ODA to the components of agricultural public capital expenditure, it is evident that ODA crowds in more rural development expenditure than any other component of agricultural public capital expenditure. It is evident that the coefficient of the Maputo variable is not significant in all relevant equations estimated in this study.

This confirms that agricultural public expenditure has not increased significantly in Nigeria since the Maputo Declaration of 2003. The causality result shows that there is a bidirectional causality between public agricultural capital expenditure and agricultural productivity, which reflects the endogeneity of agricultural public capital expenditure. The examination of the impacts of different components of agricultural public capital expenditure on agricultural productivity demonstrates that expenditure in irrigation facilities will have a greater impact on agricultural productivity in Nigeria than public investment on agricultural subsidy schemes and programmes. Comparing this finding with the agricultural public capital expenditure allocation in Nigeria reveals a misallocation of agricultural public capital expenditure, as the allocation is not aligned with the estimated impacts of the components of agricultural public expenditure. Based on the above findings, the following recommendations may increase agricultural productivity in Nigeria:

- The government and ministry of agriculture should make efforts to improve the level of agriculture budget implementation in Nigeria. Without full implementation of the agricultural budget, it will be difficult to justify the need to increase the agricultural budget.
- The share of agricultural public capital should be increased from the estimated 55% in the study. This is imperative because agricultural public capital expenditure does not only increase agricultural productivity, but also has a tendency to crowd in ODA.
- Attempts to increase and promote activities that will increase farmers' private capital will be a move in the right direction. The formation of cooperative societies and access to microcredit schemes can improve farmers' private capital formation.
- The decline in agricultural labour and land productivity in Nigeria deserves urgent attention. This can be done by improving the human capacity of farmers through extension services and adult education. Extension services and adult education will expose farmers to best agricultural practices and improve the adoption of innovation. Likewise, a decline in land productivity can be addressed through the adoption of soil improvement and land fertility restoration practices.
- The crowding out effect of agricultural public expenditure on farmers' private capital in Nigeria can be ameliorated if agricultural public expenditure patterns are structured in a way that encourages private entrepreneurship in related agricultural projects and schemes. Agricultural public expenditures on irrigation, R&D and rural development are good example of projects that can crowd in farmers' private capital and encourage private entrepreneurship in agriculture.
- As ODA has a positive and significant relationship with agricultural public

capital expenditure, conditions that are conducive to ODA reception should be promoted. This includes good governance and transparency in public expenditure management.

- Finally, agricultural public expenditure should be realigned to favour investment in irrigation, R&D and rural development, which currently attracts lower budgetary allocations in Nigerian agricultural budgets. This public investment in irrigation systems can be made more efficient and sustainable if they are small-scale and designed in a manner that will encourage farmers' participation and entrepreneurship.

Notes

1 Ceteris paribus, higher agricultural productivity results in higher production (more output is generated from the same input base) and higher agricultural profits or income.

2 When only one input is considered in determining agricultural productivity, the term single agricultural productivity indicator (such as land productivity and labour productivity) is used, while "multifactor" (or total factor) agricultural productivity takes into account all the factors of production used in agricultural production processes.

3 The number of people facing food insecurity in Nigeria had increased from 9 million in 2008 to 23 million in 2018 (FAOSTAT, 2019). Nigeria's total food and agricultural imports are growing, and is estimated at more than $10 billion in 2015 (USDA, 2016).

4 A number of studies on the impact of agricultural expenditure in Nigeria are fraught with econometric endogeneity issues (Ewubare and Eyitope, 2015; Ayunku and Etale, 2015; Ihugba et al., 2013; Itodo et al., 2012; Iganiga and Unemhilin, 2011; Lawal, 2011). This arises because of the difficulty in estimating the simultaneous relationship between agriculture public expenditure and agricultural productivity. Ignoring this could lead to biased estimates of the impact of public spending (Benin, 2015).

5 Error term measures how strongly the dependent variable reacts to a distortion from the equilibrium relationship in one period, or how quickly such an equilibrium deviation is corrected (Kripfganz and Schneider, 2018).

6 However, the variables must be tested for unit root to ensure that none of the variables in the specified model is of an order of integration that is greater than 1.

7 Not all explanatory variables need to have the same lag order, as the time in which a past change in a variable affect another variable can be different (Poynter, 2015).

8 Anderson's canonical correlation test is similar to Cragg and Donald (1993) test with the difference that Anderson's canonical correlation is a likelihood ratio test whilst Cragg and Donald (1993) test is a Wald statistic but both tests are applicable with one endogenous variable and one instrument (Anderson, 1984).

9 We employed Hansen's J statistic for identification purposes.

10 Obioma and Ozughalu (2010) reported a long-run relationship between government revenue and government expenditure in Nigeria. They indicated evidence of a unidirectional causality from government revenue to government expenditure. Their findings support the revenue-spend hypothesis for Nigeria, indicating that changes in government revenue induce changes in government expenditure.

11 GFCF in agriculture measures land improvements, machinery and equipment purchases, infrastructure constructions, crop and livestock fixed assets and inventory on the farm. The depreciated value of GFCF used each year is equal to $GFCF_{year}$ X δ .Where $GFCF_{year}$ is the GFCF for each year under consideration, δ is the depreciation rate. δ was obtained from the Pen World Table 9.1 as contained in Knoema (2019).

12 The difference in actual government agricultural expenditure and its budget was tested using the T-test.

13 We tested for significance of Cragg-Donald (1993) and Kleibergen and Paap (2006) using tabulated Stock and Yogo (2005) test statistics.

14 However, in the agricultural productivity equation where ARE is an explanatory variable and the agricultural productivity equation, where APTE is an explanatory variable, there is no cointegrating equations in the models. Likewise, in the agricultural public expenditure equation where ARE is a dependent variable and agricultural productivity is an independent variable, there is no cointegrating equations in the model. In the same vein, in the agricultural public expenditure equation where ACE is a dependent variable and agricultural productivity is an independent variable, there is no cointegrating equations in the model.

15 It also implies that any external shock to long-run equilibrium in the estimated equation in Table 6 will revert after 1.23 years (1/0.8138).

16 In Table 6, agricultural public capital expenditure is significant at a 10% level of significance in the short run.

17 It also suggests that any external shock to the long-run equilibrium in the estimated equation in Table 7 will revert after 1.23years (1/0.8104).

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Appendix

Table A1: Summary statistics of variables used (logarithm form)

Variables	Mean	Minimum	Maximum	Unit
Recurrent agriculture expenditure	4.073861	3.034227	5.399525	Million naira at 2010 constant prices
Capital agriculture expenditure	4.171408	3.779019	4.565175	Million naira at 2010 constant prices
Total agriculture expenditure	4.466978	3.89603	5.421463	Million naira at 2010 constant prices
Recurrent agriculture expenditure per farmer	6.860869	6.181239	8.000236	Naira at 2010 constant prices
Capital agriculture expenditure per farmer	7.085477	6.181239	8.000236	Naira at 2010 constant prices
Total agriculture expenditure per farmer	7.766053	6.451874	9.966892	Naira at 2010 constant prices
Farmers-population ratio (labour)	-2.22604	-2.645075	-1.795768	Ratio
Agricultural GDP	3.794118	3.0000	4.0000	Billion naira at 2010 constant prices
Agricultural value added per farmer	0.5335	0.1838	1.2228	Million naira at 2010 constant prices
Agricultural ODA	2.110382	-2.995732	5.623476	Constant 2016 USD prices
Depreciation rate	0.0501974	0.034481	0.071119	Percentage
Farmers' private investment	83.75712	6.587903	216.9905	Million naira at 2010 constant prices
Farmers' private investment (depreciated value)	3.957725	1.885235	5.379853	Million naira at 2010 constant prices
Arable land	10.3124	9.709053	10.51867	Hectares
Arable land per farmer	3.187894	2.572612	3.404525	Square metres
Rainfall	5.830949	5.26269	6.152733	Millimetres
Government revenue	6.191605	2.352327	9.316222	Billion naira at 2010 constant prices
Subsidy expenditure	3.754832	3.362483	4.148602	Million naira at 2010 constant prices
Rural development expenditure	3.096699	2.70415	3.49052	Million naira at 2010 constant prices
Agricultural R&D expenditure	2.586456	2.193125	2.980003	Million naira at 2010 constant prices
Irrigation expenditure	2.250451	1.857332	2.644439	Million naira at 2010 constant prices

Source: Authors' computation.

Table A2: Selection of instrument for endogenous variable

			Weak identification test			Over-identification test of all instruments	Under-identification test
Instrument	F statistic	Partial R	Cragg-Donald Wald F statistic	Kleibergen-Paap Wald F statistic	Stock-Yogo weak ID test critical values	Hansen J statistic	Kleibergen-Paap LM statistic
Volume of oil export	32.45	0.5459	32.45	27.47	16.38	0.000	12.67
Government revenue	35.71	0.5694	35.71	29.84	16.38	0.000	13.15
Minister of agriculture	15.81	0.3694	15.81	13.14	16.38	0.000	9.842
Exchange rate	17.17	0.3887	17.17	14.87	16.38	0.000	9.617

Source: Authors' computation.

Table A3: Lag length selection based on SBIC

Independent variables	Agric productivity equation					
Dependent variables	Agric expenditure	Private capital	Land	ODA	Labour	Rainfall
Agricultural productivity[1]	1	1	1	1	1	1
Agricultural productivity[2]	1	0	0	0	0	0
Agricultural productivity[3]	1	0	0	0	0	0
	Agric expenditure equations					
Dependent variable	Agricultural productivity	Private capital	Land	ODA	Labour	Rainfall
Agric capital expenditure	1	0	0	0	0	0
Agric recurrent expenditure	1	1	1	0	1	0
Agric total expenditure	1	0	0	0	0	0

1. When ACE is one of the explanatory variables.
2. When ARE is one of the explanatory variables.
3. When APTE is one of the explanatory variables.

Source: Authors' computation.

Table A4: Augmented Dickey-Fuller (ADF) test for unit root

	At level		Differencing		
Variables	Test statistics	5% critical value	Test statistics	5% critical value	Order of integration
Agric GDP per farmer	0.292	-2.978	-5.516	-2.980	1(1)
AGPE (total) per capita	-2.460	-2.978	-8.482	-2.980	1(1)
Agric capital expenditure per capita	-0.633	-2.978	-4.687	-2.980	1(1)
Agric recurrent expenditure per capita	-2.351	-2.978	-8.132	-2.980	1(1)
Private investment (depreciated)	-1.308	-2.978	-5.582	-2.980	1(1)
ODA	-0.989	-2.978	-4.262	-2.980	1(1)
Arable land per farmer	-3.979	-2.978	-4.240	-2.980	1(0)
Rainfall	-3.501	-2.978	-7.776	-2.980	1(0)

Source: Authors' computation.

Table A5: Results from ARDL bounds test for cointegration

Dependent variable	F-Test	Probability	T-test	Probability	Decision
Agricultural productivity[1]	5.704	0.020	-5.007	0.020	Cointegration
Agricultural productivity[2]	1.995	0.176	-2.537	0.088	No cointegration
Agricultural productivity[3]	1.703	0.256	-2.544	0.087	No cointegration
Agric capital expenditure[4]	3.813	0.099	-0.396	0.975	No cointegration
Agric recurrent expenditure[5]	3.792	0.099	-3.890	0.117	No cointegration
Agric total expenditure[6]	4.468	0.051	-4.199	0.075	Cointegration

Note: Kripfganz and Schneider (2018) critical values and approximate p-values based on finite sample (6 variables, 33 observations).

1. When ACE is one of the explanatory variables, lower bound = 2.973 and upper bound = 4.651 for F-test, and lower bound = -2.856 and upper bound = -4.426 for T-test at 5% significance level.
2. When ARE is one of the explanatory variables, lower bound = 2.978 and upper bound = 4.660 for F-test, and lower bound = -2.857 and upper bound = -4.426 for T-test at 5% significance level.
3. When APTE is one of the explanatory variables, lower bound = 2.978 and upper bound = 4.660 for F-test, and lower bound = -2.857 and upper bound = -4.426 for T-test at 5% significance level.
4. When ACE is the dependent variable, lower bound = 2.980 and upper bound = 4.525 for F-test, and lower bound = -2.894 and upper bound = -4.458 for T-test at 5% significance level.
5. When ARE is the dependent variable, lower bound = 2.980 and upper bound = 4.491 for F-test, and lower bound = -2.903 and upper bound = -4.466 for T-test at 5% significance level.
6. When APTE is the dependent variable, lower bound = 2.457 and upper bound = 3.777 for F-test, and lower bound = -2.530 and upper bound = -4.003 for T-test at 10% significance level.

Source: Authors' computation.

Table A6: IV-2SLS regression result of agricultural recurrent expenditure impact (ARE)

First-stage regression			Second-stage regression		
	F(1, 27)	3.12		F(6, 27)	174.40
	Prob > F	0.0843		Prob > F	0.0000
	Centered R^2	0.9386		Centered R^2	0.9386
	Partial R^2	0.0510			
Agric recurrent expenditure (ARE)	Coefficient	P>|t|	Agric productivity	Coefficient	P>|t|
Private capital	-0.4443*	0. 099	ARE	0.3244**	0.033
Land	5.3273***	0.002	Private capital	0.3186 ***	0.000
ODA	0.1024	0.175	Land	-2.0123**	0.005
Labour	-3.5231***	0.017	ODA	0.0425	0.141
Rainfall	0. 4214	0.405	Labour	-0.5635	0.449
Government revenue	0.3971*	0.085	Rainfall	0.0274	0.865
Constant	-5.7417	0.179	Constant	9.4261***	0.000
			H_o: Recurrent agric expenditure (ARE) is exogenous		
			Durbin (score) Chi^2	14.883**	0.000
			Wu-Hausman F	20.2415**	0.000

(*), (**) and (**) are significant at the 10%, 5% and 1% level, respectively.

Source: Authors' computation.

Table A7: IV-2SLS regression result of impact of agricultural total expenditure (APTE)

First-stage regression			Second-stage regression		
	F(1, 27)	12.85		F(6, 27)	629.29
	Prob > F	0.0013		Prob > F	0.0000
	Centered R^2	0.7855		Centered R^2	0.9863
	Partial R^2	0.2027			
Agric total expenditure (APTE)	Coefficient	P>|t|	Agric productivity	Coefficient	P>|t|
Private capital	0.2898	0. 219	APTE	0.21945**	0.000
Land	1.1190	0.320	Private capital	0.2381**	0.000
ODA	-0.0601	0.253	Land	-0.5298*	0.038
Labour	-2.4235	0.022	ODA	0.0224	0.067
Rainfall	0.3485	0.326	Labour	-1.1746**	0.000
Government revenue	0.5869**	0.001	Rainfall	0.0876*	0.046
Constant	-1.14725	0.705	Constant	7.8154**	0.000
			H_o: Total agric expenditure is exogenous		
			Durbin (score) Chi^2	12.0604**	0.000
			Wu-Hausman F	14.2925**	0.000

(*) and (**) are significant at the 10% and 5% level, respectively.

Source: Authors' computation.

Table A8: Estimates of ARDL model (impact of agricultural recurrent and total expenditure on agricultural productivity)

Impact of agricultural recurrent expenditure (ARE)			Impact of agricultural total expenditure (APTE)		
	F(9, 23)	617.02	F(7, 25)	759.78	
	P>F	0.000	P>F	0.000	
	R^2	0.9959	R^2	0.9953	
	Adj R^2	0.9943	Adj R^2	0.9940	
Agric GDP per farmer	Coefficient	P>|t|	Agric GDP per farmer	Coefficient	P>|t|
Agric GDP per $farmer_{(t-1)}$	0.5480***	0.004	Agric GDP per $farmer_{(t-1)}$	0.2078*	0.085
ARE	0.0360*	0.059	APTE	0.0483**	0.053
Private capital	0.1559***	0.000	Private investment	0.1486***	0. 000
Land	-0.3172	0.194	Land	-0.4162*	0.059
ODA	-0.0093	0.430	ODA	0.0069	0.485
Labour	-1.1128***	0.003	Labour	-1.4394***	0. 000
Rainfall	0.2248***	0.006	Rainfall	0.2048***	0.012
Constant	2.0112	0.208	Constant	5.1789***	0.000
	Log likelihood	59.64	Log likelihood	57.56	

(*), (**) and (***) are significant at the 10%, 5% and 1% level, respectively.

Source: Authors' computation.

Table A9: Estimates of ARDL model (impact of agricultural productivity on ARE and ACE)

Impact of agricultural productivity on ARE			Impact of agricultural productivity on ACE		
	F(8, 24)	16.54	F(9, 23)	66.04	
	R^2	0.8465	R^2	0.9627	
	Adj R^2	0.7953	Adj R^2	0.9482	
	Prob > F	0.000	Prob > F	0.000	
Agricultural recurrent expenditure	Coefficient	P>|t|	Agricultural capital expenditure	Coefficient	P>|t|
Agricultural recurrent $expenditure_{(t-1)}$	0.2650	0.174	Agricultural capital $expenditure_{(t-1)}$	- 0.9445**	0.000
Agric GDP per $farmer_{(t-1)}$	3.2121*	0.072	Agric GDP per $farmer_{(t-1)}$	- 0.6913	0.163
Private $capital_{(t-1)}$	0.6804**	0.027	Private $capital_{(t-1)}$	-0.1131*	0.061
Private capital	-1.1946***	0.000	Private capital	0.0483	0.472
Land	5.2243**	0.022	$Land_{(t-1)}$	1.5596	0.116
ODA	-0.0657	0.468	Land	-0.6058	0.570
Labour	3.4457	0.326	ODA	0.0471**	0.025
Maputo	-0.7982	0.188	Labour	-1.1821	0.147
Constant	-30.0008**	0.054	Maputo	0.1806	0.178
			Constant	6.3701	0.124

(*), (**) and (**) are significant at the 10%, 5% and 1% level, respectively.

Source: Authors' computation.

Table A10: Long elasticities of different components of agricultural capital expenditure with respect to ODA and farmers' private capital

	Irrigation	P>|t|	Subsidy	P>|t|	R&D	P>|t|	Rural Devpt	P>|t|
ACE component$_{(t-1)}$	0.9460***	0.000	0.9352***	0.000	0.9438***	0.000	0.9394***	0.000
Private capital$_{(t-1)}$	-0.1143*	0.059	-0.1198*	0.055	-0.1139*	0.060	-0.1156*	0.063
ODA	0.0477**	0.024	0.0498**	0.022	0.0476**	0.024	0.0502**	0.021

(*), (**) and (**) are significant at the 10%, 5% and 1% level, respectively.

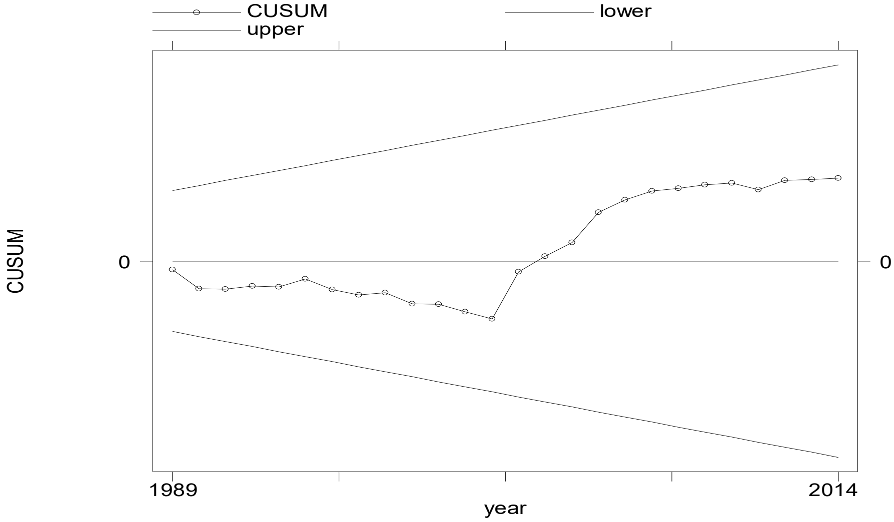
Source: Authors' computation.

Table A11: Diagnostics tests

Independent variables	Agric capital expenditure		Agric recurrent expenditure		Agric total expenditure	
Tests						
Tests for autocorrelation	F	Prob > F	F	Prob > F	F	Prob > F
Durbin's alternative test	0.160	0.6921	2.252	0.1455	2.164	0.1532
Breusch-Godfrey LM test	0.208	0.6518	2.710	0.1118	2.613	0.1181
	Chi^2	Prob > Chi^2	Chi^2	Prob > Chi^2	Chi^2	Prob > Chi^2
LM test heteroskedasticity (ARCH)	0.113	0.7365	0.004	0.9507	0.000	0.9913
Durbin-Watson d-statistic	1.783897	-	1.3717	-	1.412168	-

Source: Authors' computation.

Figure A1: CUSUM square test of stability



Source: Authors' computation.

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