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AGRICULTURAL PRODUCTION INDICATORS AND THE DYNAMIC MACROECONOMIC VARIABLES IN NIGERIA: ARDL MODEL APPROACH

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Abstract

The study established the empirical relationship between agricultural production indicators and some key macroeconomic fundamentals in Nigeria. Data (time series from 1961 to 2020) were collected from the World Bank, Food and Agricultural Organization and the Central Bank of Nigeria. The properties of the series were tested with the Augmented Dickey-Fuller unit root test and improved ADF-GLS unit root test. The Autoregressive Distributed Lag Model (ARDL) was used to establish the existence of the cointegration among the specified series. The empirical results revealed that, the per capita real GDP, land density and consumer price index are the determinants of crop production gross index in the long run, whereas, per capita income, lending rate, land density and total import are the short run determinants. Also, the per capita income, land density, consumer price index and the nominal exchange rate influence the agricultural gross production index in the long run; while the per capita income and land density were the short run determinants. Moreover, land density, per capita income and balance of trade were found to determine the livestock gross production index in the long run; while the lending rate, land density and inflation rate were the short run determinants. Based on the findings, it is recommended that, specific policy to focus on the improvement of the per capita income, restricted trade policy and reduction and or stabilization of inflation rate in the country are inevitable. The lending interest rate should be regulated to provide more credit to the agricultural sector.

***Key words**: agriculture, production, macroeconomic, crop, Nigeria*

INTRODUCTION

Agricultural sector in Nigeria is still developing and is being dominated by the small scale producers. The sector has benefitted from a myriad of government policies, incentives and programs all geared towards improving the efficiency of the sector [24]. Before the advent of crude oil exploitation in Nigeria, the agricultural sector played pivotal roles in the economy in terms of contributing a lion share to the country’s GDP, employment generation and stimulation of primary agricultural product exports [13]. The sector is likewise known to draw a considerable volume of imports, thereby making up as a catalyst for international trade [7]. With regard to poverty alleviation, the sector has played an essential role in reducing rural and urban poverty, especially in developing economies [15, 31]. These attributes of the agricultural sector were major features of the country's economy during the 1960s and into the early 1970s. For instance, the country was one of the world's largest producers of some agricultural products, including palm oil, cocoa, rubber and groundnuts among others. During this period, the sector was the main source of foreign currency exchange and played a key role in the development of the country's infrastructures. However, after this era, the agricultural sector has constantly struggled to perform its traditional roles efficiently in the economy. In recent years, Nigeria has been the largest rice importer in sub-Saharan Africa and a major rice importer in the world [45].
The agricultural sector no longer showed its prowess in terms of performing its traditional responsibilities in the economy. Following this deteriorating trend in the performance of the sector, many scholars have delved into the

archives in attempts to uncover the causes of the poor performances of the agricultural sector in Nigeria. Many researchers have identified corrupt governance regimes that have eroded the country's resources for years [27, 36, 20, 34]; some mentioned unsustain farm factor productivity [5, 4, 8, 6]; while others linked the perturbed performances of the sector to negligence and prioritizing the crude oil as the main source of revenue in the country [2, 37]. Still, the contemporary scholars have argued that, instability and unsustainable growth in the key macroeconomic fundamentals are among the major factors causing declines in the performance of the real sectors of the economy [13, 11, 12, 29, 44, 3, 38]. Accordingly, the key macroeconomic fundamentals consist of the fiscal, monetary, exchange rate regimes and trade policies. Several scholars, [13, 32, 7, 35], have through empirical investigations adjudged that the macroeconomic variables to a greater extent, determined production outcomes in the real sectors including agricultural sector and non-real sectors of the economy. Everett *et al.,* [21] and Chirwa and Odhiambo, [14] also maintained that the stability and sustainable growth in the macroeconomic fundamentals depend on the nature of the economic and political environments they exist. From this assertion, it implies that, the stability of the macroeconomic fundamentals or policies are the results of the interplay of all components of economic, political and cultural environments among others. Thus, it can be inferred that, macroeconomic fundamentals combined with other factors to influence variability in the real sector of the economy including the agricultural sector. Premised on the aforementioned fact and for the agricultural sector to play its primary responsibilities in a sustainable way, the economy must be rooted in a sound and stable macroeconomic environment among others [14].

Over the last three decades, outputs from the agriculture sector and other macro-economic variables in the country have been unpredictable. For instance, the agricultural sector outputs have been inconsistent across various economic policy regimes in the country. Growth rates, for major agricultural products between 1962 and 2019, as shown in Table 1, did not follow a regular trend. Each crop component showed wide variation in trend with conspicuous peaks and troughs. As noted by Okuneye and Ayinde [33] Akpan *et al.*, [9] and Akpan *et al.,* [13], the peaks and troughs in the trends of growth rates of crop outputs in the country followed various policy interventions by the federal government which is mostly hinged on the buoyancy of the macroeconomic environment. Similar trends in growth rates for certain key macroeconomic variables were observed in the country, as shown in Table 2.

As noted by Chirwa and Odhiambo [14], Akpan *et al.,* [13] and Akpan *et al.,* [10] agricultural production correlates with macroeconomic variables. In order to empirically establish the true relationship between the agricultural sector’s output and some important macroeconomic variables, several researchers have employed varieties of econometric methods at different time horizons to explore the relationships. For instance, Akpan *et al.,* [13] investigated the impact of some macroeconomic variables on the value of agricultural GDP from 1970 to 2010 in Nigeria. The empirical results revealed that in the short and long run periods, the real total exports, external reserves, the inflation rate and external debt had negative influence on agricultural productivity; whereas industry’s capacity utilization rate and nominal exchange rate have positive associations. However, the per capita real GDP had a positive influence on the agricultural productivity in the ECM model.

Also, Muftaudeen and Hussainatu [29] investigated the impact of macroeconomic policies on agricultural output specifically on crop production from 1978-2011 in Nigeria. They found that in the long run, agricultural production reacted to changes in government spending, farm credit, inflation rate, interest rate and the exchange rate.

Table 1. Linear growth rates/fluctuations in selected Agricultural Products in Nigeria

Agricultural product	Policy periods and linear growth rates in (%)						Average linear growth rate (%) from 1970 to 2019
	1962 - 1971	**1972 - 1981**	**1982 - 1991**	**1992 – 2001**	**2002-2011**	**2012 - 2019**	
Maize	2.16	5.37	25.92	-1.59	7.04	3.05	7.12
Rice	16.89	18.94	11.98	-0.94	6.42	8.42	10.35
Wheat	2.55	3.35	30.38	2.19	15.50	-9.79	7.96
Millet	2.75	1.59	5.04	3.21	-6.48	8.56	2.24
Yam	11.63	-5.11	15.33	4.58	3.22	5.75	5.90
Cassava	2.33	1.95	9.69	2.18	4.12	3.46	3.97

Source: Computed by authors, data from the FAO and World Bank, 2020.

Furthermore, Akpan and Patrick [7] modelled palm oil, palm kernel and rubber annual output equations from 1962 to 2013 in Nigeria. The empirical results revealed that, per capita GDP, industrial capacity utilization, lending interest rate and kilowatts per capita of electricity influenced the output of palm oil, palm kernel and rubber in the long run; whereas, per capita GDP was significant variable in the short run.

Table 2. Linear growth rates/fluctuations in selected Macroeconomic variables in Nigeria

Macroeconomic variable	**Policy periods**						**Average linear growth rate from 1970 to 2019**
	1962 - 1971	1972 - 1981	1982 - 1991	1992 – 2001	2002-2011	2012 - 2019	
Inflation rate	-219.13	30.58	49.80	32.82	2.634	4.47	-17.19
Exchange rate	-0.02	-1.24	37.19	44.27	3.67	9.57	15.78
Per capita income	12.59	32.04	12.96	28.40	19.79	8.16	19.37
GDP (naira)	15.09	35.72	15.92	31.65	22.96	11.05	22.44
Value of import	11.86	27.80	27.73	46.80	26.03	12.41	25.89

Source: Computed by authors, data from the FAO and World Bank, 2020.

As well, Adekunle and Ndukwe [1] using data set from 1981 to 2016 showed that, there was no significant long-run relationship between the real exchange rate and agricultural output in Nigeria. The finding, however, revealed significant drivers of agricultural output in Nigeria to include; industrial capacity utilization rate and government expenditure on agriculture. In a related research, Osuji *et al.,* [38], examined the effect of macro-economic variables on the national food security proxy by the expenditure on food production in Nigeria. Using the ARDL, the finding revealed that in the long run, interest and inflation rates had a negative effect on food security, while government expenditure and money supply responded positively. The result further revealed, that in the short run, interest and inflation rates reacted negatively to food security while net export, government expenditure and money supply showed positive impact. In addition, Ewubare and Iyabode [22] established a positive relationship between agricultural output and agricultural credit as well as exchange rate in Nigeria.

Elsewhere in Ghana, Enu & Attah-Obeng [19] found the real exchange rate, labor force and real GDP per capita as significant determinants of agricultural production. Also, in Malaysia, Kadir and Tunggal [26] employed the Autoregressive-Distributed Lag (ARDL) approach to investigate the impact of macroeconomic variables on agricultural productivity from the period 1980 to 2014. The empirical findings revealed that, in the long run the nominal exchange rate had a significant negative relationship with agricultural productivity. In the short run, the country’s net export and government expenditure showed negative correlations with agricultural productivity while interest rate responded positively. Besides, Muraya [30] in Kenya identified the macroeconomic variables that determined agricultural productivity from 1980 to 2013 period. Using the Johansen-Granger cointegration procedures, the result showed that, in the long run, the exchange rate and inflation had negative correlations with the agricultural productivity, while labor force, rainfall, and government expenditure had positive impacts. In the short run, labour, rainfall, and government expenditure were the major determinants of agricultural productivity in the country. Similarly, Shita *et al.*, [41] determined factors affecting agricultural productivity in Ethiopia for the period of 1990–2016 by using autoregressive distributed lag (ARDL) model. The results revealed that cereal productivity was positively influenced by the use of fertilizers and real gross domestic product (GDP) both in the long run and in the short run. While the size of arable land influences productivity positively in the long run; its short-run effect was found to be negative. Later, Shita *et al.*, [42] investigated the impact of technology adoption on agricultural productivity by using Autoregressive Distributed Lag (ARDL) approach for the period of 1990-2016. The result revealed that, technology adoption (captured as fertilizer consumption) and real GDP affects agricultural productivity positively and significantly both in the long-run and short-run. Also, area of arable land affected agricultural productivity positively in the long run but negatively in the short-run.

From the literature reviewed, it is observed that most researchers used aggregated measure of productivity to proxy agricultural sector production. The agricultural sector consists of sub- sectors that need specific policy interventions. Hence, there is an overwhelming need to disaggregate sectoral productivity indices to sub-sectoral indices in order to derive specific policy recommendations. Also, for the last two decades a lot has happened in the Nigeria's macroeconomic environment and the country is swallowed deeper in the scourge of poverty and urgently need proactive policy interventions based on the current realities. Therefore, there is need to update the available information on this topical issue. The study, therefore, sought to establish the empirical relationship between agricultural production indicators and some key macroeconomic fundamentals in Nigeria.

Materials and methods

Study Area

The study was conducted in Nigeria. The country is situated on the Gulf of Guinea in the sub-Saharan Africa. It lies between 4^0 and 14^0 north of the equator and between longitude 3^0 and 15^0 east of the Greenwich. The country has a total land area of about $923{,}769km^2$ (or about 98.3 million hectares) with 853km of coastline along the northern edge of the Gulf of Guinea and a population of around two hundred (200) million [43]. The country is gifted with significant agricultural, mineral, marine and forest resources. Its multiple vegetation zones, abundant rainfall, surface and groundwater, and moderate climate extremes enable the production of a variety of food, tree and commercial crops. Over 60 per cent of the population is involved in the production of the food crops such as cassava, maize, rice, yams, various beans and legumes, soya, sorghum, ginger, onions, tomatoes, melons and vegetable. Also, fishery, aquaculture and livestock production such as poultry, goat, sheep, pigs and cattle flourished very well in all regions of the country. The main cash crops are cocoa, cotton, groundnuts, palm oil and rubber.

Data Source

Secondary data were used to conduct the study**.** These data were sourced from the World Bank and Food and Agricultural Organization (FAO) as well as the Central Bank of Nigeria. Data covered the period from 1961 to 2019. The choice of the period was based on the availability of data.

Analytical Technique

To identify the nature of the relationship between agricultural productivity indicators and some macroeconomic variables and other relevant variables in Nigeria, three agricultural productivity equations were specified in implicit forms. The explanatory variables were selected based on the related works in the literature and availability of trusted data sources. The agricultural productivity function adopted assumes the following implicit form expressed in the Cobb-Douglas form as thus:

$$\mathbf{AGP_t} = f(RGP_t, PCI_t, LAS_t, INF_t, EXC_t) \ldots\ldots (1)$$

where:

$\mathbf{AGP_t}$ = Agricultural gross production index in time t (2014 – 2016 = 100) in (%)

RGP_t = Real gross domestic product in naira (at current market prices) to represent economy growth in time t
PCI_t = Gross domestic product per capita (Naira/person) to capture demand shock
LAS_t = Land density measures as size of arable land per rural dweller (ha/person)
INF_t = Inflation rate (%) proxy of input price changes
EXC_t = Nominal exchange rate (%) to capture the effect of external World

To further investigate the effect of the macroeconomic variables and other related variables on the sub-sector productivity, the following equations were implicitly specified in Cobb-Douglas form and estimated:

$$\mathbf{CRP_t} = f(PCI_t, LEN_t, LAS_t, CPI_t, IMP_t) \ldots\ldots (2)$$

where:
CRP_t = Crop gross productivity index 2014 – 2016 = 100 in (%),
LEN_t = Lending rate (%) to capture credit availability to the economy
PCI_t = Gross domestic product per capita (Naira/person) to capture demand shock
IMP_t = Value of total import of goods and services as a % of GDP
CPI_t = Consumer price index (%) (2010 = 100)

Also, the livestock gross production index was specified as thus:

$$\mathbf{LSK_t} = f(LEN_t, LAS_t, PCI_t, INF_t, BOT_t) \ldots (3)$$

Where,
LSK_t = Livestock gross productivity index 2014 – 2016 = 100 in (%),
BOT_t = Annual balance of trade, the ratio of the total value of exports to imports in time t.

Testing the short and long runs relationship between Agricultural production indicator and Macroeconomic variables

The Autoregressive Distributed Lag (ARDL) bound test approach developed by Pesaran and Shin [39] and Pesaran *et al.*, [40] was used to investigate the long and the short run relationship between agricultural productivity indicators and the explanatory variables. The ARDL bound model has three advantages when compared with the Engle and Granger [18] two step method and Johansen and Juselius [25] cointegration method. The ARDL method is applied to deal with series having mixed stationary issues (i.e. mixture of 1(0) and 1(1)). Hence, it relaxes the assumption that all series must be integrated of the same order. The next advantage is that the ARDL test is relatively more efficient in the case of small and finite sample data sizes. The method produced unbiased estimates of the long-run model [23].

The ARDL model for equation (1) in logarithm form is expressed as follows:

$$\Delta \boldsymbol{AGP_t} = \beta_0 + \beta_1 \sum_{i=1}^{n_1} \Delta AGP_{t-1} + \beta_2 \sum_{i=1}^{n_2} \Delta RGP_{t-i} + \beta_3 \sum_{i=1}^{n_3} \Delta PCI_{t-i} + \beta_4 \sum_{i=1}^{n_4} \Delta LAS_{t-i} + \beta_5 \sum_{i=1}^{n_5} \Delta INF_{t-i} + \beta_6 \sum_{i=1}^{n_6} \Delta EXC_{t-i} + \delta_1 AGP_{t-i} + \delta_2 RGP_{t-i} + \delta_3 PCI_{t-i} + \delta_4 LAS_{t-i} + \delta_5 INF_{t-i} + \delta_6 EXC_{t-i} + U_t \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\Delta \boldsymbol{RGP_t} = \beta_0 + \beta_1 \sum_{i=1}^{n_1} \Delta RGP_{t-1} + \beta_2 \sum_{i=1}^{n_2} \Delta AGP_{t-i} + \beta_3 \sum_{i=1}^{n_3} \Delta PCI_{t-i} + \beta_4 \sum_{i=1}^{n_4} \Delta LAS_{t-i} + \beta_5 \sum_{i=1}^{n_5} \Delta INF_{t-i} + \beta_6 \sum_{i=1}^{n_6} \Delta EXC_{t-i} + \delta_1 RGP_{t-i} + \delta_2 AGP_{t-i} + \delta_3 PCI_{t-i} + \delta_4 LAS_{t-i} + \delta_5 INF_{t-i} + \delta_6 EXC_{t-i} + U_t \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The specification of the ARDL model was also applied to the rest of the variables in equation (1), equation (2) and equation (3). The variables are as defined in equation (1), (2) and (3). The coefficients from β_1 to β_6 represent the short-run coefficients whereas the coefficients from δ_1 to δ_6 represent the long-run coefficients of the ARDL model. Also, β_0 is the drift component, "n" is the maximum lag length while U_t is the stochastic error term. The bounded F-statistic test was used to check the existence of a stable long-run relationship among the variables in the models. For instance, if the calculated F-statistic in equation (4) is greater than the appropriate upper bound critical values, the null hypothesis is rejected implying the existence of co-integration relationship. But if the value of the F-statistic is below the lower bound, the null cannot be rejected, indicating the absence of co-integration. Besides, if the F-statistic value lies within the lower and upper bounds, the results is considered inconclusive [40].

If the bound test shows evidence of co-integration among variables specified for example as in equation 4, the long and the short run (an error correction model (ECM)) are specified as follows; The long run model:

$$AGP_t = \delta_0 + \delta_1 \sum_{i=1}^{q_1} RGP_{t-i} + \delta_2 \sum_{i=1}^{q_2} PCI_{t-i} + + \delta_3 \sum_{i=1}^{q_3} LAS_{t-i} + \delta_4 \sum_{i=1}^{q_4} INF_{t-i} + + \delta_5 \sum_{i=1}^{q_5} EXC_{t-i} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The short run model (ECM model):

$$\Delta AGP_t = \beta_0 + \beta_1 \sum_{i=1}^{n_1} \Delta AGP_{t-1} + \beta_2 \sum_{i=1}^{n_2} \Delta RGP_{t-i} + \beta_3 \sum_{i=1}^{n_3} \Delta PCI_{t-i} + \beta_4 \sum_{i=1}^{n_4} \Delta LAS_{t-i} + \beta_5 \sum_{i=1}^{n_5} \Delta\Delta INF_{t-i} + \beta_6 \sum_{i=1}^{n_6} \Delta EXC_{t-i} + \emptyset ECM_{t-1} + U_t \ldots\ldots\ldots\ldots (7)$$

where: Ø is the error correction term and its measures the speed of adjustment towards the long-run equilibrium, and the remaining coefficients provide the short-run dynamics. To access the performance of the estimated model, RESET test, Serial correlation and normality of the residuals tests were conducted, whereas the cumulative sum (CUSUM) test was conducted to verify the stability nature of the model.

RESULTS AND DISCUSSIONS

The descriptive Statistics

The descriptive statistics of the variables used in the study are presented in Table 3. The coefficient of variability and skewness in the agricultural gross production index, crop gross production index and livestock gross production index revolved around the 50 % mark respectively. This implies that, these variables had average fluctuations over the specified period and concentrated more on the right-hand side of the normal distribution curve. Moreover, the exponential growth rates of these variables are around 3.0% per year, which means that all specified indicators have steadily increased at nearly the same annual growth rate.

Table 3. Descriptive Statistics of Variables Used in the Estimated Models

Variables	Minimum value	Maximum	Mean	Std. deviation	Coefficient of Variation	Skewness	Exponential growth rate (%)
AGP	19.73	103.19	51.28	28.74	0.56	0.45	3.27
CRP	18.76	103.77	49.69	29.01	0.58	0.49	3.36
LSK	15.85	101.36	58.21	29.47	0.51	0.09	3.40
RGP	4.56e+12	6.18e+13	2.58e+13	1.82e+13	0.69	0.71	4.37
LAS	0.28	0.77	0.46	0.12	0.26	0.03	0.93
INF	0.48	72.84	16.24	15.22	0.94	2.05	1.59
EXC	0.55	306.90	62.47	87.40	1.39	1.35	13.51
PCI	69.27	7.25e+5	1.20e+5	2.0e+5	1.66	1.63	18.46
IMP	3.03	23.92	14.41	5.21	0.36	-0.19	0.17
CPI	0.07	267.51	40.66	65.94	1.62	1.86	16.67
LEN	6.00	31.65	14.07	6.42	0.46	0.34	2.27
BOT	0.56	2.83	1.30	0.56	0.43	0.77	11.55

Source: Computed by authors, data from the FAO and World Bank, 2020.

The real GDP showed coefficient of variability of 69% and an exponential growth rate of 4.37% per annum. The skewness of 0.71 in RGDP implies a continuous increase in its annual value over the specified period of time. The average land density per rural dweller stood at 0.46ha with a 26.00% coefficient of variability and exponential growth rate of 0.93% per annum. The finding revealed that agricultural land expansion grew at a rate below unity per annum. This means that the continuous increase of the rural population restricts land expansion. The statistics for the nominal exchange rate (EXC), per capita income (PCI) and consumer price index (CPI) showed explosive coefficients of variability and exponential growth rates respectively. This means that, these variables were so unstable during the period specified in the study. The inflation rate also showed a high degree of variability, but grew exponentially at the rate of 1.59% per annum. The value of imports (IMP) skewed to the left hand side and has a variability rate of about 36% and the annual exponential growth rate of 0.17%.

Unit root test

The study used the ADF test developed by Dickey and Fuller in [16] and ADF-GLS unit root test developed by Elliott, Rothenberg and Stock [17] which is an improvement of the original ADF test to confirm the unit root of the specified variables. The results for both ADF and ADF-GLS unit root tests are presented in Table 4. The results revealed that, inflation rate (INF) and balance of payment (BOT) were stationary at levels; while the rest of the variables were stationary at the first difference. The test equations contain both constant and trend. Since we have a mixture of variables that are 1(0) and 1(1), it implies that the ARDL model can be used to test the co-integration in the specified models. Before estimating the ARDL model, the optimal lag lengths for the series were determined by using the Akaike Information Criterion (AIC), Schwarz and Bayesian Criterion (SBC). The various lag lengths are shown in Table 5. The F-statistics computed for the three selected equations are presented at the upper portion of Table 5. Note, each of the variable in equation 1, 2 and 3 were tested, but the results of equations of our interest are presented for discussion. The Results of the F-statistics for equation 1, 2 and 3 revealed that cointegration exist among the variables specified.

Table 4. ADF and ADF-GLS unit root tests on variables used in the specified equations

Variable	ADF (constant and trend)			ADF-GLS (constant and trend)		
	Level	1st Diff.	Decision	Level	1st Diff.	Decision
AGP	-1.539	-7.961***	1(1)	-1.407	-7.999***	1(1)
CRP	-1.487	-7.894***	1(1)	-1.355	-7.745***	1(1)
LSK	-1.164	-9.627***	1(1)	-1.357	-7.012***	1(1)
RGP	-2.241	-7.007***	1(1)	-2.213	-7.125***	1(1)
LAS	-1.636	-7.770***	1(1)	-1.653	-7.850***	1(1)
INF	-4.261***	-	1(0)	-4.333***	-	1(0)
EXC	-1.883	-5.950***	1(1)	-1.248	-6.039***	1(1)
PCI	-2.041	-6.271***	1(1)	-1.588	-6.299***	1(1)
IMP	-2.229	-7.712***	1(1)	-2.232	-7.639***	1(1)
CPI	-1.976	-3.541**	1(1)	-1.084	-3.551**	1(1)
LEN	-1.157	-7.345***	1(1)	-1.330	-7.425***	1(1)
BOT	-3.304*	-	1(0)	-3.200**	-	1(0)
	Critical values					
1%	-4.124	-4.127		-3.739	-3.58	
5%	-3.489	-3.490		-3.164	-3.03	
10%	-3.173	-3.174		-2.866	-2.74	

Source: computed by authors. Note: ***, ** and * indicate 1%, 5% and 1% significance levels respectively. Note, variables are expressed in natural logarithm.

Table 5. ARDL Bound Test (unrestricted intercept and no trend

Equations	Lag	F-Stat.	Decision
F_{AGP}(AGP │ RGP, PCI, LAS, INF, EXC)	(1,1,1,1,1)	6.89	Co-integration
F_{CRP}(CRP │ PCI, LEN, LAS, CPI, IMP)	(1,1,1,1,1)	7.07	Co-integration
F_{LSK}(LSK │ LEN, LAS, PCI, INF, BOT)	(2,2,2,2,2)	4.44	Co-integration
Critical Values Bound (at K = 5 and n = 59)			
	Lower	Upper	
10%	2.204	3.210	
5%	2.589	3.683	
1%	3.451	4.764	

Source: computed authors using Eviews 10 and data as described in equation 1, 2, and 3. Critical values are derived from Narayan, (2005). Note, variables are expressed in natural logarithm.

The F-statistics calculated for these equations were greater than the tabulate upper bound critical value at 1% level of significance. The findings imply that, the long run equilibrium or stable equations exist for equation 1, 2 and 3 and the short run or the ECM models can be generated from the equations to capture the dynamics in the agricultural production index equations in the short-run and identified the speed of adjustment as a response to departure from the long-run equilibrium. Following the establishment of the co-integration for all the specified equations, Table 6 presents the long run coefficients for the ARDL model for equation 1 (agricultural gross production Index equation).

The Long- run Coefficients of ARDL for Agricultural gross production Index equation

The results revealed that, the per capita income (PCI) has a positive and significant (at 1%) impact on agricultural gross production index. This means that, one percent increase in the per capita income will lead to 0.169 percent increase in the agricultural gross production index. The result satisfies *a priori* expectation, because increase in the PCI increases the purchasing power of the citizen thereby stimulating aggregate demand. When demand increases, farmers would have incentives to produce more resulting in increased in total production. The finding corroborates Akpan and Patrick [7] and Enu & Attah-Obeng, [19].

Table 6. The Long- run Coefficients for Agricultural gross production Index equation

Variable	Coefficient	Standard error	t-value	Probability
Constant	4.0805	1.1474	3.556***	0.0008
Real GDP	−0.0521	0.0418	−1.246	0.2181
Per capita income	0.1688	0.0232	7.281***	<0.0001
Land density	0.4013	0.0713	5.628***	<0.0001
Inflation rate	0.0023	0.0079	0.292	0.7715
Nominal exchange rate	0.0551	0.0205	2.691**	0.0095

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithm.

The coefficient of land density is positive and has a significant (at 1%) effect on the agricultural gross production index in the country. A unit increase in the land density would lead to about 0.401 increase in the agricultural gross production index in the long run. The result is as expected following the concept of economies of scale. Larger farm size would likely produce higher output compared to the smaller farms. The result is however substantiated by [41, 42] in Ethiopia.

The slope coefficient of the nominal exchange rate shows a significant positive effect (at the 5% level of significance) on agricultural gross production index in the long run. This means that increase in the nominal exchange rate increases the agricultural gross production index in the country. The plausible reason for the result could be connected to the fact that the increase in the nominal exchange rate (N/$) would constrain importation by depreciating the domestic currency (N) against appreciating US dollar. The reduced importation would likely decrease unhealthy competition in the domestic market and instead creates incentives for farmers to increase production. Similar result has been reported by Akpan *et al.,* [13], Muftaudeen and Hussainatu [29] Ewubare and Iyabode [22], but the finding however contradicts the submissions of Kadir and Tunggal [26] in Malaysia, Muraya [30] in Kenya and Adekunle and Ndukwe [1] in Nigeria.

The Error Correction Model of the ARDL for Agricultural gross production Index equation

The result in Table 7 contains the error correction representation of the ARDL model for equation 1. The coefficient of the error correction term is negative and statistically significant at 1% level, which implies the existence of co-integration among the variables included in the ARDL model for agricultural gross production index. It indicates that about 53% of the short-run disequilibrium is adjusted towards its long-run equilibrium annually. The diagnostic test for the ECM model revealed R^2 value of 0.5222 which means that the specified explanatory time series explained about 52.22% of the adjusted total variations in the agricultural gross production index. The F-statistic of 8.341 is significant at 1% probability level, indicating that the R^2 is significant and this implies that the equation has goodness of fit. The Durbin-Watson value of 2.042 indicate almost zero serial correlation. The ECM model has been shown to be robust against residual autocorrelation. Therefore, the presence of autocorrelation does not affect the estimates [28]. Also, the RESET test is significant which confirms the structural rigidity of the estimated model. The residual is normally distributed and this justified the used of OLS estimation method. The CUSUM test is significant, indicating that, the estimated model is stable. The empirical result revealed that, the current level of the per capita income has a significant positive relationship with the agricultural gross production index in the short run period. It means that, a unit increase in the PCI would lead to about 0.143 units increase in the agricultural gross production index in the country. The finding is in line with a *priori* expectation as an increase in demand will stimulate supply or production. The result is similar with the findings of Akpan *et al.,* [13]; Akpan and Patrick [7] and Enu & Attah-Obeng, [19].

Table 7. The Short - run Coefficients for Agricultural gross production Index equation

Variable	Coefficient	Standard error	t-value	Probability
Constant	0.01891	0.00957	1.976*	0.0542
ΔAGP_{t-1}	−0.02169	0.16149	−0.134	0.8938
ΔRGP_{t-1}	−0.01689	0.03989	−0.424	0.6738
ΔPCI_{t}	0.14269	0.04268	3.343***	0.0017
ΔPCI_{t-1}	−0.01884	0.03929	−0.479	0.6340
ΔPCI_{t-2}	−0.03729	0.03037	−1.228	0.2256
ΔLAS_{t}	0.37534	0.07286	5.152***	<0.0001
ΔINF_{t-1}	−0.00136	0.00703	−0.193	0.8479
ΔEXC_{t}	0.01280	0.02164	0.592	0.5569
ECM_{t-1}	−0.52555	0.12044	−4.364***	<0.0001
Diagnostic Test				
R-Squared	0.52216	Durbin-Watson		2.04289
F(9, 46)	8.340705***	Normality of residual		8.3236***
RESET test	2.68123*	CUSUM test for parameter stability		10.5132***

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithm.

The short run coefficient of the land density of farmers is positive and is significant at 1% level. This means that, increase by one unit of the farmers' land density would result in 0.375 units increase in the agricultural gross production index in the country. Land being one of the major factors of production is critical for agro - business enterprises such as crop and livestock productions. The result is strongly supported by Shita *et al.,* [40] and Shita *et al.,* [41].

The Long and short runs Coefficients of ARDL for Crop gross production Index equation

The long run model for crop gross production index equation is presented in Table 8. The result revealed that per capita income (PCI), land density (LAS) and consumer price index (CPI) have positive and significant coefficients in the estimated long run equation. A unit increase in (PCI), (LAS) and (CPI) would lead to 0.102 units, 0.655 units and 0.120 units increase in crop gross production index respectively. The increase in per capita income and land density are strongly linked to the demand power and economic of scale in production respectively. The result of the consumer price index could be explained by the fact that, increase in CPI is always associated with the increase in prices of goods in the country. Premised on this fact, crop farmers would likely utilize the opportunity of any price increase or hike to boost crop production in order to increase farm income. The results of the ECM estimates for crop gross production index are presented in Table 9. The diagnostic statistics revealed the relevance of the estimates. The values of the F-test, RESET test and normality tests as well as CUSUM test showed that the ECM has goodness of fit, structural rigidity, justified the used of the OLS estimation method and is stable within the time horizon of the data set. The coefficient of the error correction term is negative and statistically significant, which implies the existence of co-integration among the variables used in the model. It indicates that 41.97 per cent of the short-run disequilibrium is adjusted towards its long-run equilibrium annually.

Table 8. The Long run Coefficients for Crop gross production index equation

Variable	Coefficient	Standard error	t-value	Probability
Constant	3.0754	0.4636	6.634***	<0.0001
Per capita income	0.1019	0.0483	2.110**	0.0396
Lending rate	0.0295	0.0525	0.5617	0.5767
Land density	0.6548	0.0501	13.07***	<0.0001
Consumer price index	0.1204	0.0569	2.116**	0.0391
Total import	0.0259	0.0305	0.8474	0.4006

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithm.

The short run model revealed that the current value of PCI has a significant positive relationship with the crop gross production index in the country. However, the previous year value of PCI impacted negatively on the crop gross production index. That is, a unit change in the previous year value of PCI_{t-1} resulted in the reduction in the crop gross production index. Many factors could be linked to this result; among them is the changing pattern of the GDP, consumer preference and mounting rate of inflation in the country. The finding confirms the earlier reports of Akpan *et al.,* [13], Akpan and Patrick [7] and Enu & Attah-Obeng [19]. The coefficient of the previous year lending rate is positive and significant at the 5% level in the short run. This means that, as the previous year lending rate increases, the current crop gross production index increases too. Credit to the agricultural sector from the conventional banks has always been a serious issue due to risk inherent in the sector. The subsistence nature of agriculture and the biological risks involved in crop production make farmers scramble for few loan opportunities irrespective of the lending rate. However, the finding controverts the assertion of Akpan and Patrick [7]. The result with respect to the land intensity satisfies a *priori* expectation as many scholars have attributed output increase in Nigeria to land expansion instead of productivity. Hence, as the land density increases, farmers have more access to land resource and economic of scale set in, thereby resulting in an upsurge in output. The result is in consonance with the submissions of [40] and Shita *et al.,* [41]. The short run coefficient of import is negative and is significantly related to the crop gross production index in the country. This implies that, as total value of import increases by a unit in a short run, the crop gross production index decreases by 0.041 units. The result satisfies a *priori* expectation, because the increase in import reduces the domestic competition through induce dumping in the domestic economy thereby dampening local production.

Table 9. The Short run Coefficients for Crop gross production index equation

Variable	Coefficient	Standard error	t-value	Probability
Constant	0.01575	0.01026	1.535	0.1316
ΔCRP_{t-1}	−0.00856	0.12065	−0.071	0.9437
ΔPCI_t	0.09838	0.04512	2.181**	0.0344
ΔPCI_{t-1}	−0.07168	0.03425	−2.093**	0.0419
ΔLEN_{t-1}	0.10505	0.04886	2.150**	0.0369
ΔLAS_t	0.44357	0.06855	6.471***	<0.0001
ΔCPI_t	0.08202	0.03893	2.107**	0.0406
ΔIMP_t	−0.04052	0.01739	−2.329**	0.0243
ΔIMP_{t-1}	0.02636	0.02030	1.299	0.2006
ECM_{t-1}	−0.41973	0.092199	−4.553***	<0.0001
Diagnostic Test				
R-Squared	0.57046	Adjusted R-squared		0.486413
F(9, 46)	11.610***	Normality of residual		20.19153***
RESET test	9.57614**	CUSUM test for parameter stability		12. 3863***

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithm.

The result also revealed that the current consumer price index (CPI) has a positive significant relationship with the crop gross production index. A unit increase in the CPI would lead to a 0.082 units increase in the crop gross production index.

The Long and short runs Coefficients of ARDL for Livestock gross production Index equation

The estimated long run equation for the livestock sub sector is presented in Table 10, the finding revealed that, land density has a significant negative relationship with the livestock gross production index. The finding showed that as the land density increases by a unit, the livestock gross production index decreases by 0.382 units. Some of the possible reasons for this result could be linked to the land use preference of farmers, the nature of investment in terms of the size or capacity of livestock farms and the opportunity cost of land. Nevertheless, the finding is contrary to the reports submitted by Shita *et al.,* [40] and Shita *et al.,* [41].

The coefficient of the per capita income has been consistent across all indicators used in the study. The positive significant relationship between livestock gross production index and the PCI is in line with a *priori* expectations. The effective demand would always stimulate production and ensured increase in farm income. The finding is supported by Akpan *et al.,* [13] and Akpan and Patrick [7], and Enu & Attah-Obeng [19].

The coefficient of balance of trade (BOT) showed a positive significant correlation with the livestock gross production index in the country. A unit increase in the BOT would result in 0.15608 units increase in livestock gross production index in the long run. This implies that, increase in the volume of export would promote increase in production of livestock in the country. The finding also revealed that, activities at the international market significantly influence the domestic production of agricultural commodities.

Table 10. The Long run Coefficients for Livestock gross production index equation

Variable	Coefficient	Standard error	t-value	Probability
Constant	2.17487	0.12043	18.06***	<0.0001
Lending rate	0.01157	0.05903	0.1960	0.8453
Land density	−0.38175	0.06992	−5.460***	<0.0001
Per capita income	0.15246	0.00833	18.30***	<0.0001
Inflation rate	0.00689	0.01478	0.4658	0.6432
Balance of trade	0.15608	0.05256	2.970***	0.0045

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithm.

The short run coefficients for the livestock gross production index equation are presented in Table 11. The coefficient of the error correction term is negative and statistically significant at 1% level. It shows that, about 27.22% of the short-run disequilibrium is adjusted towards its long-run equilibrium annually. The R-squared explained about 38.72% of the total variations in the livestock gross production index. This however, implies that many factors that influence livestock production were not captured in the model. However, the F-statistic is significant showing that, the estimated R^2 is significant. The RESET test, normality of residual and the CUSUM test all indicate satisfactory results.

The short run model shows that; the last two-year lending interest rate has a negative significant relationship with the current value of the livestock gross production index in the country. The finding revealed the ineffectiveness of the credit system in the country towards the development of the livestock sub sector in Nigeria. Many commercial banks and other financial outfits are reductant at lending to the agricultural sector due to the inherent risks and the predominant small-scale and low-yielding businesses that dominate the sector.

The short run slope coefficient of land density in the current year period and the last two-year periods exhibited positive and negative impacts on the livestock gross production index respectively.

Table 11. The Short run Coefficients for Livestock gross production index equation

Variable	Coefficient	Standard error	t-value	Probability
Constant	0.03266	0.01018	3.208***	0.0024
ΔLSK_{t-1}	−0.05236	0.11566	−0.453	0.6529
ΔLENt-2	−0.09377	0.04815	−1.947*	0.0576
ΔLAS_{t}	0.27101	0.08737	3.102***	0.0033
ΔLAS_{t-2}	−0.30977	0.08939	−3.465***	0.0012
ΔPCI_{t}	0.02857	0.03931	0.727	0.4710
$\Delta INFL_{t}$	0.016201	0.00681	2.379**	0.0216
ΔBOT_{t}	−0.00114	0.02872	−0.039	0.9684
ΔBOT_{t-1}	−0.00486	0.02365	−0.206	0.8379
ECM_{t-1}	−0.27223	0.07583	−3.590***	0.0008
Diagnostic Test				
R-Squared	0.387177	**Adjusted R-squared**		0.267277
F(9, 46)	7.6526***	**Normality of residual**		10.1609***
RESET test	11.0239***	**CUSUM test for parameter stability**		-2.16683**

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithm.

The result indicates that, the current year land density in the short run has an accelerating influence on the livestock gross production index while the last two previous year relates negatively to the production of livestock in the country. Regarding livestock production in the country (especially cattle), there has been conflicts between the nomadic herdsmen and the landlords (farmers), making it difficult for the parties to have a sustainable land holding agreement. Hence, most communities based on their previous experiences with livestock owners will be reluctant to relinquish their land resources for livestock rearing.

The coefficient of the inflation rate is positive and significant implying that increase in inflation rate would cause marginal increase in livestock production. The plausible reason for this relationship could be explained by the adaptive nature of livestock farmers in the country. That is farmers would likely invest more on livestock production during surging of inflation with the hope of realizing higher income due to high product prices cause by the inflation.

CONCLUSIONS

The study has established the relationship between agricultural sector's production indicators and some key macroeconomic fundamentals from the period 1961 to 2019 in Nigeria. The time series data properties were analysed using the Augmented Dickey-Fuller unit root test and improved ADF-GLS unit root test. The result indicated that the series had mixed stationarity issue (i.e. I (0) and 1(1)). Based on the behaviour of the series, the ARDL model was employed to establish the cointegration among series. The existence of cointegrations among series was established and the long and short runs coefficients of the specified agricultural production indicator equations were generated. The error term from the short run models had appropriate signs and were statistically significant at the conventional probability levels. This implies that, some key macroeconomic fundamentals in Nigeria's economy interact in each period to re-establish the long-run equilibrium in the agricultural production indicator equations following the short-run random disturbances.

The empirical results revealed that, per capita real GDP, land density and consumer price index are the determinants of crop production gross index in the long run, whereas, per capita income, lending rate, land density and total import are the short run determinants. Also, the study identified per capita income, land density, consumer price index and the nominal exchange rate as the long run determinants of agricultural gross production index. The estimated model further revealed per capita income and land density as the short run determinants of agricultural gross production index in the country. Moreover, land density, per capita income and balance of trade were found to determine the livestock gross production index in the long run. Besides, the lending rate, land density and inflation rate determined the livestock gross production index in a short run.

The study established the fact that, fluctuations in some key macroeconomic variables transmit mixed effects to the agricultural sector's production indicators in the short and long run periods. The findings call for the formulation of specific policies to focus on the improvement of the per capita income of the citizenry. Also, the country's trade policy should be developed to curtail the excessive importation while promoting exports in order to protect domestic agro-enterprises. Appropriate policy package to reduce or stabilize inflation rate in the country is inevitable. The lending interest rate should be regulated to favour agricultural sector in line with its peculiar characteristics. The land use act should be reassessed to make land more available to farmers and encourage economies of scale. Finally, the study supports the present deregulation or market determined nominal exchange rate system as this will reduce excessive importation.

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