EE
E u r o E c o n o m i c a
Issue 1(41)/2022 *ISSN: 1582-8859*

EE
EuroEconomica

Does Innovation Contribute to Agricultural Development in Nigeria? Granger Causality and Error Correction Model Approach

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Abstract: This study has provided an empirical answer to the question whether innovation contributed to agricultural development in Nigeria between 1990 and 2019. Techniques such as Granger causality and Error Correction were embraced in addressing the paper`s objective with the following conclusion. There is a unidirectional causality between number of people with access to ICT and agricultural development in Nigeria. In the same vein, there is a unidirectional causality between number of people with access to mobile phone and agricultural development in the country. That shows that innovation is a strategic component for the development of agriculture in Nigeria. Furthermore, the past level of agricultural development contributed significantly to the current level of agricultural development in Nigeria in the long run. Number of people with access to mobile phone had a negative but insignificant relationship with agricultural development both in the short run and the long run. Whereas, number of people with access to ICT had a positively insignificant relationship with agricultural development in the both short run and the long run. Against the emergence of the results from this study, the policymakers and other agricultural stakeholders in Nigeria should urgently give more attention and explore innovation in the area of Information Communication Technologies to drive the development of the agricultural value added products in the country.

Keywords: Innovation; Agricultural Valued Added; ICT, Mobile Phone; Granger Causality; Error Correction Model

JEL Classification: Q14

1. Introduction

Development of agricultural sector has been one the major challenges confronting Nigeria. Agriculture is the most strategic economic sector in many developing nations where poverty and food insecurity prevail (Obiakor *et al.*, 2022; Aderemi *et al.*, 2021; FAO, 2015). Agriculture has been conceptualized as a pertinent component of initiatives targeted at reducing poverty in these regions owing to its vital spillovers (Olayemi *et al.*, 2019; Ogundari, 2014). Steaming from the indispensable roles of agriculture, efforts to address poverty and food insecurity in emerging nations has been geared towards boosting innovation in agriculture and technology (Hardaker *et al.* 1984; Kebebe, 2017; Huang *et al.* 2002). Agriculture, which is the artificial cultivation and processing of animals, plants, fungi, and other living

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forms for food, fiber, and other byproducts, therefore plays some unique roles in the economic activities of nations. However, it has been observed that the existing current gap among food and population expansion, cultivable land, and labor in Nigeria has greatly risen due to the aftermath effect of a continuous rising need for food to cater for population growth and a wide variety of nutritional requirements.

Consequently, utilization of modern technology in agriculture to eliminate poverty in Nigeria cannot be undermined. This is due to the fact that agricultural activities are driven by crude implements in this nation. Innovation has been identified a main driver of economic growth and well-being in many nations (Kaya, 2010: Kovářová, 2017; Aderemi *et al.*, 2020:1). Innovation does only guarantee social and economic growth but also the optimal utilization of natural resources. It is important to stress that the paradigm shift in the global economic, political, and environmental climates necessitates premium on increasing value of the unprocessed raw materials within a chain. The value addition to agricultural products could take the form of processing, packing, storage, transportation, and distribution of food after production; and food safety. This implies that the application of innovation in agriculture advances growth and development in agricultural activates by ensuring efficiency in output production. Meanwhile, in the recent times, debates regarding the influence of innovation on agricultural development in developing countries have become the issue of concern to the policymakers and scholars in the recent times because globalization, technical and corporate improvements have all broadened the subject matter of agriculture (Asfaw *et al*., 2010; de Janvry and Sadoulet 2001). However, the situation report from the Nigerian economy shows that there are lack of empirical studies regarding the nexus between innovation and agricultural development in Nigeria (Ebere *et al.* 2021: Obiakor *et al.*, 2021: Obiakor *et al.*, 2022: Aderemi *et al.*, 2021). Against this backdrop, this study has been carried out to fill in the existing gap in that has been noticed in the literature. This study is highly imperative because the bulk of the past empirical studies focus on the improvement of agriculture, food security and economic expansion in one hand, and agricultural development and poverty reduction on the other hand. Therefore, this study examines the relationship between innovation and agricultural development in Nigeria within the periods of 1990 and 2019.

In addition, the structure of this paper is as follows; the problem of the study was identified and justified accordingly in the introduction, literature review was carried out in the section two of the paper. Whereas, section three accommodates methodology, analysis of data and presentation of the results alongside with the policy aspect of the work.

2. Literature Review

Despite the fact that studies regarding the nexus between innovation and agricultural development are very scarce in developing countries, the authors have made efforts to present the review of the past empirical work in this section of the study as follows; Oyakhilomen and Zibah (2014) initiated a research which provided information on the interlink between agricultural improvement and rise in outputs focusing on poverty reduction from 1970-2011 using ARDL as a method of data estimation. The findings showed that agriculture has significantly influenced economic growth trend, but this growth in the economy could not sponsor reduction in poverty rate in the country. The research recommended that policies should be put in place to alleviate poverty by investing more in agricultural development.

Olowa *et al.* (2020) investigated the role of innovation alongside creativity towards propelling agriculture in order to ensure sustainable development. The study found that agricultural sector has been in decline due to lack of innovation in the sector as agriculture is the inevitable production of employment, and supply of raw materials to industries. Also, it found that Nigeria has become a net food importer as opposed to when it was a major food exporter. The study recommended that innovators should be provided with resources. Also, strengthening the country's human development by investing in the educational system and vocational training. Obiakor *et al.* (2022) embraced Cointegration and Granger causality tool to appraise how agriculture, food security and poverty reduction were interrelated in Nigeria between 1990 and 2019. The authors affirmed the presence of a long run equilibrium convergence among the principal variables in the paper. Similarly, the presence of a unidirectional causality flowing from food security to poverty reduction in was recorded in the study. Also, one way causality running from poverty reduction to agriculture was noticed in the study. Adofu *et al.* (2013) employed empirical study to interrogate what could be economic impact of improved agricultural technologies on cassava output in Kogi State, Nigeria, using the results from a household survey of 2009/2010. The data obtained was analyzed with the aid of descriptive and inferential statistical analysis. The result of the study showed that agricultural technologies had a direct influence on cassava productivity.

In the same vein, Amaefula (2019) carried out research to assess the impact of agriculture on Nigeria's economy from 1981 to 2017 using multiple linear regression model as a method of analysis. It was inferred from the author`s assertion that agricultural sector`s contribution to economic growth was positive in Nigeria. As such, government and agricultural stake holders should embrace more efforts in ensuring the improvement of some sub-sectors in agriculture such as fishery, forestry and livestock in order to achieve a robust agricultural sector contribution to economic growth in Nigeria. Kenny (2019) assessed the impact of agriculture in maintaining sustainable economic growth in Nigeria using Vector Error Correction Model as a method of data analysis. The result of the analysis informed that Agricultural Credit Guarantee Scheme Fund. (ACGSF) had a positively insignificant influence on agricultural domestic production. The study recommended that policy consistency and commitment by the government is required.

Ogundari and Bolarinwa (2018) accessed the impact of agricultural innovation adoption: a meta-analysis. The study made use of 154 studies using mete- regression analysis. The result found that adopting agricultural innovation and technology rises significantly over time. Also, their findings indicate a significant bias in the literature toward agricultural innovations and technologies that focus on high-yielding varieties while ignoring other types of complementing innovations and technologies.

3. Methodology

The appropriate research design for this study is an expo facto, this is because the objective of this paper involves how explanatory variables provides an explanation for variation in the dependent variable. Similarly, secondary data was considered from 1990 to 2019 for the empirical analysis in this study, which was at same time extracted from World Development Indicators (WDI).

3.1. Model Specification

In providing econometric analysis in this study, it is instructive to make use of a model, which was consequently adapted from the works of Aderemi *et al. (*2020:2) and Obiakor *et al.* (2021). In order to structure the adapted model to suit the objective of this present study, the variables that are relevant to this study were eliminated.

Model 1

The model for this study was adopted. The model is written as follows;

$AVA_t = F\ (ATICT_t, ATMP_t)$ (1)

Mathematically, this can be written as:

$AVA_t = F\ (ATICT_t + ATMP_t)$ (2)

The econometric model for the above equation is:

$AVA_t = \alpha + \beta_0 ATICT_t + \beta_1 ATMP_t + \mu t$ (3)

Then, the transformation of model 3 with the inclusion of logarithm changes it to this standardized form.

$AVA_t = \alpha + \beta_0\, ATICT_t + \beta_1 LnATMP_t + \mu_t$ (4)

The transformation of model (4) to reflect the short run parsimony alongside error correction and long run equilibrium relationship is presented as follows;

$$\Delta \text{Log AVA}_t = \beta_0 + \sum_{i=1}^{p} \beta_1\ \Delta \text{ Log AVA}_{t-1} + \sum_{i=0}^{p} \beta_2\, \Delta \text{Log ATICT}_{t-1} + \\ + \sum_{i=1}^{p} \beta_1\ \Delta \text{ Log ATMP}_{t-1}\, \Omega ECM_{t-1} + \theta_1 \text{Log AVA}_{t-1} + \theta_2 \text{Log AICT}_{t-1} + + \theta_3 \text{Log ATMP}_{t-1} + \mu t \quad (5)$$

Moreover, the examination of direction of causality among the variables of interest was carried out within the framework of Granger causality model, specified below;

$AVA_t = \beta_0 + \sum_{i=1}^{m} \beta_1 AVA_{t-i} + \sum_{j=1}^{n} \beta_2 ATMP_{t-j} + \sum_{k=1}^{O} \beta_3 ATICT_{t-k} + \mu_{1t}$ (6)

$ATMP_t = \alpha_o + \sum_{i=1}^{m} \alpha_1 ATMP_{t-i} + \sum_{j=1}^{n} \alpha_2\, ATICT_{t-j} + \sum_{k=1}^{O} \alpha_3 AVA_{t-k} + \mu_{2t}$ (7)

$ATICT_t = \gamma_0 + \sum_{i=1}^{m} \gamma_1 ATICT_{t-i} + \sum_{j=1}^{n} \gamma_2\, AVA_{t-j} + \sum_{k=1}^{O} \gamma_3 ATMP_{t-k} + \mu_{3t}$ (8)

Where; AVA is employed to denote agricultural development, and agricultural value added as a percentage of GDP is used to proxy it. Meanwhile, innovation is proxied by two variables namely, ATICT – no of people with access to ICT and ATMP – No of people with access to mobile phone. μ = Error term, α = Intercept of the Model. β_0, β_1, β_2 and β_3 = short run parameters and θ_1, θ_2 and θ_3 = long run parameters. Ω Represents parameter of error correction.

t = 1990-2019.

3.2. Estimation of Analysis

The study employed Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit roots test to check for the stationarity of the data series and Johansen Cointegration test was used to check the long run

equilibrium among the variables. If the data set variables possess unit root, this means they only have a short run relationship hence the need for the cointegration test to check for the long run relationship. The study also made use of Error Correction model to check and evaluate if short run connection exists between innovation and agricultural development, and as well as the long run in Nigeria. In the same vein, the study also checked for the causal relationship among the key variables using the Pairwise Granger Causality.

4. Results and Discussion

Table 1. Descriptive Statistics

	AVA	ATICT	ATMP
Mean	24.71801	10.86440	67163014
Median	24.56897	7.385000	51692052
Maximum	36.96508	33.60000	1.85E+08
Minimum	19.99025	0.008833	14000.00
Std. Dev.	4.155981	11.39486	66187838
Skewness	1.354050	0.667922	0.382606
Kurtosis	4.790117	2.061959	1.603295
Jarque-Bera	10.53832	2.664402	2.536334
Probability	0.005148	0.263896	0.281347
Sum	593.2322	260.7457	1.61E+09
Sum Sq. Dev.	397.2600	2986.383	1.01E+17
Observations	30	30	30

Source: Authors` Computation (2022)

The descriptive statistics of the estimated data set are shown in Table 1 with a view to determining if the data set conforms to the normal distribution assumption. According to the table above, AVA-agricultural value added has the mean value and the median value that are very close. However, access to mobile phones (ATMP) and access to mobile phones (ATMP) have the mean value and the median value with a slight difference. All the variables' means are bigger than their standard deviations. Because the standard deviation is less than the mean, this implies that the data is fairly distributed from its mean. Furthermore, the data set's skewness values are positively skewed, with the kurtosis that demonstrates that certain variables are platykurtic in nature because the values are less than 3.

Table 2. Augmented Dickey-fuller Test and Phillips PerronTest

Variables	Augmented Dickey-Fuller Test				
	Level	Probability	1st Diff	Probability	Remark
AVA	-2.976263	0.4284	-2.976263	0.0000	I (1)
ATICT	-2.998064	1.0000	-3.081002	0.0498	I (1)
ATMP	-2.967767	1.0000	-2.971853	0.0131	I (1)
Variables	Phillips Perron Test				
	Level	Probability	1st Diff	Probability	Remark
AVA	-2.967767	0.1884	-2.971853	0.0000	I (1)
ATICT	-2.998064	1.0000	-3.004861	0.2084	I (2)
ATMP	-2.967767	0.9998	-2.971853	0.0117	I (1)

Source: Authors` Computation (2022)

Table 2 shows the estimated results of the unit roots tests using the Augmented Dickey-Fuller (ADF) and the Phillips Perron (PP) Test. The result shows that all the variables in the data set were stationary

at level, 1st differencing and 2nd differencing. This means that all the data used in this study are a mixture of I (0), I (1) and I (2).

Table 3. Johansen Cointegration Test (Trace Statistics) and (Maximum Eigen value)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	P-Value	Max- Eigenvalue	P-Value
None *	0.605212	41.06841	0.0017	26.02338	0.0094
At most 1	0.413124	15.04504	0.0583	14.92236	0.0393
At most 2	0.004372	0.122672	0.7261	0.122672	0.7261

Source: authors` calculation (2022)

It has been established in the previous table that the variables in this study were composed of different orders of integration, ranging from order zero, one and two. This is an indication that these variable are likely to diverge in the short run. Therefore, it is important to verify the long run convergence among these variables which informed the estimation of the long run equilibrium relationship, employing Johansen Cointegration Test as shown in Table 3. It was observed from the table that the presence of a long run equilibrium existed between innovation and agricultural development in Nigeria.

Table 4. Pairwise Granger Causality Test

Null hypothesis	F-Stat	Prob.	Decision	Causality
ATICT does not Granger Cause AVA	4.96950	0.0200	Reject	Unidirectional
AVA does not Granger Cause ATICT	0.98990	0.3920	Accept	
ATMP does not Granger Cause AVA	3.42312	0.0500	Reject	Unidirectional
AVA does not Granger Cause ATMP	0.77217	0.4736	Accept	No Causality
ATMP does not Granger Cause ATICT	1.85008	0.1875	Accept	No Causality
ATICT does not Granger Cause ATMP	2.56389	0.1064	Accept	

Source: Authors' Computation (2022)

The table above shows the estimates result of the pairwise Granger causality test to check the causal relationship between innovation and agricultural development in Nigeria. The result shows that there is a causality flowing from access to internet (ATICT) to agricultural value added (AVA) but there is no causal flow from AVA to ATICT. This implies that there is a unidirectional causality between ATICT and AVA. Also, there is a causality flowing from access to mobile phone (ATMP) to agricultural value added (AVA) but there is no causality flowing from AVA to ATMP. This shows that there is a unidirectional causality between ATMP and AVA. From this standpoint, it could be deduced that innovation is a strategic component for the development of agriculture in Nigeria.

Table 5. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-668.4681	NA	1.36e+17	47.96201	48.10475	48.00565
1	-571.5325	166.1755	2.55e+14	41.68089	42.25183*	41.85543
2	-558.8406	19.03785*	2.01e+14*	41.41718*	42.41634	41.72263*

*indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Source: Authors` Computation (2022)

The estimation of ECM model requires the selection of the appropriate lag length criteria in order to ensure the robustness of the model. In view of the above, the estimated results in Table 5 indicates that all the information criteria selected lag two as the optimal lag for the estimation of the model.

Table 6. Short Run and Long Run Estimates between Innovation and Agricultural Development in Nigeria

Dependent Variable: AVA

Regressors	Long-run Coefficient	T-Stat	Prob.	Regressors	Short-run Coefficient	T-Stat	Prob.
AVA(-2)	-0.414517**	2.229261	0.0368	D(AVA(-2))	0.363935**	2.083978	0.0509
ATMP(-2)	-8.01E-08	0.763298	0.4538	D(ATMP(-2))	-7.94E-08	0.902289	0.3782
ATICT(-2)	0.440221	0.409849	0.6861	D(ATICT(-2))	0.162658	0.196105	0.8466
ECM	-0.573698**	2.626949	0.0166				

*Source: Authors` Computation (2022) Notes: The value in parenthesis denotes the p-values *** Significant at 1% **Significant at 5% *Significant at 10%*

The results displayed in Table 6 indicates the estimated ECM model showing the long and the short run relationship between innovation and agricultural development in Nigeria. It is important to state that the ECM parameter is both negative and significant affirming that 57% of the short run disequilibrium due to error was adjusted in the long run. Consequently, the past value of the agricultural development brought a negative significant impact on the current level of agricultural development in the short run. But this relationship became positive in the long run. This implies that the past level of agricultural development contributed significantly to the current level of agricultural development in Nigeria in the long run. However, both indicators of innovation had insignificant relationship with the advancement of agricultural output in Nigeria. Specifically, number of people with access to mobile phone had a negative relationship with agricultural development both in the short run and the long run. Whereas, number of people with access to ICT had a positive relationship with agricultural development in the both short run and the long run. By and large, it could be established in this study that innovation did not contribute meaningfully to agricultural development in Nigeria.

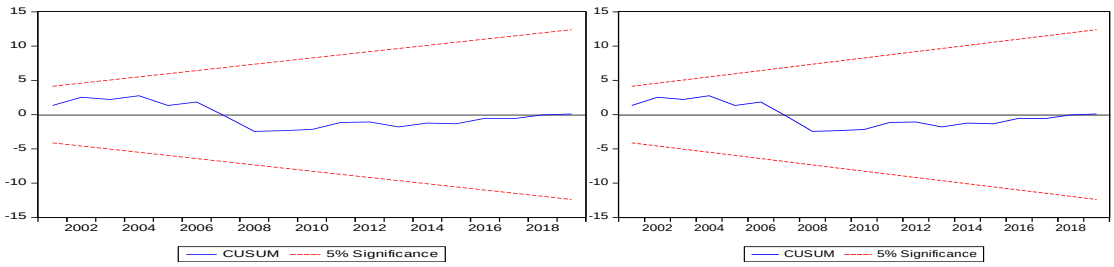
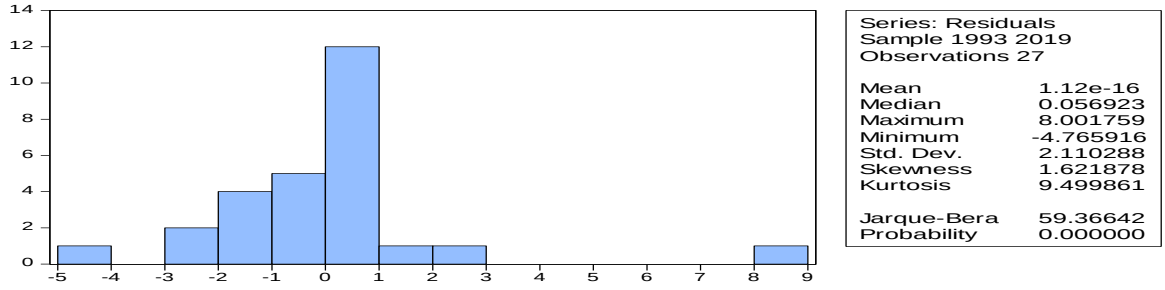


Figure 1. Stability Test: Cusum Square and Cumulative Sum of Squares
Source: Authors` Computation (2022)

Figure 1projects the tests for cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) to validate the stability or otherwise of the estimated ECM. The evidence from the figure affirms that the error-correction model`s residuals lie within the critical bounds of five percent significant level. This authenticates the stability of the estimated parameters between 1990 and 2019. Hence, the specification of the model was reasonably done for this analysis.

Figure 2. Histogram and Normality Test



Source: Authors` Computation (2022)

Table 7. Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.614218	Prob. F(2,17)	0.2281
Obs*R-squared	4.309171	Prob. Chi-Square(2)	0.1160

Source: Authors` Computation (2022)

Table 8. Heteroskedasticity Test: Breusch-Pagan-Godfrey

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.668730	Prob. F(7,19)	0.6958
Obs*R-squared	5.337166	Prob. Chi-Square(7)	0.6189
Scaled explained SS	11.23239	Prob. Chi-Square(7)	0.1288

Source: Authors` Computation (2022)

4.2. Summary, Conclusion and Recommendation

This study has provided an empirical answer to the question whether innovation contributed to agricultural development in Nigeria between 1990 and 2019. Techniques such as Granger causality and Error Correction were embraced in addressing the paper`s objective with the following conclusion. There is a unidirectional causality between number of people with access to ICT and agricultural development in Nigeria. In the same vein, there is a unidirectional causality between number of people with access to mobile phone and agricultural development in the country. That shows that innovation is a strategic component for the improvement of primary products in Nigeria. Furthermore, the past level of agricultural development contributed significantly to the current level of agricultural development in Nigeria in the long run. Number of people with access to mobile phone had a negative but insignificant relationship with agricultural development both in the short run and the long run. Whereas, number of people with access to ICT had a directly insignificant relationship with agricultural development in the both short run and the long run. Therefore, innovation did not contribute meaningfully to the improvement of agricultural outputs in Nigeria. Against the emergence of the results from this study, the policymakers and other agricultural stakeholders in Nigeria should urgently give more attention and explore innovation in the area of Information Communication Technologies to drive the development of the agricultural value added products in the country.

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