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# Evidence of long-run relationship between agriculture and manufacturing industry output in Nigeria

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## Abstract

This study investigates a long-run relationship between agriculture and manufacturing industry output in Nigeria using a time series data from 1982 to 2015. The study employs the Granger causality test, Vector Error Correction Model and co-integration technique to estimate the interdependence between agricultural productivity and manufacturing industry output in the light of selected macroeconomic variables. Empirical evidence from Granger Causality test reveals a bidirectional relationship between agricultural productivity and manufacturing industry output. Although, a positive relationship exists between agriculture and manufacturing industry output in the short and long-run estimates, a long-run divergence from the vector error correction model indicates that variations in agricultural productivity are not restored to equilibrium given the behavior of explanatory variables, which implies that macroeconomic conditions distort the linkage. A major policy implication is that developing countries need to have a measure of macroeconomic stability for a strong agriculture and manufacturing industry linkage to foster sustainable economic development.

**Key words:** Agriculture; Manufacturing Industry; Granger Causality test, Co-integration; Vector Error Correction model;

**JEL Classification Code:** C22, N17, O13, O14

## 1. Introduction

There is no doubt that the oil boom of the 1970s made Nigeria to neglect its agricultural and manufacturing sectors in favor of an unhealthy dependence on crude oil. Nigeria, though endowed with abundant agro resources and diversity, unfortunately has become a major food importer in sub-Saharan Africa. Available literature reports that despite Nigeria's rich agricultural resource endowments, there has been a gradual decline in the contribution of agriculture to the nation's economy (Manyong *et al.*, 2005; Ekpo and Umoh, 2012), which is evident in the rising value of food import. About 70 percent of the population live on less than US\$1.25 per day, suffering hunger and poverty. Despite its reputation as a petroleum exporting country, Nigeria remains an agrarian economy. The Sustainable Development Goals (SDG), Africa Regional Report indicate that aside from the common issues to be addressed such as governance and institutions, peace and security, financing, capacity development and technology transfer, other issues such as food insecurity challenges were identified in West Africa as key sub regional sustainable development priorities. To transform the Nigeria economy to a rapid growing economy with sustained and inclusive development, strategies to foster economic diversification; creating jobs, reduce inequality and ultimately reduce poverty, must be put in place. The inter-relationship between agriculture and industry has been a long-debated issue in the development literature (Saikia, 2009). The aim of this study is to empirically investigate a long-run relationship between agriculture and manufacturing industry output in Nigeria using Granger Causality test, Co-integration and Error Correction Model, on a time series data from 1982 to 2015. The study time frame is limited by data availability on key variables. This research will not only focus on industrialization as a strategy to improve agricultural productivity in Nigeria but will dwell on the interlinkage between the manufacturing industry and agricultural productivity.

Improving the agricultural sector is necessary to tackling the risks associated with agricultural intensification; and climate smart agricultural practices and overall agricultural efficiency improvements present important opportunities for climate change mitigation and adaptation, while increasing agricultural productivity and dealing with the issue of food security, unemployment and poverty. Some scholars have argued that the transformation from agriculture to industry is a movement from traditional to modern, Zeira and Zoabi (2015) contends that economic growth is driven by rising productivity of modern sectors, however, this claim is based on the assumption of a rising marginal opportunity costs for individuals in their desire to create new modern sectors. In the same vein, Diao, McMillan and Wangwe (2018) finds a positive correlation between labour productivity growth in agriculture and employment in manufacturing sector in Africa. The implication is that improvements in agriculture feeds into increasing productivity in the industrial sector.

Agriculture has been of great importance to the Nigerian economy. It still remains the mainstay of the economy but with low and declining productivity level. The importance of agriculture is clearly seen in the Agricultural Policy of 2004, which seeks to attain self-sustaining growth in all the sub-sectors and the transformation of the socio-economic development of the nation. The policy also recognized agriculture as a vital sector that could achieve the poverty reduction goal of the government. One of the major problems with agriculture in Nigeria is that majority of farmers in Nigeria practice subsistence farming. This study seeks to establish the causal link between the manufacturing industry sector and agriculture in Nigeria. The agro-industry linkage is a dynamic integrated production process and synergy between agriculture and manufacturing industry. Agro-industry linkage refers to the inter-linkage or interrelationship between agriculture and manufacturing industry sector which involves the process of

agriculture on the farm and off-farm activities such as handling, processing and packaging, transporting and marketing.

Nigeria is facing an imminent food security crisis, increasing poverty levels, high unemployment rate with a growing population which depends largely on imported food. Despite Nigeria's significant resource endowments, there is continued sporadic economic growth, poverty remains widespread since the late 1990s. An estimated 70 percent of Nigerians live on less than US\$1.25 per day. Nigeria was ranked 40th out of 79 on the 2012 Global Hunger Index and 156th out of 187 on the 2011 UNDP Human Development Index. Poverty is especially widespread in rural areas, where 80 percent of the population live below the poverty line (IFAD 2012).

Agriculture employs approximately two-thirds of the country's total labor force and contributing 40 percent to Nigeria's GDP (IFAD 2012). Nigeria is the world's largest producer of cassava, yam, and cowpea; yet it is a food-deficit nation and depends on import of grains, livestock products, and fish (IFAD 2012). Of an estimated 71 million hectares of cultivable land, only half is currently used for farming; there is similar potential for an expansion of irrigation, which now only covers 7 percent of irrigable land. Most of the rural population farm on a subsistence scale, using small plots and depending on seasonal rainfall. The lack of infrastructure such as roads further exacerbates poverty in rural areas by isolating rural farmers from needed inputs and profitable markets. Pressure from growing population is also impacting already diminished resources, further threatening food production. Over-farmed land, deforestation, and overgrazing are severe in many parts of the country. Drought has become common in the North, while erosion and flooding are major problems in the South (IFAD, 2012).

Nevertheless, studies reviewed on this subject for Nigeria focus on government providing infrastructural and credit facilities to improve the agricultural sector, none has empirically investigated the linkage between agriculture and manufacturing industry productivity; since agriculture provides necessary input for manufacturing industries. Industrialization can also boost agricultural productivity as could be seen in developed economies. There are also few descriptive studies which focus on industrialization as a strategy to improve the agricultural sector. This study focuses on the long-run relationship and the interlinkage between agriculture and manufacturing industry given the behavior of some macroeconomic variables such as inflation and exchange rate, which in turn will help to improve food sufficiency and achieve some of the sustainable development goals for Nigeria. This could be a long-term solution for continuous food security, which would ultimately lead to poverty reduction and increase employment. The primary goal for policy implication of this study is to reveal the impact of macroeconomic variables on the linkage between agriculture and manufacturing industry output, and whether government expenditure should be channeled to boost agricultural output for raw material needed for industrial development or to invest in the development of industrial output for manufactured goods to aid agricultural productivity. This study reveals a bidirectional relationship between agriculture and manufacturing industry output, but the vector error correction model diverges in the long-run, which may be attributed to the behavior of macroeconomic variables. The policy implication for this study uncovers a need for macroeconomic stability for the linkage between agriculture and manufacturing industry output to have a convergence in the long-run.

This study is presented in five sections, the second is a review of relevant literature and the third is a presentation of the theoretical framework and methodology, the fourth section

presents the empirical analysis and discuss the findings of the study, while the study concludes in the fifth section.

## **2. Literature Review**

The synergy between agricultural output and industrial productivity has been ever of old. There is a large body of literature that discusses this linkage in economic development. However, the institutional debates leave a hollow on the role of agriculture in economic growth and industrialization, especially for developing countries. It is believed in some quarters that improved agriculture will provide the necessary raw material for industries to thrive, but the other side of the discussion views increased agricultural productivity as a result of technical progress, which is driven by industrial innovation. Either way, agriculture and industrialization seem to be strongly interdependent because agriculture does not only supply inputs needed in agro-based industries but utilizes industrial outputs such as pesticides and farm equipment. The literature therefore, seems very diverse, but constructively we shall limit our reviews for this study to empirical literature that discusses the interdependency between agriculture and manufacturing industry output.

Lin and Koo (1990) investigates the relationship between China's agricultural and industrial sectors from 1952 to 1988, the findings reveal that growth in the agricultural sector contribute to growth of the industrial sector, but growth in the industrial sector did not increase growth in the agricultural sector. This implies a unidirectional causality, and we shall see in the course of this study the result of a similar empirical test conducted for the case of Nigeria. One major reason that may be proffered for a unidirectional relationship as in this case, is the Chinese adoption of Soviet styled economic development strategies where industrialization is overly emphasized as a government policy at the expense of agriculture. A very common feature of developing country development strategy is the "urban bias" policy, which places less emphasis on the agricultural sector, especially for young school leavers eager to be employed in administrative and service positions rather than on farm.

Contrary to the findings in Lin and Koo (1990) above, Koo and Lou (1997), using gross national income in the Chinese agricultural sector as dependent variable, and explanatory variables; labor, amount of capital invested in the agricultural sector, total area of arable land, total value of external trade, gross national income, on a panel data of 30 provinces, municipalities and autonomous regions between 1988 to 1992, finds a significant relationship at 5% between agricultural growth and industrial income, but the agricultural income variable is not significant in the growth model, which implies that industrial growth contributes to agricultural growth, but agricultural growth does not contribute to industrial growth. one major reason for the differing results may be due to progress in economic development of the Chinese economy and the diminishing role of agricultural sector.

In the argument of whether labour productivity in the agricultural sector has any significant effect on industrialization in Africa, Diao et al. (2018) opines that the synergy between labor productivity in agriculture and industrial sector signifies only a necessary but not sufficient condition for improvements in industrialization. The link between rural income through agriculture and the demand for manufactured goods in Africa account for why increases in agricultural labor productivity could lead to positive changes in employment in agro-based manufacturing. Suffice to say that agriculture provides the raw material for the industrial sector; but industrial machines are needed for extraction, which imbues a bidirectional causality on the relationship between the sectors. The process of agro-industrialization leads to

employment opportunities, improvement in creation of income and increased earning for farmers. This makes it possible for the employed to purchase necessary food items and increase available food for the economy. Also, as agricultural productivity increases, export increases thereby improving balance of payment, increasing foreign reserve and stabilizing exchange rate. However, this could be achieved only with the provision of basic infrastructure that supports the development of agriculture such as road, transport, water, credit, rural electrification, and a competitive market structure, coupled with the human capacity, which includes policy-makers, researchers, farmers, entrepreneurs and extension workers.

Omorogiuwa *et. al* (2014), stated that there is an inverse relationship between agricultural productivity, outputs and food importation. Furthermore, the study reveals that the oil boom of the 1970's and 80's in Nigeria resulted in a boost of the manufacturing sector and a high incidence of rural-urban migration, leading to neglect of the agricultural sector and an increase in food importation, which further impoverished the rural farmer. Nevertheless, some of the rural farmers who had acquired education left the farm for employment in the manufacturing industries, which hitherto led to the neglect of the agricultural sector and the decline in the supply of raw material for use in agro-based manufacturing sector. The need to fill this shortfall with imported raw material leads to pressure on the foreign reserve resulting in a depreciation of the local currency and high inflation on the price of manufactured goods. To this end, Nigeria is not favorably disposed to embrace the transition from agriculture to industrialization, and as a result suffer immensely from the unbalanced effect on economic development.

Subramaniam and Reed (2009) examined agricultural inter sectoral linkages and its contribution to economic growth in transition countries. The study estimated an econometric model that incorporates linkages among agriculture, manufacturing, service and trade sectors using a vector error correction model for Poland and Romania. The study also employs the Johansen procedure of co-integration analysis to identify the existence of long-run and dynamic short-run inter-sectoral linkages among different sectors in the economies. The study concludes that there are positive links between agricultural productivity and the industrialization process. This positive linkage leads to greater productivity in the use of resources and sustainable economic growth. The analysis shows that the higher demand for processed food will stimulate the economy in several ways. First, the higher demand will attract more local and international food processing firms. Second, it will stimulate foreign direct investments and many service sectors like marketing, transportation, and finance will be established, and these sectors will have spillover effects into the agricultural sector as well. Third, farmers will face greater demand for their products, and increase their productivities. Ultimately, the agricultural sector reaches positive backward relationships and establishes fundamentals for sustainable growth in the agricultural sector.

Agro-industrialization obviously leads to increased agricultural productivity. It has been found that increased agricultural productivity leads to sustainable food security. Ogundari and Awokuse (2016) investigates the effect of agricultural productivity on different food security measures in Sub-Saharan Africa (SSA), food security indicators used were per capita food available in tonnes and per capita nutrient supply, while agriculture value added per hectare and cereal production per hectare were taken as measures of agricultural productivity in the study. Balanced panel data was collected from year 1980 to 2009, which covered 41 SSA countries for the empirical analysis. The empirical results from both the dynamic and linear models show that irrespective of the choice of food security indicator considered, agricultural productivity had a positive impact on the level of food security in the study area. This result suggests that an improvement in SSA agricultural productivity is crucial in alleviating the

problems of food insecurity. The paper went further to undeniably support the role of improved agricultural productivity in reducing food insecurity but stating the major challenge in SSA's agricultural sector as sustained agricultural productivity. Fugile and Roda (2013) argue that for sustained agricultural productivity to be achieved, policy measures that start with dissemination of agricultural technologies and practices to farmers should be established and investment in research and development encouraged.

O'Ryani and Miller (2003) discusses the role of Agriculture in poverty alleviation, Income distribution and economic development for Chile economy with a view to understanding the role of agriculture in industrial development. The study examines the impact of agriculture and agro-industrial sectors on poverty and income distribution; an increase in agricultural production, agro-industrial production and industrial production is simulated. An increase is obtained through either Increasing total productivity or a price subsidy to the sector's products. The study concludes that agriculture and agro-industrial sectors are important to alleviate poverty. Furthermore, an increase in labour productivity in agriculture has higher impact on the decline of poverty incidence than an increase in industrial sector.

A historical account of differences in economic development among nations stipulates uneven rainfall pattern and high temperatures as a major cause of low productivity in agriculture for sub-Saharan Africa countries; there is evidence of only three months of heavy rainfall during the rainy season, sporadic showers and hot dry season for the other months of the year (see Acemoglu and Robinson, 2012). For agriculture to thrive, there must be favorable climatic conditions that warrant continuous yield in agricultural productivity, although technical progress makes it possible for productivity in agriculture to increase irrespective of geographical misfortune. de Souza (2015) estimates the relationship between the growth rate of agricultural productivity and the manufacturing sector for 62 developing countries using average temperature to indicate changes in agricultural supply. The study reveals that a percentage increase in agriculture raises manufacturing output growth between 0.47 and 0.56 percent in the general specification and between 0.28 and 0.47 percent for the parsimonious estimates. The paper is a significant part of the growing body of literature using climate variations to support changes (shocks) in agricultural productivity.

In addition to time series and instrumental variable techniques that have been used by authors to estimate reverse causality and omitted variable bias in agricultural development and industrialization, many studies have applied co-integration and error correction models to estimate long-run relationships; country specific studies with mixed results include Gemmell et al. (2000) for Malaysia – findings reveal that manufacturing output and productivity were exogenous in the Granger sense to increases in agriculture. On the other hand, Kanwar (2000) and Chebbi and Lachaal (2007) found a positive response in India and Tunisia, also using a sample of 85 countries for a panel co-integration Tiffin and Irz (2006) confirmed positive response for the majority of countries in the sample.

In line with some of the studies, this paper employs the Granger causality test, co-integration and error correction model to investigate the relationship between agriculture and manufacturing industry output for the Nigerian economy.

### **3. Theoretical Framework and Methodology**

#### **3.1 Theoretical Framework**

This study is rooted in Hirschman's theory of unbalanced growth, because it accounts for the forward and backward linkages that is associated with agriculture and industry relationship. The Hirschman (1958) theory postulates an unbalanced growth model, arising from certain common characteristics exhibited by developing countries, such as low levels of Gross National Income (GNI) per capita, slow growth of GNI per capita, large inequality and widespread poverty, low levels of productivity, high dependence on agriculture, a backward industrial structure, weak consumption and low savings, high rate of population growth, high dependency ratio, high levels of underemployment and unemployment, technological backwardness and existence of both the traditional and modern sectors (dualism). In addition, there exists inadequate infrastructure to harness the available resources, and lack of entrepreneurs and investors to channel the cash flow through the sectors for a balanced economic growth. To this end, Hirschman proposed a deliberate unbalanced economic development strategy to maintain the existing structural imbalance, viz., complementarity, external economies and induced investment.

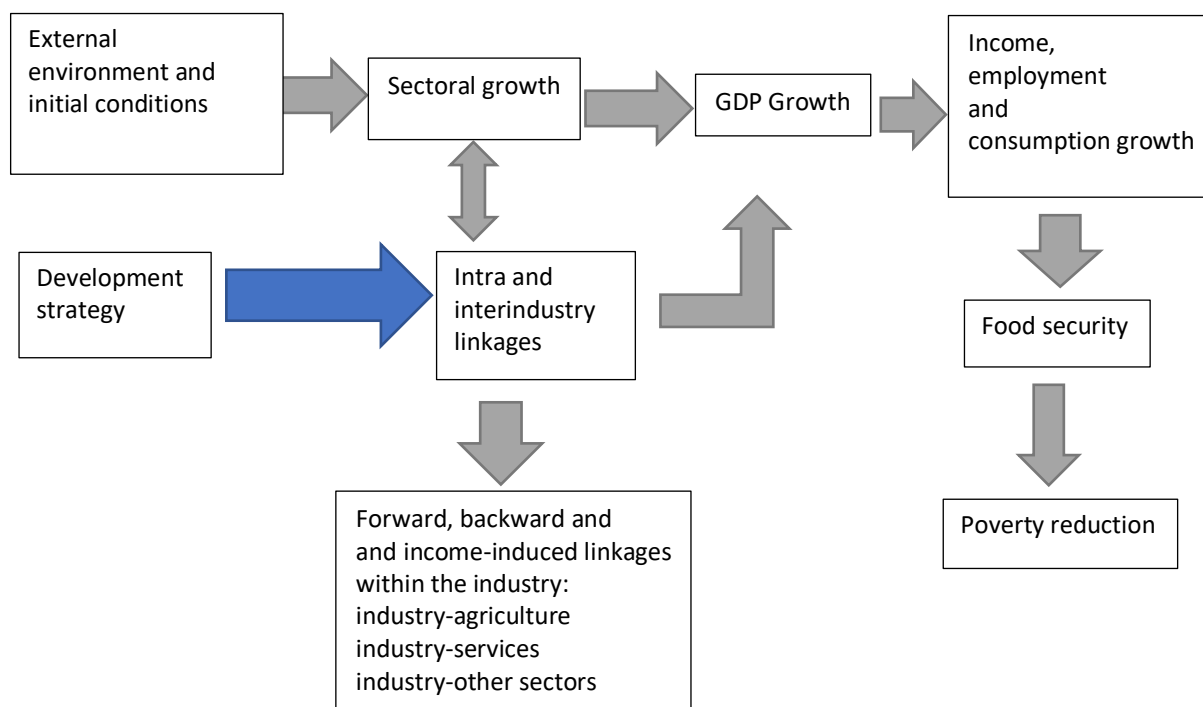
Hirschman unbalanced growth theory relates this study to Nigeria based on the need for investment in strategic sectors of the economy instead of all the sectors simultaneously. The agriculture and industrial sector in Nigeria have potentials of generating a high level of productivity. However, since the theory assumes that the sectors would automatically develop themselves through the linkages effect, the concept of Hirschman's backward and forward linkage comes into play. The forward linkage deals with the growth of certain projects owing to the initial growth which supply raw materials. That is, the products produced by this industry are used as inputs for other industries. A backward linkage is created when a project encourages investment in facilities that enable the project to succeed. Following this theory, the agricultural productivity will increase as the industrial sector will have a backward linkage with the agriculture sector by providing inputs and technologies. Whilst, the agricultural sector will have a forward linkage with the industrial manufacturing sector by providing raw materials for processing.

#### **3.2 Analytical Framework**

The illustration below shows the channel of existing relationship between agro-industrial linkage and food security. The approach below is directed at accelerating economic growth to create income-earning opportunities for the poor. Bhagwati and Srivivasan (2002) calls this approach the indirect route while the World Bank refers to it as "broad-based economic growth". The diagram below is the poverty-alleviation cum growth approach.

Figure 1: Approach to poverty-alleviation through interlinkage of agriculture and industry





The diagram shows that industrial growth would have an ultimate impact on poverty reduction through two different routes. The first is through sectoral growth which leads directly to accelerated GDP growth which would have a direct impact on income, consumption and employment and, hence, the living standards of the poor, growth-induced effects. The second route which is the focus of this study, is through the expansion of intra-and inter-sector linkages; both backwards and forward linkage types of the industrial sector, particularly the industry-agriculture which will consequently increase linkage-induced income and employment generation as industrial growth accelerates (Takahiro, Mayumi, & Tatsufumi, 2006)

### 3.3 Methodology

#### 3.3.1 Data

The data for this study spans the period 1981 to 2015, although constrained by availability, information for the period of study was obtained from Central Intelligence Agency (CIA) World Factbook, Central Bank of Nigeria (CBN) Statistical Bulletin and World Bank Development Indicator. The data for Agriculture value added and Industry value added is obtained from World Bank Development Indicator; government recurrent expenditure on agriculture, commercial bank loans and advances to the agriculture sector and official exchange of the local currency to the US dollar were sourced from the CBN statistical bulletin, while the consumer price index for inflation rate is obtained from the CIA World Factbook.

### 3.3.2 Model Specification

The model for estimation draws from the production function

$$y = f(X) \quad (1)$$

Where  $y$  represents agriculture, value added (annual % growth) used as a proxy for the level of agricultural output in the agricultural sector, while  $X$  represents all other variables that affect agricultural output.

Therefore, the model for this study can be implicitly specified as:

$$AGROUT = f(INF, INDOT, GRECA, SCLA, EXCRT) \quad (2)$$

Where:

$AGROUT$  is agriculture value added is used as a proxy for the level of agricultural output in the agricultural sector.

$INF$  is inflation rate, consumer prices (annual %).

$INDOT$  is industry value added which stands as a proxy for changes in industrial output.

$GRECA$  is the total government recurrent expenditure on agriculture.

$SCLA$  is the sectoral distribution of commercial banks' loans and advances to agriculture as a proxy for agricultural finance.

$EXCRT$  is the exchange rate of the Nigerian Naira to the dollar

The model can be specified in its explicit form as:

$$AGROUT = \beta_0 + \beta_1 INF + \beta_2 INDOT + \beta_3 GRECA + \beta_4 SCLA + \beta_5 EXCRT + U_t \quad (3)$$

Where,  $U_t$  is the error term.

From equation (3), the relationship and functional form of the model specified are nonlinear. To transform equation (3) into a log-linear form we take the double log of the equation.

$$\ln AGROUT_t = \beta_0 + \ln \beta_1 INF_t + \ln \beta_2 INDOT_t + \ln \beta_3 GRECA_t + \ln \beta_4 SCLA_t + \ln \beta_5 EXCRT_t + U_t \quad (4)$$

$$\beta_0 > 0, \beta_1 < 0, \beta_2 > 0, \beta_3 > 0, \quad \beta_4 > 0, \text{ and } \beta_5 > 0 \text{ or } \beta_5 < 0$$

Where  $t=1, 2, \dots, n$  which is the time frame for the variables,  $\beta_0$  is the intercept term,  $\beta_1, \beta_2, \beta_3, \beta_4,$  and  $\beta_5,$  are the elasticity of  $AGROUT$  with respect to  $INF, INDOT, GRECA, SCLA,$  and  $EXCRT$  respectively which also measures the percentage change in  $AGROUT$ .

$U_t$  is the error term, which is normally distributed with zero mean and constant variance.

To justify the need for the inclusion of the variables used in this study, a brief definition of each variable is given below;

Agriculture value added ( $AGROUT$ ) – as a proxy for agricultural productivity shows the yearly value of the agricultural produce after adding up outputs and subtracting intermediate inputs.

Industry value added ( $INDOT$ ) – proxy for industrial output, is the yearly value of industrial productivity, which is broader than manufacturing output in which value has been added to after adding up outputs and subtracting intermediate inputs. It is expected that as industrial output increase, agricultural output would also increase.

Inflation (*INF*) – a measure of changes in price level. This variable shows how increase in prices could affect agricultural productivity.

Government recurrent expenditure in agriculture (*GRECA*) – proxy for the level of investment directed to the agricultural sector, which also drives the level of output. In this case, it indicates the level of government investment or financing in the agricultural sector.

Sectoral distribution of commercial bank loans (*SCLA*) indicate the amount of financing to the agricultural sector via commercial banks. This is an additional variable included in the study to show the level of finances directed to the agricultural sector in order to improve agricultural output.

Exchange rate (*EXCRT*) – affects the level of output in the international market as well as the level and cost of importation of technology which affects the level of output in the agricultural sector. Therefore, it shows how the changes in the international market affects agricultural output.

### 3.3.3 Estimation Technique

To evaluate the interlinkage between agriculture and industrial manufacturing sector, the Granger causality test is carried out. This study applies the Johansen co-integration method in the analysis of long-run relationship. It has also been proven that the co-integration technique is an improvement on the ordinary least square (OLS) method because the co-integration method takes consideration of the non-stationarity associated with time series data (Granger and Newbold, 1974). Non-stationarity implies that the variables do not have a mean that is constant over time. In this study, the focus is to determine a long run relationship between agricultural output and explanatory variables.

Granger causality test is a statistical hypothesis test that shows causal relationship between two variables in a time series. This approach is used to determine whether one economic variable can be used to determine another. In time series data, variable *X* is said to Granger-cause variable *Y*, if the current value of *Y* ( $y_t$ ) is conditional on the past values of *X* ( $x_{t-1}, x_{t-2}, \dots, x_0$ ) and thus the history of *X* is likely to help predict *Y* (Granger, 1969). In this study, we are looking at the bidirectional causal relationship between agriculture and industry to provide evidence if industrial sector leads to increase in agricultural productivity and if the agricultural sector has caused increase in manufacturing industry output. Proxy variables are used to measure the industrial sector contribution and agriculture sector contribution.

The equation is hence specified as follows:

$$INDOT = \beta_0 + \sum \beta_1 INDOT_{t-1} + \sum \beta_2 AGROUT + U_t \quad (5)$$

$$AGROUT = \beta_0 + \sum \beta_1 AGROUT_{t-1} + \sum \beta_2 INDOT + U_t \quad (6)$$

Where:

*INDOT* is industry value added which stands as a proxy for the industrial sector.

*AGROUT* is agriculture value added is used as a proxy for the level of agricultural output in the agricultural sector.

A unit root test is conducted to test for stationarity or non-stationarity in a time series. Various tests that can be carried out to determine if the time series data has a unit root, they include: the Kwiatkowski-Phillips-Schmidt-Shin (KPSS), Dickey Fuller, Augmented Dickey Fuller (ADF) and the Phillips-Perron test. The ADF test will be used in this study because it takes into consideration the fact that the error term may be correlated. If a time series is found to be

stationary, it could be differenced to first difference or second difference to make it stationary. If a time series data is stationary at levels then it is said to be integrated of order 0 denoted by  $I(0)$ , if it is differenced once to make it stationary then it is integrated of order 1, denoted by  $I(1)$  and so on.

The co-integration test is used to determine if there is a long run relationship among the variables in the model. Co-integration ensures that the linear combination of variables is stationary while regression analysis based on time series data discretely assumes all values to be stationary which may not always be the case. The regression of a non-stationary time series data will lead to spurious (nonsense) regression thereby misleading results. A regression whose variables are co-integrated is called a co-integrating regression and the parameters obtained are called co-integrating parameters. This study employs the Johansen (1991) co-integration test.

A Vector Error Correction Model (VECM) is commonly used for data where the underlying variables have a long-run stochastic trend, also known as co-integration. It is useful for estimating both short-term and long-term effects of a time series on another. It also estimates the speed at which a dependent variable returns to equilibrium after a change in other variables. Economic theory expects the coefficient of the ECM to be negative and highly significant because it implies that errors generated in each period is corrected for in subsequent years. The higher the coefficient of the ECM, the higher the speed of adjustment from the short-run to the long-run. Also, when t-stat is greater than 2, the speed of adjustment is assumed to be significant.

#### 4. Empirical Analysis and Discussion of Results.

##### 4.1 Empirical Analysis

Table 1 below shows the summary statistics of the variables; agriculture value added; inflation (consumer prices, annual %), industry value added; government recurrent expenditure in agriculture; sectorial commercial bank loans and advances to agriculture; and exchange rate, for better understanding of the distribution of the variables.

Table 1: Summary Statistics of Variables

	LAGROUT	LINF	LINDOT	LGRECA	LSCLA	LEXCRT
Mean	29.37815	2.673093	29.88864	0.705966	3.244397	3.334260
Median	29.15535	2.475967	29.79232	1.454068	3.469977	3.809734
Maximum	30.40062	4.288204	30.44895	4.180522	7.533961	5.259787
Minimum	28.46383	1.683102	29.33973	-4.605170	-0.235722	-0.395325
Std. Dev.	0.642236	0.739092	0.341193	2.858917	2.058800	1.858393
Skewness	0.268619	0.848249	0.087087	-0.560134	0.053228	-0.773549
Kurtosis	1.563283	2.585569	1.727776	1.964007	2.358924	2.307985
Jarque-Bera	3.333105	4.320637	2.335930	3.298402	0.598274	4.069228
Probability	0.188897	0.115288	0.310999	0.192203	0.741458	0.130731
Sum	998.8573	90.88517	1016.214	24.00285	110.3095	113.3648
Sum Sq. Dev.	13.61143	18.02646	3.841610	269.7224	139.8758	113.9696
Observations	34	34	34	34	34	34

Source: computed by author using e-views 9

From Table 1 there is no evidence of an outlier following the measures of central tendency – mean, median and the range – maximum and minimum values, for measures of dispersion or spread; LGRECA and LEXCRT are negatively skewed while LAGROUT, LINDOT, LINF, and LSCLA are positively skewed, this is following the decision rule that if skewness is less than -1 or greater than +1, the distribution is highly skewed; if skewness is between -1 and -

0.5 or between 0.5 and 1, the distribution is moderately skewed; and if skewness is between -0.5 and 0.5, the distribution is highly skewed.

Other measures of dispersion on the table include Kurtosis, which is a measure of tailedness of the probability distribution of a real-valued random variable. If the value of the kurtosis is greater than 3, the distribution is leptokurtic, that is, peaked relative to the normal but if it is less than 3, the distribution is platykurtic which means flat relative to the normal. From the table all variables are flat.

The Jarque-Bera test is a goodness-of-fit test, which detects whether the sample data have the skewness and kurtosis matching a normal distribution. When the probability statistics is significant, the null hypothesis is rejected. From the table, all variables are not significant as the probability level is greater than 0.1.

The next step is to conduct a unit root test for all the variables to test for the stationarity of the variables, which is a necessary condition for the understanding of the long-run behavior of the variables. In carrying out this test, the Augmented-Dickey Fuller test is applied. The rule of thumb is that if the absolute value of the ADF test statistic is greater than the McKinnon critical value at 5%, then we reject the null-hypothesis that says that the variable is non-stationary. The variable is deemed stationary when the absolute value of the ADF statistics test is greater than the critical value at 5%.

Table 2: Unit root test at levels

VARIABLES	LAG LENGTH	ADF TEST STATISTICS AT LEVELS	CRITICAL VALUE (5%)	ORDER OF INTEGRATION	REMARKS
LAGROUT	0	0.234840	-2.954021	None	Non-stationary
LINF	0	-3.052959	-2.954021	I(0)	Stationary
LINDOT	0	-0.72591	-2.954021	None	Non-Stationary
LGRECA	0	-2.079774	-2.960411	None	Non-Stationary
LSCLA	0	0.318118	-2.954021	None	Non-Stationary
LEXCRT	0	-2.212044	-2.954021	None	Non-Stationary

Source: computed by author using e-views 9

Table 3: Unit root test at first difference

VARIABLES	LAG LENGTH	ADF TEST STATISTICS AT FIRST DIFFERENCE	CRITICAL VALUE (5%)	ORDER OF INTEGRATION	REMARKS
LAGROUT	0	-5.649796	-2.957110	I(1)	Stationary
LINF	0	-5.345383	-2.957110	I(1)	Stationary
LINDOT	0	-6.505653	-2.957110	I(1)	Stationary
LGRECA	0	-8.080990	-2.957110	I(1)	Stationary
LSCLA	0	-6.307447	-2.957110	I(1)	Stationary
LEXCRT	0	-4.893510	-2.957110	I(1)	Stationary

Source: Author's computation

From the table 2, all the variables are non-stationary at levels except LINF, which is stationary

Table 4: Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.732306	107.3412	95.75366	0.0063
At most 1	0.696403	65.16806	69.81889	0.1111
At most 2	0.407370	27.02236	47.85613	0.8534
At most 3	0.198666	10.28042	29.79707	0.9759
At most 4	0.088622	3.193151	15.49471	0.9574
At most 5	0.006964	0.223618	3.841466	0.6363

Trace test indicates 1 co-integrating equation(s) at the 0.05 level

Table 5: Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.732306	42.17315	40.07757	0.0286
At most 1 *	0.696403	38.14570	33.87687	0.0145
At most 2	0.407370	16.74194	27.58434	0.6022
At most 3	0.198666	7.087273	21.13162	0.9504
At most 4	0.088622	2.969533	14.26460	0.9488
At most 5	0.006964	0.223618	3.841466	0.6363

Max-eigenvalue test indicates 2 co-integrating equation(s) at the 0.05 level.

Source: computed by author using e-views 9

at levels  $I(0)$ . In order to make all variables stationary at the same level, the test is run on first difference, thereby making all variables stationary at order  $I(1)$  (see Table 3). In absolute terms, the ADF test statistics is greater than the critical value at 5%. Therefore, the variables are stationary at first difference. Co-integration requires all the variables to be integrated of the same order.

The next step is a co-integration test using the Johansen technique to ascertain the long-run relationship between the dependent variable (LAGROUT) and the independent variables (LINF, LINDOT, LGRECA, LSCLA and LEXCRT). The decision rule states that if the values of trace statistics or maximum Eigen value are greater than the critical values at 5percent then the null hypothesis of no co-integration is rejected, which depicts co-integration among variables implying a long run equilibrium relationship.

From the table, we can see that under the hypothesized no. of CE(s), at none\*, the value of the trace statistics is greater than the critical value at 5%. From Table 3, we can see that under the hypothesized no. of CE(s), at none\*, the value of the trace statistic is greater than the critical

value at 5%. Therefore, we conclude that there is one co-integrating equation, meaning there is a long run relationship between the dependent variable and one co-integrating explanatory variables. Also, from Table 4, the maximum eigenvalue test, the Max-Eigen statistics at most 1 is greater than the critical value at 5%. Thereby concluding that using the Max-Eigen test, there is a long-run relationship between the dependent variable and two co-integrating equations.

Table 5: Co-integration result

Normalized co-integrating coefficients (standard error in parentheses)					
LAGROUT	LINF	LINDOT	LGRECA	LSCLA	LEXCRT
1.000000	-0.193483	-2.553767	-0.695047	-0.028796	1.246587
	(0.07419)	(0.45151)	(0.10656)	(0.10651)	(0.14732)

Source: computed by author using e-views 9

The normalized co-integrating co-efficient is written in its implicit form, to make it explicit. It is re-written by changing the signs as follow:

$$LAGROUT = 0.193LINF + 2.554LINDOT + 0.695LGRECA + 0.029LSCLA - 1.247LEXCRT \quad (7)$$

The above results in equation 7, show a positive relationship between inflation rate and agricultural output in Nigeria. A 1% increase in inflation rate will lead to a 0.193% increase in agricultural output, *ceteris paribus*. Theoretically, this ought not to be, an increase in price level is expected to increase the cost of production thereby affecting output level but can be attributed to the structure of the Nigeria economy and the data used in carrying out the analysis. Also, we see a positive relationship between the proxy of industrial output and agricultural sector, indicating a 1% increase in industrial output increases agricultural output by 2.554%, *ceteris paribus*. This is theoretically expected as an increase in industrial output through the backward linkage supported by the Hirschman's unbalanced growth theory will lead to an increase in agricultural output.

The result shows a positive relationship between government recurrent expenditure on the agricultural sector in Nigeria and agricultural output. A 1% increase in government recurrent expenditure in the agriculture sector will lead to a 0.695% increase in agricultural output, *ceteris paribus*. Theoretically an increase in investment or government expenditure leads to improved performance or growth.

There is a positive relationship between sectoral distribution of commercial loans and advances to agriculture and agricultural output. A 1% increase in sectoral distribution of commercial bank loans and advances to agriculture will lead to a 0.029% increase in agricultural output, holding all other variables constant. One of the major factors that boost the productivity of farmers is access to loans, therefore an increase in loans and advances will boost output.

Also, in the long run there is a negative relationship between agricultural output and the exchange rate in Nigeria. A 1% increase in the exchange rate will lead to a 1.247% decrease in agricultural output, *ceteris paribus*. This means that for agricultural output to increase, there is need for a stable and favorable exchange rate. The more the local currency devalues to dollar, the more the increase in prices thereby affecting production level.

Table 6 below presents the result of a Vector Error Correction Model (VECM); the error correction mechanism (ECM) developed by Engle and Granger is a means of reconciling the short-run behavior of an economic variable with its long-run behavior (Gujarati, 2004). The

ECM must lie between 0 and 1 and is expected to be negative. A negative sign indicates a move back towards equilibrium while a positive value indicates a movement away from equilibrium. The error correction model is also known as a speed of adjustment factor which tells how fast the system will adjust to restore equilibrium.

Table 6: vector error correction model results

Error Correction:	D(LAGROT)
CointEq1	0.029258 (0.00840) [ 3.48207]
D(LAGROUT(-1))	-0.342095 (0.18971) [-1.80322]
D(LINF(-1))	0.070813 (0.02256) [ 3.13945]
D(LINDOT(-1))	0.542231 (0.24817) [ 2.18496]
D(LGRECA(-1))	-0.010076 (0.01894) [-0.53198]
D(LSCLA(-1))	0.005417 (0.02929) [ 0.18494]
D(LEXCRT(-1))	-0.152893 (0.06698) [-2.28253]
C	0.115535 (0.02467) [ 4.68288]
R-squared	0.721003
Adj. R-squared	0.507652
F-statistic	3.379420

Standard error in ( ) parenthesis,  
t-statistic in [ ] parenthesis

The error correction coefficient tells us the speed at which our model returns or converges to equilibrium after an exogenous shock. As a result, the error correction term should be negatively signed to indicate a move towards long run equilibrium. The co-efficient of the error



correction term in Table 6 has positive values. Therefore, we can say that the error correction term in the long run will diverge or move away from equilibrium. The adjustment speed is 0.0292 which implies that in the long-run given any initial shock with a speed of adjustment of 2.92% the error term diverges.

Taking the first difference of the lagged dependent variable, the error correction estimate for inflation, industrial output and sectoral distribution of loans and advances {D(LINF(-1)), D(LINDOT(-1)), and D(LSCLA(-1))} respectively as explanatory variables indicate that the model diverges in the long-run given any initial shock with a speed of adjustment of 7.08%, 54.22% and 0.54% respectively. The error correction estimate for government expenditure on the agricultural sector and exchange rate of the Naira to the dollar {D(LGRECA(-1))} and {D(LEXCRT(-1))} respectively as explanatory variables indicate that the equation converges in the long run given any initial shock with a speed adjustment of 1.00%, and 15.2% respectively.

The existence of a relationship between variables does not imply or prove a causality nor a direction of influence (Gujarati, 2004). The Granger causality test looks at how variable  $X$  can affect variable  $Y$ . The Granger (1969) approach to the question of whether  $x$  causes  $y$  is to see how much of the current  $y$  can be explained by past values of  $y$  and then to see whether adding lagged values of  $x$  can improve the explanation.  $y$  is said to be Granger-caused by  $x$  if  $x$  helps in the prediction of  $y$ , or equivalently if the coefficient on the lagged  $x$ 's are statistically significant. The test is a statistical hypothesis for determining if one-time series is useful in forecasting another. The test is carried out in this study to find out if there is a bidirectional relationship between the dependent variable agricultural output (LAGROUT) and the independent variable, industrial output (LINDOT). This is done to know if there is an interlinkage between the agricultural sector and industrial sector in Nigeria. The rule of thumb states that if the probability value after multiplying by 100 is greater than 5%, we fail to reject the null hypothesis that there is no bidirectional relationship.

Table 7: Pairwise granger causality tests

Null Hypothesis:	Obs	F-Statistic	Prob.
LINDOT does not Granger Cause LAGROUT	32	3.39421	0.0484
LAGROUT does not Granger Cause LINDOT		6.37013	0.0054

Source: computed by author using e-views 9

From table 7, we see that the probability value of LINDOT does not Granger Cause LAGROUT is 4.84% and the probability value of LAGROUT does not Granger Cause LINDOT is 0.54%. Following the rule of thumb, we therefore reject the null hypothesis. This means that there is a bidirectional relationship between agricultural sector and industrial sector in Nigeria.

Lastly, we use the Ordinary Least Squares (OLS) results to test for the short run dynamics; the results of the OLS estimate is used to ascertain the behavior of the variables in the absence of the co-integration or error correction mechanism.

Table 8: Ordinary Least Squares (OLS) regression analysis

Dependent Variable: LAGROUT

Method: Least Squares

Included observations: 34

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-21.863	6.693	-3.267	0.0029
LINF	-0.019	0.035	-0.546	0.5891
LINDOT	1.719	0.227	7.558	0.0000
LGRECA	0.031	0.042	0.732	0.4701
LSCLA	0.022	0.041	0.534	0.5975
LEXCRT	-0.050	0.063	-0.793	0.4346
R-squared	0.963	Mean dependent var	29.378	
Adjusted R-squared	0.956	S.D. dependent var	0.642	
S.E. of regression	0.134	Akaike info criterion	-1.022	
Sum squared resid.	0.503	Schwarz criterion	-0.753	
Log likelihood	23.376	Hannan-Quinn criter.	-0.930	
F-statistic	145.855	Durbin-Watson stat	1.345	
Prob(F-statistic)	0.000			

Source: computed by author using e-views 9

In the short run we observe that the only significant explanatory variable from Table 8 is industrial output. This implies that there is a positive relationship between agricultural output and industrial output even in the short run. The statistical evidence shows that a 1 percent increase or change in industrial output gives rise to a 1.7 percentage change in agricultural output, *ceteris paribus*. This corroborates the finding in the vector error correction estimate, although the magnitude of change differs but the direction is the same.

#### 4.2 Discussion of Results

The empirical result of the Granger Causality test in table 7, shows that there is a bidirectional relationship between agricultural productivity and industrial output in favor of the interlinkage hypothesis, this finding corroborates the result in Gemmel et al. (2000) for the Malaysian economy, but contradicts Koo and Lou (1997) for a unidirectional causality between agriculture income and manufacturing productivity in post-communist China. Given that agricultural produce is largely used for manufacturing in developing countries, where many industries are agro-based. On the other hand, use of manufactured goods by agro and allied outlets, increases the tendency of linkage between agriculture and manufacturing industry interaction (Diao et al. 2018). In the short run estimate, we see a positive and significant relationship between agriculture and manufacturing industry output, which supports the observation for many of the sampled countries in Tiffin and Irz (2006). However, this result is common for developing countries as stated in Kanwar (2000) and Chebbi and Lachal (2007). In developed economies where, agricultural productivity is highly mechanized, industrial output seem to be relatively divergent into several sectoral inputs, with a very low but significant contribution to the growth of agriculture, except specifically measured for agro-based industries.

From Table 6, the vector error correction coefficient is positive which shows that in the long-run, our model diverges from equilibrium given that all the lagged explanatory variables are

subject to differing, but unique behavior. In the normalized co-integration estimation (see table 5) there is a positive relationship between agricultural productivity and manufacturing industry output supporting the result in the vector error correction model, which also corroborates the short run dynamics. This evidence denotes that the behavior of our dependent variable with respect to the explanatory variables did not change over time; both in the long-run and short run. However, this observation is subject to the conditions that other explanatory variables are held constant in the estimation. Nevertheless, the positive relationship between agriculture and industrialization is supported in the literature by Subramaniam and Reed (2009), where a strong inter-sectorial linkage is found using vector error correction model and Johansen co-integration procedure. In the same vein, Ogundari and Awokuse (2016) has found a similar result for the level of food security indicators and agricultural productivity for sub-Saharan Africa countries. Worthy of note is that in the transformation from agrarian to industrial manufacturing, economies are expected to conquer the menace of hunger. To this end, industrialization connotes an unparalleled food sufficiency for the teeming population. Food sufficiency on the other hand requires improved technical know-how for agricultural productivity. The positive interplay of agriculture and industry is a necessary condition for improved economic growth and development.

Overall, in the short-run the only significant variable that would explain changes in agricultural productivity is industrial output, with a positive coefficient. All other explanatory variables were insignificant in the short-run model. However, the normalized co-integration and vector error correction estimates show similar results for all explanatory variables except government expenditure on agriculture with a positive sign in the normalized co-integrating estimate and negative for the long-run effect. However, inflation rate did not follow a priori expectation in both the short and long-run model, this may be due to the fact that inflation is largely dependent on the exchange rate in Nigeria because of the level of import dependence in the Nigerian economy. In any case, the exchange rate variable follows the expected negative sign, industrial output, sectoral loans and advances to the agricultural sector all follow expected signs both in the short and long-run analysis, except government expenditure to the agricultural sector that is negative and insignificant in the long-run and positive in the normalized co-integration model.

## **5. Conclusion**

The primary aim of this study is to investigate the relationship that exists between agriculture and manufacturing industry output, to enable policy makers understand the linkage that facilitate the direction of investment and policy implementation. The empirical analysis employed a co-integration and Johansen error correction specification on a time series data for macroeconomic variables; inflation, exchange rate, government recurrent expenditure on the agricultural sector and sectorial commercial bank loans for the period 1982 to 2015 to explain the variation in agricultural output. Results from the Granger Causality test indicate a bidirectional relationship between agriculture and manufacturing industry output, which implies backward and forward linkages in the input-output interface. This two-way linkage implies that government investment in the agricultural sector equally boost manufacturing output and vice versa. An increasing output from the manufacturing industry will invariably cause an increase in agricultural productivity.

A bidirectional positive relationship between agriculture and manufacturing industry output is subject to the condition that other explanatory variables are held constant. However, that will never be the case, in the face of existing realities, the long-run vector error correction model with a positive coefficient implies a divergence from equilibrium. To restore stability in the

long-run behavior of explanatory variables there is a need for macroeconomic balance. The macroeconomic variable – inflation, which increases the cost of input for agriculture also hampers the demand for manufacturing industry output. When there is rising prices, the demand for manufacturing industry output will fall especially in the face of high cost of imported equipment for use in manufacturing industries due to devaluation of the local currency and the resultant higher exchange rates. Another major problem that would have caused a divergence is the paucity of long-term data for analysis to provide the necessary platform for the control of seasonal and cyclical variations in a time series.

A major policy implication arising from this study is the need for increased government investment in the agricultural sector to boost yield, with counterfactual support to the manufacturing industry, so that the necessary inputs to boost agriculture could be obtained at minimum cost and agricultural productivity rising to provide necessary input for manufacturing industry output. A recommendation for further research is aimed at understanding temporal constraints and omitted variable bias, which this study has tactfully overlooked due to analytical techniques employed. Secondly, a further study into the growth of capital-labor ratio of agricultural productivity with respect to manufacturing industry output will provide the necessary information for sustainable investment in agriculture and agro-based manufacturing.

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