Empirical Evidence of a Long-Run Relationship Between Agriculture and Manufacturing Industry Output in Nigeria

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Empirical Evidence of a 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 annual time series data from 1982 to 2017. The study employs Granger causality test, vector error correction model, and co-integration techniques to estimate the interdependence between agricultural productivity and manufacturing industry output. Empirical evidence from Granger causality test reveals a bidirectional relationship between agricultural productivity and manufacturing industry output. Although a positive and significant relationship exists in the short- and long-run estimates, a long-run divergence from the vector error correction model indicates that changes in agricultural productivity are not restored to equilibrium, given that macroeconomic factors distort the linkage. Policy implications suggest that macroeconomic stability is a necessary condition for agriculture and manufacturing industry output to foster economic growth.

Keywords

agriculture, manufacturing industry, Granger causality test, co-integration, vector error correction model

Introduction

Although endowed with abundant agro-resources and ecological diversity, Nigeria has become a significant food importer. Indications from recent studies show that there is a decline in agriculture compared with manufactured goods trade for today's developing countries (Desai & Rudra, 2018). Nigeria has neither improved its agriculture nor improved manufacturing for export (Ikenwa et al., 2017). There is a fervent need to transform the Nigerian economy to a rapidly growing economy with sustained and inclusive development. Strategies to foster economic growth must include a clear understanding of the interaction between agriculture and manufacturing industry to create jobs, and ultimately reduce poverty. The linkage between agriculture and industry has been a long-debated issue in the development literature (Olomola & Nwafor, 2018; Saikia, 2009). This study investigates a long-run relationship between agriculture and manufacturing industry output for the period 1982 to 2017, using Granger causality test, co-integration, and error correction model.

Improving the agricultural sector is a necessary condition for food security, tackling the risks associated with agrarian intensification especially for climate-smart agricultural practices. Overall, agricultural efficiency presents essential 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 (Ikenwa et al., 2017; Sertoglu et al., 2017). Zeira and Zoabi (2015) contend that rising productivity of modern sectors drives economic growth. However, this claim is on the assumption of a rising marginal opportunity costs in the desire to create new modern sectors. In the same vein, Diao et al. (2018) find a positive correlation between labor productivity growth in agriculture and employment in the manufacturing sector in Africa. The study demonstrates that positive technological change in agriculture feeds into increasing productivity and growth of the industrial sector.

There is hardly any development plan or structural reform in Nigeria that overlooks the agricultural sector. But, the

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problem has always been the lack of implementation of government policies in this direction. Nigeria has an estimated current population of about 200 million (United Nations Department of Economic and Social Affairs: Population Division, 2019), with a gross domestic product (GDP) at current prices of US$568.50 billion in 2014, which dropped to US$397.27 billion in 2018 (The World Bank Group, 2019). According to the Nigerian National Bureau of Statistics (2018) report, on an annual basis the agricultural GDP grew by 14.27% in 2018 higher than 11.29% recorded in 2017. The sector contributed 21.42% to nominal GDP in 2018. In real terms, the agricultural sector annual growth rate for 2018 was 2.12%, which was lower than the 3.45% recorded in 2017. However, the manufacturing sector contribution to nominal GDP in 2018 was 9.75%, which was higher than 8.83% in 2017. However, the real GDP growth in the manufacturing sector was recorded at 2.35% in the fourth quarter of 2018. Nigeria experienced an economic downturn between 2015 and 2018, and as at the time of this publication, the country is yet to recover from a negative GDP growth rate.

The vision 20:2020 launched in 2009 made agriculture its focal point. The Economic Recovery and Growth Plan (ERGP) of the present administration is also working toward revamping the agricultural sector. Despite all these steps taken by government, the sector still suffers a lot of setbacks. Olomola and Nwafor (2018) observe that between 2001 and 2009 the projects implemented covered various areas of agricultural development such as production, marketing, storage, and financing; notably the Special Program for Food Security (SPFS); the Fadama II Program; the Fertilizer Revolving Fund (FRF); the Presidential Initiatives on Cassava, Rice, Vegetable Oil, Tree Crops and Livestock; and the restructuring and recapitalization of the Nigerian Agricultural, Cooperative and Rural Development Bank (NACRDB). To strengthen agricultural production, marketing, storage, and financing, three agricultural development and marketing companies were established—Tree Crops Development and Marketing Company, Livestock Development and Marketing Company, and the Arable Crops Development and Marketing Company. The Central Bank of Nigeria (CBN, n.d.) adopted strategies on credit delivery, the Trust Fund Model (TFM), which reduced the risks faced by banks in agricultural lending with adequate emphasis on production, processing, and marketing. Olomola and Nwafor (2018) find that the agricultural sector was able to make significant progress by increasing output in staples such as maize, millet, sorghum, cassava, rice, and yam as a result of the presidential initiatives. Despite these sporadic achievements, the challenges are enormous; productivity in both agriculture and manufacturing remain very low. In agriculture, an uncontrolled rural–urban drift reduces subsistence farming, to say the least. Inadequate infrastructure and overdependence on imports affect the state of manufacturing and agricultural productivity. And, till date, the goals of the first, second, and third implementation plans of Vision 20:2020 are yet to be realized.

Nigeria is facing an imminent food security crisis, increasing poverty levels, and high unemployment with a growing population, which depends mainly on imported food (Ikenwa et al., 2017; Olomola & Nwafor, 2018). Despite Nigeria's significant resource endowments, there is negative economic growth rate; poverty remains widespread. Studies reviewed on this subject for Nigeria focus on government providing infrastructure and credit facilities to improve the agricultural sector. None has delved into an empirical investigation of the linkage between agriculture and manufacturing industry productivity, since agriculture provides necessary input for manufacturing industries. The policy directions for this study is to seek a veritable channel for government expenditure toward increasing agricultural output for industrial development and, on the other hand, investing in industrial production for manufactured goods to aid agricultural productivity. Econometric tests in this study reveal a bidirectional relationship between agriculture and manufacturing industry output, but the vector error correction specification diverges in the long run, which arguably could be attributed to the behavior of macroeconomic variables. Policy implications show a need for macroeconomic stability as a condition necessary for long-run convergence in the linkage between agriculture and manufacturing industry output. There are five sections in this study; the next section reviews relevant literature, the "Theoretical Framework and Method" section presents concepts for theory and evaluation, the "Empirical analysis and discussion of results" section features the empirical analysis and discussion of findings, and the study concludes in the "Conclusion" section.

Literature Review

A large body of literature discusses the synergy between agricultural output and industrial productivity in economic development. The institutional debates leave a hollow on the role of agriculture in industrialization, especially for developing countries (Osuagwu & Olaifa, 2018; Rakhmetullina et al., 2017; Sertoglu et al., 2017). It is believed in some quarters that improved agriculture will provide the necessary raw material for industries to thrive (Diao et al., 2018). But, the other side of the discussion views increased agricultural productivity as a result of technical progress driven by industrial innovation (Bernstein, 2017; Ikenwa et al., 2017). 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.

Lin and Koo (1990) investigate the relationship between agriculture and industrial sectors from 1952 to 1988 in China, and the findings reveal a unidirectional causality. One primary reason that may be proffered for this relationship is the

Chinese adoption of Soviet-styled economic strategy at the time, where industrialization is overly emphasized as a government policy at the expense of agriculture. Okereke et al. (2019) observe that a pervasive 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 the farm. In contrast to the findings in Lin and Koo (1990), Koo and Lou (1997) find 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 a diminishing role of agricultural sector.

On the argument, whether labor productivity in the agricultural sector has any significant effect on industrialization in Africa, Bernstein (2017) and Diao et al. (2018) posit 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 (Osuagwu & Olaifa, 2018; Sertoglu et al., 2017). 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 the 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 the balance of payment, increasing foreign reserve, and stabilizing the exchange rate (Osabohien & Osuagwu, 2017). However, this could be achieved only with the provision of necessary 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) find an inverse relationship between productivity in agriculture, outputs, and food importation. Furthermore, the study reveals that the oil boom of the 1970s and 1980s 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, the rural farmers who have acquired education left the farm for employment in the manufacturing industries, which hitherto leads to a decline in the supply of raw material for use in the 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, suffers immensely from the unbalanced effect on economic development (Okereke et al., 2019; Olomola & Nwafor, 2018; Sertoglu et al., 2017). Another argument in this direction is the lack of government support to peasant farmers through improved social protection policies (Osabohien & Osuagwu, 2017). Also, the environmental degradation in the Niger Delta region due to oil exploitation, resulted in low agricultural yield and the outright disenchantment of individuals engaged in farming in these communities (Okereke et al., 2019; Osuagwu & Olaifa, 2018).

Ogundari and Awokuse (2016) went further to unequivocally support the role of improved agricultural productivity in reducing food insecurity, stating the major challenge in sub-Saharan Africa's (SSA) agricultural sector as sustained agricultural productivity. Fuglie and Rada (2013) argue for sustained agricultural productivity to be achieved, policy measures that start with the dissemination of agricultural technologies and practices to farmers should be established and investment in research and development encouraged. However, Desai and Rudra (2018) are of the opinion that most developing countries are transitioning from traditional agriculture and moving up the value-added chain toward processed food. O'Ryani and Miller (2003) in an earlier study on the role of agriculture on poverty alleviation, income distribution, and economic development for Chilean economy conclude that agriculture and agro-industrial sectors are essential to alleviate poverty. Furthermore, an increase in labor productivity in agriculture has a higher impact on the decline of poverty incidence than an increase in the industrial sector.

A historical account of differences in economic development among nations stipulates uneven rainfall pattern and high temperatures as a primary cause of low productivity in agriculture for sub-Saharan Africa. There is evidence of not more than 4 months of heavy rainfall during rainy season, sporadic showers, and hot dry season for the remaining months of the year (Acemoglu & Robinson, 2012; Bernstein, 2017; Okereke et al., 2019). For agriculture to thrive, there must be favorable climatic conditions, although technical progress has increased productivity in agriculture 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 productivity. The study reveals that a percentage increase in agriculture raises manufacturing output growth between 0.47% and 0.56% in the general specification and between 0.28% and 0.47% 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 output.

In addition to time series and instrumental variable techniques 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 (Desai & Rudra, 2018; Diao et al., 2018; Okereke et al., 2019). Country-specific studies with mixed results include Gemmel et al. (2000) for Malaysia—finding reveals that manufacturing output and productivity were exogenous in the Granger sense to improvements in agriculture. Rakhmetullina et al. (2017) find an empirical relationship between agriculture and economic growth via industrialization in Nigeria using autoregressive distributed lag model (ARDL) and vector error correction model (VECM). However, Kanwar (2000) and Chebbi and Lachaal (2007) observe a positive relationship 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 discussed above, this article 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.

Theoretical Framework and Method

Theoretical Framework

This study is rooted in Hirschman's theory of unbalanced growth because it accounts for the forward and backward linkages that are associated with agriculture and industry relationship. The Hirschman (1958) theory postulates an unbalanced growth theory, arising from specific common characteristics exhibited by developing countries, such as low levels of gross national income (GNI) per capita, slow growth of GNI per capita, inequality, technological backwardness, and existence of both the traditional and modern sectors (dualism). Also, there exists inadequate infrastructure to harness the available resources, and lack of entrepreneurs and investors to channel the cash flow through the sectors for balanced economic growth. To this end, Hirschman proposed a deliberate unbalanced economic development strategy to maintain the existing structural imbalance, namely, complementarity, external economies, and induced investment.

Hirschman unbalanced growth theory is based on the specific needs for investment in strategic sectors of the economy and hence could be related to the Nigerian situation. Instead of pursuing growth in all the sectors at the same time, investments should be prioritized based on comparative advantage, prospective yield, and percentage contribution to national income. Agriculture has a potential for generating increasing levels of productivity and proceeds could fuel the industrial sector for sustainable growth and development. However, as the theory assumes that sectors would automatically develop themselves through the linkages effect, the concept of Hirschman's backward and forward linkage becomes very relevant. Following this theory, agricultural productivity will increase if and only if the industrial sector has a backward linkage with the agricultural sector by providing inputs and technologies. However, the agricultural sector will have a forward linkage with the industrial sector by providing raw materials for manufacturing and processing.

Analytical Framework

The illustration below shows the channel of the existing relationship between agro-industrial linkage and food security. Economic growth creates income opportunities for the poor. Bhagwati and Srnivasan (2002) call this approach the indirect route while the World Bank refers to it as "broad-based economic growth." Figure 1 shows the poverty alleviation cum economic growth approach.

The illustration shows two routes that industrial growth would impact poverty reduction. The first is through sectoral growth, which leads to accelerated GDP growth having a direct impact on income and increased consumption and employment generation. The second link relates the expansion of intra- and inter-sector linkages; both backward and forward linkage, particularly the industry-agriculture that will in the long-run cause a linkage-induced income as industrial growth accelerates (Takahiro et al., 2006). From the illustration, favorable external conditions such as multilateral support for industrial and agricultural growth leads to growth in various sectors of the economy through investment in physical capital and employment generation.

Method

Data. The annual data for this study spans the period 1982 to 2017, obtained from Central Intelligence Agency (CIA, 2019) *The World Factbook*, CBN Statistical Bulletin, and World Bank—World Development Indicator. The data for Agriculture value added and Industry value added are obtained from World Bank—World Development Indicators. Government recurrent expenditure on agriculture, commercial bank loans, and advances to the agriculture sector and official exchange of the local currency to the U.S. dollar were sourced from the CBN statistical bulletin, while the consumer price index for inflation rate was obtained from the CIA *The World Factbook*.

Model specification. Following the studies of Diao et al. (2018) and Rakhmetullina et al. (2017), the agricultural sector is typically affected by the changes in the macroeconomy, hence the inclusion of macroeconomic variables—inflation and exchange rate—to account for fluctuations in purchasing power of the domestic currency against the U.S. dollar. The effect of industrial productivity in the explanatory variable is captured by the percentage growth rate of value added in

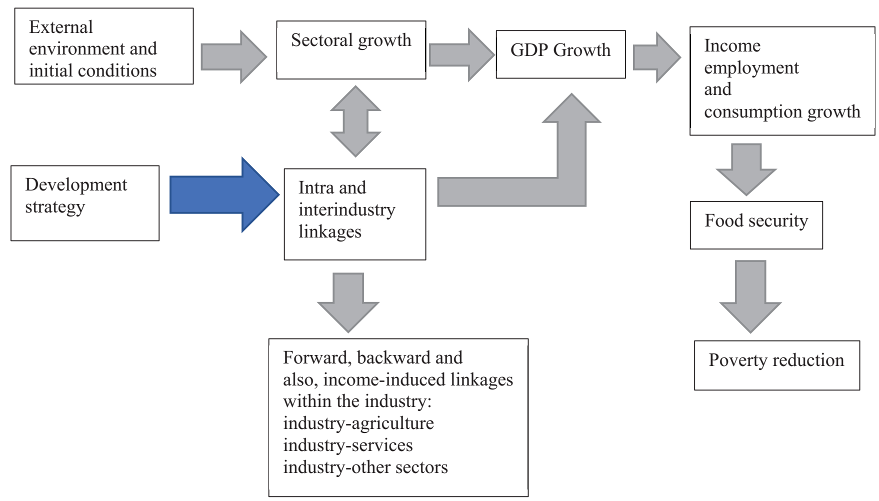

Figure 1. Poverty alleviation and the interlinkage of agriculture and industry.
Source. Adapted from Takahiro et al. (2006).
Note. GDP = gross domestic product.

industry manufacturing, government investment in the agricultural sector is measured by total government recurrent expenditure on agriculture, and private sector financing in agriculture is estimated by commercial bank loans and advances to the agricultural sector. All variables are measured in monetary values (US$ where applicable).

The model for estimation draws from a nonlinear production function:

$$y = f(X), \tag{1}$$

where y represents agriculture output—value added used as a proxy for the level of agricultural output in the economy, while X represents all other explanatory variables, presumed to affect agricultural productivity based on literature.

The implicit model specified as:

$$\text{AGROUT} = f(\text{INF}, \text{INDOT}, \text{GRECA}, \text{SCLA}, \text{EXCRT}), \tag{2}$$

where AGROUT is agriculture value added used as a proxy for the level of agricultural output; 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; and EXCRT is the exchange rate of the Nigerian Naira to the U.S. dollar.

The model specified in its explicit form:

$$\begin{aligned}\text{AGROUT} = \beta_0 + \beta_1\text{INF} + \beta_2\text{INDOT} + \beta_3\text{GRECA} \\ + \beta_4\text{SCLA} + \beta_5\text{EXCRT} + U_t,\end{aligned} \tag{3}$$

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 second log of the equation:

$$\begin{aligned}\ln \text{AGROUT}_t = \beta_0 + \ln\beta_1\text{INF}_t + \ln\beta_2\text{INDOT}_t + \ln\beta_3\text{GRECA}_t \\ + \ln\beta_4\text{SCLA}_t + \ln\beta_5\text{EsXCRT}_t + U_t,\end{aligned} \tag{4}$$

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

where $t = 1, 2, \ldots, n$, which is the time frame for the variables; β_0 is the intercept term; $\beta_1, \beta_2, \beta_3, \beta_4$, and β_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.

Estimation technique. The estimation of a long-run relationship between variables in a time series data follows a test of unit root, co-integration, and error correction modeling. The importance of testing for the existence of a unit root is now generally accepted following the study of Granger and Newbold (1974) that regression analysis between two nonstationary series could lead to a spurious result. This means that one could observe a good fit from regression results whereas the series are almost independent. Therefore, it is necessary to test for the stationarity or the presence of a unit root before any regression analysis is conducted. It has been observed that many time series variables are stationary after first or second differencing. The idea of differencing may sometime imply eliminating seasonal influences on the variable, but it eliminates very valuable information in the long run, which may be peculiar to the characteristics of the variable. Therefore, the need to integrate short-run dynamics with long-run equilibrium gave rise to the co-integration technique by Granger (1981), Engle and Granger (1987), Mills (1990), and Johansen (1991). Basically, the idea of co-integration is predicated on the thesis that even though two time series may not themselves be stationary, a linear combination of the two nonstationary time series may be stationary. If this is the case, the two original nonstationary time series are said to be "co-integrated." Usually, for co-integration, the two time series have to be stationary after the same number of differencing. If a given time series becomes stationary after first differencing, it is said to be integrated of order one **I(1)**. If the time series becomes stationary after second differencing, it is integrated of order two **I(2)**. If the original time series is stationary, it is integrated of order zero **I(0)**. However, a linear combination of two **I(1)** series is also **I(1)**. Hence, when a linear combination of two **I(1)** series is stationary, then the two time series are co-integrated.

To check for the order of integration, we follow the Dickey–Fuller test (Dickey and Fuller, 1979) for unit root stated, thus:

$$\Delta Yt = \alpha 0 + \alpha 1t + \alpha 2Yt - 1 + \mu t, \tag{5}$$

or the augmented Dickey–Fuller (ADF) tests (Dickey and Fuller, 1981):

$$\Delta Yt = \alpha 0 + \alpha 1t + \alpha 2Yt - 1 + \sum_{i=1}^{k} \alpha i \, \Delta Yt - i + \mu t. \tag{6}$$

A substantial weakness of the original Dickey–Fuller test is that it does not take account of possible autocorrelation in the error process μt. If μt is autocorrelated (i.e., it is not white noise), then the ordinary least squares (OLS) estimate of the equation and of its variants are not efficient.

Granger causality test is carried out to evaluate the link between agriculture and industrial manufacturing sector. This study applies the Johansen (1991) co-integration method in the analysis of the long-run relationship because it is easily adaptable to short time series data than the Engle and Granger (1987). Co-integration technique is an improvement on the OLS method because the co-integration method takes consideration of the nonstationarity associated with time series data (Granger & Newbold, 1974). Nonstationarity 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 a causal relationship between two variables in a time series. Variable *X* is said to Granger cause variable *Y*, if the current value of *Y* (*yt*) is conditional on the past values of *X* (*xt* − 1, *x t* − 2, . . ., *x*0) and thus the history of *X* is likely to help predict *Y* (Granger, 1969). This study is to estimate the causal relationship between agriculture and manufacturing industry; to provide evidence for industrial sector leading to increase in agricultural productivity and if the agricultural sector has caused an 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:

$$\text{INDOT} = \beta_0 + \sum \beta_1 \text{INDOT}_{t-1} + \sum \beta_2 \text{AGROUT} + U_t. \tag{7}$$

$$\text{AGROUT} = \beta_0 + \sum \beta_1 \text{AGROUT}_{t-1} + \sum \beta_2 \text{INDOT} + U_t. \tag{8}$$

A unit root test is conducted to test for stationarity or nonstationarity in a time series. The ADF test was conducted 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 the first difference or second difference to make it stationary. If a time series data are 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 denoted by **I(1)**; and so on. A regression whose variables are co-integrated is called a co-integrating regression and the parameters obtained are co-integrating parameters. Economic theory expects the coefficient of the error correction mechanism (ECM) to be negative and significant because it implies that errors generated in each period correctly adjust in subsequent years. The higher the coefficient of the ECM, the higher the speed of adjustment from the short run to the long run.

Empirical Analysis and Discussion of Results

Empirical Analysis

The first 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 understanding the long-run behavior of variables. In carrying out this test, ADF test is applied as stated in Equation 6. The rule of thumb is that if absolute value of ADF test statistic is greater than McKinnon critical value at 5%, we reject the null hypothesis that the variable is nonstationary. The variable is deemed stationary when the absolute value of the ADF statistics test is greater than the critical value at 5%.

Table 1. 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	Nonstationary
LINF	0	−3.052959	−2.954021	**I(0)**	Stationary
LINDOT	0	−0.72591	−2.954021	None	Nonstationary
LGRECA	0	−2.079774	−2.960411	None	Nonstationary
LSCLA	0	0.318118	−2.954021	None	Nonstationary
LEXCRT	0	−2.212044	−2.954021	None	Nonstationary

Source. Computed by the author using EViews 9.
Note. ADF = augmented Dickey–Fuller.

Table 2. 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.
Note. ADF = augmented Dickey–Fuller.

From Table 1, all the variables are nonstationary at levels except LINF, which is stationary at levels **I(0)**. To make all variables stationary at the same level, the test is run on the first difference, thereby making all variables stationary at order **I (1)** (see Table 2). 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.

Co-integration test using the Johansen technique is used 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 Eigenvalue are greater than the critical values at 5%, then the null hypothesis of no co-integration is rejected, which depicts co-integration among variables implying a long-run equilibrium relationship.

From Table 3, we can see that under the hypothesized number 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.

The normalized co-integrating coefficient is written in its implicit form, to make it explicit (Table 5). It is re-written by changing the signs as follow:

$$\begin{aligned} \text{LAGROUT} = {} & 0.193\text{LINF} + 2.554\text{LINDOT} + 0.695\text{LGRECA} \\ & + 0.029\text{LSCLA} - 1.247\text{LEXCRT}. \end{aligned} \tag{9}$$

The above results in Equation 9 show that there is 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 and significant relationship between the proxy of industrial output and agricultural sector, indicating a 1% increase in industrial output will lead to a 2.554% increase in agricultural output, *ceteris paribus*. This is theoretically expected as an increase in industrial output through the backward linkage supported by Hirschman's unbalanced growth theory will lead to an increase in agricultural output.

Table 3. Unrestricted Co-Integration Rank Test (Trace).

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical value	Prob
None*	0.732306	107.3412	95.75366	.0063
At most 1	0.696403	65.16806	69.81889	.1111
At most 2	0.407370	27.02236	47.85613	.8534
At most 3	0.198666	10.28042	29.79707	.9759
At most 4	0.088622	3.193151	15.49471	.9574
At most 5	0.006964	0.223618	3.841466	.6363

*Trace test indicates one co-integrating equation(s) at the .05 level.

Table 4. Unrestricted Co-Integration Rank Test (Maximum Eigenvalue).

Hypothesized		Maximum eigenvalue	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical value	Prob.
None*	0.732306	42.17315	40.07757	.0286
At most 1*	0.696403	38.14570	33.87687	.0145
At most 2	0.407370	16.74194	27.58434	.6022
At most 3	0.198666	7.087273	21.13162	.9504
At most 4	0.088622	2.969533	14.26460	.9488
At most 5	0.006964	0.223618	3.841466	.6363

*Maximum eigenvalue test indicates two co-integrating equation(s) at the .05 level.

Table 5. Normalized Co-Integrating Coefficients.

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)

Note. Standard errors in parenthesis.
**Significant at 5%.

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

There is a positive relationship between the sectorial distribution of commercial loans and advances to agriculture and the 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 a need for a stable and favorable exchange rate. The more the local currency devalues to the dollar, the more the increase in prices thereby affecting production level.

Table 6 presents the result of a VECM; the ECM developed by Engle and Granger to reconcile 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 toward equilibrium, while a positive value indicates a movement away from equilibrium. The error correction model, also known as a speed of adjustment factor, shows how fast the system adjusts to restore equilibrium.

The error correction coefficient shows the speed at which our model returns or converges to equilibrium after an exogenous shock. As a result, the error correction term should be

Table 6. Vector Error Correction Model Results.

Error correction	D(LAGROT)
CointEq1	0.029258**
	(0.00840)
D(LAGROUT(-1))	−0.342095
	(0.18971)
D(LINF(-1))	0.070813**
	(0.02256)
D(LINDOT(-1))	0.542231**
	(0.24817)
D(LGRECA(-1))	−0.010076
	(0.01894)
D(LSCLA(-1))	0.005417
	(0.02929)
D(LEXCRT(-1))	−0.152893**
	(0.06698)
C	0.115535
	(0.02467)
R^2	.721003
Adj. R^2	.507652
F-statistic	3.379420

Note. Standard error in parenthesis.
**Significant at 5%.

negatively signed to indicate a move toward long-run equilibrium. The coefficient of the error correction term in Table 6 has positive, but significant 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))} indicate that the equation converges in the long run given any initial shock with a speed adjustment of 1.00%, and 15.2%, respectively.

A relationship between variables neither implies causality nor a direction of influence (Gujarati, 2004). The Granger causality test looks at how variable *X* can affect variable *Y*. Granger's (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*, in addition if 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* is statistically significant. A further 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).

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 reject the null hypothesis. This means that there is a bidirectional relationship between the agricultural sector and industrial sector in Nigeria.

Finally, we use the OLS results in Table 8 to test for the short-run dynamics; the results of the OLS estimate are used to ascertain the behavior of the variables in the absence of the co-integration or error correction mechanism.

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% increase or change in industrial output gives rise to a 1.7% 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.

Discussion of Results

The empirical result from 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, and 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 postcommunist China. In developing countries, many industries are agro-based, given that agricultural produce are largely used as raw material for manufacturing. However, 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 the sampled countries in Tiffin and Irz (2006). However, this result is typical for developing countries as stated in Kanwar (2000) and Chebbi and Lachaal (2007). In advanced economies, Bernstein (2017) posit that where agriculture is highly mechanized, industrial output seems to be relatively divergent into several sectoral inputs, with a meager but significant contribution to the growth of agriculture, except measured explicitly for agro-based industries.

From Table 6, the vector error correction coefficient is positive, which shows that in the long run, the model diverges from equilibrium given that all the lagged explanatory variables are subject to differing, but unique behavior. In the normalized co-integration estimate (see Table 4), there is a positive relationship between agricultural productivity and manufacturing industry output supporting the result in the

Table 7. Pairwise Granger Causality Tests.

Null hypothesis	Obs.	*F*-statistic	Prob.
LINDOT does not Granger cause LAGROUT	36	3.39421	.0484
LAGROUT does not Granger cause LINDOT		6.37013	.0054

Table 8. Ordinary Least Squares (OLS) Regression Analysis.

Variable	Coefficient
LINF	−0.019
	(0.035)
LINDOT	1.719**
	(0.227)
LGRECA	0.031
	(0.042)
LSCLA	0.022
	(0.041)
LEXCRT	−0.050
	(0.063)
R^2	.963
Adjusted R^2	.956
SE of regression	0.134
F-statistic	145.855
Prob. (*F*-statistic)	.000

Note. Standard error in parenthesis.
**Significant at 5%.

VECM, which also corroborates the short-run dynamics in Rakhmetullina et al. (2017). This evidence denotes that the behavior of our dependent variable concerning 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 robust inter-sectorial linkage is found using the VECM and Johansen co-integration procedure. In the same vein, Ogundari and Awokuse (2016) present 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 (see Bernstein, 2017). To this end, industrialization connotes an unparalleled food sufficiency for the teeming population. Food sufficiency, however, requires improved technical know-how for agricultural productivity. The positive interplay of agriculture and industry is a necessary condition for improved economic growth and sustainable 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 are 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 models. 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, a major cause of decline in economic growth in developing countries (see Okereke et al., 2019; Sertoglu et al., 2017). In any case, the exchange rate variable follows the expected negative sign, and industrial output, sectoral loans, and advances to the agricultural sector all follow expected signs both in the short- and long-run analyses as observed by Bernstein (2017). But government expenditure to the agricultural sector is negative and insignificant in the long run and positive in the normalized co-integration model.

Conclusion

The primary aim of this study is to investigate the relationship between agriculture and manufacturing industry output, to enable policy makers understand the linkage that facilitates 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, which includes inflation and exchange rate, government recurrent expenditure on the agricultural sector, and sectorial commercial bank loans for the period 1982 to 2017 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 boosts 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, and 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 resulting higher exchange rates. Another major problem that would have caused the 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 in agricultural productivity. With strategic investment and support to the manufacturing sector, the necessary inputs to boost agriculture could be obtained at minimum cost and agricultural productivity rising to provide necessary input for manufacturing industry output. In the same vein, there is a need for government policy to encourage agriculture extension services, to educate rural farmers on the advantages of collaborating with commercial farmers and local financial institutions for the purchase of farming equipment, tools, and seedlings to improve productivity. To tackle the problem of high cost of imported equipment posed by foreign exchange variability, government should encourage the fabrication of local farming implements by artisans.

A recommendation for further research is understanding temporal constraints and omitted variable bias, which this study tactfully overlooked due to analytical techniques employed. Second, 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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