Heliyon 6 (2020) e04001

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Agro-financing and food production in Nigeria

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ARTICLE INFO

Keywords:
Agriculture
Arable land
Farm implements
Financing
Credit
SD
Agricultural science
Arts and humanities
Food science
Health sciences
Social sciences

ABSTRACT

This study examines how agro-financing impacts on food production in Nigeria supporting Goal 2 of the 2030 Sustainable Development Goals (SDGs) which aims to *"end hunger, achieve food security, improve nutrition, and promote sustainable agriculture"*. The study covers the period 1981–2018 using annual data sourced from the World Development Indicators (WDI) of the World Bank, Central Bank of Nigeria (CBN) Statistical Bulletin. The Johansen and the Canonical Cointegration approaches are employed and findings reveal that agro-financing is statistically significant in explaining the level of food production in Nigeria.

The result implies that a 1% increase in farmers' access to agricultural finance is associated with an increase in food production by 0.002%–0.006% depending on the model specification. This result aligns with the '*a priori*' expectations as it is expected that more agro-funding at low-interest rates motivates farmers to secure high-yield seedlings, machinery and other farm implements, organic inputs that positively impact on total agricultural yield, leading to more food production. Therefore, the study recommends that more funding be allocated to the agrarian sector with less stringent credit conditions, and more arable land be allotted for farming purposes amongst others.

1. Introduction

The increased global need for food is a problem for humanity (Osabohien et al., 2020; Jacobsen et al., 2013). Increasing food production to feed the teeming world population will continue to be a difficult task due to fewer arable land, high cost of farm implements needed for production as a result of inflation, less credit access to farmers, the land competition of food production with bio-fuel production and rural-urban migration among others (Jacobsen et al., 2013). As a result of this, there is a strong on-going deliberation on the best approach to gain speed with world population growth and increasing food production to meet the United Nations (UN) Sustainable Devolvement Goal 2 (which is to achieve food security at all level, improve nutrition for all, and promote sustainable agriculture) by 2030 (Osabohien et al., 2020; Osabohien et al., 2019).

To improve food production, various strategies have been envisaged by government and stakeholders at all levels; one of such strategies is hinged on the need to increase farmers access to agricultural finance (credit) to increase productivity, while others focus on agricultural diversity (Osabohien et al., 2020a,b). These strategies are important because, in developing countries, especially in Africa, the agricultural sector accounts for more than 50% of the entire labour force and it contributes significantly to the Gross Domestic Product (GDP) (Osabohien et al., 2020a,b; Matthew et al., 2019). In the same way, the production of food across the African content, especially in Nigeria, agriculture represents a crucial proportion of activities engaged and captures about 80% of total industry size with livestock, forestry and fishing accounting for the balance of 20% (Osabohien et al., 2019). Irrespective of its crucial role, its contribution to GDP has currently dropped as a result of low yields resulting from constrained or limited access to credits by farmers. The sector's contributions to GDP dropped from 31% (113.64 billion USD to 78 billion USD between 2013 and 2017 (Nevin et al., 2019).

Low food production is one of the major issues that require urgent attention in Africa, with over 50% of the people depending on subsistence farming, coupled with low production as their sole means of survival (Bachewe et al., 2018). However, it should be mentioned at this stage that African countries differ in terms of mass, demography, and endowment of resources. Therefore, the potential of agriculture to meet the needs of the people varies between countries (Omondi, 2019). Food production is significant, because, shortage in the production of food leads to the deterioration of household's means of livelihood and food security (Omordi, 2019).

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https://doi.org/10.1016/j.heliyon.2020.e04001
Received 26 March 2020; Received in revised form 24 April 2020; Accepted 13 May 2020

On a general note, over 45% of Africa's population live in the rural communities, and the continent's economy seems to be heavily dependent on agriculture as a means of livelihood and food security (Osabohien et al., 2020a,b; Matthew et al., 2019). The agriculture sector in Africa is known to be one of the essential sectors, given its contribution to the overall economy, as it is the most significant single contributor to GDP (Matthew et al., 2019). This is hinged on the fact that, in this region, agriculture contributes more than 40% to GDP, while the number of the people engaged in farming are between 65-70% with the use of crude implements (labour intensive). Despite this huge contribution of the sector to the economy, the productive capacity of the sector has declined in recent years which has been further reduced due to post-harvest losses (due to road networks and others), while about 65% of the overall employment in Africa is engaged in the food economy (Omondi, 2019; Mota et al., 2019; Osabohien et al., 2018a,b).

The food economy is responsible for food production, which comprises of all forms of practices at the farm level, including processing, packaging, transportation, distribution and retailing. This food economy employs about 85 million people in Nigeria (Osabohien et al., 2018) where more than 75% of food economy employment remains in agriculture, with 65% of employment in local communities, about 20% are in the processing of food, marketing and food away from their localities (Alola and Alola, 2019; Osabuohien et al., 2018). However, food production in Africa has declined, resulting in rise in food imports. By 2017, food import expenditure stood at about 35 billion USD, and this figure is estimated to further increase to about 110 billion USD by 2025 (Osabohien et al., 2020a,b; Nevin et al., 2019; Allen et al., 2018). Overall, the continent accounts for 60% of the world's global uncultivated arable land estimated at 600 million hectares (Nevin et al., 2019).

The cultivation and production of food are done mainly via subsistence means and engulfed by low technical known-how and with intensive human resources (labour intensive) due to lack of credit and machinery (Osabohien et al., 2018; Osabohien et al., 2020a,b). The Nigerian agriculture sector which contributed to GDP has declined in the recent decades due to low level of agricultural productivity resulting from low engagement in agriculture, increased cost of machineries and other farm implements due to inflation (Matthew et al., 2019) and also other internal factors such as crisis and conflicts as well as the lack of social protection to mitigate the impact of climate change which has made agriculture unattractive for employment (Osabohien et al., 2019a, b; Osabohien et al., 2019c).

Nigeria relies heavily on importation of food; though, the importation has reduced from 481billion in the second quarter of 2017 to 349.9 billion in the second quarter 2018 (Osabohien et al., 2018a,b; Nevin et al., 2019). However, there is the need to take action in controlling the importation of food, as food import has gradually shown an upward trend, which was shown in the first and second quarters of 2018 (Omondi, 2019; Mota et al., 2019, Alola and Alola, 2019; Xie et al., 2018; Waha et al., 2018). In order to control the importation of food, local food production has to increase, which can be done through improving agricultural financing. It has been observed that agricultural financing has declined in Nigeria, as shown in budgetary allocation (Nevin et al., 2019).

The ratio of Nigeria's budget for agriculture to annual budget is below the prescribed standard set by the Maputo Declaration on Agriculture and Food Security. Through the declaration, the African Union (AU) agreed to allocate at least 10% of its member-countries annual national budget to agriculture. Budgetary allocation for agriculture of N0.20 trillion accounts for 2.2% of the proposed 2018 budget of N9.12 trillion (Osabohien et al., 2020a,b; Nevin et al., 2019). In 2017, the agriculture budget of N0.10 trillion represented 1.3% of the total budget of N7.44 trillion (Nevin et al., 2019; Osabohien et al., 2018). Also, credit to agriculture declined from 83.20 (2013) to 66.64 (2014) this further declined to 40.62 (2015) from 2013 to 2016, agricultural finance in Nigeria declined by about 42.58% (Nevin et al., 2019; Osabohien et al., 2018).

In a bid to increase agricultural financing, the Nigerian government implemented some programmes which include: Agricultural Transformation Agenda (ATA), Anchor Borrowers, Commercial Agriculture Credit Scheme (CACS), and Agricultural Credit Guarantee Scheme Fund (ACGSF) among others (Osabohien et al., 2020a,b). Different states of the country have also supported the federal government by deploying funding strategies to unlock growth in the agricultural products of their comparative advantage (Nevin et al., 2019). The above programmes are implemented to deepen the credit market for agribusiness. For instance, about 74% of the 200-billion-Naira[1] special credit intervention fund was disbursed to 191 businesses between 2009 and 2016 based on the report on CACS of the Central Bank of Nigeria. Of the total,45% of the beneficiaries are involved in crop production, 23% in livestock production and 15% in agricultural processing (Osabohien et al., 2020a,b).

According to the National Bureau of Statistics, credit to agriculture was 3.26% and 3.36% of total credit to the private sector in 2016 and 2017 respectively. Though, the government, in its effort to increase productivity, has implemented the above programmes; credit access to agriculture remains low. This is because, compared to the banking sector credit to other industries, the agricultural sector receives the lowest credit allocation from banks despite the sector's more contribution to GDP than other industries (Nevin et al., 2019; Osabohien et al., 2018a,b). This study contributes to the existing literature by examining how agro-financing contributes to food production in Nigeria. The study is structured into five sections; following this introduction is section 2 which is the review of related and current studies on the issue of study, section 3 details the methodological approach, section 4 covers the presentation and interpretation of findings and section 5 concludes with policy recommendations.

2. Brief literature review

One of the significant constraints to agricultural productivity is the inability of farmers to gain access to credit due to the perceived risk and volatility of the sector (Osabohien et al., 2020a,b). Most important one being that banks and other financial institutions are still very reluctant to fund agricultural projects which is evident by stringent credit conditions. As a result, meagre funding sips into the agricultural sector, which accounts for over 70% of the total labour force of most African economies (FAO, 2011). The contributory and substantial role of the agricultural sector to economic growth and development and particularly, for the realisation of the Sustainable Development Goals by 2030 cannot be understated. Hence, it is imperative to do a review of the agro-food and agro-financing literature, without claiming to be exhaustive.

Various studies examined and evident the significant role of farmers' access to finance for the purchase of agricultural machinery and other farm implements to improve agricultural production. From the study of 21,576 dairy farmers in Kenya and using the double-hurdle approach for inferential analysis, Njoku et al. (2018) revealed the positive and significant relationship between farmers' production capacity and access to credit. The study recommends that to boost agro-productivity, there is the need to enhance credit farmers, initiate agricultural insurance and seek alternative collaterals. In a similar study, Osabohien et al. (2018) using the Autoregressive Distribution Lag (ARDL) econometric approach examined how access to credit facilities affect agricultural production and food security in Nigeria, and finds that credit facilities significantly impact on agricultural production and food security in Nigeria.

As per the study by Rahji and Fakayode (2009), agriculture is a significant and positive predictor of economic growth of Nigeria; yet, its contribution is often limited by stringent credit conditions particularly for small-scale farmers which limit their access to credit. However, this argument is supported by the study by Odoemenem and Obinne (2010) which argues that small-scale farmers are having poor access to credit

[1] Nigerian Currency.

and as a result of their inability to provide loan collaterals results in spill-over effects of uncertainty of agricultural production. Contrarily, Egwu (2016) suggests that the cash-reserve ratio should be reduced so that banks have more loanable funds available, thereby reducing stringent loan conditions.

Furthermore, evidence from Abu and Issahaku (2017) shows that small-scale farmers unable to back-up loan applications with the needed collateral have difficulties accessing credit and experience slug in their agricultural output. However, for large households in Malawi with corresponding large farm sizes, Sebu (2013) finds that external financing and large farmlands are positively correlated. That is, households with large farmlands are more likely to get access to credit than small-landholders. Njuguna and Nyairo (2015) also found that inability to provide loan collateral impede on access to credit by farmers in Kenya while Adeleke, Kamara, and Brixiova (2010), found investment potentials exist for small-holder producers.

On the review of agricultural policy in Nigeria, Mallum (2016) noted that the role of credit in agricultural development is very paramount, and any shortcomings can affect a farmer's investment ability. The study recommends further to gain farmers' confidence and to minimize the risk of credit default, diversification of loans must be encouraged, and specialized staff must be appointed to mentor local farmers. Some studies (Okojie et al., 2010; Adeleye et al., 2020) on the critique of the conditions and process of accessing credits by farmers' particularly female farmers show that bureaucratic procedures lead to credit denials. Philip, Nkonya, Pender and Oni (2009) show that when financial intermediaries charge high rates of interest amidst structuring only short-term loans given the uncertainties in the agricultural sector, such scenario leads to the removal of the incentive of farmers to borrow.

Similarly, Adejobi and Atobatele (2008) propose that failure to repay loans could impact negatively on farmers' credit rating and limit the access to further credit in future. Based on empirical evidence concerning the relationship between agro-financing and economic growth, Obansa and Maduekwe (2013) and Adeleye et al. (2020) examine if there exists a causal relationship between agro-financing and economic growth. Using the Granger test for causal analysis, they conclude that a bi-directional causal relationship exists. In order words, adequate and substantial funding of the agricultural sector results in positive contributions to economic growth. At the same time, economic growth spurs the need for more agricultural investment. In the event that the impact of immediate financing is not significant to boosting agriculture, the long-term finding may be required, which can trigger the needed products in the sector (Antonio and Yap, 1994).

Similarly, the crucial role of the agricultural sector in supporting growth is not unconnected to adequate funding which allows the farmer to engage in new and modern equipment, including the purchase quality seedlings (Mafimisebi et al., 2009). Using the autoregressive distributed lag (ARDL) and error correction mechanism (ECM), Udoh (2011) finds that the relationship between public expenditure, private investment and agricultural sector growth is asymmetric. While government public expenditure boosts agro-output, the impact of private investment is insignificant. This outcome is somewhat unsurprising as private investors often view the agricultural sector as having low returns and volatile. Likewise, Ayeomoni and Aladejana (2016) use the autoregressive distributed lag (ARDL) model and error correction mechanism (ECM) to show that there exist both long-run and short-run relationships between agricultural credit and economic growth. Other control variables used in the investigation revealed that while the inflation rate shows a negative relationship, private domestic investment and the real exchange rate have shown a positive relationship. The study concludes that dynamic factors like agro-financing, real exchange rate, real interest rate, private domestic investment and inflation rate determine economic growth.

From Oboh and Ekpebu (2011) using the ordinary least squares (OLS) procedure to study the factors of formal agricultural credit allocation to the farm sector, results show the need to critically evaluate dynamics affecting the rate of credit allocation by beneficiaries of the government's credit scheme. Also, to validate the above claim, in a more recent study, Osabohien et al. (2020a,b) using the Propensity Score Matching (PSM) model on a cross-sectional data using Wave 2 of the Living Standard Measurement Study- Integrated Survey on Agriculture (LSMS-ISA) finds that agricultural credit is statistically significant and have a positive impact on agricultural production in Nigeria. According to Osabohien et al. (2020a,b) the implication of the result is that households with access to agricultural credit had yields thrice more than households without access to agricultural credit. Going beyond the existing empirical literature, the present study contributes not limiting by examining the agro-finance-growth nexus, yet it goes to analyse how economic growth responds to shocks from other endogenous regressors in the model.

3. Methodology and data

As stated earlier, the study examines how agro-finance impact on food production in Nigeria. To achieve this objective, the study employs the Johansen and the canonical cointegration and hinged on the empirical work of Osabohien et al. (2020a,b) and Abu et al., (2017), the implicit form of the model is presented as:

$$FP_t = f(AGF_t, MAC_t, AE_t, ARL_t, INF_t) \quad [1]$$

where, *FP* represents food production (indexed 2004–2006 = 100), *AGF* represents agro-financing (agricultural credit guarantee scheme fund - operations - cumulative loans, million naira) *MAC* represents agricultural machinery (tractors), *AE* means agricultural employment (% of total employment) *ARL* means arable land (hectare) and *INF* means inflation (consumer prices-annual %). The explicit and non-linear form of model is stated as:

$$FP_t = \alpha . AGF_t^{\beta_1} . MAC_t^{\beta_2} . AE_t^{\beta_3} . MAC_t^{\beta_4} . INF_t^{\beta_4} . e_t \quad [2]$$

Since Eq. (2) will be difficult to estimate in its non-linear form, it is linearised by taking the natural logarithm of variables on both sides of the equation, that is:

$$\ln FP_t = \beta_0 + \beta_1 \ln AGF_t + \beta_2 \ln MAC_t + \beta_3 \ln AE_t + \beta_4 \ln ARL_t + \beta_5 \ln INF_t + e_t \quad [3]$$

where, β_0 represents the constant term, β_1 is the coefficient of agro-financing, β_2 is the coefficient of machinery, $\beta_3$is the coefficient of agricultural employment, β_4 is the coefficient of arable land, $\beta_5$represent the coefficient of inflation, *t* represents time and *e* represents the error term. The study made use of annual data sourced from the World Bank (2019) World Development Indicators (WDI) and the Central Bank of Nigeria (CBN) Statistical Bulletin for the period 1981 to 2018.

The double-log model is adopted in order to align the variables to the same base (unit of measurement), reduce the incidence of heteroscedasticity and to establish an elasticity relationship while ensuring that the estimates are Best Linear and Unbiased–BLUE (Ejemeyovwi et al., 2018; Adeleye et al., 2020). The '*a priori*' expectations of the variables are as follows: agro-financing, agricultural machinery, arable land should have a positive relationship with food production, while inflation is expected to have a negative coefficient, which is symbolically shown as: $\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 > 0$, $\beta_5 < 0$. The argument is that an increase in agro-financing is expected to increase farmers' level of productivity. Similarly, machinery, arable land allotted for farming activities, employment in agriculture are expected to boost food production, while inflation could reduce production similar to the findings of Ayeomoni and Aladejana (2016). Table 1 gives brief definitions of the variables and their corresponding summary statistics.

From Table 1, the average of food production is 77.110; the standard deviation is 31.735, while the minimum and maximum values are 29.97 and 125.770, respectively. Similarly, agro-financing has a mean of 19.50, the standard deviation of 11.113 and ranges from 1 to 38 million Naira. Also, agricultural employment has a mean value of 44.011. Arable land

Table 1. Summary statistics of variables.

Variable	Identifier	Measurement	Source	Mean	SD	Min	Max
Food production	*FP*	food production (indexed 2004–2006 = 100)	WDI	77.110	31.735	29.97	125.770
Agro-financing	*AGF*	Agricultural credit guarantee scheme fund (ACGSF)-Operations - Cumulative Loans (million naira)	CBN	19.500	11.113	1.000	38.000
Machinery	*MAC*	Agricultural machinery, tractors	WDI	9.349	0.582	7.972	10.119
Agricultural employment	*AE*	Employment in agriculture (% of total employment)	WDI	44.011	5.077	36.384	50.172
Arable land	*ARL*	Arable land (hectares)	WDI	0.256	0.0438	0.182	0.324
Inflation	*INF*	Inflation, consumer prices (annual %)	WDI	7.721	2.073	0.892	5.48

Note: WDI means World Development Indicators. CBN Means Central Bank of Nigeria Statistical Bulletin. SD means standard deviation. Min means minimum value and Max means maximum value.
Source: Authors' Computations

has an average value of 44.011 with a standard deviation of 5.077 and ranges between 36.384 and 50.172. Finally, inflation has a mean value of 9.349, a standard deviation of 0.582, which ranges from 7.972 to 10.119, respectively.

4. Results and interpretations

The study builds on the hypothesis that agro-financing contributes significantly to food production in Nigeria. This is on the premise that access to finance will serve as a motivation for agricultural engagement, especially for the rural population whose main occupation is agriculture. Thus, having access to finance will enhance their production capacity, thereby leading to increased food production/food security. To achieve the objectives, we apply the Johansen and Canonical cointegration techniques to empirically examine the long-run contributions of agro-financing to food production. Following Adeleye et al. (2019), the impact of shocks on food production using the impulse-response analysis is engaged.

4.1. Unit root tests

When performing a time series analysis, visual examination about the stationarity of the variables is insufficient. Therefore, it is vital to scientifically ascertain that the series do not exhibit a unit root to avoid obtaining spurious results. In essence, the variables must be stationary (Adeleye et al., 2019; Adeleye et al., 2018). Therefore, to determine the stationarity of the five variables, they are subjected to tests using the Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) approaches. The underlying null hypothesis for both tests is that the series is non-stationary of which the null hypothesis can be rejected, if the test statistic is statistically significant. The results displayed in Table 2 confirms that all variables engaged in this study are at first-difference stationary with statistical significance ranging from 1% to 10%.

4.2. Cointegration analysis

Having confirmed stationarity at first-difference, it is important to determine if the variables exhibit a long-run association. In other words, establishing cointegration is essential for any long-run analysis. Deploying the Johansen test for cointegration with one lag structure, results in Table 3 indicate that we cannot reject the Null hypothesis of one cointegrating relationship from the Mackinnon-Haug-Michelis probability-value. Thus, the likelihood of a long-run relationship among the variables in the model is established.

From the outcomes from the Johansen test, we proceed to establish long-run relationships with the results from the canonical cointegration regression. Using three model specifications with: (1) no trend in column [1], (2) linear trend in column [2], and (3) quadratic trend in column [3], findings displayed in Table 4 shows that consistently across the three models, arable land in hectares increases food production in the long-run, machinery also increase food production in the long-run while inflation leads to a long-run decline in food production. For instance, a percentage change in arable land (hectares) is associated with approximately 0.87 %, 0.96% and 0.84% increase in food production. Also, a 1% increase in the use of machinery in farming activities is associated with 2.87%, 2.11% and 2.36 respective increase in food production.

This outcome is expected, because more arable land allocated to individuals, small- and large-scale farmer will boost food production similar to the findings of Osabohien et al. (2020a,b). Agricultural employment was found to be insignificant in explaining the level of food production in Nigeria which means that increasing participation in agriculture does not necessarily improve the level of food production as a percentage change in agro-employment is statistically insignificant in explaining the level of food production in the long-run. This result can be validated that increased level of agricultural engagement without access to machineries and other mechanised agricultural implements may cause farmers to adopt labour-intensive mechanism of farming which may not significantly increase production in the long-run. This result is similar to the findings of Njuguna and Nyairo (2015) which shows that the inability

Table 2. Unit root tests.

Variables	ADF		PP		Decision
	Level	Ist Difference	Level	Ist Difference	
Food Production	-2.344	-3.270*	-1.879	-7.952***	*I* (1)
Agro-financing	-0.798	-5.718***	-0.802	-5.718***	*I* (1)
agricultural employment	-0.474	-6.127***	-0.573	-6.049***	*I* (1)
Arable land	-2.219	-5.583****	-2.544	-5.585***	*I* (1)
Inflation	-1.968	-2.908*	-1.582	-2.849*	*I(1)*
Machinery	-0.903	-6.605***	0.9813	-5.07***	*I(1)*

Note: *** and * denote statistical significance at 1% and 10% levels, respectively; ADF = Augmented Dickey-Fuller; PP = Philips-Perron; Food production (log) stationary with the trend; Estimations augmented with 4 lags obtained from Schwarz Information Criterion (SIC) using the routine in EViews10.
Source: Authors' Computations

Table 3. Johansen cointegration results.

Cointegrating Rank	Trace Test			Maximum Eigenvalue		
	Statistic	Critical Value	p-value	Statistic	Critical Value	p-value
None *	77.25820	69.81889	0.0113	35.9014	33.87687	0.0283
At most 1	41.35672	47.85613	0.1776	17.3680	27.58434	0.5485
At most 2	23.98872	29.79707	0.2009	12.8771	21.13162	0.4636
At most 3	11.11157	15.49471	0.2047	5.95384	14.26460	0.6191
At most 4	3.157723	3.841466	0.0231	3.15772	3.841466	0.0231

Note: * rejection of null hypothesis of no cointegration.
Source: Authors' Computations

Table 4. Canonical cointegration results.

Variable	[1]	[2]	[3]
Constant	39.038 (0.145)	57.061 (0.128)	42.725*** (0.101)
Agro-financing	0.002* (0.000)	0.006* (0.000)	0.003* (0.000)
Agricultural Employment	0.039 (0.879)	0.465 (0.4424)	0.016 (0.955)
Arable land	0.867* (0.000)	0.956* (0.000)	0.842* (0.000)
Inflation	-0.079** (0.012)	-0.065** (0.044)	-0.065** (0.027)
Machinery	2.386* (0.002)	2.109* (0.008)	2.361* (0.002)
Linear Trend		0.027 (0.432)	0.082 (0.574)
Quadratic Trend			-0.004 (0.678)
Observations	28	28	28
R-squared	0.984	0.984	0.985

Note: ***, ** and * represent statistical significance at the 1%, 5% and 10% level, respectively; Long-run covariance estimate (Prewhitening with lags = 3 from AIC maxlags = 3, Bartlett kernel, Newey-West fixed bandwidth = 3.0000). Variables are in their logarithm form.
Source: Authors' Computations

to provide loan collateral impede on access to credit by farmers in Kenya and may lower production. Similar findings are seen in Osabohien et al. (2020) using the PSM model indicates that households with credit access had yields thrice more than households without credit assess.

On the contrary, inflation was found to be negatively related to food production. Implying that a 1% increase in inflation rate is associated with approximately 0.08%, 0.07%, and 0.07% decrease in food production in Nigeria. The result obtained aligns with the '*a priori*' expectations because, high rate of inflation will reduce farmers, especially small-holder farmers purchasing power parity (PPP)[2] with regards to the purchase of farm machinery and other agricultural implements and therefore will be forced to adopt manual labour with low production. Concerning the result obtained for inflation; also, for Nigeria, aside from that fact that no data capture agro-participation between 1980 and 1989, the data showed that employment in agricultural has consistently dwindled annually and hence, the contribution to food production was in an adverse position. In the same way, increasing the number of the people in agriculture in Nigeria without proper access to finance and proper policies (example, social protection policies) may not have a significant effect on food production (Osabohien et al., 2020; Matthew et al., 2019).

Depending on the model specification, agricultural credit revealed the asymmetric relationship. For instance, using *no* trend, a linear trend and a quadratic trend specification, agricultural credit significantly contributes 0.002%, 0.006% and 0.003% increase to food production in the long-run which aligns with the 'a expectations' as it is expected that more agro-funding at low-interest rates motivates farmer to secure high-yield seedlings, farm implements, organic inputs that positively impact on their total yield leading to more food production. Hence, it can be concluded that agro-credit significantly boosts food production in the long-run as empirically confirmed by Osabohien et al. (2020). Lastly, the linear and quadratic trend specifications indicate that arable land increases food production by 0.96% and 0.84% respectively in the long-run. This finding is consistent with the '*a priori expectations*' because arable land contributes positively to food production given the presence of enabling environment and the contrary obtains if the infrastructures to promote agriculture are not provided to farming households.

4.3. Diagnostics

To give some level of confidence in the findings, the model was subjected to diagnostics tests. The results shown in Table 5 provides evidence that the model passed the autocorrelation, normality and heteroskedasticity tests. Based on these tests, we proceeded further to analyse the effect of shocks and the results are presented in Table 5.

4.4. Impulse response function results

The analysis is concluded by accounting for the response of food production to shocks or impulses from other endogenous variables in the

Table 5. Diagnostics checks results.

Test	Statistic	p-value
Autocorrelation LM Test	10.11394	0.3413
Jarque-Bera	17.8453	0.0576
Heteroskedasticity, No cross terms	75.7372	0.7283
Heteroskedasticity, Cross terms	151.285	0.5801

Source: Authors' Computations

[2] Purchasing power parity is a term that measures prices in different areas using a specific good/goods to contrast the absolute purchasing power between currencies-Wikipedia.

Table 6. Response of food production to Cholesky 1 Standard Deviation Innovations.

Periods	Employment	Agro-financing	Arable land	inflation	machinery
1	0.003598	0.078938	0.016128	-0.025422	0.001396
2	(0.00326)	(0.12543)	(0.00449)	(0.01624)	(0.00269)
3	0.000407	-0.074689	0.016926	-0.033717	-0.002461
4	(0.00489)	(0.19023)	(0.00865)	(0.02918)	(0.00434)
5	0.002912	-0.080651	0.013655	-0.017814	-0.002761
6	(0.00702)	(0.27483)	(0.01546)	(0.04817)	(0.00637)
7	0.004885	-0.002795	0.004027	-0.003144	-0.003292
8	(0.00958)	(0.31935)	(0.02108)	(0.06834)	(0.00801)
9	0.005806	0.038942	0.001752	0.002835	-0.004271
10	(0.01315)	(0.42431)	(0.03093)	(0.08774)	(0.01067)

Note: Responses of food production to one standard deviation shocks from the endogenous regressors with Cholesky ordering.
Source: Authors' Computations

model (Adeleye et al., 2019; Gershon et al., 2019). An impulse response function (IRF) explains the reaction of an endogenous variable to one of the innovations in the vector autoregression (VAR) system. It describes the progression of the variable of interest along a specified time horizon after a shock in a given moment (Lütkepohl, 2005). This is an essential tool in empirical and policy effectiveness analysis, hence, our reasons for its incorporation. Table 6 shows the response of food production to a one standard deviation change in the endogenous regressors.

Analysis reveals that as the time horizons expand, agro-finance and employment in the agricultural sector tend to drive food production in Nigeria (Osabohien et al., 2018a,b). It shows that the response of food production to a one standard deviation change in agro-finance is similar to the conclusion reached with the outcomes of the canonical cointegration regression. Food production increases from a positive shock to funding in the agricultural sector.

The response of food production to one standard shock to employment is consistently positive throughout the 10-year horizon even though the outcomes are unsupported by the results from the canonical cointegration regression. Also, the response to shocks from arable land (hectares) is consistently positive throughout the horizon. The analytical explanation given in Table 6 is clearly represented in Figure 1 below.

5. Summary and conclusion

The motivation for this study aligns with Goal 2 of the 2030 Sustainable Development Goals (SDGs), which aims to *"end hunger, achieve food security, improve nutrition and promote sustainable agriculture"*. Using annual data on Nigeria from 1981-2018 employing several econometric techniques, the study established that there exists a positive and long-run relationship between agro-financing and food production. The key exogenous variable, which is agro-finance, significantly explains the level of food production in Nigeria and shows that a 1% increase in access to credit will contribute about 0.002%, 0.006% and 0.003% increase in food production in the long-run. Also, the analysis reveals further that as the time horizons expand, agro-credit (finance), machinery and arable land (hectares) tend to drive food production in Nigeria.

Findings from the study which are consistent across models revealed that arable land, agro-financing, and machinery have an asymmetric impact on food production in Nigeria. The study shows that a 1% increase in farm machinery will approximately increase food production by 2.39%, 2.11% and 2.36%, arable land was found to increase food production approximately by 0.87%, 0.96% and 0.842% while inflation was found to reduce food production by 0.08% and 0.07% respectively. The result obtained is in line with the '*a priori*' expectation, as credit access will help farmers purchase agricultural inputs such as high-yield

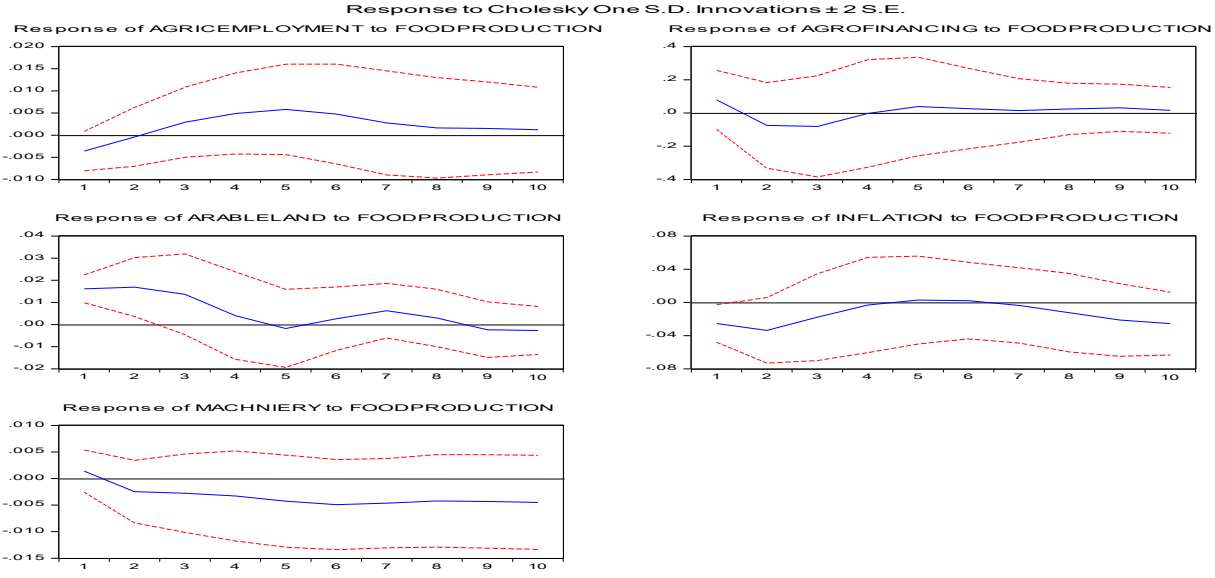

Figure 1. Response of Food production to Cholesky One Standard deviation shock.
Source: Authors' Computations

seedlings and high inflation rate may lower their ability to purchase farm implements and may likely adopt a labour-intensive farming method which may lower productivity.

Finally, to boost food production and ensure food security, the study recommends the following: (1) more funding should be allocated to the agrarian sector; (2) there is need to seek alternative financing such as agricultural insurance schemes, farmers' cooperatives etc.; (3) private involvement in agro-funding should be encouraged with less stringent credit conditions; (4) more arable land allotted for farming purposes; and (5) enabling conditions should be made available as incentives for more participatory engagement in the agricultural sector. For further research, the impact of pastoralists-farmers conflicts as a threat to food security in Nigeria may be taken up, given data availability and include equity as a proxy for capital. Similarly, it will be interesting to know if the findings of this study can be validated with the use of farm-level or regional panel data. This may also be taken up in future research.

Declarations

Author contribution statement

R. Osabohien: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

T.D. Alwis: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

N.G. Adeleye: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Funding statement

The Equipment Subsidy Grant awarded by the Alexander von Humboldt Foundation [REF: 3.4- 8151/19047] to Centre for Economic Policy and Development Research (CEPDeR), Covenant University facilitated the revision of the paper.

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

The authors appreciate the useful comments from the anonymous reviewers. Also, the authors appreciate the publication support from Covenant University Centre for Research, Innovation and Discovery.

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