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Article

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Analysing the socio-financial determinants shaping food production in the South African agriculture sector

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ABSTRACT

The 2023 Sustainable Development Goals (SDGs) encompass a specific objective that is to 'end hunger, achieve food security, enhance agriculture, and improve nutrition'. The realization of this goal relies heavily on efficient agriculture sector management in developing countries. Consequently, assessment of factors that influence agricultural production is one of the way to solve issues that hinders the attainment of the SDGs. This paper aims to investigate the determinants of food production within the South African agricultural sector. Employing econometric methods like Johansen and Canonical Cointegration, VAR and VECM, this study analyses annual time series data spanning from 1961 to 2022. The analysis indicates that factors such as accessible financing, heightened agricultural sector investment, fertilizer usage, and rural demographic growth positively influence food production; contributing to mitigating food insecurity in South Africa. Conversely, elevated lending rates and inflation pose challenges to South African food production. These results indicate the role played by monetary policy to improve food production in South Africa. To bolster food production in South Africa, policymakers should focus on enhancing agricultural skills, easing credit conditions to improve financial accessibility, and encouraging active investment from government and private sectors in agricultural activities.

IMPACT STATEMENT

The current study offers vital insights into the multifaceted determinants of food production within the South African agricultural sector, directly contributing to achieving the 2023 Sustainable Development Goals (SDGs), particularly the aim of "ending hunger, achieving food security, enhancing agriculture, and improving nutrition." By employing rigorous econometric analyses on comprehensive time series data, this research enhances the existing literature by identifying and elucidating various bottlenecks that obstruct production growth in the South African agricultural sector. Additionally, the study conducts a thorough investigation into the impact of key factors of production in agriculture, providing evidence-based recommendations and robust strategies designed to alleviate hunger and malnutrition through enhanced food production techniques. It underscores the critical significance of targeted investment growth, agricultural skills enhancement, and improved financial accessibility as essential strategies for boosting agricultural productivity. The findings are not only relevant to South Africa but also offer valuable lessons for other developing countries facing similar agrarian challenges. By illuminating the pathways to improved food production and food security, this study serves as a foundational resource for policymakers, agricultural practitioners, and other stakeholders striving to create sustainable food systems that can effectively eradicate hunger and elevate nutrition standards on a global scale. This study highlights the usefulness of a collaborative approach incorporating government initiatives, private sector investments, and community engagement to foster a resilient agricultural sector capable of adapting to changing socio-economic conditions.

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1. Introduction

One of the major global problems that persist in many developing countries is the issue of food insecurity (Jacobsen et al., 2013). Despite advancements in technology aimed at assisting agricultural activities

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and increasing food production, challenges in achieving food security continue to plague these countries. One of the primary obstacles to food security is the rapid population growth coupled with limited arable land available for agricultural purposes. The high population growth rate and limited arable land create an imbalance between food demand and supply. This means that the amount of food needed surpasses the available supply, resulting in heightened food insecurity (Miladinov, 2023). Difficult access to finance, high production costs due to inflation rates, and the migration of youth from rural to urban areas in search of a better life are additional factors that impede the food production process and further exacerbate food insecurity in developing countries (Jacobsen et al., 2013; Pawlak & Kołodziejczak, 2020). As discord between population growth and food production in these countries remains a global concern; increasing food production has become one of the United Nations' Sustainable Development Goals, as outlined in the second goal: 'to achieve food security at all levels, improve nutrition for all, and promote sustainable agriculture'.

To address these challenges and strive towards the UN's sustainable goal, governments and social stakeholders have implemented various strategies. These strategies encompass adapting to climate change, improving water and soil management, promoting agricultural diversity, and enhancing farmers' capacity and financial access. It is expected that the implementation of these strategies will play a significant role in developing countries, as the majority of their labour force relies on the agricultural sector, which in turn contributes to their economic growth (Matthew et al., 2019). Correspondingly, agriculture plays a pivotal role in the South African economy, as it contributes to poverty reduction, food security, social development, job creation, and economic growth even during difficult economic conditions. For instance, despite the impact of the COVID-19 pandemic on economic activities, the agricultural sector still contributed approximately 2.3 percent to the country's GDP in 2020 (Matsei, 2021). This contribution was the highest over a decade, as indicated in Table 1.

The role of the agriculture sector in South Africa's job creation is crucial and greatly significant in rural areas. Highlighting its significant impact on aggregate employment, Sihlobo (2023) argues that in the third quarter of 2023, over 956000 people were employed in the agriculture sector. Additionally, although the direct contribution of agriculture to the GDP may be relatively small, it remains a crucial source of raw materials for the manufacturing sector. Around 70 percent of agricultural output is utilized in the production of final goods in the manufacturing industry, while only about 30 percent is directly consumed (Matsei, 2021). This emphasizes the important role of agriculture in the manufacturing process.

Beyond farming, the food production industry encompasses various activities such as transportation, processing, packaging, and distribution. While machinery and technology may play a role in these processes, human capital is also essential. Therefore, the agriculture sector creates jobs not only in farming but also in the broader food production industry. Furthermore, the agriculture sector has a significant impact on a country's currency exchange rate through its trade balance. Figure 1 shows that between July 2016 and June 2021, the sector experienced a trade surplus, highlighting its contribution to the country's economy.

Irrespective of agriculture sector performance and its contribution to economic growth, Dlamini et al. (2023)'s findings suggest that food security remains a serious issue in South Africa. One of the reasons for food insecurity might be that the produced food is not sufficient to sustain all South African households. Nonetheless, given the role of the agriculture sector and its contribution to food production,

Table 1. Contribution of agriculture to GDP (2011–2020).

Year	Total value added (R'million)	Contribution of agriculture value added (R'million)	Contribution of agriculture as % of total value added
2011	2 724 400	58 739	2,2
2012	2 932 879	60 003	2,0
2013	3 183 618	63 121	2,0
2014	3 414 943	70 342	2,1
2015	3 624 908	71 904	2,0
2016	3 891 559	82 406	2,1
2017	4 173 328	93 400	2,2
2018	4 341 292	90 148	2,1
2019	4 523 580	81 337	1,8
2020	4 428 711	101 650	2,3

Source: Matsei (2021).

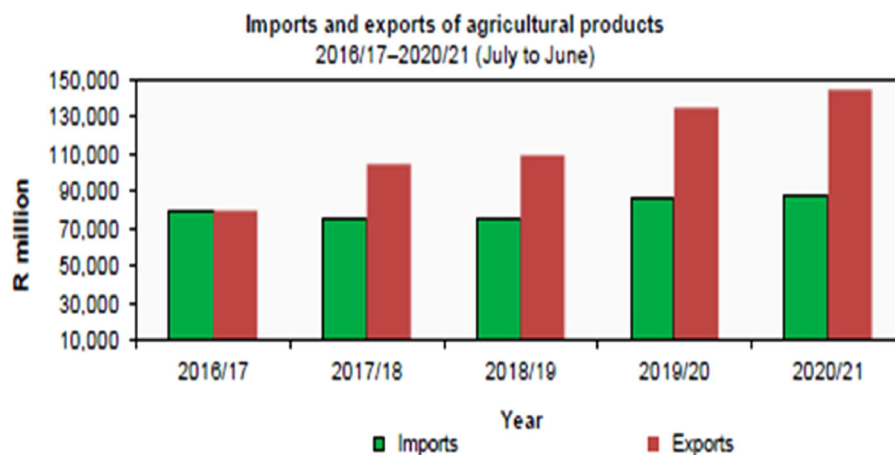


Figure 1. Imports vs exports of agricultural products.

Source: Matsei (2021).

economic growth and employment creation, the current paper aims to analyse the financial and social determinants of food production in South Africa. The existing literature highlights only the importance of access to finance as a solo means to improve agriculture production.

This article breaks new ground by taking a holistic approach to addressing food insecurity, recognizing that social factors play a crucial role in improving the production process. While existing literature often focuses solely on the importance of access to finance, this article goes beyond that, emphasizing the need to consider the broader social context in which agriculture operates. By considering social factors, this article offers a more comprehensive understanding of the challenges facing agricultural production. It argues that addressing these social factors and improving financial accessibility is essential for sustainable and equitable improvements in food production and food security.

2. Concise summation of literature and existing studies

Agricultural food production is influenced by various factors, such as limited and inadequate land, changes in climate, availability of irrigation water, crop characteristics, and financial access for farmers. Among these factors, the availability of financial support is crucial for successful food production. However, due to the risks associated with farming, some banks and financial institutions are reluctant to provide funding for agricultural projects. As a result, the agricultural sector faces a significant issue of insufficient funding, despite employing more than 70 percent of the labour force in many developing economies (Food and Agriculture Organization (FAO)), (2011). The role of the agriculture sector in socio-economic development, especially in achieving the Sustainable Development Goals by 2030, cannot be overstated. Hence, a comprehensive review of the literature on agro-financing and agro-food production is essential.

The significance of the agricultural sector as the primary source of food has prompted both developed and developing countries to take proactive measures over the centuries, and this trend continues in developing nations today (Martin & Clapp, 2015). In developed countries, the agriculture sector laid the foundation for industrialization through financial regulation and support, while in many developing countries, agriculture remains a crucial sector for socioeconomic development (Chang, 2009; Garidzirai, 2020; Friedmann, 1982). It is essential to note that financial support is necessary during the agrarian process, but it is challenging to obtain. This difficulty in financing agricultural activities primarily stems from the fact that farming investments carry higher risks compared to other forms of economic investment, such as services and manufacturing. Consequently, without government assurance, private investors are more hesitant to invest in farming activities (Martin & Clapp, 2015).

Agricultural development and food production are influenced not only by investment and allocation of resources to the sector but also by market conditions and exchange rates. The exchange rate plays a crucial role, particularly for food-exporting countries, as it interacts with exports. When the domestic

currency is strong and there is an increased global demand for food, farmers are incentivized to boost their production and supply in order to meet the demand and increase their profits. On the other hand, a weak domestic exchange rate leads to high production costs, reducing farmers' profits (Orman & Dellal, 2021). Additionally, farm size is a factor that not only affects aggregate production but also access to financial credit. Generally, larger plots used for food production result in higher output. Moreover, investors are more inclined to fund large-scale farmers as they primarily produce for commercial purposes, compared to small-scale farmers who typically produce for household consumption (Anupama & Falk, 2018). The next paragraph provides a concise review of empirical studies on food production and their respective outcome.

Several studies investigated the importance of farmers' access to finance and its implications towards food production. Using a double-hurdle approach, the study of Njogu et al. (2018) in Kenya analysed the role of financial access on 21576 farmers and the production capacity. The study's inferential analysis discovered a significant and positive link between financial access and aggregate production. The authors of the study recommended improvement and easing of financial credits to farmers to increase food production and agricultural activity in Kenya. Using the Autoregressive Distribution Lag (ARDL) model, another study was conducted by Osabohien et al. in Nigeria to assess the effect of access to credit facilities and agricultural food production. Similar to the Njogu et al. (2018) results in the Kenyan agriculture sector, the Osabohien et al. findings indicated a significant positive impact of access to credit facilities to food production in Nigeria. Irrespective of easy credit facilities towards agricultural production both studies, the study by Rahji and Fakayode (2009) suggested small-scale farmers have limited access to financial credits as, in the perception of financial institutions, they present a high risk of defaulting their credits. Similar results were presented in the study by Odoemenem and Obinne specifying that small-scale farmers found difficulties in obtaining financial loans owing to their incapacity to afford loan collaterals. The issue of limited ability to access financial loans impedes small-scale farmers' agricultural activities and thereafter reduces the contribution of the agricultural sector to socio-economic improvement. Nonetheless, the study by Adeleke et al. indicated that the case of incompatibility between farming size and loan access should be generalised as in the same place there exist investors willing to fund small-scale farmers.

Besides the role of farmers' financial access in food production, Sebu (2013) considered also the role of farmland as the combination of the latter with financial access can enhance the agricultural output. In his study, Sebu (2013) found that in Malawi farm sizes influence access to loans and the combination of the two results in high food production.

3. Research methodology

As indicated in the introduction section, the study investigates socio-finance determinants of food production in the South African agriculture sector. The study applied the Johansen and canonical cointegration on annual time series data to achieve this objective. The data sample complies with 60 observations starting from 1961 to 2021. The choice of sample size was based on the data availability and the data was sourced from the World Development Indicator (WDI) and South African Reserve Bank (SARB). As presented in Table 2, the analysis of food production in South Africa comprises 6 (cash credit access, arable land, inflation rate, fertilizer consumption, rural population growth, and interest rate) independent variables. These variables were selected based on their role not only in food production but also in food affordability or food security.

Table 2. Variable description and summary statistics.

Variable	Ellipsis	Measurement	Source	Mean	Max	Min	SD
Food production	FP	Indexed 2004–2006 = 100	WDI	4.115	4.739	3.472	0.345
Cash credits Access	CCA	Millions of rand	SARB	8.059	10.200	4.905	1.587
Arable land	ARL	Hectares	WDI	15.489	15.830	14.892	0.301
Inflation	INF	Annual percentages	WDI	1.897	2.926	0.220	0.656
Fertilizer consumption	FTC	Kgs per hectare of arable land	WDI	4.047	4.651	2.885	0.345
Rural population growth	RPG	annual percentages	WDI	1.294	2.876	−1.092	1.361
Interest rate	IR	Annual percentages	WDI	12.527	22.333	5.500	4.697

Source: Authors' compilation.

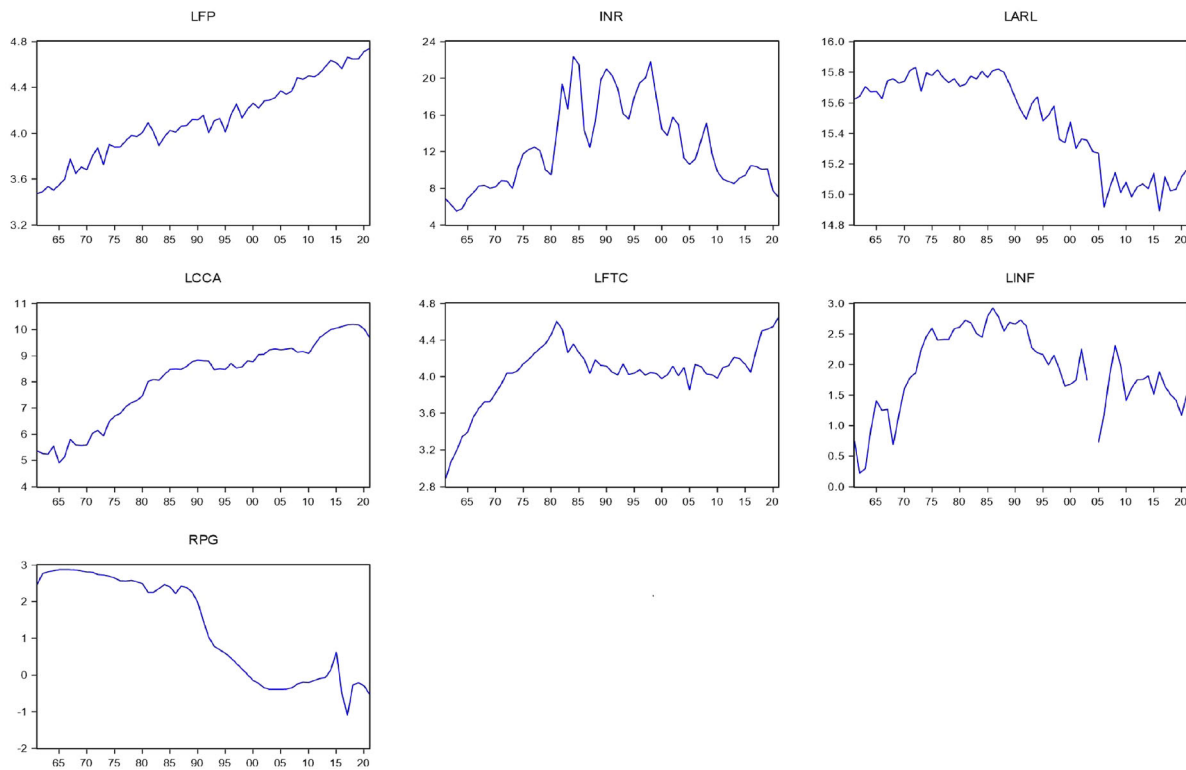


Figure 2. Graphical representation on used data.

The descriptive statistics of selected variables are displayed in [Table 2](#) below. The averages of used variables are 4.115; 8.059; 15.489; 1.897; 4.047; 1.294 and 12.527 for food production cash credits, arable land, food inflation, fertilizer consumption, interest rate and rural population growth respectively. As designated by the difference between maximum and minimum values, over the sample period, interest rate experienced the highest fluctuation with a standard deviation of 4.697 while the lowest variation was experienced in the arable land with a standard deviation of 0.301. This implies data since 1961 the number of people interested in farming did not increase significantly or other individuals interested did not have access (were not permissible) to arable land. The history of land distribution in South Africa backs these results as for decades, even centuries arable land remains a monopoly of certain groups of individuals (Hall & Kepe, 2017).

The graphical representation or plot of used variables shows trends in all variables. While dominant trends for LFP, LCCA, LINF and LFTC are positive, INR, LARL and RGP experienced downward trends. These observed trends suggest that used data is not stationary at levels as shown in [Figure 2](#). Thus, stationarity or unit root test is required to determine integration order for each variable.

3.1. Model specification

In the context of the current study, the relationship between food production and its determinants in South Africa is implicitly presented as follows:

$$FP_t = f(CCA_t, ARL_t, FTC_t, INF_t, IR_t, RGP_t) \quad [1]$$

Where the latter t is associated with each variable indicates the period. From [Equation 1](#), a non-linear model is delivered and presented as follows:

$$FP_t = \alpha + CCA_t^{\beta_1} + ARL_t^{\beta_2} + FTC_t^{\beta_3} + INF_t^{\beta_4} + IR_t^{\beta_5} + RGP_t^{\beta_6} + e_t \quad [2]$$

The process of addressing challenges that may arise in estimating [equation 2](#) in its non-linear form involves employing the strategy of linearizing the equation. This was accomplished by applying a

double-log transformation to [equation 2](#), resulting in the formulation of [equation 3](#). By utilizing the natural logarithm to transform the variables, a common unit of measurement is established. This establishment enables a more meaningful interpretation of the estimated coefficients, facilitating the comparison of the effects of different variables on the outcome. Furthermore, the transformation aids in reducing the occurrence of heteroscedasticity, which pertains to the uneven spread and variance of the error term. The linearization technique diminishes the likelihood of heteroscedasticity within the model, ensuring that the assumption of constant variance is met and improving the accuracy of the estimated coefficients. Additionally, the double-log transformation facilitates the estimation of a Best Linear and Unbiased Estimator (BLUE). The BLUE estimation yields efficient and unbiased estimates of the model coefficients, making it a desirable characteristic within the realm of econometric analysis. By linearizing [equation 2](#) through the utilization of the transformation method, the resulting formulation of [equation 3](#) enables the application of standard linear regression techniques, thereby enabling the estimation of the coefficients through the utilization of rigorous and well-established statistical methods.

$$\ln FP_t = \varphi_0 + \varphi_1 \ln CCA_t + \varphi_2 \ln ARL_t + \varphi_3 \ln FTC_t + \varphi_4 \ln INF_t + \varphi_5 \ln IR_t + \varphi_6 \ln RGP_t + e_t \quad [3]$$

Where \ln represents natural logarithm, φ_0 denotes the intercept term, φ_1 is the coefficient of cash credit access or agro-financing, φ_2 is the coefficient of arable hectares, φ_3 is the coefficient of Fertilizer consumption, φ_4 is the coefficient food inflation, φ_5 the coefficient of landing interest rate, φ_6 is the coefficient of rural population, t denotes time and e signifies the error term. The expected results are that agro-financing, arable land, fertilizer consumption and population growth have a positive effect on food production while inflation and interest rates are expected to have a negative on food production. The expected results can, symbolically be presented as follows, $\varphi_0 > 0, \varphi_2 > 0, \varphi_3 > 0, \varphi_6 > 0, \varphi_4 < 0, \varphi_5 < 0$. The reason behind the expected results is that an increase in agriculture funds will enable farmers to increase and speed up their farming productivity while large arable land, more fertilizer and more labour (population growth) would lead to high output. On the other hand inflation and interest rates are expected to reduce food production through low demand and high cost of production respectively.

3.2. Unit root test

Each study that employs time series to assess a relationship amongst two or more variables should first be subjected to stationarity tests. The latter assists in destemming an adequate cointegration approach following the established integration order. Additionally, the unit root tests are vital in ascertaining that the analysed time series are stationary and there the study outcomes are not spurious. The Augmented Dickey-Fuller test (ADF) and Phillips-Perron (PP) tests were used to establish the integration order of the study variables. It is important to note that the ADF is built on the first-order autoregressive process model (Box & Jenkins, 1970). Following the ADF approach, the following equation was applied to assess whether collected variables have unit roots or not.

$$Y_t = \emptyset_1 Y_{t-1} + u_t \quad t = 1, \dots, T \quad [4]$$

Where \emptyset_1 represents a constant term, u_t denotes the non-systematic factor of the model that meets the features of the white noise process. The subsequent hypotheses are used to diagnose the absence or presence of a unit root in a specified variable:

The null hypothesis $H_0 : \emptyset_1 = 1$ suggests that the variable contains a unit root and it is, consequently, not stationary at level, and can become stationary after the first difference $I(1)$.

The alternative hypothesis $H_0 : |\emptyset_1| < 1$, suggests that the variable does not contain a unit root and is stationary at level $I(0)$. The Phillips-Perron test follows the same procedure described in [Equation 4](#). However, contrary to ADF which considers T-statistics, to assess unit root, the PP test considers Z-statistics for a similar outcome. The next section presents and discusses the study results.

4. Results report and interpretations

4.1. Unit root test

The unit root results from both tests (Augmented Dickey-Fuller test and Phillips-Perron) are presented in Table 3. All variables are stationary after the first difference with more than a 95 percent level of confidence as all series are statistically significant at less than one percent level ($P\text{-value} < 0.01$).

4.2. Lag length determination

Given that the unit root test results indicated that all variables under consideration are integrated of the first order, it is noteworthy to determine the number of lags to be included in the model. From the results displayed in Table 4, the majority of lag length criteria suggest the use of one lag. In this regard, Schwarz's information Criterion (SC) is selected as the best owing to the study sample which is not too large, and the SC is the choice for a small sample.

4.3. Cointegration

In order to analyse the relationship between the respondent variable (food production) and its explanatory variables (Cash credits, arable land, food inflation, fertilizer consumption, rural population growth, and interest rate), it is necessary to first confirm whether these variables are stationary. Once it is established that the variables are stationary, the next step is to assess the presence of a long-run relationship between them. The Johansen test for cointegration is a suitable approach to determine the presence of a long-run relationship when the variables are stationary at first difference. Through conducting this test, evidence of cointegration between the variables under consideration can be ascertained. The results of the Johansen test for cointegration, displayed in Table 5, indicate a rejection of the null hypothesis. This rejection suggests that there is indeed evidence of cointegration, indicating the presence of a long-run relationship between the variables. In other words, the Johansen test results provide valuable insights into the dynamics and interdependencies among the analysed variables, contributing to the general understanding of the factors influencing food production in South Africa.

From the Johansen test results, the authors of the study proceeded with the establishment of a long-run relationship using the canonical cointegration regression. The cointegration test outcome in Table 5 indicates that a long-run relationship exists between food production, cash credits or investment, arable

Table 3. Unit root results.

Variable	ADF		PP		Conclusion
	Level	1 st difference	Level	1st difference	
Food production	0.9997	0.0000***	0.9979	0.0000***	I(1)
Cash credits	0.5430	0.0000***	0.5164	0.0000***	I(1)
Arable land	0.8865	0.0000***	0.8631	0.0000***	I(1)
Inflation	0.3114	0.0000***	0.2875	0.0000	I(1)
Fertilizer consumption	0.5672	0.0000***	0.5698	0.0000***	I(1)
Rural population growth	0.9161	0.0000***	0.9232	0.0000***	I(1)
Interest rate	0.3507	0.0000***	0.3833	0.0000***	I(1)

Source: Authors' compilation.

Table 4. Lag length selection.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	638.0445	NA	5.57e-20	-30.14498	-29.93811	-30.06915
1	840.9746	347.8802*	1.18e-23*	-38.61784	-37.37665*	-38.16289*
2	866.0126	36.96074	1.24e-23	-38.61965	-36.34413	-37.78558
3	891.3028	31.31168	1.40e-23	-38.63347	-35.32362	-37.42028
4	918.6165	27.31375	1.68e-23	-38.74364	-34.39947	-37.15133
5	955.7670	28.30516	1.64e-23	-39.32224	-33.94374	-37.35081
6	987.8650	16.81322	3.29e-23	-39.66024*	-33.24741	-37.30968

Source: Authors' compilation.

Table 5. Johansen cointegration results.

Cointegrating rank	Trace test			Maximum eigenvalue		
	Statistic	Critical value	p-value	Statistic	Critical Value	p-value
None *	139.7583	125.6154	0.0052	50.487	46.23142	0.0165
At most 1	89.2705	95.75366	0.1285	31.6452	40.07757	0.3228
At most 2	57.6253	69.81889	0.3155	28.2081	33.87687	0.2041
At most 3	29.4179	47.85613	0.7482	19.1707	27.58434	0.4015
At most 4	10.2465	29.79707	0.9765	7.88636	21.13162	0.9105
At most 5	2.36010	15.49471	0.9885	2.31613	14.26460	0.9816
At most 6	0.04397	3.841465	0.8339	0.04397	3.841465	0.8339

Both Trace and Eigenvalue tests suggest the existence of 1 cointegration equation.

Note. * rejection of H_0 of no cointegration.

Source: Authors' compilation.

Table 6. Canonical cointegration results.

Variable	Coefficient	Std. error	t-Statistic	Prob.
Arable land	-0.165300	0.073930	-2.235900	0.0295**
Cash credits	3.09620	0.635217	4.874244	0.0000***
Fertilizer consumption	0.155584	0.075105	2.071541	0.0431**
Inflation	-0.31616	0.103315	-3.060168	0.0032**
Lending interest rate	-1.627208	0.251180	-6.478244	0.0000***
Rural population growth	1.053696	0.255919	4.117304	0.0001***
Observation	60			
R-squared	0.931846			
Adjusted R-squared	0.925535			

Note. *** & ** represent statistical significance at the 1% and 5% and 10% level. Long-run covariance estimate (Prewhitening with lags = 1 from SIC maxlags = 1, Bartlett kernel, Newey-West fixed bandwidth = 4.0000). Variables were in their logarithm form.

land, food inflation, fertilizer consumption, rural population growth and interest rate. The explanatory variables' coefficients possess the expected sign except for arable land. In other words, cash credit, fertilizer consumption and population growth have a positive impact on food production, while arable land, food inflation and interest rates negatively affect food production in the South African agriculture sector.

The statistical results indicate that a one percent increase in arable is associated with an approximately 0.17 decline in food production. The expected finding was that increasing the number of hectares used in food production would assist in impressing the quantity of produced food. The inverse relationship between arable land and food production implies that people or farmers with skills, knowledge and other means for food production have enough land to use. Increasing the arable land will require to include farmers with low skills and less farming knowledge consequently, the average of food production per arable hectare will decline. These results are opposed to those of Osabohien suggesting that increasing arable land increases food production. Additionally, the results in Table 6 indicate that a one percent increase in inflation leads to a nearly 0.32 percent decline in food production in South Africa. This finding was expected as high inflation leads to a high cost of production through the high cost of agricultural input and also reduces farmers' profits as high inflation is associated with low demand. Similarly, a high-interest rate causes a decrease in food production as a high interest rate implies a high cost of borrowing. Besides a reduction of investment in the agriculture sector, high interest rates will lead to a high cost of living resulting in low demand for agricultural products. Consequently, irrespective of the high cost of production, farmers will be forced to reduce the price of their crops to be able to sell what they have produced. These corroborate with those of Iliyasu (2019) stipulates that interest rates cause disturbances in agricultural activities in Nigeria.

Contrary to Arable land, inflation and interest rates that are inversely related to food production in South Africa, cash credits, fertilizer consumption and population growth have a positive effect on food production in South Africa. For instance, a one percent increase in cash credit results in approximately a 3.10 percent increase in food production while a one percent increase in fertilizer consumption is associated with an almost 0.16 percent increase in food production. In addition, food production in the South African agriculture sector increases by approximately 1.05 percent as a response to a one percent increase in population growth.

Among all analysed variables, cash credit or access to finance has a crucial positive effect on food production in South Africa. This is because all farming activities involve money and constraints in the latter slow food production processes. These results support those of Njuguna and Nyairo and Osabohien et al. indicating that low access to finance and loans impede food production in Kenya and Nigeria respectively. Concerning a positive relationship between rural population growth and food production, it implies that more farming activities in South Africa are performed in rural areas and more people imply more labour. Although people in rural areas might not meet all the requirements of large-scale farmers, they can be small-scale farmers and those unable to farm for themselves become farming workers to those with high farming capacity and resources. Thus, other things being equal, more and less expensive workers are associated with food production growth. Lastly, increasing fertilizer consumption results in a high quantity of produced food as the latter remains one of the factors in food production. As a summary, of these findings, improvement in agro-food production mostly relies on two major drivers namely access to finance and human capital availability.

4.4. Vector error correction model (VECM) analysis

The presence of long-run relationships among variables requires the estimation of the vector error correction model. The latter offers a mechanism to comprehend the long-run as well as short-run behaviour of the variables in the system. The error correction term (ECT) from the VECM estimation, provided in Table 7, determines whether the model's short-run dynamics revert to long-run equilibrium or if the model is explosive. It is important to highlight that this study considers the error terms located at the right side in the cointegrating equation. In other words, the reported error terms are from independent variables. Therefore, these terms can explain long-term equilibrium if their coefficients are statistically significant and have a negative sign. As displayed in Table 7, D(LFP), D(LARL), D(LINF) and D(LFTC) are the ones that explain the model adjustment towards long-run equilibrium. The rest are not statistically significant.

4.5. Diagnostic results

To ensure the validity and trustworthiness of the findings, the employed model was subjected to various diagnostic tests. The results in Table 8 provide an endorsement that the study employed an adequate model. This is supported by a rejection of the null hypotheses for normality, autocorrelation and heteroscedasticity tests.

4.6 Granger causality

Having established the integration order for the observed variables, the subsequent step of analysis is to perform the Granger causality test. The granger causality test will assist in determining the causation among variables and selecting variables ordering while performing impulse responses function and variance decomposition. The general principle of Granger causality analysis is to test the hypothesis

Table 7. VECM results.

Variable	D(LFP)	D(INR)	D(LARL)	D(LCCA)	D(LFTC)	D(LINF)
ECT	−0.519540	0.212661	−0.346433	0.018168	−0.714152	−0.346453
S.E	(0.17390)	(0.15239)	(0.10243)	(0.62623)	(0.27822)	(0.104893)
t-Value	[−2.98758]	[1.39547]	[−3.38199]	[0.02901]	[−2.56683]	[−3.30291]

Source: Authors' compilation.

Table 8. Residual diagnostic test results.

Test	P-value	Decision
Jarque-Bera for Normality	0.995	Residuals are distributed symmetrically around zero
LM test for autocorrelation	0.5350	Residuals are independently and identically distributed
White for heteroscedasticity	0.7283	Residuals are homoscedastic
Ramsey RESET Test	0.3617	The model has no omitted variables

Source: Authors' compilation.

Table 9. Granger causality results.

Null Hypothesis	F-Statistic	P-Value
INR does not Granger Cause LFP	2.20149	0.0465*
LFP does not Granger Cause INR	1.34198	0.2560
LARL does not Granger Cause LFP	2.57850	0.0323*
LFP does not Granger Cause LARL	2.32838	0.0496*
LCCA does not Granger Cause LFP	2.06008	0.0787**
LFP does not Granger Cause LCCA	0.64754	0.6917
LFTC does not Granger Cause LFP	2.43601	0.0290
LFP does not Granger Cause LFTC	0.70041	0.7165
LINF does not Granger Cause LFP	3.41683	0.0102**
LFP does not Granger Cause LINF	0.66361	1.14401
RPG does not Granger Cause LFP	2.33956	0.0487*
LFP does not Granger Cause RPG	0.77433	0.5945

Note. * and ** denotes rejection of the null hypothesis at 5% and 10% significance level.

suggesting that the past values of the explanatory variables help to explaining the present value of independent variables and vice versa. The results from the granger causality test in Table 9 indicate that a bidirectional causation exists between arable land (LARL) and food production (LFP) whilst a unidirectional causation exists between cash credit access (LCCA), fertilizer consumption (LFTC), rural population growth (RPG), inflation (LINF), interest rate (INR) and food production (LFP).

4.7. Impulse response function

The results emanating from the Stationarity tests, as highlighted in previous section, aided in guiding the study with respect to the selection of the appropriate estimation technique. Thus, this study selected the vector autoregressive (VAR) model as best suited to examine the dynamic interdependencies and relationship among the variables. Čičak and Sorić (2015) argue that in a VAR model, the estimated parameters themselves are not important because the variance decomposition and impulse response function provides insightful interpretation and conclusions of the dynamic relationship between the variables. Hence, VAR model results are not presented in this study. To construct the variance decomposition the study ensured that the variance-covariance matrix of the VAR residuals are orthogonal. Then the Cholesky factorisation technique was selected, presuming a certain order of variables in the model. The authors were cautionary with this step because the order of variables could affect the quality of results. Consequently, a variable with no effect or weak causation on the dependent variable is placed last. The ordering of variables in Cholesky factorisation was determined on the basis of the results of the Granger causality results presented in Table 9 above.

Based on the validity and dependability of the model as indicated by the results on Figure 3, it is important to assess the impact of shocks in explanatory variables towards the response variable. It is also necessary to evoke that an impulse response function (IRF) elucidates the response of an endogenous variable to specific innovations in the vector autoregression (VAR) model. It explains the evolution of a given variable within an identified time following a shock or change at any point in time. The impulse responses of food production towards a one standard deviation alteration in endogenous variables are exhibited in Figure 3. The impulse response results confirm the canonical cointegration regression outcome as both results indicate that changes in explanatory variables cause changes in food production.

The results in Figure 3 suggest that from the second quarter of first year to the second year, food production negatively respond to positive shock in arable land. From the second year to the tenth year, the response of LFP to one standard deviation in LARL increases at the steady state but always in negative zone. The response of LFP to one standard deviation shock in LINF is negative for the early period but from the second year it increases up to the third year and between then third and fourth year is constant. Between the fourth and tenth year it declines and then become constant up to the tenth year. For shocks in LFTC, the LFP responds positively and then declines consistently but remains in the positive zone. The response of LFP to shocks or innovation in INR over the analysed period is negative but, though in negative zone, increases gradually. Lastly, the response LFP towards shocks in RPG and LCCA is generally positive and constant but close to zero. Briefly, LFP responses to innovation or shocks in itself, LARL, LINF are more significant than responses to changes in LFTC, INR, RPG and LCCA.

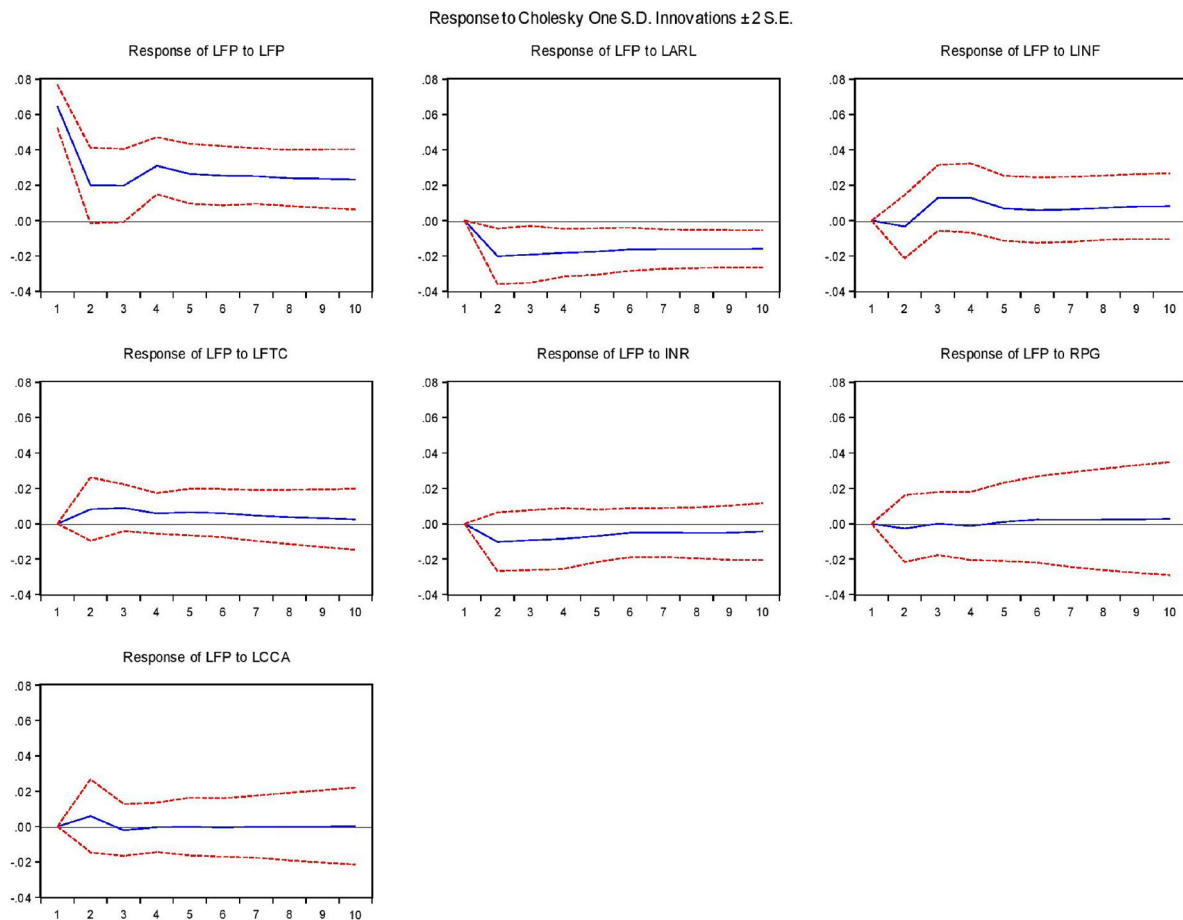


Figure 3. Impulse response functions results.

Table 10. Variance decomposition (LFP VS LARL, LINF, LFTC, INR, RPG, LCCA).

Period	S.E	LFP	LARL	LINF	LFTC	INR	RPG	LCCA
1	0.064576	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.072125	87.69777	7.949987	0.231210	1.276021	2.01867	0.146058	0.680283
3	0.079356	78.62802	12.46705	2.797388	2.326425	3.03355	0.120772	0.626792
4	0.088632	75.18744	14.26884	4.277892	2.304272	3.33614	0.120264	0.505140
5	0.094869	73.36082	15.90185	4.253427	2.486800	3.43863	0.117510	0.440958
6	0.100042	72.36497	16.96676	4.167140	2.589408	3.35564	0.156544	0.399536
7	0.104832	71.61450	17.85842	4.147884	2.546282	3.28537	0.183505	0.364032
8	0.109212	70.80858	18.66558	4.247473	2.465831	3.26207	0.215024	0.335427
9	0.113371	70.06385	19.35733	4.424985	2.363328	3.23069	0.248494	0.311313
10	0.117265	69.41034	19.98554	4.608534	2.252729	3.16408	0.287299	0.291468

4.7.1. Variance decomposition

Table 10 presents the variance decomposition estimated results for the prognostic period of 10 years. Prior to the estimation of variance decomposition, first the variance-covariance matrix of VAR residuals was orthogonalized, and the Cholesky factorization was selected following variables ordering discussed in the impulse responses section. The results in Table 10 indicates that changes in the explanatory variable will have no impact on food production in the first future period, the LFP fully explains the variance of its prognostic error. After the first year, this percentage declines to approximately 87.70 percent. In other words, LFP explains 87.7 percent of the variance of its changes in the second year. From the second years, 7.95 percent the variance of the LFP prognostic error is explained by LARL. In the fifth years, 15.90 percent, 4.25 percent, 2.49 percent, 3.44 percent, 0.12 percent and 0.44 percent of the variance of LFP prognostic errors are explained by changes in LARL, LINF, LFTC, INR, RPG and LCCA respectively. In the tenth year, approximately 20 percent of variance in LFP is explained by availability of arable land (LARL) while cash credits access explains only 0.29 percent of the

variance of food production (LFP) prognostic error. Based on the results in Table 10, among the selected explanatory variables LARL, LINF and INR have more influence in explaining the future variation of food production compare to other selected variables.

5. Conclusion and recommendations

The second goal of the 2030 Sustainable Development Goals (SDGs) aims to promote sustainable agriculture through which hunger can be eliminated and food security achieved. This goal formed the motivation for the current study. Applying various econometric techniques on annual data from 1961 to 2021, the study findings revealed the presence of a long-run relationship between agro-finance and food production in the South African economy. The crucial driver of food production was found to be access to cash credit, population growth and fertiliser consumption. The study also established an inverse relationship between high borrowing interest rates, inflation and food production in South Africa. Additionally, increasing arable land was found to cause a decline in average food production. This implies that, if the aim is to improve production in the agriculture sector and its contribution to economic growth, the policy of land distribution in South Africa needs to be implemented with caution.

Except for arable land, the study findings met the a priori expectation. Cash credit access will assist farmers in hiring more labour and acquiring other agricultural inputs machinery, seedlings, fertilisers and pest control chemicals while population growth will reduce cost production, in terms of labour, and increase aggregate production. In contrast, a high interest rate will reduce access to finance which is the key content in food production whilst an inflation rate is more likely to reduce farmer's ability to purchase necessary farming implements. A combination of high interest rates and inflation may limit the farmers' ability to improve their productivity through capital and advanced technology and force them to mainly focus on labour-intensive which might reduce total productivity.

Based on the aforementioned findings, to ensure national food security and improved food production in South Africa, the study recommends the following: (i) sufficient funds should be assigned to the agriculture sector; (ii) new farmers should be given training, skills development workshops and starting funds; (iii) besides government supports, private investors should be encouraged to invest in the agriculture sector; (iv) a creation farmers association would allow the positive impact of the increase in arable land towards food production. In future studies, the role of land redistribution and agriculture structural change on food security and economic growth should be considered.

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No potential conflict of interest was reported by the author(s).

Authors contributions

This article was collaboratively produced by two researchers namely Thomas Habanabakize and Zandri Dickason-Koekemoer. Habanabakize essentially took the lead on conceptualizing the topic, data collection, data analysis and results discussion. Dickason-Koekemoer focused mainly on the literature review of the paper. The rest parts of the article were processed through close collaboration between the two authors.

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Data availability statement

Data available on request from the authors.

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