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Shikur, Zewdie

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Credit market development and agricultural production in selected African countries: Climate change perspective

Zewdie Habte Shikur[1]

[1] Wolaita Sodo University, Sodo, Ethiopia

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Abstract. This study aimed to examine the long and short-run relationships between credit market development and agricultural production using the Autoregressive Distributed Lags (ARDL) Bounds test for cointegration, as well as the direction of causality by using the Granger causality test. The results of the ARDL Bounds test revealed that institutional credit development had a significant long-run effect on agricultural production in all countries under examination, except for Tunisia; that is: Benin, Kenya, and Nigeria. In the short run, credit market development had a significant and positive effect on agricultural production in Nigeria. By contrast, the effect of credit market development on agricultural production was negative in the short-run in Benin, Kenya, and Tunisia. The result of granger causality test revealed the existence of significant bi-directional causal links between institutional credit development and agricultural production in Benin, Kenya and Nigeria, no significant interdependence was found between the two variables in Tunisia. Capital formation had a significant and positive effect on agricultural production in the long-run and short-run in all countries. Climate change was negatively associated with agricultural production in all countries except for Nigeria. The exchange rates and real interest rates had a negative effect on agricultural production in the long-run and short-run in all countries.

JEL classification: F33, Q11, Q14

Key words: agricultural production, credit market development, real interest rate, agricultural loan supply, climate change

1 Introduction

Agricultural policies (Shikur 2020a), industrial policies (Shikur et al. 2020, Shikur 2020b), irrigation utilization (Shikur 2021a,b), adoption of technology (Shikur 2020a), information asymmetry (Habte et al. 2016), sector linkage (Habte et al. 2017, 2020), market coordination (Shikur 2021a,b), agricultural product export (Shikur 2022a,b), and labor and capital supply (Shikur 2022c) are cited as influential factors related to agricultural production and productivity at country level. A large body of literature argues that agricultural production substantially depends on climate change (UNFCCC 2007) as well as credit market development (Badibanga, Ulimwengu 2019, Zhu et al. 2021). Thus, this study is useful to contribute to the scarce literature on the role of climate change and credit market development played in agricultural production.

Climate change could cause reduced productivity of agricultural land, labor, capital, and agricultural technologies by shortening growing periods and reducing crop and pasture yields (UNFCCC 2007). This implies that agricultural credit loans have not been transformed into agricultural productivity due to climate change. Climate change may influence agricultural production by altering ecosystem services like water/rainfall availability, animal feed availability, and disease outbreak (Vining 1990). Warming climate causes increased heat, reduction in water supplies and the quantity and quality of animals' feed supplies; and results in insect and pest outbreaks (Ayal, Leal-Filho 2017). However, the effect of climate change on agricultural production may vary across countries due to environmental policy differences. As a result, the empirical findings are inconsistent across countries. So including the environmental control variable in the model is very useful for improving financial policy and its application; and influencing credit utilization and resource allocation efficiency across sectors of the economy. Moreover, the impact of climate change on agricultural growth has not been thoroughly researched in earlier empirical studies.

Credit market development substantially determines agricultural growth and productivity by increasing farmers' purchasing power of agricultural technologies and resource allocation efficiency (Anetor et al. 2016, Badibanga, Ulimwengu 2019, Zhu et al. 2021). Thus, subsidized credit loans have widely been employed in many developing countries to reduce poverty (Chandio et al. 2020, Kaya, Kadanalı 2021). However, there has been continued debate on the impact of financial development on economic growth in the literature. The magnitudes and signs of financial development coefficients in the agricultural sector differ across countries. The impact of financial development on agricultural growth significantly varies across levels of economies (An et al. 2020). They identified the positive and negative effects of financial development on agricultural growth in low and high-income countries, respectively.

The study chooses nations like Benin, Kenya, Nigeria, and Tunisia to bridge the gap between theory and practice. The effect of financial market development on agricultural production is yet unknown in the selected countries, despite the fact that agricultural loans, exchange rates and interest rates are the major drivers of agricultural productivity and production. This study differs from earlier studies by investigating the impact of credit market development on agricultural growth, where the real interest rates and the agricultural credit loans were not used as proxy variables for financial development in the empirical literature related to this sector. This literature on bank-based financial systems provides new insights into the possible mechanisms through which agricultural lending interest likely affects rural economic development.

The empirical findings show that there is also no clear consensus on the causal direction between financial development and economic growth. Also, there is a lack of empirical evidence on the causal direction of this topic in selected African countries. For instance, empirical studies have shown the existence of a bi-directional relationship between the two variables (Mukhopadhyay et al. 2011, Kaya, Kadanalı 2021). Financial development leads to economic growth (Boulila, Trabelsi 2002); a unidirectional causality running from economic growth to financial development (Lian, Teng 2006). Other empirical findings show that there is no causal relationship between financial development and economic growth (Boulila, Trabelsi 2004). Therefore, to fill this scientific gap, it is important to investigate the relationships between credit market development and agricultural production.

The paper is structured as follows. This paper critically reviews the theoretical and empirical literature on the nexus between financial development and economic growth at country and sector levels in Section 2. The study explains each variable and describes the methods of analysis in Section 3. Section 4 presents the findings, and provides interpretations of the results. Finally, the policy implications are presented in the conclusions (Section 5).

2 Literature review

The conceptual framework for this study is primarily framed by the theory of McKinnon (1973) and Shaw (1973). The McKinonn-Shaw model argues that there are two main components of financial development that have an impact on economic growth. Developing domestic financial markets could benefit from increasing the effectiveness of capital formation is one way. On the other hand, financial intermediation might contribute to an increase in savings rate, which would then raise the investment rate.

The McKinnon-Shaw hypothesis states that there should be a close association between the level of financial intermediation and the current real interest rate. When the real interest rate is kept below normal competitive levels, it shows the severity of financial repression. According to this argument, a high real interest rate promotes savings and financial intermediation, which raises the quantity of credit supply to the private sector (Fry 1997). This promotes investment and economic growth in turn. The McKinnon-Shaw theory (McKinnon 1973, Shaw 1973) emphasizes real interest rates' effects on savings as the primary route of transmission, but it is also recognized that positive real interest rates boost the efficiency of how investable funds are distributed, having a further positive impact on economic growth. Real interest rates have an impact on savings rates, according to the McKinnon-Shaw hypothesis, but it is also known that higher real interest rates stimulate more efficient use of investable capital.

The theory assumes that money supplied as loans to the private sector is referred to as inside money since it is backed by the internal debt of the private sector investors. Saving is a function of nominal interest rate and predicted inflation rate. Saving at real economic growth rate is positively affected by the real interest rate (nominal interest rate minus predicted inflation rate). Throughout this process, the rate of economic growth rises, and both the volume and quality of investment are increasing, which together have a positive impact on the growth rate.

The competitive free-market equilibrium deposit rate of interest may be raised without harming the lending rate by reducing reserve requirements or by paying the competitive loan rate on required reserves. The actual credit supply will rise as a result, accelerating economic development (McKinnon 1973, Shaw 1973). The rate of economic growth is influenced by real deposit rate of interest in the steady state by both quantity and average productivity of investment (Fry 1997). Changes in the real deposit rate have an impact on both short-term growth and inflation through the availability of working capital finance.

A high level of monetization should be positively correlated with economic growth, according to the original McKinnon-Shaw hypothesis, because in theory, a monetized economy indicates a highly developed capital market. The fundamental issue with this argument derives from the fact that financial markets' two main goals are to transfer money from savers to those in need and to provide liquidity (or transactional services). More importantly, the banking sector's ability to successfully supply and distribute loans is as a measure of financialization.

The extent of the credit market's development may be more closely connected with these measures when compared to more limited definitions of money (M_1), but other factors besides financial depth may still be significant. Neal (1988) in particular relied on indicators of quasi-liquid assets by leaving out M_1 and M_2 because M_3 still contains liquid assets (M_1). Even though credit seems to be the strongest indicator of how much financial intermediation takes place through the banking system, it may be a less reliable indicator of financial development overall because a sizable portion of financial development takes place outside the banking sector. This trend seems to be more prominent in industrialized countries where non-bank financial innovation has been substantial (Goldstein et al. 1992). Similar to real interest rates; there are problems with substituting monetary aggregates for the degree of financial intermediation. These aggregates are most likely to result in major problems. In contrast, the majority of financial progress in emerging countries has occurred within the banking sector. As a result, credit is arguably a stronger indicator of overall financial progress in these countries.

Although there is no consensus on financial development indicators, the size of the formal financial intermediary sector relative to GDP, the importance of banks relative to the central bank, the percentage of credit allocated to private firms, and the ratio of credit granted to private firms to gross domestic economic growth are commonly used as indicators of the level of financial development (King, Levine 1993). Credit to the private sector is also a frequently used variable in the literature (Beck et al. 2000, Levine 2005). Similarly, this study uses the amount of credit granted to the agriculture sector as an indicator of financial sector intermediation. The main benefit of credit over other monetary aggregates is that it more correctly captures the function of financial intermediaries in distributing funds to private market participants by excluding credit to the government sector. Financial intermediation should be defined in this way to better understand how investment levels and efficiency relate to economic growth.

Many scholars argue economic growth is retarded by indiscriminate distortions of financial prices such as interest rates and foreign exchange rates (McKinnon 1973, Shaw 1973, Greenwood, Jovanovic 1990, King, Levine 1993). Financially restrictive regulations, such as restrictions that result in negative real interest rates, reduce the households' incentives to save. Lower savings also have an adverse effect on growth and investment. They come to the conclusion that higher interest rates resulting from financial liberalization induce households to save more money. Saving at the real economic growth rate is positively affected by the real interest rate. Throughout this process, the rate of economic growth rises, and both the volume and quality of investment increase, which together have a positive impact on the growth rate.

In general, the McKinnon-Shaw theoretical arguments are supported by some empirical works (Anwar, Nguyen 2011, Arestis et al. 2015). The empirical results confirm that financial development leads to economic growth in Indonesia, Singapore, the Philippines, China, and India (Mukhopadhyay et al. 2011), Egypt, Mauritania, and Turkey (Boulila, Trabelsi 2002). The relationship between financial development and sectors of economic growth has also been studied in Africa (Adu et al. 2013, Ustarz, Fanta 2021). In general, empirical results provide divergent results concerning the strength and sign of the coefficient or connection of two variables in the agricultural sector. These arguments and empirical evidence oppose Keynes' arguments.

Numerous scholars have criticized the McKinnon-Shaw theory's empirical validity. For instance, the Latin American experience suggests that financial depth increases the marginal productivity of capital rather than the amount of savings and investment (Diaz-Alejandro 1985). The literature underlines that real interest rates may be high even when they are unrelated to the marginal productivity of capital because of elements such as public expectations of inflation, outright rejection of government obligations, and, more broadly, lack of credibility of economic policy. These elements include explicit opposition to government commitments and public expectations of inflation. A number of factors, including the presence of a precarious financial structure, a lax regulatory environment, and the absence of an effective legal framework to protect property rights, can affect real interest rates in the case of Eastern European countries (Calvo, Coricelli 1992).

Keynes argued that the role of interest rates in the process of the functioning of financial systems is relatively unimportant for economic development. He argues that investment finance does not depend upon the level of savings. Money needed for private sector investment could largely be supplied by the banking system. His argument is supported by the work of Demetriades et al. (1998). They argue that financial policies, specifically controlled interest, directed credit programs to specific industries, and high reserve and liquidity requirements, have a statistically significant influence on average capital productivity in five Southeast Asian economies: India, South Korea, Sri Lanka, the Philippines, and Thailand.

The supporters of the neoclassical view argue that financial development has little or no role in the process of economic growth and wealth creation because the financial system operates efficiently. They believe that economic growth is mainly derived from physical capital formation; human capital, and technological changes. A large body of literature points out that the neoclassical perspectives do not operate in the real-world situation due to financial market failures, such as unfair terms on loans, higher interest rates, and unfamiliar characteristics of production risks. On the other hand, investment finance in developing countries is expected to be financed by producers (Mathieson 1980, Fry 1997).

Despite advances in the growth literature, the question of whether financial development plays a causal role in economic growth remains debatable. Probably, the opposite is true: According to Robinson (1952), financial development is derived from economic growth. It is supported by other scholars (Stiglitz 1994, Lian, Teng 2006). High economic growth tends to produce large, privately funded financial systems and increase demand for financial services.

On the other hand, scholars argue that financial development is derived from economic growth and vice versa. Specifically, the findings show that institutional credit development leads to higher agricultural growth in developing countries (Iqbal et al. 2003, Kar et al. 2011, Chandio et al. 2020, Kaya, Kadanalı 2021). Abu-Bader, Abu-Qarn (2008) identify unidirectional causality running from financial development to economic development in five out of the six countries (Algeria, Egypt, Israel, Morocco, Syria, and Tunisia). Only weak support could be found for causality running from economic growth to financial development, but no causality in the other direction in Israel. This argument is in line with the empirical findings of Lian, Teng (2006).

Also, there is no evidence of a causal relationship between financial development and economic growth in Algeria, Jordan, Kuwait, and Saudi Arabia (Boulila, Trabelsi 2002). Previous research, on the other hand, has largely focused on aggregate growth, with little evidence on whether impact of financial development varies across industries. Previous empirical studies extensively focused on aggregate economic growth and the assumption that the agriculture sector or agricultural growth responds in the same way to financial development. Therefore, sectoral-based evidence could help policymakers in developing sector-specific policies to boost growth across a wide range of industries. This study fills the research gap by analyzing the direction of causality between institutional credit development and agricultural growth for each of the four selected countries simultaneously, to determine whether the development process is financial supply-driven or financial demand-driven in each context.

3 Data and Method of Analyses

3.1 Sources of data

Annual time series data on agricultural production, agricultural loans, agriculture capital stock formation (i.e., physical investment in agriculture), climate changes and the exchange rate are collected covering the 1991-2020 periods in this study. This study uses the agricultural credit loans and real interest rate as proxies for credit market development. Agriculture credit provided to the agriculture sector by commercial banks, private banks, and micro-financial institutions is used as proxy for the degree of credit market development. Real interest rates are used as a proxy for the degree of financial intermediation. Sources of data and all the details of the variable measurements for Benin, Kenya, Nigeria, and Tunisia are described in the appendix Table A.1.

3.2 Methods of analyses

Before analyzing data using the Autoregressive Distributed Lag (ARDL) bounds test, unit root tests were carried out to test the existence of non-stationary time series data and exclude the probability of dealing with I(2) variables using the Augmented Dickey-Fuller test.

The existence of long-run cointegration among time-series data, as well as long-run and short-run relationships between institutional credit development and agricultural production, was investigated using ARDL bound tests. The ARDL approach was developed by Pesaran, Shin (1999), Pesaran et al. (2001), and it has advantages over traditional cointegration analyses. For example, the ARDL bound tests for cointegration offer several advantages over other approaches to cointegration, such as Engle, Granger (1987), Johansen (1988), and Johansen, Juselius (1990). ARDL bound tests to cointegration not only distinguish between dependent and independent variables (i.e., it overcomes endogeneity problem), but they can also estimate long-run and short-run dynamic relationships at the same time. ARDL model delivers unbiased long-run model estimations (Harris, Sollis 2003). The ARDL test is more effective in the case of small ($n \leq 30$) samples or finite-sample observations. The ARDL error correction representation becomes relatively more efficient. The ARDL bounds testing approach to cointegration can be applied irrespective of whether the regressors are of 1(0) or 1(1). However, the dependent variable must be of level I(1), and none of the independent variables must be of level I(2) or higher. The following formula is the ARDL bounds tests for cointegration:

$$\begin{aligned} \Delta Y_t = \alpha + \gamma_1 Y_{t-1} + \gamma_2 X_{t-1} + \gamma_3 R_{t-1} + \gamma_4 Z_{t-1} + \gamma_5 C_{t-1} + \gamma_6 E_{t-1} + \\ \sum_{i=1}^{p} \beta_{1i} Y_{t-i} + \sum_{i=1}^{q} \beta_{2i} X_{t-i} + \sum_{i=1}^{r} \beta_{3i} R_{t-i} + \sum_{i=1}^{s} \beta_{4i} Z_{t-i} + \sum_{i=1}^{v} \beta_{5i} C_{t-i} + \\ \sum_{i=1}^{w} \beta_{6i} E_{t-i} + \epsilon_t \end{aligned} \tag{1}$$

where γ and β are coefficients, α is constant, p, q, r, s, v, and w are optimal lag orders, the lengths for p, q, r, s, v, and w are not the same, ϵ_t captures the disturbance term. First, we run equation (1) to test the presence of long-run cointegration equilibrium. Then, each dependent variable in the remaining five cointegration equations has been regressed on dependent variable (agricultural production) and other independent variables, such as agricultural credit loans, agricultural capital formation, real interest rate, exchange rate, and climate change in the model to check the existence of long run cointegration. For instance, agricultural loan has been regressed on agricultural production, agricultural capital formation; real interest rate, exchange rate, and climate change in the model (see Table 3).

Under the null-hypotheses of no cointegration, the bounds test is primarily based on the joint F-statistic, which has a non-standard asymptotic distribution. The first step in ARDL bound test is to estimate the six equations by employing Ordinary Least Square (OLS). The next step of the ARDL bounds test procedure is to test for a long-run relationship among the variables by conducting the F-statistic test for the joint significance of the coefficients of the lagged levels of the variables i.e., H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$ (i.e., suggesting the absence of a long-run relationship) against an alternative hypothesis (i.e. presence of cointegration) of H_A: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq 0$. The calculated F-statistics are compared with tabulated F-statistics (95% bounds and 99% bounds) values estimated by Pesaran et al. (2001) which are split into lower critical bounds (I(0)) and upper critical value bounds (I(1)) that result in correct conclusion about cointegration. If the calculated F-statistic value is greater than the upper tabulated value, the null hypothesis of no cointegration is rejected independent of the order of integration of the series, otherwise, the null is accepted.

ARDL Bounds test for cointegration is used to estimate the long-run relationships and short-run dynamic relationships among the variables of interest (agricultural production, credit to agriculture, real interest rate, climate change, fixed capital investment and exchange rates). This study utilized the autoregressive distributed lag (ARDL) approach of Pesaran et al. (2001) to evaluate the existence of a long-run relationship between agricultural production and agricultural credit supply. The ARDL long-run model for agricultural production and agricultural credit supply can be expressed as:

$$\begin{aligned} Y_t = \alpha_{01} + \sum_{i=1}^{p} \beta_{1i} Y_{t-i} + \sum_{i=1}^{q} \beta_{2i} X_{t-i} + \sum_{i=1}^{r} \beta_{3i} R_{t-i} + \sum_{i=1}^{s} \beta_{4i} Z_{t-i} + \\ \sum_{i=1}^{v} \beta_{5i} C_{t-i} + \sum_{i=1}^{w} \beta_{6i} E_{t-i} + \epsilon_t \end{aligned} \tag{2}$$

where β_1, β_2, β_3, β_4, β_5, β_6 are ARDL long-run coefficients, and ϵ_t is the white noise error term.

Following Pesaran, Shin (1999), and Pesaran et al. (2001), the error-correction version of ARDL model is specified as follows:

$$\begin{aligned}\Delta Y_t = \alpha_{0j} + \theta \mathrm{ECT}_{t-i} + \sum_{i=1}^{p} \gamma_{1i} \Delta Y_{t-i} + \sum_{i=1}^{q} \gamma_{2i} \Delta X_{t-i} + \sum_{i=1}^{r} \gamma_{3i} \Delta R_{t-i} + \\ \sum_{i=1}^{s} \gamma_{4i} \Delta Z_{t-i} + \sum_{i=1}^{v} \gamma_{5i} \Delta C_{t-i} + \sum_{i=1}^{w} \gamma_{6i} \Delta E_{t-i} + \epsilon_t\end{aligned} \tag{3}$$

where θ is the speed of adjustment and the coefficient of error correction term which is obtained as residual from the long-run relationship in equation (3). γ_1, γ_2, γ_3, γ_4, γ_5 and γ_6 are the short-run dynamic coefficients of the model's convergence to equilibrium, and ϵ_t is the white noise error term. The Δ denotes the difference operator.

Granger (1969) suggested Granger causality analysis examines causal relationships between two time-series data. The presence of long-run and short-run relationships between two variables only implies the presence of causality in at least one direction (Granger 1988). However, the cointegration test and error correction model is not sufficient to determine the direction of causality between two-time series data. To test whether credit market development Granger causes agricultural production or not, this study used the Granger causality test suggested by Granger (1969). This Granger causality test consists of two variables, institutional credit development, and agricultural production written as:

$$X_t = \alpha_1 + \sum_{j=1}^{k} \beta_j X_{t-j} + \sum_{i=1}^{k} \beta_i Y_{t-i} + u_{1t} \tag{4}$$

$$Y_t = \alpha_2 + \sum_{i=1}^{k} \beta_i Y_{t-i} + \sum_{j=1}^{k} \beta_j X_{t-j} + u_{2t} \tag{5}$$

where X_t and Y_t are institutional credit development and agricultural production, respectively.

Both null hypotheses and alternative hypotheses are derived from the literature review. Based on coefficients (β_j and β_i) of equations (4) and (5), four different hypotheses about the association between institutional credit development and agricultural real GDP growth can be specified as follows.

1. Granger causality is unidirectional: Granger causality runs from agricultural production to institutional finance development. In this situation, agricultural production causes an increase in the availability of institutional credit, but not the other way around. As a result, $\beta_i \neq 0$ and $\beta_j = 0$.

2. Granger causality is unidirectional: Granger causality runs from institutional credit development to agricultural production. In this scenario, institutional credit development boosts agricultural real GDP forecasting, but not the other way around. Thus, $\beta_i = 0$ and $\beta_j \neq 0$

3. Bidirectional causality: Agricultural production and institutional credit development are both affected by feedback causality. Agricultural production is derived from institutional credit development, and vice versa in this situation. As a result, $\beta_i \neq 0$ and $\beta_j \neq 0$.

4. Independence: There is no feedback between agricultural production and institutional loan supply in this situation. Thus, $\beta_i = 0$ and $\beta_j = 0$.

4 Results and Discussions

4.1 Results of descriptive statistics

The average value of agricultural credit in Benin increased from \$7.82 million in 1991–1999 to \$41.83 million in 2009–2020. The average value of Tunisian agricultural credit

Table 1: Summary statistics for all study countries

Variable	1991–1999	2000–2008	2009–2020
Benin AC	7.82(12.13)	14.64(3.67)	41.83(9.00)
Benin AP	615.87 (135.51)	984.54 (325.32)	1779.75 (132.50)
Benin AFCF	20.81 (3.52)	38.86 (8.92)	60.16 (13.81)
Benin CH	0.58 (0.30)	0.87 (0.23)	1.17 (0.19)
Kenyan AC	322.89 (25.09)	383.75 (57.61)	697.87(159.34)
Kenyan AP	3073.99 (689.88)	4342.57 (1094.52)	12690.55 (4039.59)
Kenyan AFCF	183.44 (19.052)	323.98 (122.41)	1094.80 (392.18)
Kenyan CH	0.34 (0.15)	0.67 (0.13)	1.06 (0.27)
Nigeria AC	407.64 (77.68)	541.740 (267.49)	1733.78 (797.42)
Nigeria AP	13227.89 (1893.33)	39167.08 (26475.19)	95543.5 (12125.11)
Nigeria AFCF	364.436 (56.70)	1683.63 (886.28)	3988.545 (601.49)
Nigeria CH	0.66 (0.32)	0.84 (0.31)	1.13 (0.23)
Tunisian AC	1123.00 (180.35)	961.61(70.00)	1112.89 (55.09)
Tunisian AP	2189.34 (244.43)	2662.46 (561.40)	3928.49 (398.17)
Tunisian AFCF	301.33 (52.92)	506.55 (201.71)	708.26 (53.59)
Tunisian CH	0.78 (0.59)	1.34 (0.34)	1.53 (0.52)

Notes: AC stands for the amount of credit to the agriculture sector (value US millions of dollars using constant 2015 prices) to agriculture, forestry and fishing. AP stands for agricultural production (value US millions of dollars using constant 2015 prices), and AFCF stands for agriculture fixed capital formation (value US millions of dollars using constant 2015 prices). CH refers to climate change.
Source: Author's calculations based on the FAOSTAT and World Bank Indicators databases (2022).

decreased from \$1123.00 million in 1991–1999 to \$1112.89 million in 2009–2020. On the other hand, Tunisian average real agricultural production increased from \$2189.34 million in 1991–1999 to \$3928.49 million in 2009–2020. Agricultural loans granted in Tunisia experienced a negligible reduction in the amount of agricultural loans granted over the periods (Table 1). This implies that investment finance is financed by producers in Tunisia. The reasons for little links between agricultural production and institutional credit supply in Tunisia can be explained by Islamic motives and state-owned banks (Boulila, Trabelsi 2004). Since Islam disallows interest, producers may be hesitant to borrow from the state-owned banks.

The level of reduction in agricultural loan supply over periods in Tunisia (Table 1) implies that financial development assumptions do not work for the case of Tunisia. The theory argues that financial development stimulates economic growth by increasing the rate of capital accumulation. It also justifies fact that the financial systems promote productivity. Financial systems determine selection of higher-quality entrepreneurs and projects, mobilization of external financing for these entrepreneurs, provision of superior vehicles for diversifying the risk of innovative activities, and more accurate explanation of large profits associated with the uncertain business of innovation. The fixed agricultural capital formation significantly increased agricultural production from \$2189.34 million in 1991–1999 to \$3928.49 million in 2009–2020 (see Table 4).

4.2 *Augmented Dickey-Fuller test and ARDL bounds test for cointegration results*

The results of unit root tests showed that all variables such as agricultural production, credit to agriculture, fixed capital formation, real interest rate, climate change and exchange rate were stationary at the first difference (FD), but not stationary at the level (Table 2).

The findings of the model shown the existence of the long-run cointegration among agricultural production, agricultural credit supply, agricultural fixed capital formation, exchange rates, real interest lending rates and climate change for all countries except for Tunisia (Table 3).

Table 2: Augmented Dickey-Fuller test for following variables with constant (H0: unit root)

Variable	Benin T value		Kenya T value		Nigeria T value		Tunisia T value	
	Level	FD	Level	FD	Level	FD	Level	FD
AP	-1.55	4.97***	-0.60	-4.92***	-0.35	-4.01**	-0.35	-4.12***
	(0.91)	(0.00)	(0.98)	(0.00)	(0.91)	(0.02)	(0.91)	(0.00)
AC	-2.78	-6.76***	-2.04	-4.36***	-1.02	-3.57**	-1.02	-3.87**
	(0.20)	(0.00)	(0.58)	(0.00)	(0.75)	(0.03)	(0.75)	(0.04)
AFCF	-0.61	4.89***	-1.58	-4.70***	-0.46	-4.11***	-0.46	-3.10**
	(0.98)	(0.00)	(0.80)	(0.00)	(0.59)	(0.4)	(0.89)	(0.05)
EXCR	-2.17	-4.80***	-2.69	-4.45***	-0.28	-3.05**	-2.28	-4.71***
	(0.50)	(0.00)	(0.24)	(0.00)	(1.43)	(0.04)	(0.43)	(0.00)
RI	-1.34	-4.37***	-1.21	-3.99***	-1.28	-3.31**	-1.87	-5.11***
	(0.71)	(0.00)	(0.14)	(0.00)	(0.43)	(0.03)	(0.73)	(0.00)
CH	-2.88*	-7.80***	-2.69*	-6.39***	-2.11	-5.25***	-1.98	-6.01***
	(0.07)	(0.00)	(0.04)	(0.00)	(0.53)	(0.00)	(0.21)	(0.00)

Notes: FD refers to the first difference. AC stands for the amount of credit to the agriculture sector. AP stands for agricultural production, and AFCF stands for agriculture fixed capital formation. EXCR stands for the exchange rate. RI stands for the real interest rate. CH refers to climate change. Values of probabilities are in parenthesis. ** and *** represent statistically significant at 5% and 1%, respectively.

4.3 Results of ARDL bound test and Granger causality

The results showed that institutional credit availability had a long-run impact on agricultural production. The findings supported the theory and earlier empirical findings that expanding agricultural financing led to higher agricultural output in Benin, Kenya, and Nigeria (King, Levine 1993, Levine 2005, Chandio et al. 2020). The findings were also consistent with the work of Ustarz, Fanta (2021) in all countries except for Tunisia, (Table 4). They found that agricultural and service sector growth was significantly and positively influenced by the financial market and financial institution development in Sub-Saharan Africa. Credit supply, on the other hand, has a negative impact on middle-income African and sample Sub-Saharan African countries (An et al. 2020).

Table 4 demonstrated that a 10% increase in agricultural credit supply resulted in about a 19.9% increase in agricultural production in the long run in Benin. The long-run coefficients of error correction terms were significant with the right signs (i.e., negative) in all cases except for Tunisia (Table 4). The negative ECM coefficients (-0.69, -1.33, -0.19, and -0.26) indicated that production equilibrium was stable with the highest in Kenya and the lowest speed of adjustments in Tunisia (Table 4). The magnitude of the equilibrium error correction coefficient (-0.69) indicated that 69% of the previous year's deviation from the equilibrium position was corrected in a particular year. The dynamic speed of adjustment for Kenyan agricultural production was relatively the fastest (-1.33), in absolute value than other countries and it was a reflection of the quicker transformation of agricultural credit loans in productivity concerning speed in one year. Nigerian agricultural production relatively adjusts slowest, and it was lesser flexible than other countries to restore the long-run equilibrium.

In the short run, the credit market development had a significant and positive effect on agricultural production in Nigeria due to the input subsidy policy. Production in agriculture is significantly impacted by input subsidies (Shikur 2020a). As a result, farmers may use credit to finance agricultural technologies to increase their profit since agricultural input subsidies decrease the costs of inputs as well as production.

On the contrary, the effect of institutional credit development on agricultural production was negative in the short-run in Benin, and Kenya. The coefficients of lagged agricultural credit supply and agricultural credit supply in Table 4 are -3.43 and -3.12, respectively, indicating a 10% rise in lagged agricultural credit supply and agricultural credit supply would result in a 34.3% and 31.2% decline in agricultural production in the short run in Benin. Agricultural credit loans may not lead to positive change in the agricultural production situation where farmers may not use the loans to purchase agricultural technologies. Many farmers in Africa did not use credit to finance agricul-

Table 3: Results of bound test for cointegration

Country	Equation	F-statistic	Decision
Benin	AP_F/ AC, AFCF, ECXR, CH	5.56***	Cointegration
Benin	AC_F/ AFCF, AP, ECX, CH	3.75**	Cointegration
Benin	$AFCF_F$ / AC, AP, ECXR, CH	2.99	No cointegration
Benin	$ECXR_F$ / AP, AC, AFCF, CH	5.41***	Cointegration
Benin	CH_F / AP, AC, AFCF, ECXR	5.41***	Cointegration
Kenya	AP_F/ AC, AFCF, ECXR. RI, CH	11.54***	Cointegration
Kenya	AC_F/ AFCF, AP, ECXR, RI, CH	3.35**	Cointegration
Kenya	$AFCF_F$/ AC, AP, ECXR, RI, CH	2.61	No cointegration
Kenya	$ECXR_F$ / AC, AFCF, AP, $_{RI}$, CH	15.38***	Cointegration
Kenya	RI_F/ AP, AC, AFCF, ECXR, CH	5.03***	Cointegration
Kenya	CH_F/AC, AFCF, AP, ECXR, RI	3.67**	Cointegration
Nigeria	AP_F/ AC, AFCF, ECXR, RI, CH	18.30***	Cointegration
Nigeria	AC_F/ AFCF, AP, ECXR, RI, CH	3.49**	Cointegration
Nigeria	$AFCF_F$/ AC, AP, ECXR, RI, CH	1.14	No cointegration
Nigeria	ECXR / AC, FCF, AP_F. RI, CH	3.41**	Cointegration
Nigeria	RI_F/ AC, AFCF, AP. ECXR, CH	4.11**	Cointegration
Nigeria	CH / AC, AFCF, AP,. ECXR, RI	3.99**	Cointegration
Tunisia	AP_F/ AC, AFCF, ECXR, CH	1.03	No cointegration
Tunisia	AC_F/ AFCF, AP, ECXR, CH	5.22**	Cointegration
Tunisia	$AFCF_F$/ AC, AP, ECXR, CH	1.75	No cointegration
Tunisia	$ECXR_F$ / AC, AFCF, AP, CH	1.05	No cointegration
Tunisia	CH_F/ AC, AFCF, AP, ECXR	1.87	No cointegration

Notes: Subscript F represents "function of independent variables".AC stands for the amount of credit to the agriculture sector. AP stands for agricultural production, and AFCF stands for agriculture fixed capital formation. EXCR stands for the exchange rate. RI stands for the real interest rate. CH refers to climate change.Lower-bound critical and upper-bound critical values are 3.23 and 4.35 at 5%, respectively. Lower-bound critical value and upper-bound critical value are 4.29 and 5.61 at 1%, respectively. Regarding the lower critical bound, it is assumed that all the variables are I(0) (i.e., no cointegration among variables), and regarding the upper critical bound, it is assumed all the variables are I(1) (i.e., cointegration among variables). ** and *** represent statistically significant at 5% and 1%, respectively.

tural technologies or external inputs purchases due to fear of climate and market risks (Adjognon et al. 2017, Nakano, Magezi 2020). Farmers in Benin have experienced the absence of fertilizers, improved vegetable seeds, and other crops, and exposed high production and market risks like climate change, high input prices, and limited input supply (Adjimoti et al. 2017). Price support and stabilization policies were not effective in many African countries to address price fluctuation, low agricultural technology adoption and low agricultural productivity (Shikur 2022c). By contrast, these policies increase the extensive utilization of agricultural technologies as well as production by addressing price fluctuation in several Asian and Latin American countries (Shikur 2020a).

Climate change was negatively associated with agricultural production in the long and short runs in all countries except for Nigeria. Climate change reduces livestock production and crop production by altering ecosystem services like water/rainfall availability; livestock feed quality and quantity availability; and disease outbreaks (Vining 1990, UNFCCC 2007). Tunisian agricultural production has declined with rising temperatures, sea level and aridity, and low precipitation (Prior, Santomá 2010). This implies that without environmental policy, the effect of the adoption of agricultural technologies may not be manifested in agricultural productivity in the short run in the three countries (Nelson et al. 2009).

On the contrary, the effect of climate change has not been manifested in agricultural production in Nigeria since a number of institutional and programmatic reforms and innovations have been adopted by the Nigerian government to promote the use of small and large-scale irrigation systems. This implies that irrigation policies in Nigeria might remove the effect of climate change on agricultural production by reducing the effect of climate change on animal feed and water/rainfall availabilities in regions (Carter et al. 2016). So, an irrigation policy could reduce the effect of little or inconsistent rainfall on agricultural production and productivity.

The real interest lending rates had a negative effect on agricultural production since

Table 4: Results of bound test for cointegration

Variable	Benin	Kenya	Nigeria	Tunisia
		Long-run relationship		
AC	1.99***(0.71)	5.04**(1.99)	0.14***(0.05)	0.25 (0.32)
AFCF	0.34 (0.23)	0.45*(0.03)	0.22*(0.12)	0.47**(0.19)
Exchange rate	-1.12***(0.32)	-5.70*(4.14)	0.31*(0.16)	0.23 (0.50)
Real interest rate	–	-1.28 (5.58)	-4.83 (5.21)	–
Climate change	-3.23(9.98)	-2.13 (12.21)	2.45** (.98)	-2.78**(1.29)
		Short-run dynamics		
AP (L_1)	0.9 8**(0.48)	0.55** (0.27)	-0.18 (0.21)	-0.15 (0.23)
AC	-3.12(2.73)	-25.55*(2.44)	0.18*(0.09)	-0.36 (0.67)
AC(L_1)	-3.43(2.56)	-19.49*(1.95)	0.25***(0.07)	–
AFCF	0.7 3**(0.30)	0.45**(0.13)	0.67** (0.23)	0.69*** (0.21)
AFCF(L_1)	0.89***(0.33)	0.89***(0.33)	0.89***(0.33)	0.89***(0.33)
Exchange rate	-0.34 (2.01)	-1.34 (1.67)	2.20 (2.01)	-0.87 (1.31)
Exchange rate (L_1)	-0.83(1.95)	-0.99 (1.32)	0.67(0.85)	-0.76 (1.41)
Real interest rate	–	-1.25 (1.65)	-7.07 (10.16)	–
Real interest rate (L_1)	–	-1.56(13.87)	-4.34 (9.67)	–
Climate change	-3.36 (2.86)	-8.60(5.87)	1.99** (2.86)	-3.44(4.87)
Adjustment (ECT)	-0.69***(0.18)	-1.33**(0.10)	-0.19**(0.07)	-0.26 (0.15)
Constant	2.91**(1.14)	3.14(10.23)	10.16**(4.00)	12.28 (31.03)

Note: * ... significant at 10%, ** ... significant at 5%, *** ... significant at 1%. L_1 denotes lag one. Values of standard errors are in parenthesis.
Source: Author's calculations based on the FAOSTAT and World Bank Indicators databases (2022).

Table 5: Results of Granger causality tests (F-statistics)

Variable	Benin	Kenya	Nigeria	Tunisia
Credit market development led	4.31*	7.06**	13.40***	0.84
agricultural productivity	(0.09)	(0.03)	(0.00)	(0.66)
Agricultural productivity led	7.42**	10.61***	7.00**	0.14
credit market development	(0.02)	(0.00)	(0.03)	(0.93)

Note: *** ... significant at 1%, ** ... significant at 5%, * ... significant at 10%. Probabilities in parenthesis.
Source: Author's calculations based on the FAOSTAT and World Bank Indicators databases (2022).

it increases the cost of production and decreases profitability. As a result, a high-interest rate reduces farmers' credit utilization for technologies. The exchange rate was negatively associated with agricultural production (Table 4). The devaluation of the exchange rate is one of the indirect taxation mechanisms used by the government to tax producers that increase the costs of agricultural production (Shikur 2020a). The scholars argued that moderate agricultural taxation has a significant effect on aggregate agricultural productivity. Still, high or low rates of agricultural taxation do not affect agricultural productivity (Hu, Antle 1993).

Capital formation had a significant and positive effect on agricultural production in the long-run and short-run. Whereas the effect of agricultural credit development on agricultural production was positive and insignificant in the long-run, but insignificant and negative in the short-run in Tunisia due to extensive and over-government interventions in financial, input, and output markets. For instance, the government fixes the high-interest rate cap and guaranteed minimum output prices (Prior, Santomá 2010).

Granger causality test identified significant bi-directional causal relationships between credit market development and agricultural productivity in Benin, Kenya, and Nigeria. This result implied that agricultural credit loans were a basic input in the process of agricultural production; therefore, financial development enhances agricultural production significantly. Similarly, the previous empirical studies support the existence of a feedback causal relationship between these two variables (Demetriades, Hussein 1996, Anwar, Nguyen 2011, Mukhopadhyay et al. 2011, Hassan et al. 2011, Jedidia et al. 2014, Kaya, Kadanalı 2021).

The empirical results strongly support the hypothesis that financial development leads to growth in Algeria, Egypt, Morocco, and Tunisia (Kar et al. 2011), and Ghana (Adu et al. 2013). In the agriculture sector, the findings show that an increase in institutional credit development leads to higher agricultural growth in developing countries (Iqbal et al. 2003, Isial et al. 2011, Chandio et al. 2016, 2020, Chaudhry, Hussain 1986).

There was no significant causal relationship between agricultural productivity and institutional credit development in Tunisia. This finding corroborated the findings of Boulila, Trabelsi (2002) in Algeria, Jordan, Kuwait, and Saudi Arabia and the works of Mukhopadhyay et al. (2011). The reasons for little links between agricultural production and institutional credit supply in Tunisia can be explained by agricultural policies, Islamic motives, and the state-owned banks (Boulila, Trabelsi 2004). Since Islam disallows interest, producers may be hesitant to borrow from owned banks. The credit supply in this country has been highly dominated by state-owned micro-financial institutions leading to lower access to credit services as well as lower credit demand (Prior, Santomá 2010).

5 Conclusions

The findings of models showed that agricultural production was positively and significantly associated with institutional credit supply in all countries in the long run except for Tunisia. To ensure faster agricultural growth, governments in emerging nations should significantly increase agricultural credit loans as well as adopt directed credit with a soft interest rate to the agricultural sector to achieve faster agricultural productivity growth.

The Granger causality test identified two patterns in the causal relationship between the two factors in these countries. A first pattern, there was a significant bi-directional causal relationship between credit market development and agricultural production in Benin, Kenya and Nigeria. The empirical results provide important implications for policymakers to use agricultural policies and financial market development policies at a time. The results encourage the country to follow an integrated approach that may be very useful to obtain more successful production due to the causal interactions of agricultural policies and financial market development policies.

The financial policies should focus on developing financial systems by expanding many financial institutions and supplying various financial products and services to promote financial development, thereby accelerating agricultural growth. In such a context, governments should adopt integrated agricultural production and credit market policies to achieve faster growth in agricultural productivity in all countries.

The second pattern is described by the relationship between agricultural production and institutional credit supply being too weak to determine the direction of causality in Tunisia. The study suggests the Tunisian government should promote financial liberation and self-investment financing to enhance agricultural productivity and production. The conclusion regarding one country is that financial credit development does not explain agricultural growth. This implies that the results appear inconsistent across countries. Credit market development acts as a facilitator for agricultural production in Benin, Kenya and Nigeria whereas it retards agricultural growth in Tunisia.

Governments in the study countries should encourage continuous supervision and training of farmers to use credit to finance agricultural technologies and secure adequate credit supply to achieve faster agricultural growth. The variations in the findings across countries imply policies, degree of financial regulation, and supervision, the extent of agricultural credit and capital supplies, climatic conditions, and so forth are the main determinants of agricultural productivity.

The manifestation of credit market development impact in agricultural production may not be seen in the absence of agricultural input and product market policies. Thus, considering agricultural input and product markets in development policies can make a country more effective at increasing agricultural production than a country considering credit market development policy alone. It has to do with developing stable input and output markets around the introduction of new, better methods, routes, innovative financial systems, and interventions required to achieve policy objectives. The policy requires new skills and competencies to adopt new organizational structures, introduce, disseminate farm practices, and upgrade the value chain.

The result indicated that climate change was negatively associated with agricultural production in long- and short-runs in all countries except for Nigeria. It is consistent with theoretical arguments that climate change adversely influences livestock production and crop production by altering ecosystem services like water/rainfall availability, livestock quality and quantity, feed availability, and disease outbreaks. Agricultural production was positively influenced by climate change in Nigeria in both long- and short-runs. A number of small- and large-scale irrigation policy reforms adopted by the government could remove the effects of climate change on agricultural production effectively in the case of Nigeria. This implies that climate-smart agricultural practices are needed to neutralize the effect of temperature change on agricultural input/technology productivity in the short-run and long-run agricultural production. In addition to these justifications, the combination of environmental and agricultural support policies implemented by the Nigerian government has enabled farmers to more easily access agricultural inputs as well as enabled them to translate agricultural credit loans into agricultural productivity. The study suggests further research on the association between livestock production and financial market development.

Competing interests

There are no conflicts of interest to declare.

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A Appendix:

Table A.1: Data Description

Variable	Description of the variables	Source
Y_t	The agricultural production, which is measured by real value of agriculture value-added, is noted by Y_t in equation (1).	WDI database
X_t	Agricultural credit loan (X_t) is measured by the real amount of agricultural loans provided to the agriculture sector.	FAOSTAT databases
R_t	Real interest rate (R_t) is the lending interest rate (%) adjusted for inflation which is measured by the GDP deflator. Real interest rates are used as a proxy for the degree of financial intermediation.	WDI database
Z_t	Capital stock (Z_t) is measured by real gross fixed capital formation/physical investment in agriculture, forestry, and fishing with using the System of National Accounts (SNA) concept. Gross capital stock is the total value of all fixed assets in use, regardless of age, based on the cost of new assets.	FAOSTAT databases
C_t	Climate change (C_t) is proxied by annual mean temperature anomalies, i.e., temperature change with respect to baseline climatology. So, climate change is measured as annual mean temperature anomalies. Temperature change refers to ozone. Since, higher temperatures are generally associated with higher ozone levels, while higher relative humidity is generally associated with lower ozone levels This happens when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources chemically react in the presence of sunlight.	FAOSTAT databases
E_t	Annual exchange rates (E_t) are obtained by dividing Standard Local Currency Units (SLC) by the US dollar. Annual exchange rates reflect financial repression.	FAOSTAT databases

Note: WDI refers to World Development Indicator Database. FAOSTAT refers to FAO Statistical Databases (Food and Agriculture Organization of the United Nations).