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Reconsidering agricultural credits and agricultural production nexus from a global perspective

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Abstract

Access to credit has been a key component in protecting a country's agriculture sector against uncertainties and climate-related shocks. Agricultural credits may also increase both agribusiness sectors' and farming-related commercial activities' exposure to world markets. This study aims to investigate agricultural credits' short-run and long-run effects on agricultural production using control variables such as foreign direct investments, inflation rate, and government expenditures. We found that credits to agriculture affect value-added agriculture positively in the long-run; specifically, when agricultural credits increase by 1%, value-added agriculture will increase by 0.19%; that is, an increase in credits to the agricultural sector leads to a significant increase in value-added agriculture, while FDI and government size both reduce agricultural value-added across countries. The findings of the pairwise causation test show that bidirectional causal links exist among almost all variables, validating feedback among agricultural value-added, credit to agriculture, FDI, government expenditures, and inflation.

KEYWORDS

agricultural credits, agricultural production, foreign direct investment, government expenditures

1 | INTRODUCTION

Rapid urbanization, climate change, and disaster risks place pressure on agricultural production and baseline vulnerability. Since there has been a steady increase in population growth during the past decade, future generations need to be able to meet a sufficient quantity of appropriate food available inclusively and sustainably. Obviously, food security and sustainability can be achieved by increasing production in agricultural production and finding alternative sustainable ways to produce more food on less land. In addition to parameters such as fertilizer, irrigation, medicine, seed, labor, soil, tool-machine, and technology usage, agricultural financing with low interest for the elimination of farmers' financial constraints to carry out their activities more comfortably and efficiently is vital to sustainable rural development, particularly for the least developed countries. Besides, advances in technology within agriculture have forced businesses to use more modern inputs and increase their capital requirements to access new knowledge, investments, and innovative farming methods. Furthermore, price risks due to the low elasticity of demand in agricultural products may result in uncertainty in producer incomes, necessitating the

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use of policy tools such as base price mechanisms, agricultural input subsidies, and short-run financing loans to producers (Binswanger, 1989; Leatham & Hopkin, 1988; Thompson, 1916; Tweeten & Zulauf, 2008).

First and foremost, agriculture can strategically achieve social welfare development through spreading employment and income gains. In conjunction with steady growth in real wages, increasing production growth in all sectors is critical to increasing domestic demand. To increase agricultural production as well as inefficient production methods, labor market distortions should also be prevented. As Phan (2012) demonstrated, credit constraints may drive migration for rural households. Besides, during agricultural development process, agricultural support policies such as cash subsidies, credits, and tax benefits make agriculture competitive, improve investments, increase resource allocation and profitability, and thereby, continue farming in a sustainable manner (Kahan, 2013). Specifically, stimulating agricultural credit policies ensures the quantity and continuity of agricultural production by providing input to higher output gains. In particular, the existence of mostly small-sized farms in low-income countries, most of which are family-owned and operated, the timing, techniques, and conditions of harvesting, adopting new technology, and diversifying their production are responsible for agricultural credit demand. As a result of the uncertainties inherent in agricultural production, producers may not always receive the expected income, which leads to lower production by increasing vulnerability (Kahan, 2013; Rajan & Ramcharan, 2015).

The main challenge for developing countries is to improve their agricultural credit systems toward sustainable agricultural and rural development. As it is known, one of the most common problems of the agricultural sector in developing countries is the financial needs of small-scale farmers, farming businesses, and agri-food companies due to increasing input usage and transportation costs. Moreover, agricultural price fluctuations tend to be particularly strong, and market supply is relatively inelastic in short-run. Besides, the food supply is unable to respond quickly to price fluctuations due to the overall lengthy production process of many agricultural products, leading to volatile price movements of agricultural commodities. In addition, food supply cannot respond quickly to price fluctuations as many agricultural products generally require long production runs, resulting in fluctuations in agricultural income. On the other hand, technological advancement could impact a lot on farming; however, implementation costs tend to be high, especially for small-scale farmers. Nevertheless, Nguyen (2002) advocated the effective use of technological advances in the agricultural sector might result in an increase in welfare by increasing the effective demand with the increase of rural income. In all this process, it is essential to financially support small-scale farmers and family businesses. For low-income countries especially, first and foremost, access to credit, especially for small-sized family farms, needs to be improved. Generally, lending to the agricultural sector can be classified into two types according to their intended use: short-run or farm-operating loans to help with day-to-day expenses and investment loans to support agricultural enterprises to finance their investment expenses (Salami & Arawomo, 2013). Another aspect that deserves attention is the nexus between agricultural credit and agricultural productivity and its effect on economic growth. In fact, agricultural sector can also serve as a crucial "buffer sector" by creating jobs for other industries during economic downturns. However, the ability of credit to induce agricultural productivity is also an issue for many developed countries. Besides this, access to adequate credit affects farm output by contributing to the sustainability of farming systems and technology. Since managing risk to stabilize farm income is an important aspect of the farming business, access to credit is a key component in protecting farmers against uncertainties. That is, easy availability and access to credit increase farmers' and entrepreneurs' options to undertake new investments. One of the arguments for the contribution of agricultural credits to agricultural production by Braverman and Guasch (1986) is that agricultural loan interest rate should not be the market rate; otherwise, these types of programs may result in some kind of subsidies and income transfers; that is, since subsidies and income transfers are proportional to the size of the loan, larger landholders receive larger income transfers and subsidies in case of larger loan size. However, it is crucial to determine the extent to which agricultural sector financing, particularly the increased availability of bank credits to agricultural businesses and farmers, affects agricultural production. But more importantly, to what extent agricultural financing may be more effective in contributing to higher agricultural production as well as stimulating growth? Going one step further, does making efforts to subsidize agricultural credit in developing countries and providing credit to finance new technology adoption give an opportunity for those countries to promote rural development as well as increase agricultural production?

This issue is directly related to the assumption that the use of agricultural credits might result in an increase in the efficiency of the agricultural production process since the accessibility of agricultural mechanization tools and modern fertilization opportunities necessary for climate change adaption in agriculture can be facilitated more rapidly. This study aims to investigate the short- and long-run dynamics and causal linkages between agricultural value-added and agricultural credits in light of

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this context. In the discussion of the role of agricultural credits in value-added agriculture in both the short- and the long-run, the ARDL of Pooled Mean Group (PMG), Mean Group (MG), and Dynamic Fixed Effects (DFE) approaches are employed using a dataset comprising 53 countries in the period from 2000 to 2018. Additionally, Dynamic OLS (DOLS), Arellano-Bond dynamic panel-data estimation, and panel pairwise causality tests are employed to test the robustness of estimations. According to this narrative, the aim of this study is to investigate the effect of agricultural credits on value-added agriculture utilizing inflation, net foreign direct investments, and general government total expenditures as the relevant control variables to ameliorate omitted variable bias. Previous studies conducted to examine the nexus between credit and agricultural output using country or region-based data sets show conflicting and inconclusive results. The current study has the following specific contributions to the existing literature: First, this study was conducted using heterogeneous panel data covering 53 countries to avoid biased estimates due to the lack of appropriate data for other countries not included in the panel set, which actually allowed us to estimate with a balanced data set. Secondly, along with advanced dynamic panel data techniques that allow capturing slope heterogeneity among each country, we have unfolded the panel causality dynamics between agriculture to credit and value-added agriculture for a broad panel of countries. The remainder of this research is organized as follows: Section 2 introduces the literature review; Section 3 describes previous literature; Section 4 presents the data; empirical results are summarized in Section 5; followed by a discussion in Section 6, and finally Section 7 is the conclusion and policy implications.

2 | LITERATURE REVIEW

A substantial number of recent studies have been devoted to investigating the effects of agricultural credits on agriculture. While some of these studies used household/farm-level data such as Chandio et al. (2017), Ullah et al. (2020), Chandio et al. (2021), Ma et al. (2022), and Yadav and Rao (2022), some of them identified and addressed linkages using country-level data such as Misra et al. (2016), Rehman et al. (2017), Anh et al. (2020), Seven and Tumen (2020), Manoharan and Varkey (2021), Chandio, Abbas, et al. (2022), Chandio, Jiang, et al. (2022), and Mahapatra and Jena (2023). The majority of the studies in the first category concluded that agricultural credits help to improve agricultural production efficiency. For instance, Misra et al. (2016) observed a positive effect of credit intensity on total factor productivity in agriculture under a state-level panel model for the Indian economy. Based on a Cobb–Douglas production function for 120 sugarcane growers and using a binary-choice probit model, Chandio et al. (2021) noted that credit utilization during the production process can increase crop production and the farmers' overall income. However, based on the 2016 China Labour-Force Dynamics Survey, Ma et al. (2022) demonstrated that access to credit significantly reduces household income due to the ineffective use of these loans.

In the studies conducted using country-level data, Rehman et al.'s (2017) findings for Pakistan first draw attention. The authors did discrimination among loan types using time series data and concluded that total food production, loans disbursed by modern agriculture technology machinery and agriculture loans, and other loans provided by numerous institutions had a positive and significant effect on the agricultural gross domestic product, though the cropped land and cooperative loans had an insignificant negative effect on the agricultural gross domestic product using time series data in Pakistan. A distinction was made by Manoharan and Varkey (2021) in the context of credits as direct and indirect agricultural credits to investigate the nexus between agricultural productivity. Their study revealed that, in contrast to indirect credits, which have a significant negative effect on productivity, direct agricultural credits have a positive impact on productivity in India. Anh et al. (2020) utilized the ARDL and Toda and Yamamoto tests of Granger causality to look at the relationship between agricultural credit and agricultural GDP for the period between 2001 and 2016 in Vietnam. The results revealed a unidirectional causal relationship running from agricultural credit to agricultural GDP. A more comprehensive study was carried out by Seven and Tumen (2020) using cross-country data for the period between 1991 and 2014. Accordingly, agricultural credit expansion contributes to high agricultural growth rates in almost all countries. However, this effect differs between developing and developed countries depending on the agricultural component of GDP and agricultural labor productivity. Another recent study by Chandio, Abbas, et al. (2022) aimed to investigate the impact of private sector domestic credits on value-added agricultural and cereal production between 1970 and 2016 in ASEAN economies. However, their study differs from previous studies in one point in particular. Accordingly, the relationship between private domestic credits, which are proxied as financial development, and value-added agriculture has been examined both linearly and nonlinearly. They did obtain noteworthy results. Based on their findings, the relationship in question is linearly positive but nonlinearly negative. In other words, their findings reveal an inverted U-shaped nexus between

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financial development and value-added agriculture. Finally, based on a monthly dataset of China's climate and agricultural variables, He et al. (2022) reported that agricultural credits have a significant long-term effect on cereal production. Overall, there is a strong consensus in the literature that agricultural credits make a significant contribution to bolstering agricultural output in some way. To the best of our knowledge, no prior research has been conducted to evaluate the nexus between agricultural credits and value-added agriculture using panel cointegration and panel autoregressive distributed lag (ARDL) approach with a heterogenous country-level panel data. Using a heterogeneous panel of countries with different dynamic characteristics, this study provides fresh empirical evidence on the nexus between agricultural credits and value-added agriculture. Table 1 provides an overview of recent studies examining the nexus between agricultural production and credits on a country basis.

3 | METHODOLOGY

The study aims to empirically evaluate the short-run and long-run effects of agricultural credits on value-added agriculture based on a global sample of 53 countries over the period 2000–2018.[1] We initially present the conceptual framework that we follow and then outline the statistical approach that we implement to estimate the long-run equilibrium parameters.

Before the estimation, it is crucial to evaluate the properties of the panel data since any specificities may exist that may lead to inconsistent and incorrect results. In this context, a set of preliminary tests should be performed before estimating the model of interest as Variance Inflation Factor (VIF) to detect the existence of multicollinearity, cross-section dependence (CSD) test (Pesaran, 2004) to account for serial correlation of an unknown form in the error term, second-generation unit root test (CIPS-test) (Pesaran, 2007) to determine the stationarity of the data,

TABLE 1 Recent country-level studies on the analysis of credits and agricultural production nexus.

Authors	Time and countries	Methods	Findings
Misra et al. (2016)	2000–2020, India	ARDL	A statistically significant relationship between agricultural credit and the yield of total cereals, millets, and rice
Narayanan (2016)	1995–2012, India	SURE (Seemingly Unrelated Regression Equation)	The evidence of the impact of credit on agricultural GDP is weak
Rehman et al. (2017)	1960–2015, Pakistan	Johansen Co-integration test, OLS	Positive linkage between loan disbursements and agricultural gross domestic product
Anh et al. (2020)	2001–2016, Vietnam	Toda–Yamamoto Granger causality test.	Agricultural GDP and credit have a one-way causal relationship; credit causes agricultural GDP
Bahsi and Cetin (2020)	1998–2016, Turkey	OLS, DOLS, FMOLS	Agricultural credits boost agricultural production
Seven and Tumen (2020)	1991–2014, 104 developed and developing countries	Fixed effects panel, IV-2SLS, and GMM	Doubling agricultural credits lead to higher agricultural productivity
Manoharan and Varkey (2021)	1990–2017, India	Fixed Effects regression	Direct credits had a significant positive impact on agricultural productivity while indirect credit had a significant negative impact on agricultural productivity
Chandio, Abbas, et al. (2022)	1970–2016, Southeast Asian economies	FMOLS	Financial development influences cereal production and agricultural value added in an inverted U pattern
Chandio, Jiang, et al. (2022)	1990–2017, China	ARDL	Agricultural credit significantly and positively stimulates grain crops output
He et al. (2022)	1978–2018, China	ARDL	Agricultural credit significantly improved cereal production
Mahapatra and Jena (2023)	2000–2020, India	ARDL	The long-run impact of crop loans has a positive effect on the yield of total cereals and rice, but it has no statistically significant effect on the yield of millets.

Abbreviations: 2SLS, Two Stage Least Squares; ARDL: Autoregressive Distributed Lag; DOLS, dynamic ordinary least square; FMOLS, Fully Modified Least Square; IV, Instrumental Variables.

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and finally, second-generation cointegration test (Westerlund, 2007) to reveal the order of integration of the variables included in the model for analyzing the long-run relationship among them.

Considering the outcomes of these tests, we employ a heterogeneous dynamic panel model to investigate the relationship between agricultural credit and agricultural production. A combined autoregressive distributed lag (ARDL) panel approach, namely, the Mean group (MG) developed by Pesaran and Smith (1995), the Pooled mean group (PMG) developed by Pesaran et al. (1999), and the Dynamic Fixed Effect (DFE) estimators, have been performed to assess the short-run and long-run linkages between value-added agricultural and credit to agriculture with other control variables.

Pesaran et al. (1999) developed two estimators to estimate the panel ARDL model: MG (Mean Group Estimation) and PMG (Pooled Mean Group Estimation). The MG estimator places no restrictions on the coefficients in the long-run. The DFE model further limits the speed of adjustment coefficient and short-run coefficient to be the same or equal and subject to the bias between the error term and the lagged dependent variable. PMG approach, associated with pooling and averaging the coefficients over the cross-sectional units, allows a greater degree of parameter heterogeneity than the usual estimator procedures in the short-run while imposing homogeneity on long-run coefficients. In other words, PMG restricts long-run coefficients but allows the intercepts and short-run coefficients to differ freely across countries. Therefore, the PMG estimator improves the efficiency of the estimates in comparison to mean group estimators under the assumption of long-run slope homogeneity (Pesaran et al., 1999).

As shown in Pesaran and Shin (1996), the aim of the Panel ARDL approach is to estimate the nexus between agricultural production and agricultural credit, and can be specified by the following equation:

$$\Delta Y_{\text{it}} = \sum_{j=1}^{p} \beta_{i,j} Y_{i,t-j} + \sum_{j=0}^{q} \gamma_{i,j} X_{i,t-j} + \mu_i + \varepsilon_{\text{it}} \quad (1)$$

By rearranging terms such as:

$$\Delta Y_{\text{it}} = \emptyset_i \left(Y_{i,t-1} - \theta_i X_{i,t} \right) + \sum_{j=1}^{p-1} \beta'_{ij} \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \gamma'_{ij} \Delta X_{i,t-j} + \mu_i + \varepsilon_{\text{it}} \quad (2)$$

with i and t representing country and time respectively, Y is the agriculture, forestry, and fishing value added as a percentage of GDP, $X_{i,t}$ is a kx1 vector of explanatory variables containing the credit to agriculture, net foreign direct investments as a percentage of GDP, annual rate of changes in CPI (%) and general government total expenditure as a percentage of GDP, $\emptyset_i$ is the group-specific speed of adjustment coefficient, θ_i is the long-run coefficients of explanatory variables, $\text{ECT} = [Y_{i,t-1} - \theta_i X_{i,t}]$ is the error correction term, and finally, β' and γ' represent the short-run coefficients linking agriculture, forestry, and fishing value added with its past values and the variables of interest $X_{i,t}$.

Further, one more estimation technique is employed as a part of the robustness check. The Dynamic Ordinary Least Square (DOLS) was proposed by Stock and Watson (1993) and later extended by Kao and Chiang (2001).[2] DOLS method can be employed with mixed and higher orders of integration to estimate long-run nexus for heterogeneous panel by controlling simultaneity, endogeneity, serial correlation, and small sample bias among the regressor[3] (Kumar et al., 2021; Masih & Masih, 1996; Stock & Watson, 1993). Additionally, Arellano-Bond Dynamic panel-data estimation, a generalized method of moments estimator (GMM), by Arellano and Bond (1991) which provides consistent estimates even in panels with small T and large N, is applied to check the robustness of the estimated models.

4 | DATA

An annual balanced panel data set of 53 countries over the 2000–2018 period was used. The data for the selected countries can be extracted from the World Development Indicators (WDI, 2020), and from the Food and Agricultural Organization (FAO). The selected countries are listed in Appendix S1. The description of the variables used in this study is presented in Table S1. The selection of the countries and time span was limited by data availability. Agriculture, forestry, and fishing value-added series (AGV) that measure the output of the agricultural sector less the value of intermediate inputs, as identified by the FAO statistical annex, were used as a proxy for agricultural production.[4] AGC is the credit to agriculture, forestry, and fishing as the amount of the loans and advances given by the banking sector to agricultural cooperatives, farmers, or rural households in constant LCU. INF is inflation as the annual percentage change in consumer prices, FDI is the net foreign direct investments as a percentage of GDP, INF is the annual rate of changes in CPI (%), and GOV is the general government total expenditure as a percentage of GDP. AGV and AGC are converted into natural logarithms for consistent and reliable empirical results. As can be seen in Figure 1, there is a strong correlation between agricultural production and agricultural credits.

In order to conduct a thorough analysis and investigate the role of agricultural credits in value-added

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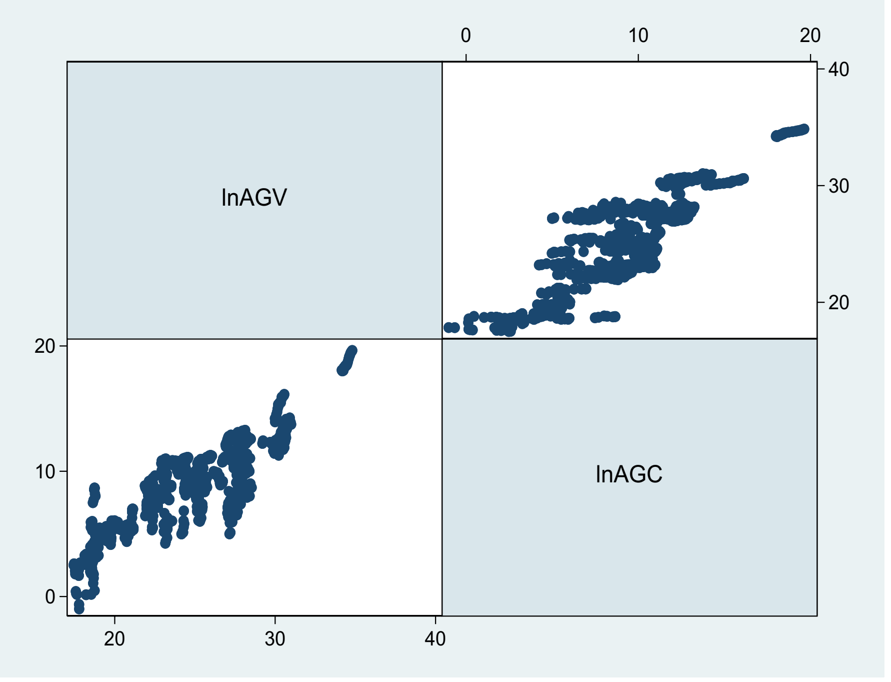

FIGURE 1 Correlation between value-added agriculture and credits to agriculture (2000–2018).

agriculture, we employ the following equation as the basic model:

$$LAGV_{it} = \alpha_0 + \alpha_1 LAGC_{it} + \alpha_2 FDI_{it} + \alpha_3 GOV_{it} + \alpha_4 INF_{it} + \mu_i + \varepsilon_{it} \quad (3)$$

Since ignoring cross-sectional dependence of errors may have serious consequences, such as unbiasedness, consistency of standard panel estimators, and incorrect statistical inference, VIF and CSD tests should be applied first, such as the CSD test developed by Pesaran (2004). Panel unit root tests are then performed followed by panel cointegration tests, MG-PMG-DFE estimations, Dynamic OLS, and Arellano-Bond dynamic panel-data estimation tests for robustness check, and panel causality tests.

5 | RESULTS

5.1 | Preliminary tests

To select the most appropriate technique to evaluate short- and long-run relationships under panel data approach, it is crucial to investigate whether multicollinearity problems and cross-section dependence among the variables exist. The variance inflation factor (VIF) is typically used to identify the possible existence of multicollinearity with the cross-section dependence (CSD) test to control whether the variables are cross-sectionally dependent (Pesaran, 2004). The null hypothesis for the CSD test is the existence of CSD. It can be visibly seen from the results of the VIF test present in Table S2 that all of the variables are lower than the benchmark of 5.0, supporting that multicollinearity is far from being a concern. The null hypothesis for the CSD test is not rejected except for LAGV in the first differences; that is, the CSD test shows the presence of cross-sectional dependence in most cases.[5]

Due to the presence of cross-sectional dependence, an extension of Im et al.'s (2003) unit root test, known as the second-generation unit root test, was applied in order to detect the integration orders of the variables. As seen in Table 2, the CIPS test was performed under the null hypothesis of nonstationarity. Considering the null hypothesis of the CIPS test, all series except LAGV are stationary at level I (0) without trend. Similarly, only FDI and INF are stationary at level I (0) with trend. Accordingly, the null hypothesis of nonstationarity cannot be rejected for the dependent variable LAGV both without trend and trend, ensuring none of the series is I (2).

5.2 | Panel cointegration tests

As the next step, we estimate Westerlund's (2008) second-generation panel cointegration test to check the existence of cointegration relationship among the series. The advantage of this procedure is that it is valid even if variables are integrated of different orders as long as the dependent variable is I(1). We perform Westerlund cointegration tests both with a "trend" and "trend and demean," as presented in Table 3. Accordingly, the results provide stronger evidence of the cointegration relationship among the variables, indicating a long-run relationship among the variables in the model.

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5.3 | Dynamic panel ARDL tests

5.3.1 | PMG-DFE-MG

The results from the long-run and short-run estimations under the PMG, MG, and DFE estimators along with the Hausman h-test to compare the estimators of the model parameters are shown in Table 4 and Table 5, respectively.[6] The MG models allow for heterogeneity in short- and long-run parameters. The PMG allows for short-run differences while restricting long-run equilibrium to be homogenous across countries. Finally, the DFE model assumes both the long- and short-run coefficients to be homogeneous (Gemmell et al., 2016; Pesaran et al., 1999). Furthermore, the Hausman model specification tests are applied to compare PMG with both MG and DFE. As seen in Table 5, the Hausman test's findings show that the null hypothesis should not be rejected, implying that the PMG results are more appropriate than both MG and DFE (Pesaran et al., 1999). Consequently, we rely on the estimates obtained with the favorable PMG approach.

Based on PMG-ARDL (1,1,1,1) from Table 4, the estimated coefficients of all variables, also known as elasticities, are all statistically significant in the long-run. However, only credits to agriculture affect agricultural production positively. Furthermore, the elasticity of credit to agriculture is the highest one with respect to others; that is, when comparing with the coefficients of the other variables, it shows that the elasticity of agricultural credit has a higher value than the elasticity of FDI, government spending, and inflation, implying that agricultural credit has a stronger effect on increasing agricultural production. In broad terms, a 1% increase in agricultural credits leads to 0.19% increase in agricultural production across countries; that is, an increase in the amount of credits to agricultural sector leads to a significant increase in value-added agriculture. Besides, FDI and government size both reduce agricultural production across countries, suggesting that both FDI and government expenditures harm agriculture businesses significantly. The reason behind this inverse association may be that FDI promotes migration from rural to urban as creating jobs in urban areas with higher wages which encourages workers in rural areas to migrate (Ben Slimane et al., 2016). Similarly, government expenditures leave less for private investments in physical capital both in the short- and long-run, which ultimately leads to underinvestment of agricultural products, even in export-based goods (Anríquez et al., 2016; López et al., 2017). Agricultural production, as expected, also moves in the opposite direction to inflation, conceding that high input prices and cash flow problems for agribusiness sectors and farmers result in low production. The short-run coefficients of these variables are significant only for government expenditures. Based on the PMG estimator, the error correction parameter for GOV is significant and negative, indicating that government expenditures discourage agricultural production even in the short-run. Intuitively, as reported by FAO (2021), the reduction in the share of agriculture in government expenditures in all regions except Asia between 2001 and 2009 might have a

TABLE 2 Second-generation unit root test (CIPS-test).

		Second-generation unit root test Panel unit root test (CIPS)	
		Without trend	With trend
Variables	Lags	Zt-bar	Zt-bar
LAGV	1	−1.319	2.251
LAGC	1	−3.344***	0.047
FDI	1	−2.626***	−1.879**
GOV	1	−1.890**	−0.059
INF	1	−6.501***	−5.561***
DLAGV	1	−10.769***	−9.221***
DLAGC	1	−6.473***	−3.826***
DFDI	1	−13.662***	−10.672***
DGOV	1	−8.218***	−6.089***
DINF	1	−13.446***	−9.636***

Note: ***, ** represent statistically significant at 1%, and 5% level, respectively; DL represents variables in natural logarithms and first-differences of logarithms respectively. The null for the CIPS test is nonstationarity. The results are only given with three digits after decimals to save space.

TABLE 3 Panel cointegration tests.

	With trend		With demean		With demean and trend	
	Variance ratio	*p*-Value	Variance ratio	*p*-Value	Variance ratio	*p*-Value
Ho: No cointegration Ha: All panels are cointegrated	1.12	0.13	2.61***	0.00	3.30***	0.00
Ho: No cointegration Ha: Some panels are cointegrated	1.67**	0.04	6.81***	0.00	1.77**	0.03

Note: ***, **, * shows 1%, 5%, and 10% of significance level, respectively. The results are only given with three digits after decimals to save space.

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TABLE 4 Long-run and short-run estimators.

	Variable	MG Coefficient	MG SE	PMG Coefficient	PMG SE	DFE Coefficient	DFE SE
Long-run equation	LAGC	−0.064	0.123	0.196***	0.014	0.118***	0.027
	FDI	−0.010	0.076	−0.004***	0.001	0.005	0.003
	GOV	−0.010***	0.058	−0.008***	0.001	0.000	0.005
	INF	−0.005	0.018	−0.003**	0.001	−0.004	0.003
Short-run equation	ECT	−0.484***	0.059	−0.215***	0.039	−0.175***	0.017
	D (LAGC)	−0.053	0.058	−0.030	0.044	−0.003	0.008
	D (FDI)	−0.002	0.004	−0.001	0.001	−0.000	0.000
	D (GOV)	0.002	0.002	−0.004**	0.001	−0.004***	0.001
	D (INF)	0.001	0.002	−0.000	0.001	−0.000	0.000
	C	11.14***	1.376	4.745***	0.853	4.163***	0.415

Note: ***, **, * shows 1%, 5% and 10% of significance level, respectively. The results are only given with three digits after decimals to save space.

TABLE 5 Hausman tests.

Ho: Difference in coefficients not systematic	MG and PMG	DFE and PMG	DFE and MG
χ^2 (4)	1.89	0.00	0.00
p-Value	0.75	1.00	1.00
Decision	The Ho of homogeneity cannot be rejected	The Ho of homogeneity cannot be rejected	The Ho of homogeneity cannot be rejected
Appropriate model	PMG	PMG	MG

Note: ***, **, * shows 1%, 5% and 10% of significance level, respectively.

deleterious effect on agricultural and rural development in both the short- and the long-run.

5.3.2 | Robustness of long-run estimation approach

To perform the robustness tests, we applied Panel Dynamic OLS (PDOLS), proposed by Kao and Chiang (2001), rather than FMOLS (Fully Modified OLS) due to the mixed order of integration.[7] The DOLS procedure has the advantage of being free of endogeneity and serial correction problems in the heterogeneous panel cointegrated series while allowing for individual heterogeneity through different short-run dynamics, individual-specific fixed effects, and individual-specific time trends (Luis et al., 2007; Mark & Sul, 2003). Furthermore, the Arellano-Bond dynamic panel-data estimation was employed to verify the robustness of the PMG estimations.

Based on the evidence of the presence of a cointegrating relationship, the long-run coefficients of the regressors on agricultural production were estimated using the weighted DOLS estimator. All the variables are significant; nevertheless, the signs of FDI and GOV are not consistent with that of the PMG estimation. Results are displayed in Table 6, indicating that a 1% increase in credits to agriculture enhances almost 0.11% in agricultural production. However, contrary to the PMG estimation results, the FDI and GOV coefficients are negative based on the DOLS estimates. On the other hand, results from the Arellano-Bond Estimator estimation suggest rather a small impact of credit to agriculture on agricultural production, as 0.019%. Furthermore, the findings also demonstrate that GOV has a significantly negative effect on LAGV, whereas INF and FDI have negative coefficients that are similar to PMG but not statistically significant.

Finally, we proceed by investigating the existence of a causality between agricultural production and its determinants using a pairwise causation test by Dumitrescu and Hurlin (2012) to reach a more parsimonious conclusion. The results of the Pairwise Dumitrescu-Hurlin panel causality test are shown in Table 7. The findings of the pairwise causation test indicate a bidirectional causality relationship between LAGV-LAGC, LAGV-INF, LAGV-FDI, and LAGV-GOV. Overall findings suggest that agricultural credits, inflation, foreign direct investments, and

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TABLE 6 Results of dynamic ordinary least squares estimator and arellano-bond dynamic panel-data estimation (Dependent variable: LAGV).

	DOLS			Arellano-bond estimator		
Variable	Coefficient	SE	*t*-Value	Coefficient	SE	*z*-Value
LAGC	0.1116***	0.008	12.612	0.01976***	0.0049	4.02
INF	−0.0086***	0.001	−8.058	−0.00016	0.0004	−0.38
FDI	0.0064***	0.001	5.829	−0.00009	0.0003	−0.28
GOV	0.0066***	0.001	5.291	−0.0048***	0.0007	−6.27

Note: ***, **, * shows 1%, 5% and 10% of significance level. The results are only given with three digits after decimals to save space. As suggested by Pedroni (2000) and Kao and Chiang (2001), pooled weighted DOLS were used in this study. Fixed leads and lags specification (lead = 1, lag = 1) was chosen.

TABLE 7 Pairwise Dumitrescu-Hurlin panel causality tests.

Causal relationship	*W* statistics	*Z*-bar statistics	*Z*-bar tilde statistics
LAGC→LAGV	8.442	11.434*** (0.000)	2.095** (0.036)
LAGV→LAGC	9.105	13.141*** (0.000)	2.664*** (0.007)
INF→LAGV	1.468	2.412** (0.015)	1.244 (0.213)
LAGV→INF	9.047	12.991*** (0.000)	2.614*** (0.008)
FDI→LAGV	7.756	9.668*** (0.000)	1.506 (0.131)
LAGV→FDI	7.944	10.152*** (0.000)	1.668* (0.095)
GOV→LAGV	1.715	3.681*** (0.000)	2.220** (0.026)
LAGV→GOV	8.245	10.927*** (0.000)	1.926* (0.054)

Note: ***, **, * shows 1%, 5% and 10% of significance level. *p*-values are in parenthesis.

government expenditures play a significant role in the net output of agricultural sector. Our estimated causality findings are consistent with the PMG model long-term estimations. The results of the causality test are also consistent with recent empirical studies such as Rehman et al. (2017), Bahsi and Cetin (2020), Anh et al. (2020), Chandio, Abbas, et al. (2022), and Chandio, Jiang, et al. (2022).

6 | DISCUSSION

In the pursuit of unraveling the intricate relationship between agricultural credits and agricultural production, our study yields valuable insights that contribute to the discourse on sustainable economic development. The empirical findings underscore the central role of financial support in propelling agricultural yield, a phenomenon with far-reaching implications for policymakers and practitioners alike. The elasticity we unearthed emphasizes the responsiveness of agricultural production to credit accessibility. This finding has broad implications for agricultural development strategies. In the context of our findings, the alignment of agricultural credit provision with an increased agricultural production strengthens the case for the financial sector's pivotal role in steering economic development. The financial sector's capacity to discern opportunities for productive investment can synergize with the agricultural sector's potential, effectively transforming credit into a driver of sustainable growth. By bolstering access to agricultural credits, policymakers can empower farmers to invest in critical resources and technologies that augment productivity and overall income.

Our research resonates deeply with the economic theories of Lewis (1954) and Ranis & Fei (1961) regarding the interconnectedness of sectors in developing economies. These economists emphasized the mutual development of agriculture and manufacturing as a catalyst for sustained economic progress. By illuminating the critical role of agricultural credits in enhancing productivity, we reinforce the symbiotic relationship between these sectors. Our study sheds light on the potential path of influence: improved access to credit stimulates agricultural output, thereby nurturing an environment conducive to the expansion of the manufacturing sector. The ramifications of this interconnectedness are profound. Overcoming financial constraints that impede credit accessibility becomes imperative. Facilitating credit access empowers farmers to invest in modern technologies and inputs, thereby spurring agricultural productivity. This catalytic effect extends to the manufacturing sector through increased raw material supply and labor force. The virtuous cycle of growth thus extends from agriculture to manufacturing, reflecting the interdependence of sectors in driving overall economic development. Targeted interventions that fortify agricultural credits emerge as a transformative tool for stimulating economic growth and alleviating poverty. By nurturing the intertwined progress of agriculture and manufacturing, developing economies can chart a course toward sustainable prosperity.

Building upon the idea that targeted interventions fortifying agricultural credits are pivotal for economic growth and poverty alleviation, a study by Sher et al. (2023) underscored the crucial role of interest rates in shaping agricultural productivity. The research revealed how interest-free credit can significantly impact smallholders' decisions, leading to enhanced market participation, better prices, and technological advancements. This multifaceted link between interest rates and productivity is particularly beneficial for underserved farmers, as the study's findings highlight the transition from exploitative local lenders to modern practices. Consequently, the study resonated within the discourse on agricultural credits, emphasizing the need for accessible and affordable credit options to bolster positive outcomes for smallholder farmers.

Besides, as detailed in FAO (2014), the strategic allocation of credit toward agriculture can engender a multiplier effect, amplifying the impact across the entire value chain. This, in turn, aligns to foster value-added agriculture and ignite a virtuous cycle of economic growth. The nature of credit as an enabling input further shapes its role in agricultural production decisions. Unlike direct physical inputs, credit operates as an enabling input in agricultural production. This subtlety renders its role more intricate, as it influences farmers' choices in resource allocation and technology adoption. The nuanced relationship between credit and agricultural output underscores the need for a comprehensive approach to credit accessibility. It necessitates policies that not only increase credit availability but also support farmers in making informed decisions about investment in resources that align with their specific needs and objectives.

In conclusion, our study provides a comprehensive understanding of the interplay between agricultural credits and agricultural production. The elasticity of agricultural credit in shaping agricultural output serves as a clarion call for policy interventions aimed at enhancing credit accessibility. Through a synthesis of economic theory and empirical evidence, we emphasize the synergy between the financial sector's role in capital allocation and the agricultural sector's potential for growth. This holistic perspective underscores the need for multifaceted strategies that empower farmers, foster value addition, and drive sustainable economic development.

7 | CONCLUSION AND POLICY IMPLICATIONS

Food systems and the sustainable use of natural resources are ongoing challenges in rural areas. One of the biggest barriers to smallholder farmers adopting sustainable agricultural production is the lack of access to agricultural loans. Small-scale farmers, especially in developing countries, have to compete with large farmers for limited financial resources. The nature of credit constraints facing smallholder farmers affects agricultural production directly and indirectly. By increasing the amount of loans and advances given to financial institutions to farmers or rural households, as well as the amount of subsidies provided by governments as a tool for agriculture finance, agricultural output and rural household income can be improved and, ultimately, as agricultural productivity increases, the negative impact of factors that cause food security problems such as climate change can be minimized. In this study, we estimated the short-run effect and the long-run effect of agricultural credits on agricultural value-added by considering a global sample of 53 countries over the period 2000–2018. Long-run coefficients are significant for all variables, but only agricultural credits have been found to positively affect value-added agriculture. Estimated short-run coefficients are significant only for government expenditures. Based on the PMG estimator, the error correction parameter for GOV is significant and negative, indicating that government expenditures discourage agricultural production even in the short-run. Furthermore, as can be seen from the causality tests, there exists a bidirectional causality between agricultural credits and agricultural production, apparently assuming that infrastructure works and incentives to be applied to increase agricultural production indirectly increase the use of agricultural credits.

Expanding the options to access credits can help maintain and boost agricultural productivity in the long term. Yet, small businesses and small-scale farmers may also require support to overcome barriers to accessing these credits. Even more importantly, the amount and share of agricultural loans received may not be enough to adopt regenerative agriculture practices to lessen the effects of climate change and to prevent the adverse consequences of greenhouse gas emissions on agricultural productivity. Smart repurposing of agricultural support policies by governments and financial institutions should cover climate-friendly agriculture transformation as well as improved management techniques and efficient food systems. Accordingly, improving agribusiness enterprises' and farms' sustainability and efficiency, while reducing their operating expenses enable a quicker recovery of them from multi-dimensional uncertainties such as the increased risk of flooding, extreme weather events, and more intense temperature pressures. In addition, accessible financial networks and assistance will undoubtedly increase on-farm preparedness and resilience to extreme weather conditions, as high-quality seeds and agricultural tools help especially small farmers, family farmers, and rural producers to combat climate-related extreme events.

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Increasing agricultural productivity has become a top priority because of the rising demand brought on by population growth, the detrimental consequences of global warming on agricultural production, and the need for food security. However, increasing global industrialization and changes in the services sector have resulted in a decline in the agricultural sector's share in the world economy in recent decades. As Swinnen and Gow (1999) argued, credits intended probably for agricultural activities shifted to more profitable sectors. This is in line with our intuition that agriculture credit subsidies provided by governments to the agriculture sector might lead to distributive and allocative inefficiencies. Despite a general decline in agricultural investment profitability, pressures on food security and poverty alleviation will be driven not only by changes in demand but also by the susceptibility of production to weather and other climatic hazards. Consequently, it is urgently needed to change the agricultural system to one that is more environmentally friendly and climate-smart in order to meet future demand. In this regard, loans to be provided by financial institutions as well as government grants can play a major role in promoting food security. Lack of affordable financing has been the main obstacle to farmers adopting sustainable agriculture. Failure to remove the restrictions faced by farmers on rural credit, weak credit distribution system, and/or inadequate institutional support may lead to productivity losses and inevitably lead to a change in the structure of the economy from agriculture to non-agricultural investments. In addition to examining short-run and long-run effects and causalities, future research may be conducted to investigate cross-country dynamic interlinkages in greater detail by using sensitivity analysis within the Bayesian Model Averaging framework. Data-driven techniques such as LASSO (Least absolute shrinkage and selection operator), artificial neural network (ANN), and/or random forest can be used to construct early warning models signaling a risk of a financial stress of agribusiness firms and farming-related commercial activities.

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ENDNOTES

[1] The countries in the panel are listed in Appendix S1.

[2] For more information, please see Stock and Watson (1993).

[3] Fully Modified OLS (FMOLS) is also commonly used to control the robustness of DOLS results in the literature; however, all variables must be stationary in the same order under this approach (Yahyaoui & Bouchoucha, 2021). As Kao and Chiang (2001) proposed, DOLS performs better than FMOLS estimators in terms of mean biases. Ali et al. (2017) notes that the main advantage of DOLS is that it can be applied under the mixed order of integration of variables in the cointegration framework.

[4] For more details, please see https://www.fao.org/3/a0050e/a0050e10.htm.

[5] In order to save space, the results of the Pesaran and Yamagata (2008) slope homogeneity test are not presented here. According to our findings, the slope coefficients are heterogeneous in the cross-sectional dimension.

[6] All estimations were conducted with the Stata module "xtmg" (Eberhardt, 2012).

[7] As mentioned previously, FMOLS can only be used for the long-run estimates of I(1) variables.

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