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ARTICLE

The Influence of Public and Private Credit on the Production Value of Agricultural Sector in Saudi Arabia

Mohammed Al-Mahish * **, *Fatmah Al-Kulaib***

Department of Agribusiness and Consumer Science, King Faisal University, Al-Hofuf 31982, Saudi Arabia

ABSTRACT

Private commercial credit and governmental funding play an essential role in increasing agricultural production, achieving food security and stabilizing domestic market prices. This study examined the influence of both private and public funding on the value of agricultural products in Saudi Arabia. Utilizing annual time series data from 1990 to 2022, the unit root test results indicated a mixed order of integration among the variables. Consequently, the Autoregressive Distributed Lag (ARDL) error correction model was used to assess the effects of financing and production inputs on the value of domestic agricultural output. The findings reveal that private funding exerts a positive effect on the value of agricultural products, whereas public funding does not demonstrate a similar positive contribution. This outcome is likely due to inefficiencies in the allocation of public funds by beneficiaries, with a significant portion directed towards foreign agricultural investments and import activities. Labor as a production factor was found to positively impact the value of agricultural output. This research has also explored the presence of economies of scale within the Saudi agricultural sector and concluded that the sector is currently experiencing diseconomies of scale. This paper recommends designing a policy that ensures that the allocated funds used in agricultural and food activities will eventually enhance the value of domestically produced food and agricultural commodities. It is very important to balance between increasing the available quantity of agricultural products through importing and protecting the value of domestically produced agricultural products.

Keywords: Agriculture Finance; Economies of Scale; ARDL

*CORRESPONDING AUTHOR:
Mohammed Al-Mahish, Department of Agribusiness and Consumer Science, King Faisal University, Al-Hofuf 31982, Saudi Arabia;
Email: malmahish@kfu.edu.sa

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1. Introduction

Given that humans cannot live without food, it is not only a basic human right but also a critical requirement. Poverty and hunger have historically posed significant challenges globally. Civilizations around the globe rely heavily on the agriculture sector as their primary livelihood. The products from this sector not only provide sustenance but also serve as essential resources for diverse industries [1]. Agriculture is significant across various aspects of society including the political, social, cultural, economic, and environmental domains. The agricultural sector helps address the numerous financial challenges faced by developing nations, such as low income, high unemployment rates, the balance of payment deficits, and diminishing central bank reserves in foreign currencies. Since the agriculture sector contributes to sustaining the food supply [2], there is a need to enhance performance and productivity in this sector. In emerging nations, enhancing agricultural productivity faces numerous challenges, including the continual demands driven by population growth and the critical deficiency of soil nutrients [3]. The total population of the Kingdom of Saudi Arabia (KSA) was reported as 30.77 million people in 2014, covering an area estimated to be 2,149,690 square kilometers, encompassing most of the Arabian region (80%) [4, 5]. The agriculture and food industry in KSA is in charge of ensuring food security and preserving stable food prices. The agriculture sector not only promotes social and rural development but also provides production inputs for a wide array of food and beverage companies. This fundamental role of supplying raw materials supports production across multiple sectors, as highlighted by MEWA [6]. Consequently, Saudi Arabia contributes to global initiatives that are intended to combat hunger. Aligned with the Sustainable Development Goals for Saudi Arabia 2030 vision, the country aims to enhance the contribution of its agricultural sector in the GDP by broadening its agricultural production base and stimulating economic growth to advance both local and global food security objectives [7]. Despite the challenging climate conditions marked by severe temperatures that negatively affect cultivation, Saudi Arabia is currently undergoing an agricultural transformation. This transformation seeks to enhance domestic crop yields and reduce the reliance on imported food, a motivated effort as approximately 90% of the country's land comprises desert terrain. Nevertheless, the country maintains self-sufficiency and even generates surplus food items such as vegetables (70%), fresh milk (122%), table eggs (115%), and dates (115%) [8].

Finance forms the foundation of all agribusiness operations. Within the agricultural sector, credit can be sourced from both formal and informal channels, including commercial banks, brokers, local dealers, and unofficial credit associations, as well as from relatives and friends. The availability of credit from financial institutions serves as a valuable tool in enhancing agricultural productivity [9]. Acquiring land and modern technologies like fertilizers in agriculture involves substantial capital investment along with external financing [1]. Agricultural credit plays a vital role in enabling producers to meet the financial demands that are important for the unique production cycle of farming during which minimal revenue is generated, while expenses for inputs and resources must be covered [10]. Agricultural transition from traditional practices to modern methods necessitates agricultural funding to procure advanced farming supplies. Access to capital is essential for farmers to enhance agricultural productivity [11].

Financial institutions have played a positive and effective role in promoting technological changes in the agricultural sector and increasing agricultural returns for small farmers. This is due to the increasing requirements for farmers to utilize more expensive types of machinery and equipment, pesticides, and fertilizers. As a result, agricultural credit has become an urgent necessity to modernize agriculture and meet its needs [12]. Inadequate investment funding remains the primary barrier to agricultural progress. Banks are fundamental financial intermediaries whose primary goal is to reinvest or loan surplus funds from spending units back into the economy. Through encouraging savings, providing capital for growth, facilitating trade, supporting investments, advising small business owners, promoting international trade, and cultivating capital markets, banks play a vital role in driving economic expansion [13]. The Agricultural Development Fund (ADF) in Saudi Arabia

was set up as a specialized credit institution to optimize agricultural resources, enhance food security, foster rural development, and boost productivity. Saudi Arabia is committed to investing in the agricultural sector to enhance production, efficiency, and sustainability while formulating credit-related strategies, policies, and initiatives.

Loans provided are aimed at diversifying the agricultural sector through crops cultivation, fruits cultivation, fishing boats, tourist ventures, clinics, veterinary pharmacies, and vegetable carts. These loans, designed for specialized projects, are considered long-term direct investments, whether they funding new, expanded, or rehabilitated projects. The objective of these specialized project loans is to yield annual returns within a specified timeframe, facilitating the creation and management of production facilities with allocated financial resources. Due diligence or feasibility studies with approval from the Ministry of Environment, Water, and Agriculture are essential prerequisites for accessing this service. The feasibility study should involve an examination of cash flow, creditworthiness, and project viability to determine the repayment period. If the repayment period is not more than one year, the service provides financing options through indirect loans to support working capital for specialized projects. Another alternative is foreign investment, a key component of the Kingdom's food security strategy, enabling farmers to export their products as long as they maintain self-sufficiency within the country. This service also contributes to enhancing the diversity and stability of foreign food supplies. The Agricultural Development Fund (ADF) offers a ten-year loan with a two-year grace period, available in either US dollars or Saudi riyals. Additionally, the Fund finances up to 60% of the total cost of a given project. While both private and public credit sources influence productivity in the agricultural sector, their contribution effect may differ.

To deliver tailored financial solutions for the agricultural industry, the ADF partnered with Saudi Fransi Bank and the Saudi Investment Bank. This strategic alliance has contributed to the creation of economic resources aligned with farmers' needs and is aimed at strengthening food security. The collaboration fosters effective cooperation between the ADF and banking institutions, supporting a balanced integration of public and private sector efforts in the Kingdom.

To broaden its clients' financing options, the ADF entered into agreements with Samba, Alrajhi Bank, and the Saudi Investment Bank. These agreements are an extension of the previous agreements signed by the ADF with commercial banks, intending to provide more financing options for ADF's clients. Since the launch of the bank-partnered financing program in 2018, the fund has approved loans worth more than SAR 2.5 billion and is now seeking to expand this lending through its updated strategy. The credit facilities resulting from the partnership between the Fund and commercial banks are to provide various financing products to the Fund's clients, whether they are institutions, companies, or individuals[14]. The ADF approved SR2 billion ($533.33 million) in loans and credit facilities to enhance food sustainability and security throughout the Kingdom.

Public and private credit's distinct effects on agricultural output have not been considered in previous research that has looked at the relationship between agricultural funding and production value. Several elements affect agriculture's output throughout both long and short time frames. The primary concern that needs to be considered is how agricultural production value is impacted by both public and private finance, which is the main purpose of this study.

KSA has accelerated the collaboration between the ADF and banks by offering credit services. These services empower farmers to access credit, thereby boosting production and income through the adoption of modern agricultural inputs. Recent shifts and the need to enhance the agricultural sector's contribution to the Kingdom's economy have underscored the necessity of updating traditional farming practices that may no longer align with contemporary requirements. To elevate the sector's productivity and enhance its impact on economic and social realms, substantial capital must be provided to farmers. This financial support enables them to acquire the equipment and machinery that is essential for advancing agricultural practices across the country. Because of the limited income of some farmers, recourse to credit is as imperative as access to loans and

other credit services. Some farmers may be ineligible for financing due to credit guarantees and the conditions set by formal institutions [15]. The importance of credit in driving the progress of the agricultural sector is clear, as it serves as a key factor in helping the sector achieve its desired goals [16].

Given the research problem stated, it is important to address the following research questions:

1. Have government and private bank credit contributed to the augmentation of agricultural production value in Saudi Arabia?
2. What is the extent of the effectiveness of the factors of production in achieving economies of scale in the Saudi agricultural sector?

Due to the limited availability of academic literature examining the impact of financing—whether public or private—on the agricultural sector in KSA, this study aims to address this shortage in the literature by analyzing how governmental and private credit influence the value of agricultural products.

Literature Review

Several recent studies have been established to examine the influence of agricultural funding on agricultural sector. Some of them used household or farm-level data [9, 12, 17, 18]. Misra et al.; Tuan Anh; Seven & Tumen; Manoharan & Varkey; Mahapatra & Jena [19–23] analyzed and utilized national-level data. The majority of published papers stated that agricultural loans enhance agricultural production efficiency. For instance, Misra et al. [19] found that credit in India has positive effect on the total factor productivity of the agricultural sector [9]. One study applied the Cobb-Douglas production function to data collected from 120 sugarcane growers and estimated it using a binary probit selection model. The results indicated that the use of credit as an input of production can enhance both production yield and the farmers' revenue.

In South Africa, a study investigated the association between agricultural production and credit by utilizing secondary data. Johansen's co-integration test was applied to assess the long-term relationship between agricultural output and bank credit. In addition, an error correction model was estimated to examine short-term dynamics and the speed of adjustment toward long-run equilibrium. Granger's causality test was also employed. The results revealed a positive long-term connection between agricultural output and bank credit, with a unidirectional causality suggesting that an increase in bank facilities led to growth in agricultural output [24].

Ngozi & Anthony [25] evaluated the impact of agricultural loans on food production in Nigeria using multiple regression analysis. The findings revealed a positive significant relationship between agricultural loans and food production, indicating that enhanced access to credit for farmers leads to higher levels of food output. The results underscore the importance of credit availability in supporting food security and agricultural productivity in the country.

Tokunbo [26] examined the impact of bank credit on the manufacturing and agricultural sectors in Nigeria. The study revealed that bank credit had a significant positive impact on the Nigerian manufacturing sector growth. The study also noted that some policies are needed to facilitate the flow of credit to the agricultural sector to enhance its productivity and contribution to economic growth.

Ita et al. [27] investigated the effect of bank credit in Nigeria on the expansion of the agricultural sector using regression analysis. The results indicated that commercial bank credit exerts a positive and statistically significant influence on agricultural sector growth. Additionally, the study found that the exchange rate applied by commercial banks to agricultural credit also has a positive and significant impact on the sector's expansion, highlighting the importance of both credit availability and favorable financial conditions in promoting agricultural development.

Abdullahi et al. [28] analyzed the impact of credit on the agriculture, small enterprise, and manufacturing sectors in relation to Nigeria's economic growth. The findings demonstrate a consistent correlation among the variables. In both the short- and long-term, credit extended to the agricultural sector positively affected GDP. In contrast, credit directed toward small enterprises had a negative impact on GDP in the short-term but turned

positive in the long-term. Credit allocated to the manufacturing sector exhibited a negative influence on GDP in both timeframes.

In a related study[29], agricultural finance and credit constraints in Ghana were assessed using household surveys in rural areas, along with regression and descriptive analysis. The results indicate that limitations in access to agricultural credit and financing significantly hinder agricultural productivity.

Agbodji & Johnson[30] examined the impact of agricultural facilities on cereal productivity in Togo, aiming to provide a comprehensive analysis while accounting for potential biases and internal factors affecting the connection between credit access and productivity. They gathered preliminary data by surveying smallholder farmers in the region, employing slope score matching to establish comparable groups of credit recipients and non-creditors while mitigating selection bias, and internal shift regression to address underlying factors influencing both credit access and productivity. The evaluation by Agbodji & Johnson[30] is significant as it sheds light on how agricultural credit influences cereal productivity in Togo. Their study revealed that agricultural credit in general has a positive and significant impact on the productivity of maize, sorghum, and rice. The differential effect based on the type of credit. Also, has varying effects where in-kind credit positively affected maize and sorghum productivity but did not have an impact on rice. Cash credit results were mixed with a negative impact on corn, a positive effect on sorghum, and no significant impact on rice.

Meanwhile, Nakazi & Sunday[31] examined both the short and long-term effects of commercial bank credit on the growth of the agricultural sector in Uganda. Using secondary data and estimating using the Autoregressive Distributed Lag (ARDL) approach, the research explored the association between commercial bank credit and agricultural GDP. The findings indicated that in the long-run, bank credit positively impacts agricultural output. Notably, production credit exerted a greater influence on agricultural output compared to credit allocated for processing and marketing activities. In the short-term, commercial bank credit was found to have no immediate effect on agricultural output.

Chandio et al.[32] examined the cumulative impact of capital investments (including agricultural credit), CO2 emissions, and advancements in technology including farming equipment on Chinese grain crops production using the ARDL methodology. The ARDL-bounds testing method established a long-term relationship among the variables. The findings revealed that agricultural research and development investment positively impacts grain crop yields over both short- and long-term periods. Agricultural credit was identified as a significant factor in improving grain crop output. Conversely, CO2 emissions were found to negatively affect grain production in both the short- and long-term. Additionally, the allocation of land to grain crops and the utilization of fertilizers were noted to positively influence grain production across both time frames.

Kn[33] analyzed trends in agricultural credit flow in India and assessed their impact on agricultural GDP and exports. The study indicates that credit provided to the agricultural sector has a statistically significant positive impact on agricultural GDP in India, and this suggests that increased access to credit increases agricultural production and overall growth in the sector. In contrast, the positive association between interest and agricultural GDP does not directly determine productivity.

Manoharan & Varkey[22] investigated the association between agricultural financing and agricultural productivity in India, adopting a fixed effects model to conduct a state-level panel data analysis. The results demonstrate that direct agricultural credit positively influences productivity, while indirect credit exerts a significant negative impact.

Mahapatra & Jena[23] explored the effect of agricultural credit disbursement—specifically crop loans and term loans—on the yields of total cereals, millet, and rice. Through the ARDL model, the study assessed the relationship between credit types and crop yields. The empirical results from the bounds F-test indicate a statistically significant association between agricultural credit and the yields of the examined crops at the 1% significance level. In the long-run, crop loans were found to have a positive effect on the yields of cereals and rice, though no significant impact was observed on millet yields. On the other hand, the conditions of loans nega-

tively affected the yields of cereals, millet, and rice, with the effect being more pronounced on rice than on millet. In the short term, both crop and term loans were associated with negative impacts on the yields of all three crop categories.

Tuan Anh et al.[20] employed the ARDL model along with the Toda and Yamamoto Granger causality tests to examine the relationship between agricultural finance and agricultural GDP in Vietnam. The findings revealed a unidirectional causal relationship from agricultural credit to agricultural GDP, indicating that credit plays a significant role in driving agricultural economic growth.

Similarly, Khan et al.[34] investigated the impact of agricultural credit disbursement on agricultural growth in Pakistan using a Vector Error Correction Model (VECM). The analysis confirmed a positive and statistically significant long-term relationship between agricultural credit and the growth of the agricultural sector.

In another study, also based on country-level time series data from Pakistan, differentiated between various types of credit such as those related to food production, credit for modern agricultural machinery, and general agricultural financing. The results affirmed that credit extended by a range of financial institutions had a positive and significant influence on agricultural GDP[12]. The findings indicate that land loans and cooperative loans had a negative but statistically insignificant effect on the agricultural gross domestic product.

In a related study conducted in Pakistan, researchers employed a probit model to identify the factors affecting farmers' access to formal credit. They then applied the Cobb-Douglas production function to assess the impact of formal credit on sugarcane productivity. The results confirmed a significantly positive effect from formal credit on sugarcane output, highlighting that access to and the effective utilization of credit in the production process can enhance crop yields and increase farmers' income. Hence, ensuring the secure and timely disbursement of crop-specific credit is critical, as it enables farmers to apply agricultural inputs efficiently at appropriate stages of production.

Islam[35] investigated the impact of agricultural finance on agricultural productivity in Bangladesh, aiming to assess how access to credit influences the efficiency and output of the agricultural sector. The analysis employed the ARDL bounds testing approach to examine both short- and long-term relationships between agricultural credit and productivity. The findings demonstrate a significant and positive correlation between agricultural credit and agricultural productivity in both timeframes, indicating that improved access to credit for farmers in Bangladesh contributes to higher levels of agricultural output.

Bahşi & Çetin[36] investigated the relationship between agricultural credit and the value of agricultural production in Turkey, employing Ordinary Least Squares (OLS) as the primary statistical estimation method. The regression results indicated that the terms of credit had a more significant impact on agricultural production value than the amount of agricultural credit itself.

Seven & Tumen[21] investigated the relationship between agricultural credit and agricultural productivity in Arab countries using various econometric techniques, including standard cross-sectional least squares, cross-sectional regressions with fixed effects, two-stage least squares (2SLS) regressions using instrumental variables, generalized method of moments (GMM), and IV-2SLS estimation techniques. The findings indicate that states with more robust agricultural financing systems tend to exhibit higher levels of agricultural productivity. A positive correlation was identified between agricultural credit and agricultural productivity, emphasizing the crucial role of credit availability in enhancing sectoral efficiency and output. The positive impact of agricultural credit on productivity remains even after the consideration of alternative measures related to agricultural production, such as agricultural labor productivity.

Alrwis et al.[37] estimated the impact of water scarcity on agricultural economic development and economic development indicators in the Kingdom of Saudi Arabia. Descriptive analysis and econometric analysis were used to estimate the proposed regression models. The findings indicate that an increase in employment and agricultural loans corresponded to a rise in the total value added to agricultural production. The total value of agricultural production contributes to an increase in GDP.

Looney[38] investigated the feasibility of agriculture in Saudi Arabia using descriptive approach. The results indicate that access to credit has the possibility of increasing productivity through increased investment in the sector.

Alzyadat[39] analyzed the influence of banking credit facilities on non-oil economic growth in Saudi Arabia using the ARDL model. The study findings reveal that an increase in bank facilities is linked to a positive impact on non-oil economic growth in Saudi Arabia. Additionally, the results highlight that bank loans from different banking sectors had a nonlinear effect on growth within the non-oil economy.

Most of the reviewed literature analyzed the impact of credit on the agricultural GDP without segregation between public and private credit. Thus, this paper aims to fill the gap in the economic literature by examining how public and private credit, along with other essential explanatory variables, affect the value of agricultural production. This paper also examines the existence of economies of scale in terms of the value of agricultural production instead of quantity produced or agricultural GDP.

2. Materials and Methods

To judge whether the input of agricultural sector in Saudi Arabia is being utilized efficiently in the creation of output, this paper will use the log-linearized version of the Cobb-Douglas production function specified below:

$$ly_t = a_0 + \pi_1 ll_t + \pi_2 lg_t + \pi_3 lp_t + \pi_4 la_t + \pi_5 lf_t + u_t \quad (1)$$

Where the dependent variable is the log of agricultural production value and u represents the error term. The independent variables represent the logs of labor (ll_t), government credit (lg_t), private credit (lp_t), size of agricultural land area (la_t), and fertilizer (lf_t). The independent variables were selected because they represent the most important factors of production in the agricultural sector. The impact of credit can be hypothesized using partial derivatives as: $\frac{\partial ly}{\partial lg} = \pi_2 > 0$; $\frac{\partial ly}{\partial lp} = \pi_3 > 0$. These partial derivatives indicate that the change in agricultural output with respect to public funding and private credit is expected to be positive, i.e. that an increase in public or private credit is expected to increase the agricultural sector output.

The authors relied on multiple sources to collect the necessary data for this research. The data for this study were obtained from several official sources, including the Ministry of Environment, Water and Agriculture (MEWA), the Agricultural Development Fund, the Saudi Central Bank (SAMA), and the General Authority for Statistics. The collected data consisted of annual time series data from 1990 to 2022. **Table 1** shows the summary statistics of the collected data.

Table 1. Summary Statistics.

Variable	Minimum	Maximum	Mean	Std. Deviation
Agricultural production value (billion Riyal)	27.000	195.000	104.061	52.691
Agricultural production are (million hectare)	4.200	7.400	5.800	0.967
Private credit (billion Riyal)	0.800	7.200	4.000	1.934
Government funding (billion Riyal)	0.200	6.600	3.400	1.934
Total labor (thousands of workers)	300.000	950.000	596.600	204.678
Fertilizers (million tons)	0.960	2.810	1.848	0.592

By comparing the minimum value to the maximum value, we notice that the value of agricultural production has increased significantly. On average, private credit was higher than government funding. The total amount of labor including domestic workforce and expatriates working in the agricultural sector in Saudi Arabia reached its highest level in 2021, with 950,000 workers.

To avoid the trap of estimating spurious regression using time series data, the first step in the time series analysis should involve inspecting the unit root properties of the collected data. **Table 2** shows the results of the Augmented Dickey Fuller (ADF) unit root test.

The results of the ADF test show that the values of

agriculture production, private credit, and public funding are stationary I(0). Agriculture area, total labor force, and fertilizers are not stationary at their level, and they need to be differenced to become stationary I(1).

Table 2. Results of the Augmented Dickey Fuller.

Variables	Level I(0)		First Deference I(1)	
	Test Statistics	Decision	ADF Test	Decision
Value of agriculture production	$-16.972**$	stationary		
Agriculture area	-2.1432	Unit root	$-6.5429**$	stationary
Private credit	$-19.256**$	stationary		
Governmental funding	$-12.351**$	stationary		
Total labor	-1.0401	Unit root	$-5.185**$	stationary
Fertilizers	-1.5438	Unit root	$-5.447**$	stationary

Since we have mixed order of integrations as shown in **Table 2**, this paper will use the Auto Regressive Distributed Lag (ARDL) methodology [40] for estimating the production function as specified in equation (1). The first step of the ARDL requires examining the existence of cointegration using an F-test, i.e. ARDL bounds test approach [41], as below:

$$\begin{aligned}\Delta ly_t = \beta_0 + \pi_1 ly_{t-1} + \pi_2 ll_{t-1} + \pi_3 lg_{t-1} \\ + \pi_4 lp_{t-1} + \pi_5 la_{t-3} + \pi_6 lf_{t-1} \\ + \sum_{i=1}^{p} a_i \Delta ly_{t-i} + \sum_{i=1}^{p} b_i \Delta ll_{t-i} \\ + \sum_{i=1}^{p} c_i \Delta lg_{t-i} + \sum_{i=1}^{p} d_i \Delta lp_{t-i} \\ + \sum_{i=1}^{p} e_i \Delta la_{t-i} + \sum_{i=1}^{p} f_i \Delta lf_{t-i} + u_t\end{aligned} \tag{2}$$

As shown in the above equation, the lag length is one period. Except for the agricultural land, the lag length was set to 3 because agricultural land needs more time to be cultivated and for its output to be transferred to a monetary value.

To test for the existence of long-run relationships among the variables, the following null and alternative hypotheses are constructed:

$$H_0 : \pi_1 = \pi_2 = \ldots \pi_6 = 0 \tag{3}$$

$$H_1 : \pi_1 \neq \pi_2 \neq \ldots \pi_6 \neq 0 \tag{4}$$

Rejection of the null hypothesis indicates the existence of a long-run relationship and the fact that the variables are cointegrated. This allows us to proceed to the second step, which is estimating the ARDL model in the error correction format as below:

$$\begin{aligned}\Delta ly_t = \sum_{i=1}^{p} a_i \Delta ly_{t-i} + \sum_{i=1}^{p} b_i \Delta ll_{t-i} \\ + \sum_{i=1}^{p} c_i \Delta lg_{t-i} + \sum_{i=1}^{p} d_i \Delta lp_{t-i} \\ + \sum_{i=1}^{p} e_i \Delta la_{t-i} + \sum_{i=1}^{p} f_i \Delta lf_{t-i} \\ + \lambda\, ecm_{t-1} + u_t\end{aligned} \tag{5}$$

Where ecm refers to the residuals from the cointegration equation (2), representing the error correction term.

3. Results and Discussion

The results of the cointegration test as specified in equation (2) are shown in **Table 3**. The results indicate the rejection of the null hypothesis of no cointegration at the one percent level.

Table 3. Bounds F-test (Wald) for no cointegration.

F-Statistics	Decision
10.839	Reject H_0

Since the existence of a long-run relationship has been confirmed, we estimated the ARDL error correction model (5) with no constant and no trend because including them resulted in non-significant parameters for both the intercept and trend. The parameters of the estimated model are shown in **Table 4**, while **Table 5** shows the diagnostic tests of the estimated model.

The results of the Jarque Bera normality test show that the residuals are off normal, which is due to the relatively small number of observations. The results of the Breusch-Pagan heteroscedasticity test reject the null hypothesis of homoscedasticity, which justifies the use of

heteroscedasticity-autocorrelation robust standard errors in the estimated model as shown in **Table 4**. The Breusch-Godfrey test for serial correlation in the residuals shows that we fail to reject the null hypothesis of autocorrelation in the residuals. The CUSUM test shows that we fail to reject the null hypothesis where the process mean is constant over time, indicating that the parameters are stable over time. Also, **Figure 1** shows that our model is stable.

Table 4. Coefficients of the Estimated ARDL Error Correction Model.

Variable	Short-Run Coefficient	Long-Run Coefficient
Δly_{t-1}	0.138 (0.165)	0.148
$\Delta lArea$	−2.439*** (0.814)	−2.622
$\Delta lPrivate\,Credit$	3.172*** (0.708)	3.409
$\Delta lPublic\,Funding$	−1.479*** (0.349)	−1.590
$\Delta lLabor$	0.184*** (0.050)	0.198
$\Delta lFertilizer$	0.004 (0.033)	0.005
ecm	−0.930*** (0.274)	
Adjusted R-squared=0.98	Residual Standard Error = 0.007	F-Statistic 344

Note:***,**,* indicate the significance level at the one, five, and ten percent level, respectively. Standard errors are in parentheses.

Table 5. ARDL Model Diagnostic Tests.

Test Name	Test Statistics	Decision
Jarque Bera Test	29.641	Reject Null Hypothesis
Breusch-Pagan Test	15.865	Reject Null Hypothesis
Breusch-Godfrey Test	2.869	Fail to Reject Null Hypothesis
CUSUM Test	0.636	Fail to Reject Null Hypothesis

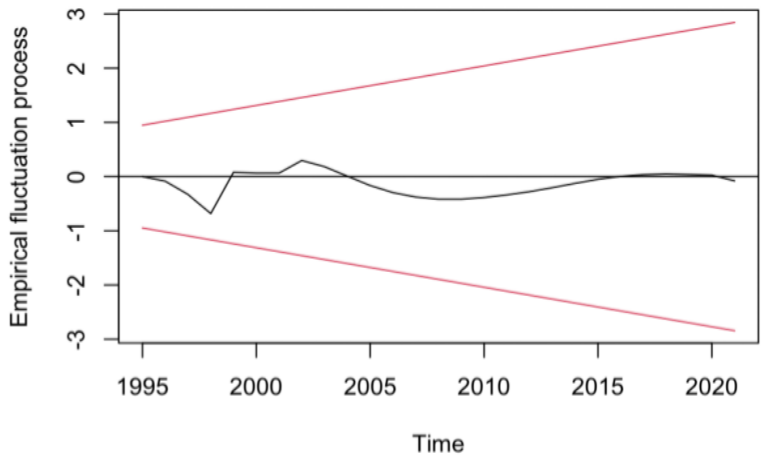

Figure 1. Recursive CUSUM Test.

The adjusted R-squared value indicates that the model explains approximately 98% of the variation in the dependent variable, reflecting a strong goodness of fit. The error correction term (ECT) carries the expected negative sign and is statistically significant at the 1% level, suggesting a rapid adjustment back to long-run equilibrium, with a correction speed of 93% per year. The long-run coefficients were estimated using the partial adjustment approach, calculated by dividing the negative of the short-run coefficient by the error correction term [42, 43]. Overall, the results indicate that the long-run impact is slightly greater than the short-run effect. Among the financing variables, private credit exhibits the strongest positive influence on the value of agricultural production in Saudi Arabia. In the short run, a 1% increase in private credit is associated with an approximate 3% rise in the value of agricultural output. These findings are consistent with previous stud-

ies that have demonstrated a positive relationship between financing and both agricultural productivity and agricultural GDP [24, 27, 28, 31]. Surprisingly, public funding has a negative impact on the value of agricultural production. This can be attributed to the fact that some of the agricultural funding is directed toward importing agricultural products and agricultural investments abroad. Although this policy helps achieve food security and lower food prices in the domestic market, it contributes to the depreciation of the value of domestic agricultural products. Gebeyehu & Bedemo [44] indicated that the negative impact of public funding was attributed to misallocation by farmers, who often divert the funds toward non-agricultural activities, thereby diminishing its effectiveness in supporting agricultural production. Policy reforms regarding public funding in Saudi Arabia should consider measuring and monitoring how publicly funded projects, commodities, or inputs affect the value of domestically produced products. More credit facilities should be disbursed to projects, commodities, or inputs that ultimately result in increasing the value of domestic agriculture production. Also, tax waivers as another policy should be considered a support for projects that contribute to the appreciation of domestic agricultural production and increase the welfare of domestic farmers and agricultural entrepreneurs. Also, in order to ensure alignment with agriculture production goals, the paper suggests that public funding recipients are provided with targeted production quantity and at the end of production cycle are evaluated based on achieving the targeted quantity. Those producers who successfully achieve the targeted quantity will guarantee future credit facilities. However, producers who do not achieve the targeted production quantity will, in the future, receive reduced credit facilities that are consistent with their produced quantities.

The results also show that the increase in the size of the agricultural production area negatively affects the value of domestic agricultural product. This is because as the domestic area of agricultural production expands, the supply of agricultural products in the domestic market will increase, hence the prices of domestic agricultural products will decrease as a result of the supply increase. Some studies state that when demand is high, expanding the agricultural area can help stabilize market prices [45, 46]. Conversely, the total labor force employed in the agricultural sector exerts a positive influence on the value of domestic agricultural production [44].

The final step in the analysis is to examine whether the Saudi agricultural sector is operating with increasing returns to scale, decreasing returns to scale or constant returns to scale. **Table 6** shows the results of examining the null hypothesis that the Saudi agricultural sector is operating under constant returns to scale.

Table 6. Constant returns to Scale Test.

F-Statistics	Decision
8.7417	Reject null hypothesis

The results in **Table 6** show that we reject the null hypothesis of constant returns to scale. Thus, we conclude that the Saudi agricultural sector is operating under diseconomies of scale.

We also conduct the robustness check to ensure the signs of estimated parameters are invariant to addition of model's independent variables. We add water as an independent variable since it is a very important input in agricultural production, even though, we do not have full observations of the water variable that covers the entire period of this study (1990–2022). Specifically, we have two missing observations, and we recovered them using trend extrapolation method. **Table 7** shows the parameters of the ARDL model after adding water as an explanatory variable.

The results of the robustness check show that the sign and the significance of the variables have not changed. Also, the parameters of public and private lending have not changed. The major concern of this model is that the error correction term's value is slightly higher than one in absolute value, which could indicate over correction.

Table 7. Robustness Check.

Variable	Short-Run Coefficient
Δly_{t-1}	0.161 (0.160)
$\Delta lArea$	−2.522*** (0.812)
$\Delta lPrivate\,Credit$	3.152*** (0.664)
$\Delta lPublic\,Funding$	−1.474*** (0.328)
$\Delta lLabor$	0.183*** (0.046)
$\Delta lFertilizer$	0.002 (0.032)
$\Delta lWater$	−0.128 (0.318)
ecm	−1.062*** (0.266)
Adjusted R-squared=0.98	Residual Standard Error=0.006

Note:***,**,* indicate the significance level at the one, five, and ten percent level, respectively. Standard errors are in parentheses.

4. Conclusions

Commercial banks, financial institutions, and the Saudi government provide various forms of funding and support to the agricultural sector with the primary goals of developing and expanding domestic agricultural capacity, achieving self-sufficiency in key agricultural commodities, supporting local farmers, enhancing food security, and stabilizing the prices of food and agricultural products within the country. Given the critical role of financing in agricultural production, this study aims to evaluate the impact of both private credit and public funding on the value of domestic agricultural products. By utilizing annual time series data covering the period from 1990 to 2022, unit root tests revealed that the main variables exhibit a mixed order of integration. To achieve the paper's objectives, the Autoregressive Distributed Lag (ARDL) model was adopted as an estimation tool to examine the effect of key production factors on the value of agricultural output.

The findings indicate that private credit plays a significant and positive role in enhancing the value of agricultural products. In contrast, governmental funding was found to have no positive contribution, a result primarily attributed to the misallocation of public credit by farmers toward non-agricultural activities, as well as the diversion of public funds to support agricultural investments abroad and import operations. Additionally, the expansion of cultivated agricultural land demonstrated a positive impact on increasing the domestic supply. If the increase in supply is not matched by adequate demand, it may result in price declines—especially given the perishable nature of agricultural products. The total labor force engaged in agriculture in Saudi Arabia was shown to positively influence the value of the agricultural sector. This study also rejected the assumption of constant returns to scale, concluding instead that the sector operates under diseconomies of scale. Based on these results, this paper recommends the development of policies aimed at striking a balance between increasing the quantity of agricultural products available in the domestic market and enhancing the overall value of domestically produced agricultural goods. This is while ensuring that publicly allocated funds are transformed into food and agricultural commodities that enhance the value of domestically produced products, increasing the welfare of domestic farmers.

The main limitation of this paper is that water as an input was included only in robustness check model due to the unavailability of observations that cover the entire period of this study. Future research should include water along with other relevant factors of production. Also, this paper recommends estimating cost function in the Saudi agricultural sector using appropriate estimation techniques that reveal the most important factors that elevate the cost of domestic agricultural production, as well as suggesting relevant mitigation policies that have produced the highest possible output with the lowest possible cost of production.

Author Contributions

Conceptualization, M.A. and F.A.; methodology, M.A.; software, M.A. and F.A.; validation, M.A.; formal analysis, M.A. and F.A.; investigation, M.A. and F.A.; resources, M.A. and F.A.; data curation, F.A.; writing—original draft preparation, M.A. and F.A.; writing—review and editing, M.A. and F.A.; supervision, M.A.; and

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The data used in this article can be found at the following links:

Ministry of Environment ,Water and Agriculture

https://www.mewa.gov.sa/en/InformationCenter/OpenData/Pages/Home.aspx

Agriculture Development Fund

https://adf.gov.sa/en/FundLibrary/OpenData/Pages/default.aspx

Saudi Central Bank

https://sama.gov.sa/en-US/EconomicReports/pages/database.aspx

General Authority for Statistics

https://dp.stats.gov.sa/dashboard

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Conflicts of Interest

The authors declare there to be no conflicts of interest.

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