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Research Article

Exploring the Nexus Between Agriculture Orientation Index, Government Subsidies, and Exchange Rates: New Evidence from Türkiye

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Abstract: Access to agricultural credit is a key factor of rural development, productivity growth, and food security; however, there is no clear consensus on how it should be allocated. Using annual data from 1999 to 2023, this study investigates the long-run and causal relationship between the Agriculture Orientation Index for Credit (AOIC), government agricultural support, and exchange rates in Türkiye. To capture long-run dynamics and to accommodate structural breaks and nonlinearities, we employ the Fourier Augmented Dickey-Fuller (ADF), Fourier Autoregressive Distributive Lag (FADL), and Fourier Toda-Yamamoto (TY) causality tests. The results indicate the existence of a significant cointegration relationship between the variables, with 1% increase in government agricultural support and exchange rate leading to a decline in AOIC by 3.13% and 2.62%, respectively. Causality tests verify unidirectional linkages from government support and exchange rates to agriculture credit orientation. These findings suggest that subsidies can replace rather than complement formal agricultural credit, while exchange rate fluctuations further constrain banks' willingness to direct funds into the sector. By identifying AOIC as a new indicator and applying sophisticated econometric tools, this study provides new empirical evidence for a middle-income economy, offering important implications for the construction of subsidy systems and macroeconomic stabilization policies.

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1. Introduction

Access to agricultural credit constitutes a fundamental component of rural development, productivity enhancement, and food security in developing and emerging economies. By enabling farmers to finance modern inputs, adopt innovative technologies, smooth inter-seasonal consumption, and manage exposure to price and yield volatility, credit functions not merely as a liquidity instrument but as a catalyst for structural transformation (Balana and Oyeyemi, 2022; Kuhn and Bobojonov, 2023). The structural characteristics of agricultural production—extended turnover cycles, seasonal income realization, and pronounced exposure to climatic and market risks—render external financing indispensable. In many production systems, farmers must incur substantial input expenditures months before harvest revenues are realized, creating persistent liquidity gaps that cannot be bridged through internal savings alone (FAO, 2022).

Although the importance of agricultural credit is well established, its allocation is embedded within a broader macroeconomic and policy environment. Exchange rate movements influence input costs, export competitiveness, and investment expectations, thereby shaping both credit demand and supply conditions (Wagao et al., 2024). Government agricultural supports, in turn, aim to stabilize farm income and enhance repayment capacity, potentially altering the orientation of lending in the banking sector. Consequently, agricultural credit dynamics cannot be fully understood without jointly considering macroeconomic volatility and public policy interventions.

Despite an expanding body of research, two major gaps remain. First, the bulk of empirical evidence is concentrated in Sub-Saharan Africa and South Asia, with comparatively limited attention to middle-income economies undergoing structured and policy-driven transformation, such as Türkiye. This geographical concentration constrains the generalizability of existing findings, particularly for countries characterized by persistent exchange rate volatility and evolving subsidy regimes. Second, although individual determinants of agricultural credit supply—such as subsidies, interest rates, or exchange rates—have been widely examined, there is limited research analyzing their long-run cointegration and causal interdependencies within a unified empirical framework. This omission is especially consequential in economies where agrarian support mechanisms and currency risk exert substantial influence on financial markets and sectoral credit allocation.

Türkiye provides a particularly instructive case in this context. The country combines substantial agrarian potential with prolonged macroeconomic instability, recurrent exchange rate fluctuations, and gradually evolving support structures. Farmers frequently experience extended periods of negative cash flow throughout the production cycle, rendering working capital financing essential for sustaining output and investment continuity (Keskin, 2024b and 2024c). In such an environment, understanding whether and how exchange rate dynamics and government support structurally influence the banking sector's credit orientation toward agriculture is of direct policy relevance.

Against this backdrop, the present study investigates the long-run and causal relationships among agricultural credit orientation, government agricultural supports, and exchange rates in Türkiye over the period 1999–2023. Employing Fourier-based unit root, cointegration, and causality techniques robust to smooth structural breaks and nonlinear adjustments, the analysis captures gradual regime shifts that conventional linear models may overlook (Nazlioglu et al., 2016; Banerjee et al., 2017).

In line with these directions, we guide the following research questions in this study:

1. Do government agricultural supports and exchange rates exhibit long-run cointegration with agricultural credit orientation in Türkiye?
2. What is the direction of causality among these variables?
3. How do the Turkish findings compare with and contribute to the broader international evidence on macroeconomic and policy determinants of agricultural credit supply?

In brief, this research contributes by providing new empirical evidence from a volatile middle-income economy, by applying Fourier-based econometric techniques to agricultural finance, and by situating the Turkish case within a comparative international perspective. The remainder of the paper proceeds with a systematic review of the relevant literature (Section 2), followed by methodology (Section 3), empirical findings (Section 4), and concluding policy implications with future research directions (Section 5).

2. Literature Review and Theoretical Background

Agricultural credit constitutes a cornerstone of rural development, agricultural modernization, and food security, particularly in developing and emerging economies. Access to finance enhances farmers' investment capacity, facilitates technological upgrading, smooths liquidity constraints, and mitigates production and income risks. A substantial body of empirical evidence demonstrates that agricultural credit contributes positively to productivity growth, income diversification, rural infrastructure investment, and long-term sectoral resilience (Keskin, 2024a and 2024d). Beyond short-term liquidity provision, credit access supports structural transformation in agriculture by enabling capital deepening and risk management (FAO, 2024).

Despite this consensus regarding its developmental relevance, the determinants of agricultural credit supply and allocation remain highly heterogeneous across contexts. The literature suggests that agricultural credit dynamics are shaped by an interplay of policy-driven incentives, macroeconomic

conditions, institutional arrangements within banking systems, and household-level behavioral factors. Importantly, findings are far from uniform; rather, they reveal context-specific transmission mechanisms and occasionally contradictory empirical outcomes.

2.1. Policy incentives and the subsidy–credit nexus

A longstanding debate concerns whether government agricultural subsidies crowd out or crowd in private credit. In the European Union context, Ciaian et al. (2011) demonstrate that subsidies exert nonlinear and conditional effects on farm borrowing, depending on liquidity needs and the severity of credit constraints. State transfers may stimulate borrowing by enhancing farm solvency and repayment capacity, yet they may also substitute for external finance, thereby dampening demand for bank loans.

Evidence from emerging markets reinforces this ambiguity. Okezie and Erendu (2016) find that government expenditure in Nigeria generally supports agricultural credit expansion, although the magnitude of this effect depends on prevailing interest rate structures. Similarly, Wagao et al. (2024) report a positive association between public expenditure and agricultural lending in Tanzania, while Wulandari et al. (2024) highlight the importance of targeted subsidies in the D-8 countries to overcome structural barriers to credit access. Conversely, Efanga et al. (2020) identify negative effects of government spending on agricultural credit in Nigeria, underscoring the contextual sensitivity of fiscal interventions.

More recently, Amaglobeli et al. (2024) argue that producer subsidy schemes may generate allocative distortions depending on their design, thereby altering both farmers' financing needs and lenders' sectoral risk perceptions. Rashmi and Anusha (2025) further contend that rising budget allocations do not automatically translate into agricultural value-added growth unless complemented by effective credit transmission mechanisms. Collectively, these findings indicate that the net impact of subsidies on credit orientation depends critically on policy design, implementation efficiency, and prevailing financial conditions (Salam et al., 2024).

2.2. Macroeconomic volatility and financial transmission channels

Macroeconomic variables, particularly exchange rates and interest rates, represent another crucial dimension of agricultural credit dynamics. Exchange rate movements affect imported input costs, export competitiveness, and inflation expectations, thereby influencing both credit demand and supply (Wagao et al., 2024). However, empirical findings remain inconclusive. Efanga et al. (2020) report that exchange rate volatility has an adverse but statistically insignificant effect on agricultural credit in Nigeria, whereas Wasswa (2021) finds that high interest rates inhibit credit expansion in Uganda, whereas inflation exerts a favorable influence. In contrast, Wagao et al. (2024) identify positive effects of interest rates, exchange rates, public expenditure, and foreign direct investment on agricultural lending in Tanzania.

Recent evidence from Türkiye strengthens the argument that macroeconomic uncertainty plays a critical role. Buyun (2024) shows that exchange rate volatility weakens the bank lending channel by reducing banks' risk appetite, reinforcing the "wait-and-see" behavior highlighted by Nthebe (2025) for developing economies. Yet, Harish Kumar et al. (2024) demonstrate in India that structural agricultural factors—such as irrigation coverage—may outweigh macroeconomic variables. They show that sector-specific characteristics mediate the financial transmission mechanisms. These divergent findings underscore that macro-financial shocks interact with institutional and structural features, producing heterogeneous credit responses across countries.

2.3. Institutional structures and banking behavior

Institutional configurations within banking systems significantly shape agricultural credit allocation. Studies of commercial bank behavior in Nigeria (Enya and Alimba, 2008; Okezie and Erendu, 2016) and South Africa (Henning et al., 2019) emphasize the importance of collateral requirements, repayment history, and loan size in determining credit access. Similar conclusions emerge from Kenya, where collateral constraints and credit rationing systematically exclude smallholders (Njuguna and Nyairo, 2015).

In developed financial systems, deregulation and deposit structure shifts have also influenced agricultural lending. Betubiza and Leatham (1995) and Featherstone et al. (2005) document declines in

agricultural loan portfolios among U.S. banks following structural reforms, highlighting the sensitivity of sectoral lending to institutional incentives. Maloba and Alhassan (2019) further demonstrate that liquidity, bank size, and non-performing loans significantly affect agricultural credit supply in Kenya, indicating that balance-sheet robustness is essential for sustained lending.

Interestingly, Yeasmin et al. (2024) find in Bangladesh that credit targets stimulate agricultural lending, while non-performing loan growth does not necessarily reduce credit supply. Harish Kumar (2024) add that the expansion of rural bank branches in India substantially enhances agricultural credit flows, underscoring the importance of spatial financial inclusion. These findings collectively present that macroeconomic policy, institutional capacity, regulatory frameworks, and banking sector health condition agricultural credit allocation.

Complementing these institutional perspectives, micro-level evidence from Nigeria further clarifies lending determinants. Okerenta and Orebiyi (2005) show that interest rates, perceived risk, and farmers' asset holdings significantly influence lending behavior. Similarly, Ali et al. (2011) find that lending rates, repayment performance, and savings mobilization strongly explain variations in agricultural credit supply, while Chidiebere-Mark et al. (2014) emphasize that inadequate collateral and high interest rates constrain loan disbursement among agro-enterprises. Together, these findings underscore that pricing policies, risk assessment, and borrower balance-sheet strength jointly shape agricultural credit allocation.

2.4. Household characteristics, behavioral constraints, and risk perceptions

Beyond supply-side determinants, farmer-level characteristics and behavioral constraints exert substantial influence on credit outcomes. Kuhn and Bobojonov (2023) introduce the concept of "risk rationing," illustrating how farmers' fear of default and collateral loss constrains borrowing even when formal credit is available. Similarly, Akudugu (2012), Oluwasola and Alimi (2008), Nwaru et al. (2011), and Kalala et al. (2023) document that age, gender, household composition, and socio-economic status significantly affect credit demand.

Ullah et al. (2024) highlight the role of social capital and trust networks in shaping informal credit utilization, while Yeasmin et al. (2024) show that farm size and experience increase borrowing likelihood in Bangladesh. Henning et al. (2019) emphasize that diversified income strategies and strong repayment histories improve loan approval probabilities in South Africa.

Furthermore, Heil et al. (2024) demonstrate that agricultural insurance mechanisms reduce delinquency risk and strengthen repayment performance, suggesting that risk-sharing arrangements within financial systems can indirectly stimulate credit supply. These contributions underscore that agricultural finance is embedded in socio-institutional contexts where behavioral dynamics and risk perceptions interact with formal banking criteria.

2.5. Measuring credit orientation: from AOI to AOIC

To assess the structural alignment of financial flows with agriculture's economic importance, the Food and Agriculture Organization (FAO) introduced the Agricultural Orientation Index (AOI), which compares agriculture's share in public expenditure with its contribution to GDP (FAO, 2024). Extending this logic to credit markets, the Agriculture Orientation Index for Credit (AOIC) measures the proportion of commercial bank loans directed to agriculture relative to the sector's economic weight.

An AOIC below unity signals under-provision of credit relative to the sector's economic weight, whereas a value above one indicates preferential allocation (Keskin and Çalışır, 2024). By employing AOIC as the dependent variable, this study shifts the analytical focus from absolute loan volumes to the structural orientation of banks toward agriculture, thereby capturing sectoral alignment rather than mere credit expansion.

2.6. Research gaps and contribution

Although the literature provides rich insights into policy, macroeconomic, institutional, and behavioral determinants of agricultural credit, several gaps persist. First, empirical evidence predominantly concentrates on sub-Saharan Africa and South Asia, with comparatively limited attention to middle-income economies undergoing structural transformation, such as Türkiye.

Second, most studies rely on static regression frameworks, offering limited insight into long-run equilibrium relationships and causal dynamics among subsidies, exchange rates, and credit orientation. Few investigations explicitly model structural breaks and nonlinearities, despite the prevalence of macroeconomic volatility in emerging markets.

Third, AOIC has not been systematically employed in prior empirical analyses, leaving a methodological gap in assessing whether banking sector allocations correspond to agriculture's macroeconomic importance.

Addressing these shortcomings, the present study examines the long-run cointegration and causal relationships between government agricultural support, exchange rate dynamics, and agricultural credit orientation in Türkiye over the period 1999–2023. Türkiye offers a compelling case due to its substantial agrarian potential, recurrent macroeconomic volatility, and evolving subsidy frameworks. Farmers frequently experience seasonal negative cash flows, rendering production sustainability highly dependent on working capital financing (Keskin, 2024b and 2024c).

Methodologically, the study applies Fourier-based unit root, cointegration, and causality tests—specifically Fourier ADL cointegration and Fourier Toda–Yamamoto causality approaches—which are robust to smooth structural breaks and nonlinear dynamics (Nazlioglu et al., 2016; Banerjee et al., 2017). By integrating AOIC with advanced econometric techniques, the study contributes novel empirical evidence on the equilibrium and directional interactions among public support, exchange rate volatility, and banking sector credit orientation.

In doing so, the research advances three primary contributions: (i) it provides empirical validation of long-run and causal dynamics in a volatile middle-income context; (ii) it enhances methodological rigor in agricultural finance research through the application of Fourier-based econometrics; and (iii) it situates the Turkish case within the broader comparative literature, enabling assessment of cross-country consistency and contextual divergence in the determinants of agricultural credit allocation.

3. Data and Methodology

In this study, data representing the agricultural orientation index of credit in Türkiye, government agricultural support, and the exchange rate were collected, as the research investigates the cointegration and causal relationships among these variables. The dataset covers the period 1999–2023 (Table 1).

Table 1. Data set

Variables	Abbreviations Used in the Models	Data Source	Explanation About the Data
Agriculture Orientation Index for Credit (Dependent Variable)	AOIC	(FAO, 2025)	The relative importance that commercial banks assign to the agricultural sector in the context of agrarian lending is represented by a threshold value of 1 (one)*.
Government Support on Agriculture (Independent Variable)	GSA	(OECD, 2025)	Government support for agriculture is represented under the heading of 'total support amount' and expressed in millions of U.S. dollars.
Exchange Rate (Independent Variable)	ER	(WDI, 2025)	It expresses the annual average price of the U.S. dollar in Turkish lira.

The dataset begins in 1999, the year AOIC data first became publicly available. While the study employs nominal values following standard practices in similar literature, high inflation periods in Türkiye may influence the magnitude of the estimated coefficients. Future studies should consider using real effective exchange rates and inflation-adjusted government support values to isolate price level effects.

* An index value of 1 reflects a balanced distribution of credit, indicating that the agricultural sector receives a level of financing equivalent to its share of GDP.

The fully log-linearized model is presented below in Equation 1.

$$logAOIC_t = \alpha + \beta logGSA_t + \gamma logER_t + \varepsilon_t \quad (1)$$

AOIC, government agricultural supports, and the exchange rate were selected as the main variables in this study because, in the context of the developing Turkish economy, the agricultural sector is generally regarded as being strongly interconnected with public support payments and exchange rate movements. The dataset covers the period from 1999 to 2023.

Descriptive statistics for the variables are reported in Table 2. As can be observed, none of the variables follows a normal distribution. Moreover, the AOIC variable exhibits considerably higher volatility compared to the others.

Table 2. Descriptive statistics (based on raw data series)

	AOIC	**GSA**	**ER**
Mean	0.195	16544.970	3.936
Median	0.046	14987.720	1.700
Maximum	0.854	36704.750	23.700
Minimum	0.002	7152.180	0.400
Standard Deviation	0.289	6543.920	5.378
Skewness	1.277	1.267	2.618
Kurtosis	2.926	4.828	9.286
Jarque-Bera	6.808 (p=0.033)	10.170 (p=0.006)	69.720 (p=0.000)

The Agriculture Orientation Index for Credit (AOIC) is calculated using the following formula as defined by the FAO (FAO, 2023):

$$Share\ of\ agriculture\ in\ total\ credit = \frac{Agricultural\ credit}{Total\ credit}$$
$$Share\ of\ agriculture\ in\ GDP = \frac{Agricultural\ value\ added}{GDP} * 100 \quad (2)$$
$$AOIC = \frac{Share\ of\ agriculture\ in\ total\ credit}{Share\ of\ agriculture\ in\ GDP}$$

This index measures whether the agricultural sector receives a share of credit commensurate with its contribution to the economy.

As illustrated in Figure 1, all three variables display structural breaks. For instance, the AOIC experienced a sharp shift in 2000, GSA exhibited a marked change in 2010, and ER underwent a significant adjustment in 2021. These discontinuities highlight the necessity of accounting for structural breaks in the empirical analysis. Accordingly, the econometric tests applied in this study were deliberately chosen with this consideration in mind, thereby enhancing the robustness of the findings. The methodological procedures are outlined below.

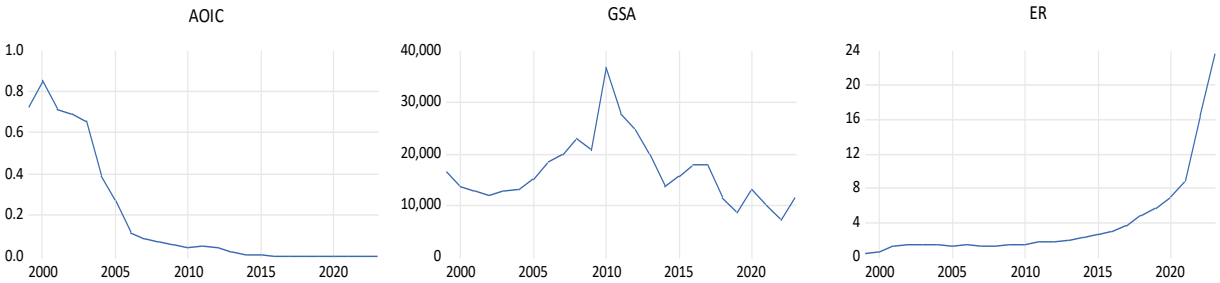

Figure 1. Changes in variable values over the years.

Unlike traditional structural break tests—such as the Zivot–Andrews approach—which require the a priori specification of break dates or permit only sharp regime shifts, the Fourier approximation employed in this study allows for the modeling of multiple smooth structural breaks of unknown timing and functional form (Enders and Lee, 2012). This flexibility is particularly advantageous when analyzing volatile macroeconomic data, such as that of Türkiye.

Enders and Lee (2012) extend the classical Augmented Dickey–Fuller (ADF) unit root test (Dickey and Fuller, 1979) by incorporating Fourier functions into the specification. A distinctive advantage of this approach is that it does not require prior knowledge of the number, timing, or nature of structural changes. The proper frequency value (k) in the Fourier function is the key parameter to be estimated, as it determines the model's capacity to capture underlying structural dynamics.

$$\Delta y_t = \rho y_{t-1} + \beta_1 + \beta_2 trend + \beta_3 \sin\left(\frac{2\pi kt}{T}\right) + \beta_3 \cos\left(\frac{2\pi kt}{T}\right) + \mu_t \quad (3)$$

k denotes the estimated frequency, *t* represents the trend term, and *T* refers to the total number of observations in Equation 3.

If the trigonometric terms, in Equation 3, of the Fourier function prove to be statistically insignificant, the results of the conventional ADF test are reported instead. However, when these functions are significant, the Fourier ADF test statistic is employed to assess the stationarity of the series. In this context, the statistical significance of the lagged dependent variable (y_{t-1}) is evaluated using the standard *t*-test.

Building on this foundation, Banerjee et al. (2017) introduced the Fourier ADL cointegration test, which is particularly robust in the presence of structural shifts. Similar to the Fourier ADF framework, the first step involves estimating the unknown frequency parameter *k*. To address potential autocorrelation, lagged differences of the explanatory variables are incorporated into the right-hand side of the equation. The significance of the one-period lag of the dependent variable is tested once the optimal lag length *k* is determined. This procedure allows for the examination of the null hypothesis (H_0), which posits the absence of a cointegration relationship among the variables.

$$\Delta y_t = \alpha_0 + \theta_1 \sin\left(\frac{2\pi kt}{T}\right) + \theta_1 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 y_{t-1} + y_1' x_{t-1} + \vartheta_1' \Delta x_t + \varepsilon_t \quad (4)$$

The model specification in Equation 4 incorporates the deterministic component, the one-period lagged values of independent and dependent variables, as well as the first difference of the independent variable, and the residual terms. For the test to be valid, the variables must be integrated of order one, I(1).

Nazlioglu et al. (2016) extended the classical Toda and Yamamoto (1995) causality test by incorporating Fourier functions. This new approach uses an augmented VAR model with additional lags, allowing the test to capture potential structural shifts and cyclical patterns that traditional methods may overlook (see Equation 5).

$$\begin{aligned} y_t &= \beta_0 + \beta_1 \sin\left(\frac{2\pi kt}{T}\right) + \beta_1 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 y_{t-1} + \delta_2 y_{t-2} + \cdots + \delta_{p+d} y_{t-(p+d)} + \sigma_t \\ x_t &= \beta_0 + \beta_1 \sin\left(\frac{2\pi kt}{T}\right) + \beta_1 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 x_{t-1} + \delta_2 x_{t-2} + \ldots + \delta_{p+d} x_{t-(p+d)} + \sigma_t \end{aligned} \quad (5)$$

The Fourier TY causality test evaluates the level form of the variables rather than their first differences. This choice is not accidental, as the test actually adds more lags to the VAR model, up to the maximum degree of integration between variables. It retains the long-run movements inherent in the series; therefore, it prevents loss of information while differencing. A distinctive strength of this framework is its capacity to detect causal linkages without imposing restrictive transformations on the data. The critical values required for statistical inference are derived through bootstrap simulations, which account for small-sample limitations and potential deviations from standard distributional assumptions, thereby enhancing the robustness of the results.

4. Findings

During the analysis stage, all variables were transformed into their logarithmic form. This transformation was undertaken for several reasons: to bring the variables to comparable scales, to mitigate potential heteroskedasticity, to facilitate the interpretation of coefficient estimates in terms of elasticities, and to eliminate dependence on measurement units.

The analysis began with an examination of the stationarity properties of the series. As shown in Table 3, the trigonometric terms included in the Fourier functions proved statistically insignificant. Consequently, the classical ADF unit root test, rather than the Fourier ADF test, was employed. The results indicate that all variables become stationary after first differencing, implying that they are integrated of order one, I(1).

Table 3. Results of the Fourier ADF and classical ADF unit root tests

	Variable	Fourier Frequency (k)	F-Statistic for the Restriction Test	Lag Length	Test Statistic
Fourier ADF	logAOIC	1	6.383***	4	-3.676
	logGSA	1	7.010***	1	-3.497
	logER	1	1.732***	5	-0.299
	Variable	**t-Statistic**		**p-Value**	
Classical ADF	logAOIC	-0.692		0.9621	
	logGSA	-1.734		0.4023	
	logER	0.922		0.9940	
	logAOIC(1)	-4.406		0.0102**	
	logGSA(1)	-5.003		0.0006*	
	logER(1)	-3.227		0.0319**	

Note: *** indicates that the null hypothesis, which posits the insignificance of the functions, is accepted at the 10% significance level. In this context, the critical value used for comparison in the table is 7.780. The critical values are reported in Enders and Lee (2012).
* and ** denote the rejection of the null hypothesis—asserting that a variable contains a unit root (i.e., is non-stationary)—at the 1% and 5% significance levels, respectively.

Since all series were found to be I(1), the conditions for applying the Fourier ADL cointegration test were satisfied. The results, presented in Table 4, reveal a statistically significant cointegration relationship between the variables.

Table 4. Results of the Fourier ADL cointegration test

Model	Fourier Frequency (k)	Test Statistic	Rho Coefficient	Critical Values (%1/%5/%10)	Conclusion
logAOIC = f (logGSA, logER)	2	-5.629*	-1.483*	-5.220/-4.570/-4.230	There exists a cointegration relationship.

* Significant at the 1% level (as required by the method, significance is assessed in absolute terms).

Following the identification of cointegration, long-run coefficients were estimated. As displayed in Table 5, both GSA and ER exert negative effects on AOIC. Specifically, a 1% increase in GSA and ER reduces AOIC by 3.13% and 2.62%, respectively. These findings suggest that the adverse impact of GSA on the AOIC is more pronounced than that of exchange rate movements.

The results lend support to the evidence reported by Efanga et al. (2020), while standing in contrast to the findings of Wagao et al. (2024), Ciaian et al. (2011), and Okezie and Erendu (2016). This divergence can be attributed to the "crowding-out" hypothesis; in high-inflation environments like Türkiye, banks may view increased government subsidies as a signal to reduce their own risk exposure to the sector, assuming the state will cover the financing gap. Furthermore, unlike the Tanzanian context, the high volatility in the Turkish financial market may cause banks to be more risk-averse despite subsidies.

Table 5. Estimation results of long-run coefficients using the FMOLS estimator

Variables	Coefficients	Standard Error	t-Statistic	p-Value
logGSA	-3.130	1.012	-3.091	0.0060*
logER	-2.619	0.450	-5.818	0.0000*
C	29.271	10.043	2.914	0.0089*

* Indicates significance at the 1% significance level.

Finally, to investigate the direction of causality among the variables, the Fourier TY causality test was employed. As shown in Table 6, unidirectional causal relationships run from GSA and ER to AOIC.

Table 6. Results of the Fourier TY causality test

Direction of Causality	Wald Test Statistic	Bootstrap p-Value	Lag
logGSA → logAOIC	3.916	0.0910***	1
logER → logAOIC	5.830	0.0260**	1
logAOIC → logGSA	0.288	0.5950	1
logER → logGSA	0.082	0.7790	1
logAOIC→ logER	2.898	0.1100	1
logGSA → logER	0.385	0.5400	1

** and *** indicate significance at the 5% and 10% significance levels, respectively.
Note: The test was performed using 10 000 bootstrap simulations.

Notably, no empirical study in the literature was identified that directly examines causality among these variables; therefore, the present causal evidence cannot be benchmarked against previous research.

Conclusion and Recommendations

This study aims to examine the long-run and causal relationships among agricultural credit orientation, government agricultural support, and exchange rates in Türkiye for the period 1999–2023. Using Fourier-based econometric techniques, the analysis confirmed a statistically significant cointegration among the variables and revealed that both GSA and ER exert negative long-run effects on AOIC. Specifically, a 1% increase in GSA and ER reduces AOIC by 3.13% and 2.62%, respectively. Moreover, causality analysis demonstrated unidirectional linkages running from GSA and ER to AOIC. These findings suggest that the credit orientation of the banking sector in Türkiye is determined mainly by changes in the government's agricultural policy and macroeconomic currency fluctuations.

Interpreted in relation to the research questions, the results verify that government support and exchange rate cointegrate with agricultural credit orientation, and that they have a contractionary rather than expansionary long-run equilibrium relationship. This outcome contrasts with strands of the literature that highlight crowding-in effects of subsidies or positive associations between macroeconomic variables and agricultural credit (Ciaian et al., 2011; Okezie and Erendu, 2016; Wagao et al., 2024). Instead, the results align more closely with evidence from Nigeria reported by Efanga et al. (2020), where adverse impacts of government expenditure and exchange rate movements on agricultural credit were observed. The divergence across contexts underscores the highly country-specific nature of agricultural credit markets, shaped by institutional arrangements, subsidy designs, and macroeconomic volatility.

The significance of these findings lies in their implications for both policy and financial institutions. The negative long-run effect of subsidies on AOIC suggests that direct government transfers may substitute for, rather than complement, commercial bank lending to agriculture. Similarly, exchange rate depreciation appears to discourage banks from channeling credit to the sector, possibly due to increased import costs for inputs and heightened risk perceptions. In practical terms, these dynamics highlight the need for carefully calibrated support mechanisms that encourage, rather than displace, formal credit provision, as well as macroeconomic stabilization policies that mitigate currency-driven volatility in agricultural finance.

The study makes several contributions to the literature. First, it provides new empirical evidence on Türkiye, a middle-income economy that has received comparatively limited scholarly attention despite its large agricultural base and persistent macroeconomic instability. The second major contribution of this study lies in the introduction of a novel indicator—AOIC—into the empirical analysis for the first time, thereby capturing how banking systems adapt to the financing needs of the agrarian sector. Also, the study advances the methodological frontier by employing Fourier-based unit root, cointegration, and causality tests, which are robust to structural breaks and nonlinearities that typically characterize macro-financial time series. Thus, the research addresses critical gaps in the existing literature, which largely relies on static regression techniques and does not incorporate AOIC as a measure of credit orientation.

Nevertheless, several limitations should be acknowledged. The empirical analysis is confined to the 1999–2023 period due to data availability, which inevitably restricts the historical scope of the findings. Furthermore, the model includes only two independent variables—government support and exchange rates—while excluding other potentially significant determinants of agricultural credit orientation, such as interest rates, inflation, and institutional reforms. For these reasons, future research would benefit from expanding the temporal coverage, incorporating a broader set of explanatory factors, and applying complementary methodologies, including panel cointegration techniques or micro-level survey data. Such extensions would enable a more comprehensive understanding of the determinants of agricultural credit and provide a stronger empirical foundation for policy recommendations.

In conclusion, this study demonstrates that government support and exchange rate dynamics are associated with the agriculture credit orientation in Türkiye; however, their effects tend to be contractionary over the long-run. These findings challenge the conventional assumption that subsidies automatically expand the supply of formal credit and instead underscore the necessity of maintaining stable macroeconomic conditions to sustain agricultural finance. Despite the data availability constraints, the inclusion of AOIC and the application of Fourier-based econometric techniques offer significant contributions to the literature. Future research that builds upon this foundation will be particularly valuable for designing financial and policy frameworks that aim to align agricultural credit provision more closely with the developmental needs of the sector.

This study is not without limitations. First, the sample period is confined to 1999–2023 due to data availability, thereby restricting the temporal coverage of the analysis. Second, the empirical specification includes only two independent variables. Future research should therefore extend the time horizon and incorporate additional explanatory factors to achieve a more comprehensive evaluation of long-run dynamics, capture other relevant economic determinants, and provide a stronger empirical basis for policy formulation. Moreover, although the study employs nominal variables in line with prevailing practices in the literature, periods of high inflation in Türkiye may affect the magnitude of the estimated coefficients. Subsequent research could improve robustness by utilizing real effective exchange rates and inflation-adjusted support measures to isolate price-level effects more precisely.

Drawing on the empirical findings, two policy implications emerge. First, as government subsidies appear to crowd out commercial credit, policymakers should reconsider the reliance on direct income transfers and instead adopt credit-linked subsidy mechanisms, such as interest rate subventions or loan guarantee schemes. Such instruments would encourage banks to expand lending rather than withdraw from the sector when public support increases. Second, given the adverse impact of exchange rate volatility, financial institutions should introduce currency-hedged agricultural loan products to shield both farmers and lenders from currency shocks. By mitigating exchange rate risk, these instruments could help stabilize the AOIC during periods of heightened macroeconomic uncertainty.

Ethical Statement

Ethical approval is not required for this study because no human or animal data is used.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Artificial Intelligence Declaration

The authors declare that no generative artificial intelligence tools were used at any stage of the preparation of this manuscript, including the writing, editing, or refinement of the text, or the creation of any images, figures, graphics, tables, or related titles.

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References

Akudugu, M. A. (2012). Estimation of the determinants of credit demand by farmers and supply by rural banks in Ghana's upper east region. *Asian Journal of Agriculture and Rural Development*, *2*(2), 189-200.

Ali, O., Odoemenem, I. U., & Lawal, W. L. (2011). Determinants of agricultural credit supply by rural banking institutions to small scale farmers in Benue State, Nigeria: 2009-2011. *International Journal of Agricultural and Development Economics*, *2*(2), 1-14.

Amaglobeli, D., Benson, T., & Mogues, T. (2024). *Agricultural producer subsidies: Navigating challenges and policy considerations.* IMF Notes, 2024/002. https://doi.org/10.5089/9798400285950.068

Balana, B. B., & Oyeyemi, M. A. (2022). Agricultural credit constraints in smallholder farming in developing countries: Evidence from Nigeria. *World Development Sustainability*, *1*, 1-12. https://doi.org/10.1016/j.wds.2022.100012

Banerjee, P., Arčabić, V., & Lee, H. (2017). Fourier ADL cointegration test to approximate smooth breaks with new evidence from Crude Oil Market. *Economic Modelling*, *67*, 114-124. https://doi.org/10.1016/j.econmod.2016.11.004

Betubiza, E. N., & Leatham, D. J. (1995). Factors affecting commercial bank lending to agriculture. *Journal of Agricultural and Applied Economics*, *27*(1), 112-126.

Buyun, B. (2024). Does exchange rate volatility affect the bank lending channel? *İktisat Politikası Araştırmaları Dergisi*, *11*(1), 51-61. https://doi.org/10.26650/JEPR1343548

Chidiebere-Mark, N. M., Oguoma, N., Onyeneke, R. U., & Henri-Ukoha, A. (2014). Factors influencing the disbursements of loans from selected commercial banks to small-scale and medium-scale agro-based enterprises in Imo State, Nigeria. *Agricultura Tropica et Subtropica*, *47*(2), 72-78. https://doi.org/10.2478/ats-2014-0010

Ciaian, P., Pokrivcak, J., & Szegenyova, K. (2011). *Do agricultural subsidies crowd out or stimulate rural credit institutions?: The case of CAP payments* (Comparative Analysis of Factor Markets for Agriculture across the Member States). Centre for European Policy Studies (CEPS). https://aei.pitt.edu/58508/1/Factor_Markets_4.pdf, Access date: July 03, 2025.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366), 427-431. https://doi.org/10.1080/01621459.1979.10482531

Efanga, U. O., Etim, R. S., & Akpan, O. D. (2020). Impact of exchange rate on commercial banks' credit to agricultural sector in Nigeria. *American Journal of Multidisciplinary Research & Development (AJMRD)*, *2*(4), 52-62.

Enders, W., & Lee, J. (2012). The flexible Fourier form and Dickey-Fuller type unit root tests. *Economics Letters*, *117*(1), 196-199. https://doi.org/10.1016/j.econlet.2012.04.081

Enya, V. E., & Alimba, J. O. (2008). Analysis of factors affecting the supply of commercial banks credit to the agricultural sector in Nigeria (1986-2005). *Continental J. Agricultural Economics*, *2*, 74-77. https://doi.org/10.5281/zenodo.809995

FAO. (2022). *Credit to agriculture*. https://openknowledge.fao.org/server/api/core/bitstreams/2f5b6de0-6668-4fcc-b837-48a038ae8751/content, Access date: July 03, 2025.

FAO. (2023). *Dataset information*. https://files-faostat.fao.org/production/IC/README-Methodological-Note-C2A.pdf, Access date: September 08, 2025.

FAO. (2024). *The agriculture orientation index for government expenditures*. https://www.fao.org/sustainable-development-goals-data-portal/data/indicators/2a1---agriculture-orientation-index-for-government-expenditures/en, Access date: July 03, 2025.

FAO. (2025). *Credit to agriculture*. https://www.fao.org/faostat/en/#data/IC, Access date: July 06, 2025.

Featherstone, A. M., Wilson, C. A., Kastens, T. L., & Jones, J. D. (2005). *Factors affecting the agricultural loan decision-making process*. Paper presented at the Agricultural and Rural Finance Markets in Transition, October 3-4, 2005, Minneapolis, Minnesota, https://doi.org/10.22004/ag.econ.132749

Heil, M., Pogach, J., & Polson, C. (2024). *Agricultural lending, insurance, and implications of climate change*. Working Paper No. 2024-05. Washington, D.C.: FDIC Center for Financial Research.

Henning, J. I. F., Bougard, D. A., Jordaan, H., & Matthews, N. (2019). Factors affecting successful agricultural loan applications: The case of a South African credit provider. *Agriculture*, *9*(11), 243-257. https://doi.org/10.3390/agriculture9110243

Harish Kumar, H. V., Anuja, A. R., Shivaswamy, G. P., Lama, A., Rajesh, T., Singh, K. N., & Raju, R. (2024). Determinants of formal agricultural credit flow to districts in India: An econometric analysis. *Journal of Scientific Research and Reports*, *30*(12), 438-446. https://doi.org/10.9734/jsrr/2024/v30i122688

Kalala T, F., Nkashama M, J-C., Tshibola B, G., & Mbiya M, E. (2023). Déterminants de la demande et de l'offre du crédit agricole aux petits exploitants de la Ville de Kinshasa. *African Scientific Journal*, *3*(20), 1072-1098. https://doi.org/10.5281/zenodo.10159185

Keskin, Ö. (2024a). Analysis of the impact of agricultural credits on agricultural mechanization in Türkiye. *Mustafa Kemal University Journal of Agricultural Sciences*, *29*(1), 158-167. https://doi.org/10.37908/mkutbd.1386236

Keskin, Ö. (2024b). Analysis of the effects of agricultural credits and subsidies on crop production efficiency: Fractional-frequency fourier ARDL bounds testing. *Bingol University Journal of Economics and Administrative Sciences*, *8*(1), 213-227. https://doi.org/10.33399/biibfad.1452129

Keskin, Ö. (2024c). The impact of exchange rate on pesticide consumption in Türkiye: Evidence from fractional-frequency Fourier tests. *Journal of Agriculture Faculty of Ege University*, *61*(4), 475-486. https://doi.org/10.20289/zfdergi.1442274

Keskin, Ö. (2024d). Analysis of the effect of agricultural loans on agricultural labor productivity in Türkiye. *International Journal of Agricultural and Wildlife Sciences*, *10*(2), 203-215. https://doi.org/10.24180/ijaws.1387647

Keskin, Ö., & Çalışır, M. (2024). A study on the effect of agricultural loan interest rates on crop production amount in Türkiye. *Dogus University Journal*, *25*(2), 213-230. https://doi.org/10.31671/doujournal.1388182

Kuhn, L., & Bobojonov, I. (2023). The role of risk rationing in rural credit demand and uptake: Lessons from Kyrgyzstan. *Agricultural Finance Review*, *83*(1), 1-20. https://doi.org/10.15185/izadp.7055.1

Maloba, M., & Alhassan, A. L. (2019). Determinants of agri-lending in Kenya. *Agricultural Finance Review*, *79*(5), 598-613. https://doi.org/10.1108/AFR-10-2018-0094

Nazlioglu, S., Gormus, N. A., & Soytas, U. (2016). Oil prices and real estate investment trusts (REITs): Gradual-shift causality and volatility transmission analysis. *Energy Economics*, *60*, 168-175. https://doi.org/10.1016/j.eneco.2016.09.009

Njuguna, E., & Nyairo, N. (2015). Formal conditions that affect agricultural credit supply to small-scale farmers in rural Kenya: Case study for Kiambu county. *International Journal of Sciences: Basic and Applied Research*, *20*(2), 59-66.

Nthebe, T. (2025). Heterogeneous effects of real effective exchange rates on agricultural exports in emerging markets. *South African Journal of Economic and Management Sciences*, *28*(1), 1-12, https://doi.org/10.4102/sajems.v28i1.6082

Nwaru J. C., Essien, U. A., & Onuoha, R. E. (2011). Determinants of informal credit demand and supply among food crop farmers in Akwa Ibom State, Nigeria. *Journal of Rural and Community Development*, *6*(1), 129-139.

OECD. (2025). *Total support estimate*. Agricultural Policy Monitoring and Evaluation. https://data-explorer.oecd.org/vis?tm=Agricultural%20Policy%20Monitoring%20and%20Evaluation%3A%20all%20data&pg=0&snb=2&vw=tb&df[ds]=dsDisseminateFinalDMZ&df[id]=DSD_AGR_POLIND%40DF_MONEVA&df[ag]=OECD.TAD.ARP&df[vs]=&pd=2013%2C&dq=TUR.A.TSE.CPC_EX_TO.&to[TIME_PERIOD]=false, Access date: July 06, 2025.

Okerenta, S. I., & Orebiyi, J. S. (2005). Determinants of agricultural credit supply to farmers in the Niger Delta area of Nigeria. *Journal of Agriculture and Social Research*, *5*(1), 67-72.

Okezie, C. R., & Erendu, I. (2016). Determinants of agricultural credit supply in Nigeria (1981-2014). *International Journal of Economics and Business Management*, *2*(6), 25-34.

Oluwasola, O., & Alimi, T. (2008). Determinants of agricultural credit demand and supply among small-scale farmers in Nigeria. *Outlook on Agriculture*, *37*(3), 185-193.

Rashmi, B., & Anusha, K. (2025). Effectiveness of government spending on agriculture: A study on impact of subsidy & access to agri-credit on agricultural gva. *International Journal of Research and Scientific Innovation*, *12*(7), 540-545, https://doi.org/10.51244/IJRSI.2025.120700054

Salam, M., Rustan, Y., Rukka, R. M., Rahmadanih, R., Maulidiyah, R., Muslim, A. I., Ali, H. N. B., & Ridwan, M. (2024). Employing the Cobb-Douglas function model to examine how input allocation affects rice production: In search of ways to improve the rice farming management. *Yuzuncu Yıl University Journal of Agricultural Sciences*, *34*(4), 584-595. https://doi.org/10.29133/yyutbd.1492753.

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, *66*, 225-250.

Ullah, A., Verner, V., Madaki, M. Y., Adams, F., & Bavorova, M. (2024). Factors influencing informal credit access and utilization among smallholder farmers: Insights from mountainous regions of Pakistan. *Agriculture*, *14*(10), 1764. https://doi.org/10.3390/agriculture14101764

Wagao, H. J., Akyoo, A. M., & Ndyetabula, D. W. (2024). Macro-determinants of formal agricultural credit supply in Tanzania. *African Journal of Social Issues*, *7*(1), 836-859. https://doi.org/10.4314/ajosi.v7i1.60

Wasswa, G. (2021). *Economic determinants of agricultural sector credit in Uganda*. (PhD), Makerere University, Science in Quantitative Economics, Kampala, Uganda.

WDI. (2025). *Official exchange rate*. Financial Sector: Exchange Rates & Prices. https://databank.worldbank.org/source/world-development-indicators, Access date: July 06, 2025.

Wulandari, R., Hermanto, S., Muhammad, F., & Irfan, S. B. (2024). Agricultural credit supply in D-8 member countries: The behavior towards agricultural risk. *Agro Bali: Agricultural Journal*, *7*(3), 739-751. https://doi.org/10.37637/ab.v7i3.1773

Yeasmin, S., Haque, S., Adnan, K. M. M., Parvin, M. T., Rahman, M. S., Rahman, K. M., Salman, M., & Hossain, M. E. (2024). Factors influencing demand for, and supply of, agricultural credit: A study from Bangladesh. *Journal of Agriculture and Food Research*, *16*, 1-10. https://doi.org/10.1016/j.jafr.2024.101173