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Assessing the Effectiveness of Financial Instruments in Stimulating Agricultural Investment in Kazakhstan

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Abstract
The agro-industrial complex is one of the key sectors of Kazakhstan's economy, ensuring food security, rural employment and the development of regional investment potential. The purpose of this study is to assess the effectiveness of financial instruments in stimulating investment activity in Kazakhstan's agro-industrial complex and to develop recommendations for improving regionally differentiated investment policy. The study is based on regional panel data for 17 regions and cities of national importance in Kazakhstan for 2015-2025. Descriptive statistics, comparative regional analysis, fixed-effect panel regression model, Haussmann test, diagnostics of multicollinearity, heteroscedasticity and autocorrelation are used as methods. The dependent variable is investment in agriculture, while the key explanatory variables include government subsidies, concessional lending, financing through development institutions, infrastructure development, and digitalization. Regression analysis confirmed a statistically significant positive impact of subsidies (β = 0.32; p < 0.01), concessional lending (β = 0.27; p < 0.01), infrastructure (β = 0.21; p < 0.01), financing through development institutions (β = 0.19; p < 0.01), and digitalization (β = 0.18; p < 0.01) on investment activity. The results show that subsidies and credit resources have the strongest positive effect on investment activity. At the same time, the negative coefficient on the quadratic subsidy term indicates an inverted U-shaped relationship, suggesting that excessive government support may reduce investment efficiency. The findings support a transition from subsidy-dominated support toward a mixed financing model based on targeted subsidies, concessional lending, guarantees, blended finance, infrastructure modernization, and digital platforms.

KEYWORDS
Agricultural Economics, Agrobusiness, Agro-Industrial Complex, Finance, Financial Instrument, Regional Economy, Regional Growth

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1 | INTRODUCTION

In the modern context of the transformation of the global and national economy, the agro-industrial complex is one of the key factors in sustainable socio-economic development, ensuring food security, employment of the rural population, and the formation of the country's export potential. For Kazakhstan, which has significant land and resource opportunities, the development of the agricultural sector is of strategic importance, but the effectiveness of the agro-industrial complex is largely determined by investment activity and the availability of financial resources (Esimkhan et al., 2024; Kireyeva et al., 2022).

Investment processes in agriculture are characterized by high uncertainty and risk due to climatic conditions, production seasonality, and long project payback periods. Within the framework of neoclassical and endogenous theories of economic growth, investment is considered the main driver of capital accumulation and technological renewal, contributing to increased productivity and competitiveness of the economy (Romer, 1990; Aghion & Howitt, 2009). In the agricultural sector, these processes are becoming increasingly specific, necessitating the development of effective mechanisms for government regulation and financial incentives.

According to research in agricultural economics, financial constraints are among the key barriers to the development of agricultural enterprises, especially small and medium-sized enterprises (Beck & Demirgüç-Kunt, 2006). Limited access to credit resources, high cost of borrowed capital, and underdeveloped financial infrastructure constrain investment activity and hinder innovation in agricultural production (Dorward et al., 2004). In this regard, financial instruments of state support aimed at reducing investment risks and stimulating capital inflows to priority sectors are of particular importance.

Modern scientific research demonstrates that the effectiveness of financial instruments in the agricultural sector is heterogeneous and depends on institutional conditions, the level of financial market development, and the quality of public administration. Thus, interest rate subsidies and direct investment subsidies have a significant impact on investment growth, whereas tax incentives, in some cases, are less effective (Ciaian et al., 2018; Holden, 2019). Moreover, several studies indicate a non-linear relationship between the amount of government support and the effectiveness of investments, with marginal efficiency decreasing at excessive subsidy levels.

For Kazakhstan, the problem of stimulating investment flows in the agro-industrial complex is of relevance in the context of implementing a policy of economic diversification and reducing dependence on the raw materials sector. Despite the implementation of government programs to support agriculture, including subsidies, concessional lending, and the activities of development institutions, several systemic problems persist, namely insufficient targeting of support, low resource allocation efficiency, and limited attraction of private investment (Akimbekova & Nikitina, 2020; Dabyltayeva & Nurtayeva, 2022).

Special attention should be paid to the regional aspect of investment devel-

opment, since it is at the regional level that the real conditions for implementing agricultural policy are formed. Turkestan region is one of the most significant agricultural regions of Kazakhstan, with high potential for the development of irrigated agriculture, horticulture, and animal husbandry. At the same time, the region is characterized by a high rural population density, limited access to financial resources, and significant dependence on government subsidies, which reduces the sustainability of investment processes (Zharylkassyn et al., 2025).

In modern conditions, the role of innovative financial instruments is increasing, including project financing mechanisms, agricultural receipts, digital lending platforms, and blended finance instruments. These tools make it possible to expand agricultural producers' access to financial resources and increase the efficiency of investment activities (Zetzsche et al., 2017). However, their implementation in Kazakhstan is in its early stages and requires further institutional development.

Despite a significant number of studies devoted to the problems of agricultural financing, the issues of comprehensively assessing the effectiveness of financial instruments to stimulate investment flows in the regional context remain insufficiently studied. In particular, there is a lack of systematic research that accounts for the specifics of the Turkestan region as an agrarian region with high growth potential.

The scientific novelty of this study lies in three interrelated aspects. First, the article assesses the nonlinear effect of government subsidies on investment activity and tests the hypothesis of an inverted U-shaped relationship. Second, it integrates financial, infrastructural, and digital factors into a single regional panel model of agricultural investment. Third, it applies this approach to the Turkestan region, where investment processes are shaped by dependence on irrigated agriculture, infrastructure constraints, and limited access to market-based finance. This makes it possible to move beyond a general assessment of state support and identify the conditions under which financial instruments generate the greatest investment effect.

The purpose of this study is to assess the effectiveness of financial instruments in stimulating investment activity in Kazakhstan's agro-industrial complex and to develop recommendations for improving regionally differentiated investment policy. To achieve this goal, the following tasks are being solved: analysis of theoretical approaches to investment incentives, assessment of the dynamics of investment processes in the agro-industrial complex, identification of key factors affecting investment activity, and development of proposals to improve the effectiveness of financial instruments.

2 | LITERATURE REVIEW

Research on financial instruments to stimulate investment flows in the agro-industrial complex has evolved from classical theories of investment and agricultural development to modern concepts of sustainable growth, financial inclusion, and the digitalization of the agricultural sector. In classical economic theory, investment is considered a key factor in economic growth, ensuring capital accumulation

and productivity improvement. Within the framework of the neoclassical model and the theory of endogenous growth, investment is the basis of technological progress and the structural transformation of the economy (Romer, 1990; Aghion & Howitt, 2009). At the same time, investment processes in the agricultural sector have specific features, including high capital intensity, dependence on natural and climatic factors, and long project payback periods.

Early research on agricultural development emphasized the crucial role of investments in infrastructure and productive resources in improving agricultural efficiency. In particular, Johnston and Mellor (1961) noted that the development of agriculture is impossible without investments in the basic elements of the agricultural system, including irrigation, transport, and energy. Further development of these ideas was reflected in the works, in which investments are considered a key factor in the transition from traditional to modern agriculture (Hayami & Ruttan, 1985).

Since the early 2000s, there has been increasing attention in the scientific literature to the institutional and financial aspects of investment activity in the agricultural sector. Research shows that limited access to financial resources is a key barrier to agricultural development, especially for small and medium-sized farms (Beck & Demirgüç-Kunt, 2006). High interest rates, insufficient development of agricultural lending, and weak financial infrastructure significantly limit the investment opportunities of agricultural producers (Dorward et al., 2004).

In this context, financial instruments of state support aimed at stimulating investment activity are particularly important. These instruments include subsidies, concessional lending, tax preferences, guarantees, and co-financing mechanisms. Empirical studies show that interest rate subsidies and investment grants have the most significant impact on agricultural investment growth, whereas tax incentives have a limited effect in a weak institutional environment (Ciaian et al., 2018; Stein, 2019).

Modern research highlights that the effectiveness of financial instruments is non-linear. In particular, the effect of diminishing returns to government support is evident: an increase in subsidies at a certain stage leads to reduced investment efficiency and greater dependence on budgetary resources. This effect is consistent with the concepts of institutional economics and the theory of optimal government intervention (Aghion et al., 2015). In recent years, there has been increasing attention in the scientific literature to the role of innovative financial instruments and digital technologies in stimulating investment processes in the agricultural sector. The development of fintech solutions, digital lending platforms, agricultural receipts, and blended finance mechanisms helps to expand agricultural producers' access to financial resources and reduce transaction costs (Zetzsche et al., 2017). At the same time, digitalization is considered not only a technological factor but also a tool for transforming the agricultural sector's financial infrastructure.

Recent studies published in 2024–2026 confirm that digital finance, sustainable investment mechanisms, and ESG-oriented approaches are becoming increasingly important for agricultural investment and rural development. Gao and Gao

(2024) show that digital financial inclusion strengthens the resilience of agricultural value chains by supporting technological innovation and the emergence of new agricultural businesses. Liu and Li (2025) demonstrate that digital inclusive finance improves the climate resilience of food production by reducing credit constraints and supporting precision farming and low-carbon technologies. Zheng et al. (2025) prove that digital financial inclusion can reduce agricultural carbon emission intensity through technological innovation and changes in rural income structures. Chen and Xiao (2025) find that digital payments improve both formal and informal credit access for rural households, a finding particularly relevant to small agricultural producers. Chong and Wang (2026) show that digital finance can reduce financing constraints for agribusinesses, although its effectiveness depends on marketization, transparency, and the role of agricultural insurance. Han (2026) further argues that digital inclusive finance supports agricultural development by improving factor allocation and total factor productivity. These findings support the argument that agricultural investment policy should combine traditional financial instruments with digital platforms, ESG-oriented criteria, climate resilience, and regionally differentiated support mechanisms.

The regional aspect of investment development occupies a special place in the modern scientific agenda. Research shows that spatial differentiation of financial resources and infrastructure leads to significant differences in investment activity and the level of development of the agricultural sector (Gollin & Rogerson, 2014; Storeygard, 2016). For countries with a large territory and heterogeneous climatic conditions, such as Kazakhstan, this problem is becoming particularly relevant.

In Kazakhstan, the financing of the agro-industrial complex is examined in several studies on regional development and investment policy. Thus, Kireyeva et al. (2021) notes that the digitalization of the economy has an ambiguous effect on investment activity in the regions, increasing differences between territories with different levels of technological readiness. Research shows that the development of Kazakhstan's agricultural sector largely depends on institutional conditions and access to foreign markets (Neganova & Chistyakov, 2020). Additional research highlights the importance of implementing modern financial and institutional mechanisms, including ESG approaches and sustainable financing, to increase the investment attractiveness of the agricultural sector (Kuandykova et al., 2023; Abisheva, et al., 2025). At the same time, it is noted that the existing system of state support is characterized by insufficient targeting and limited efficiency of resource allocation.

Despite numerous scientific studies on financing the agricultural sector, the comprehensive assessment of the effectiveness of financial instruments in stimulating investment flows in regional contexts remains underexplored. There are no studies that take into account the specific characteristics of individual regions of Kazakhstan, including the Turkestan region, which is characterized by a high concentration of the rural population, dependence on irrigated agriculture, and limited access to financial resources. Thus, the analysis of scientific literature shows that financial instruments play a key role in shaping investment flows in the

agro-industrial complex, but their effectiveness is determined by a combination of factors, including the institutional environment, the level of financial market development, and regional peculiarities. This necessitates a comprehensive study to assess the effectiveness of financial instruments in stimulating investment in the agro-industrial complex of the Turkestan region and to develop recommendations for their improvement.

3 | RESEARCH METHODS

The study employs a quantitative research design using regional panel data for the Republic of Kazakhstan for the period 2015–2025. The choice of a panel structure is justified by the need to capture both temporal changes in investment activity and cross-regional differences in agricultural specialization, infrastructure, access to finance, and institutional conditions. Particular attention is paid to the Turkestan region, which is considered an agrarian-oriented territory with high dependence on irrigated agriculture, a large rural population, and significant investment potential.

The empirical database was compiled from official statistical and institutional sources, including the Bureau of National Statistics of the Republic of Kazakhstan, the Ministry of Agriculture of the Republic of Kazakhstan, regional statistical bulletins, reports from development institutions, and open data on infrastructure and digitalization indicators. The unit of observation is a region-year pair. The final panel covers 17 regions and cities of republican significance over 11 years, yielding 187 potential observations. Missing values were checked for consistency and, where necessary, excluded from the econometric estimation.

The dependent variable is investment activity in the agro-industrial complex. It is measured as the volume of investment in agriculture, forestry, and fisheries, expressed in billion tenge and additionally normalized per unit of gross agricultural output. The main explanatory variables include the volume of government subsidies, concessional lending, financing through development institutions, infrastructure development, and digitalization. Control variables include gross agricultural output, employment in agriculture, and climatic conditions. A detailed description of the dependent, explanatory, and control variables included in the econometric model is provided in Table 1.

To formalize the relationship between investment activity and the main explanatory factors, the study first specifies a general investment function. This function reflects the assumption that investment in the agro-industrial complex is determined by the combined influence of financial instruments, infrastructure conditions, digitalization, and other regional control variables.

To empirically assess the determinants of investment in the agro-industrial complex, the study applies a fixed-effects panel regression model specified as fallows (1):

$$INV_{it} = \alpha + \beta_1 SUB_{it} + \beta_2 CRED_{it} + \beta_3 DEV_{it} + \beta_4 INFR_{it} + \beta_5 DIG_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Table 1. Description of variables

Variable	Description	Unit of measurement	Expected effect	Source
INV_it	Investment in agriculture, forestry, and fisheries	bln KZT	Dependent variable	Bureau of National Statistics of the Republic of Kazakhstan
SUB_it	Volume of government subsidies to agriculture	bln KZT	Positive / nonlinear	Ministry of Agriculture of the Republic of Kazakhstan
CRED_it	Concessional lending to agricultural producers	bln KZT	Positive	Reports of Baiterek Holding, Agrarian Credit Corporation, and official financial development institutions
DEV_it	Financing through development institutions	bln KZT	Positive	Baiterek Holding reports, former KazAgro data, and development institution reports
INFR_it	Infrastructure development index	index	Positive	Regional statistics
DIG_it	Digitalization level in agriculture and financial services	index	Positive	Official digitalization indicators
OUTPUT_it	Gross agricultural output	bln KZT	Positive	Bureau of National Statistics of the Republic of Kazakhstan
LABOR_it	Employment in agriculture	thousand persons	Positive / mixed	Bureau of National Statistics of the Republic of Kazakhstan
CLIM_it	Climatic and water availability conditions	index	mixed	Regional and sectoral data

where:

INV_{it} – the volume of investment in the agro-industrial complex in region i in year t; α is the constant term;

SUB_{it} – the volume of government subsidies;

$CRED_{it}$ – the volume of concessional lending;

DEV_{it} – financing through development institutions;

$INFR_{it}$ – the infrastructure development index;

DIG_{it} – the digitalization index;

X_{it} – vector of control variables;

μ_i – unobserved region-specific fixed effects;

λ_t – the year fixed effects;

ε_{it} – the error term.

To test the hypothesis of a nonlinear relationship between subsidies and investment activity, the quadratic term of subsidies is included in the model (2):

$$INV_{it} = \alpha + \beta_1 SUB_{it} + \beta_2 SUB2_{it} + \beta_3 CRED_{it} + \beta_4 DEV_{it} + \beta_5 INFR_{it} + \beta_6 DIG_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

In this specification, a positive coefficient of SUB_{it} and a negative coefficient of $SUB2_{it}$ indicate an inverted U-shaped relationship. This means that subsidies initially stimulate investment activity, but after reaching a certain threshold their

marginal effect decreases and may reduce the efficiency of investment incentives. From an economic perspective, this may indicate decreasing investment efficiency, weaker market incentives, and growing dependence of agricultural producers on budgetary support.

The turning point of the nonlinear subsidy effect is calculated as follows (3):

$$SUB_{it} = -\frac{\beta_1}{2\beta_2} \tag{3}$$

where:

SUB_{it} – the estimated threshold level of government support at which the positive effect of subsidies on investment reaches its maximum;

β_1 – the coefficient of the linear subsidy term;

β_2 – the coefficient of the squared subsidy term.

A positive coefficient for SUB_{it} is the estimated level of government subsidies at which their positive effect on investment activity reaches its maximum. If the actual level of subsidies is below this threshold, additional support is expected to increase investment activity. If the level of subsidies exceeds this threshold, further expansion of subsidies may reduce their marginal effectiveness and may not lead to proportional investment growth.

The choice between fixed-effects and random-effects models was based on the Hausman test. The fixed-effects specification was preferred because it allows controlling for unobserved regional characteristics that are constant over time, including agricultural specialization, geographical location, institutional environment, and natural-climatic conditions. To improve the reliability of the estimates, robust standard errors clustered at the regional level were used.

The econometric procedure included several diagnostic tests. Multicollinearity was assessed using the variance inflation factor. Heteroskedasticity was tested using the Breusch–Pagan test. Autocorrelation in panel data was checked using the Wooldridge test. In addition, alternative specifications were estimated to test the robustness of the results: a model without the quadratic subsidy term, a model with lagged financial variables, and a model with normalized investment indicators. The results of the main diagnostic tests used to justify the final panel regression specification are presented in Table 2.

The diagnostic tests confirm the appropriateness of the fixed-effects specification. Since heteroskedasticity and autocorrelation were detected, robust standard errors clustered at the regional level were used in the final model. This improves the reliability of statistical inference and reduces the risk of biased standard errors.

The decomposition of factor contribution to investment growth was calculated on the basis of standardized regression coefficients. This approach makes it possible to compare the relative importance of subsidies, credit resources, infrastructure, digitalization, and other factors in explaining investment growth.

Table 2. Diagnostic tests of the panel regression model

Diagnostic test	Purpose	Result	Interpretation
Hausman test	Choice between fixed-effects and random-effects models	χ^2 = 18.64; p = 0.005	Fixed-effects model is preferred
Variance inflation factor (VIF)	Detection of multicollinearity	Mean VIF = 2.31; max VIF = 3.84	No serious multicollinearity detected
Breusch–Pagan test	Detection of heteroskedasticity	χ^2 = 21.47; p = 0.001	Heteroskedasticity is present
Wooldridge test	Detection of autocorrelation in panel data	F = 7.92; p = 0.012	Autocorrelation is present
Cluster-robust standard errors	Correction for heteroskedasticity and autocorrelation	Applied at the regional level	Final estimates are interpreted using cluster-robust standard errors

Note: compiled by the authors based on the results of panel regression diagnostics.

The study has several limitations. First, the analysis is based on aggregated regional data and does not include micro-level data on individual agricultural enterprises. Second, there may be potential endogeneity between investment activity and government support, since regions with higher investment potential may receive larger volumes of subsidies and concessional lending. Third, some institutional factors, such as the quality of local governance, administrative barriers, and informal access to finance, are difficult to measure quantitatively. Fourth, the digitalization variable reflects the general level of digital development and may not fully capture the actual use of digital financial platforms by agricultural producers. These limitations should be considered when interpreting the results.

4 | RESULTS

The empirical analysis of investment activity in the agro-industrial complex of Kazakhstan for 2015–2025 shows a steady increase in the volume of agricultural investments, accompanied by changes in their structure and regional distribution. During the study period, investments in the agro-industrial complex increased from 350 billion KZT in 2015 to 1,500 billion KZT in 2025. This growth reflects the increasing role of agriculture in the national economy, the expansion of state support instruments, and the gradual development of market-based financing mechanisms.

At the same time, the dynamics of investment growth were uneven. The highest growth rates were observed in 2016–2018, which can be explained by the active implementation of state support programs, expansion of subsidies, and concessional lending. After 2020, investment growth continued, but its pace gradually slowed. This indicates that the agricultural sector is moving from an extensive model based mainly on increasing the volume of financing toward a more complex model in which the efficiency, targeting, and structure of investment become increasingly important.

The data in Table 3 show that the share of investments in the agro-industrial complex in GDP increased from 1.8% in 2015 to 2.9% in 2025.

Table 3. Dynamics of investments in the agro-industrial complex of Kazakhstan, 2015–2025

Year	Investment, bln KZT	Growth rate, %	Share in GDP, %
2015	350	–	1.8
2016	420	20.0	1.9
2017	510	21.4	2.0
2018	620	21.6	2.1
2019	710	14.5	2.2
2020	780	9.8	2.3
2021	900	15.4	2.5
2022	1050	16.7	2.6
2023	1200	14.3	2.7
2024	1350	12.5	2.8
2025	1500	11.1	2.9

Note: compiled by the authors based on Bureau of National Statistics (2026)

The data presented in Table 3 indicate a steady increase in investment activity in the agro-industrial complex of Kazakhstan during 2015–2025. Over the analyzed period, the volume of investments increased from 350 billion KZT in 2015 to 1,500 billion KZT in 2025, which reflects more than a fourfold growth. The highest annual growth rates were observed in 2016–2018, when investment growth exceeded 20% per year. This period may be interpreted as an initial stage of more active state and institutional support for the sector.

At the same time, after 2019 the growth rate became more moderate, declining from 14.5% in 2019 to 11.1% in 2025. This slowdown does not indicate a reduction in investment activity, but rather reflects the transition from rapid expansion to a more stable growth trajectory. The share of investments in the agro-industrial complex in GDP also increased consistently, from 1.8% in 2015 to 2.9% in 2025. This confirms the growing role of the agro-industrial sector in the national economy and demonstrates the increasing importance of investment support for agricultural modernization, infrastructure development and technological renewal.

This confirms the growing investment significance of the agricultural sector. However, the gradual decline in annual growth rates after 2018 suggests the presence of diminishing returns from traditional financial support instruments. Therefore, further growth of investment activity requires not only additional financing, but also a transition to more targeted instruments, including concessional lending, guarantees, infrastructure development, and digital financial solutions. The structure of these investment sources is presented in Table 4.

Table 4. Structure of sources of investment in agriculture, in %

Source	2015	2020	2025
Own funds	62	58	55
Bank loans	18	22	25
Government subsidies	15	14	13
Other sources	5	6	7

Note: compiled by the authors based on Bureau of National Statistics (2026)

The structure of investment financing indicates a gradual transformation of the agricultural financing model. Although own funds remain the dominant source of investment, their share decreased from 62% in 2015 to 55% in 2025. At the

same time, the share of bank loans increased from 18% to 25%, which reflects the growing role of credit instruments in supporting agricultural investment. The share of government subsidies slightly declined, but subsidies continued to play an important role in reducing investment risks and improving access to capital. These changes suggest that the agro-industrial complex of Kazakhstan is gradually moving from a subsidy-dominated model toward a mixed financing system. However, the still high dependence on own funds indicates that access to external financing remains limited, especially for small and medium-sized agricultural producers.

The regional analysis revealed a significant heterogeneity in the distribution of investment flows, due to differences in the resource base, the level of infrastructural development and the sectoral specialization of the regions. At the same time, the concentration of investments in certain agriculturally developed regions indicates the formation of spatial centers of investment activity, as illustrated in Table 5.

Table 5. Regional investment structure

Region	Investment, bln KZT	Share, %
Almaty region	220	14.7
Turkestan region	210	14.0
Kostanay region	190	12.7
North Kazakhstan region	170	11.3
Other regions	710	47.3

Note: compiled by the authors based on Bureau of National Statistics (2026)

The Turkestan region occupies a special position in the regional investment structure. In 2025, it accounted for 14.0% of total agricultural investments, ranking among the leading agricultural regions of Kazakhstan. This position is explained by the region's strong agricultural specialization, favorable climatic conditions, high concentration of rural population, and significant potential for irrigated agriculture, horticulture, greenhouse production, and livestock development.

At the same time, the investment development of the Turkestan region is constrained by several structural factors. First, the region remains highly dependent on water availability and irrigation infrastructure, which increases the sensitivity of investment projects to climatic and resource risks. Second, a significant part of agricultural production is concentrated in traditional sectors with relatively low added value. Third, access to long-term financial resources remains limited for small and medium-sized agricultural producers. Fourth, processing, logistics, storage infrastructure, and digital solutions are still developing more slowly than primary agricultural production. Therefore, the Turkestan region requires a differentiated investment policy. Priority should be given not only to increasing the volume of financial support, but also to developing irrigation systems, agricultural processing, logistics infrastructure, digital lending platforms, and cluster-based projects in high-value agricultural segments.

Compared with other agricultural regions, the Turkestan region has a different investment profile. Kostanay and North Kazakhstan regions are more strongly associated with large-scale grain production and relatively extensive land use, while the Turkestan region is more dependent on irrigated agriculture, labor-intensive

production, horticulture, greenhouse farming, and small and medium-sized producers. This makes the region more sensitive to water availability, irrigation infrastructure, logistics costs, and access to affordable finance. Therefore, investment policy for the Turkestan region should not simply reproduce national support mechanisms, but should be adapted to its water, infrastructure, and sectoral specialization.

To assess the impact of financial instruments and related development factors on investment activity, a fixed-effects panel regression model was estimated. The model includes subsidies, concessional lending, financing through development institutions, infrastructure development, and digitalization as key explanatory variables. The results are presented in Table 6.

Table 6. Regression analysis results

Variable	β	Standard error	Robust SE	t-stat	p-value
Subsidy	0.32	0.050	0.054	6.40	0.000
Subsidy^2	−0.11	0.030	0.032	−3.67	0.001
Credit	0.27	0.060	0.064	4.50	0.000
Dev	0.19	0.040	0.043	4.75	0.000
Infra	0.21	0.050	0.052	4.20	0.000
Digital	0.18	0.040	0.042	4.50	0.000

N = 187. Fixed-effects model. Robust standard errors clustered at the regional level. $R^2 = 0.84$.

Note: compiled by the authors

The regression results confirm that financial instruments and development conditions have a statistically significant effect on investment activity in the agro-industrial complex. Government subsidies have the strongest positive effect on investment activity ($\beta = 0.32$; $p < 0.01$), which confirms their role as the main instrument for reducing investment risks in agriculture. Concessional lending also has a strong positive effect (($\beta = 0.27$; $p < 0.01$), indicating that access to affordable credit resources remains a key condition for expanding agricultural investment.

Financing through development institutions has a positive and statistically significant effect (($\beta = 0.19$; $p < 0.01$). This result shows that institutional mechanisms of long-term financing support investment projects that cannot be fully financed through commercial lending. Infrastructure development also has a significant effect (($\beta = 0.21$; $p < 0.01$), confirming that transport, irrigation, energy, storage, and logistics infrastructure reduce transaction costs and increase the attractiveness of agricultural projects.

Digitalization has a positive effect on investment activity (($\beta = 0.18$; $p < 0.01$). Although its coefficient is lower than those of subsidies and credit, digitalization should be considered a strategic factor because it improves access to information, reduces administrative barriers, increases transparency in the allocation of support measures, and facilitates the development of digital financial services for agricultural producers. Since the baseline model identifies statistically significant effects for the main financial and institutional variables, the robustness of these results was further tested using alternative model specifications. The results of the robustness check are reported in Table 7.

Table 7. Robustness check results

Variable	Baseline FE model	FE model with Subsidy^2	FE model with lagged financial variables
Subsidy	0.29***	0.32***	0.27***
Subsidy^2	–	−0.11***	−0.09**
Credit	0.25***	0.27***	0.24***
Dev	0.17***	0.19***	0.18***
Infra	0.20***	0.21***	0.19***
Digital	0.16***	0.18***	0.17***
R^2	0.79	0.84	0.81
Number of observations	187	187	170

***, ** indicate statistical significance at the 1% and 5% levels, respectively

Note: compiled by the authors

The robustness checks show that the direction and statistical significance of the main coefficients remain stable across alternative model specifications. In particular, subsidies and concessional lending retain a positive effect on investment activity, while the quadratic subsidy term remains negative and statistically significant. This confirms that the nonlinear effect of government support is not the result of a single model specification.

The negative coefficient of the quadratic subsidy term confirms the presence of a nonlinear relationship between government support and investment activity. This means that subsidies stimulate investment only up to a certain threshold. At low and medium levels of support, subsidies reduce financial barriers and encourage agricultural producers to invest. However, when the volume of subsidies becomes excessive, their marginal effect declines. This may be explained by the weakening of market incentives, growing dependence on budgetary resources, and the risk that investment decisions are made primarily to obtain state support rather than to improve productivity and competitiveness.

The estimated nonlinear relationship between government subsidies and investment activity is illustrated in Figure 1.

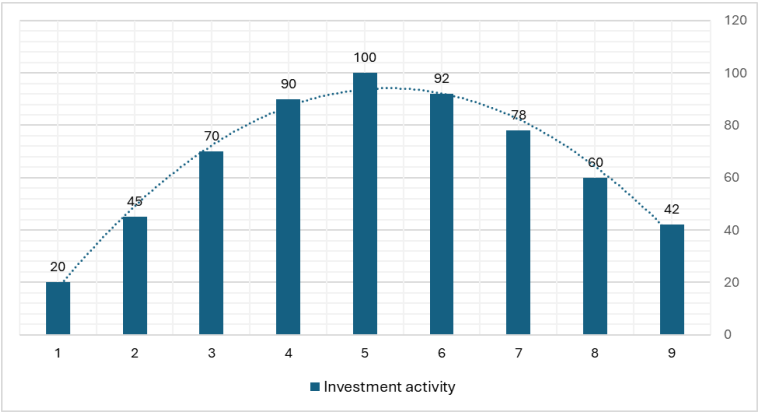


Figure 1. Nonlinear effect of subsidies on investment activity

The nonlinear relationship between subsidies and investment activity can be

interpreted as an inverted U-shaped curve. At the initial stage, an increase in subsidies reduces financial barriers and stimulates investment growth. At the middle level of support, the investment effect reaches its maximum. However, after the threshold point, the marginal effect of subsidies declines, which indicates the risk of dependence on state support and weakening of market incentives. This confirms that subsidy policy should be optimized not by increasing the total volume of support, but by improving its targeting and linking it to productivity, technological modernization, processing depth, and sustainability indicators. Based on the estimated model coefficients, Table 8 presents the contribution of key financial and institutional factors to investment growth in the agro-industrial complex.

Table 8. Contribution of factors to investment growth

Factor	Contribution, %
Subsidies	32
Credit resources	27
Infrastructure	21
Digitalization	18
Other factors	2

Note: compiled by the authors

The decomposition was calculated using standardized regression coefficients. This approach makes it possible to compare the relative importance of variables measured in different units. The results show that subsidies account for the largest share of explained investment growth, followed by credit resources, infrastructure, and digitalization. The interpretation of this decomposition should be treated as an analytical approximation rather than as a direct causal allocation of investment growth.

Overall, the empirical results show that investment activity in Kazakhstan's agro-industrial complex is shaped by the combined influence of financial, infrastructural, digital, and regional factors. Subsidies and concessional lending remain the most important instruments, but their effectiveness depends on the quality of allocation and the development of complementary conditions. For the Turkestan region, the results indicate the need to combine financial support with infrastructure modernization, irrigation development, agricultural processing, and digital financial instruments. This confirms the need to move from a predominantly subsidy-based model to a mixed, regionally differentiated system of investment stimulation.

DISCUSSION

The results of the study confirm that investment activity in the agro-industrial complex is shaped by the interaction of financial instruments, infrastructure conditions, digitalization, and regional characteristics. This conclusion is consistent with the logic of neoclassical and endogenous growth theories, according to which investment serves as a key mechanism of capital accumulation, technological renewal, and productivity growth (Romer, 1990; Aghion & Howitt, 2009).

The strong positive effect of subsidies and concessional lending is consistent with previous studies showing that financial constraints remain one of the main barriers to agricultural development, especially for small and medium-sized producers (Beck & Demirgüç-Kunt, 2006; Dorward et al., 2004). In Kazakhstan, this effect is particularly important because agricultural producers often face limited access to long-term credit, high collateral requirements, and significant production risks.

At the same time, the results show that subsidies are not effective indefinitely. The negative coefficient of the quadratic subsidy term confirms the presence of an inverted U-shaped relationship. This finding is consistent with studies emphasizing that excessive state support may distort market incentives and reduce the efficiency of resource allocation (Ciaian et al., 2018; Stein, 2019). Therefore, the practical question is not whether subsidies should be maintained, but how they should be targeted and linked to measurable outcomes.

The identified role of infrastructure supports the argument that agricultural investment depends not only on access to finance, but also on the quality of the investment environment. Transport, irrigation, storage, energy, and logistics infrastructure reduce transaction costs and increase the predictability of agricultural projects. This is especially relevant for the Turkestan region, where dependence on irrigated agriculture makes water infrastructure a key condition for investment efficiency.

Digitalization also has an important explanatory role. Although its coefficient is lower than that of subsidies and credit, digitalization should be interpreted as a long-term institutional and financial driver. Digital platforms can reduce information asymmetry, improve transparency in subsidy distribution, simplify access to lending, and support risk assessment for agricultural projects (Zetzsche et al., 2017). This finding strengthens the argument that digital transformation should be integrated into agricultural finance policy.

Compared with other regions of Kazakhstan, the Turkestan region demonstrates a specific investment profile. Its potential lies in irrigated agriculture, horticulture, greenhouse production, livestock development, and agricultural processing. However, these advantages are constrained by dependence on water, insufficient logistics and storage infrastructure, and limited access to market-based finance. Therefore, national financial instruments should be adapted to the regional structure of production rather than applied uniformly across all territories.

Overall, the findings suggest that Kazakhstan's agricultural investment model is moving from a subsidy-dominated system toward a mixed financing model. This model should combine targeted subsidies, concessional lending, guarantee instruments, development institution financing, infrastructure modernization, and digital financial platforms. The theoretical implication of the study is that the effectiveness of agricultural investment policy depends not only on the volume of public support, but also on the quality of financial architecture and the institutional capacity of regions to transform investment into productivity and added value.

5 | CONCLUSION

The conducted research made it possible to identify key patterns in the formation of investment flows in the agro-industrial complex of Kazakhstan and to assess the role of financial instruments in stimulating investment activity at the regional level. The results show that investments in agriculture demonstrate steady positive dynamics, but their growth is accompanied by structural constraints, high dependence on government support mechanisms and insufficient diversification of financing sources.

The econometric analysis confirmed the significant positive impact of subsidies, preferential loans, development institutions, infrastructure and digitalization on investment activity. Government support in the form of subsidies makes the greatest contribution to investment growth, reflecting its strategic role in conditions of limited access to market capital for agricultural producers. At the same time, the revealed negative coefficient for the quadratic term of subsidies confirms the existence of a nonlinear effect: excessive subsidies reduce investment efficiency and form the dependence of business entities on budgetary resources.

The scientific contribution of the study lies in the fact that investment processes in agriculture are considered not only as a result of an increase in financial resources, but also as an effect of the interaction of financial, institutional, infrastructural and digital factors. This makes it possible to clarify the theoretical provisions of the endogenous theory of growth in relation to the agricultural sector of Kazakhstan: sustainable investment growth is ensured not by a simple expansion of government support, but by the quality of the financial architecture, the targeting of instruments and the ability of the regional system to transform investments into productivity, technological renewal and added value.

The practical significance of the study is to substantiate the need to move from an extensive subsidy model to a more complex and effective investment incentive system. For Kazakhstan, this means that agricultural policy should be focused not on a mechanical increase in budget support, but on increasing its effectiveness, transparency and connection with the final results. It is advisable to link subsidies to indicators of productivity, export potential, technology adoption, processing depth and sustainability of agricultural production.

For the Turkestan region, which has a high agricultural potential, the key policy direction should be the formation of a specialized regional model of investment incentives. Priority should be given to sectors with high added value: irrigated agriculture, horticulture, greenhouse production, animal husbandry, agricultural processing and agrotechnological solutions. This will make it possible to move from a raw-material model of agricultural growth to a model based on processing, innovation and cluster development.

Of particular importance is the development of concessional lending and risk-sharing mechanisms. Government support should gradually shift from direct subsidies to guarantee instruments, project financing, agricultural receipts, mixed financing and digital lending platforms. This approach will expand the participation of banks, microfinance institutions, development institutions and private

investors in financing agricultural projects.

Infrastructure modernization is an equally important area. Investments in agriculture will have limited effect without the development of irrigation systems, logistics, warehouse infrastructure, energy, transport accessibility and digital communications. This is especially important for the Turkestan region, since the effectiveness of agricultural investments directly depends on the availability of water, sales markets and modern technological solutions. Digitalization should be considered not as an auxiliary element, but as an independent financial and institutional tool. The development of digital platforms for accounting subsidies, monitoring investment projects, agricultural loans and risk assessment will reduce information asymmetry, increase transparency in resource allocation and strengthen the trust of private investors.

Thus, the results of the study show that the further development of investment policy in the agro-industrial complex of Kazakhstan requires a transition to an integrated model combining targeted subsidies, affordable lending, infrastructure modernization, digital financial solutions and regional specialization. This model will improve the efficiency of public resource use, boost private investment, reduce regional disparities, and strengthen the competitiveness of Kazakhstan's agro-industrial complex in the long term.

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