“Government spending in the agricultural sector: Optimal ratio with lending and the impact on the agricultural production”

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GOVERNMENT SPENDING IN THE AGRICULTURAL SECTOR: OPTIMAL RATIO WITH LENDING AND THE IMPACT ON THE AGRICULTURAL PRODUCTION

Abstract

An effective government agropolicy should be balanced: To reduce the state budget pressure, it is important to reduce public spending and encourage farmers to use agricultural loans. Reducing public spending should not lead to a shortage in the agricultural market. The paper aims to substantiate the directions of government agropolicy transformation based on the optimal ratio of public expenditures and loans in the agrosector and the dependence of agroproduction dynamics on state financing. The research base is data from 10 countries with different income levels (World Bank), presented in FAOSTAT for 2004–2021. For each country, the optimal (determined by the structural modeling method) and actual proportions between state financing and lending in the agrosector are compared, adjusted for the agroproduction index. The modeling showed that the share of public funds should increase in Germany, Israel, Italy, and the UK and decrease in Azerbaijan and Georgia; the current proportion is optimal in the USA, Russia, Turkey, and Ukraine. Based on a panel regression model with fixed effects, the influence of the actual level of state agrofinancing on the FAO Production Indices of the main types of agroproducts was determined. It is the largest for crops, meat, and milk (a decrease in state funding by USD 1 million threatens to reduce the respective indices by 4.5, 3.47, and 3.79 points), medium for cereals and sugar crops (according to points 2.69 and 2.11), and the smallest for livestock and non-food products (by 1.53 and 0.001 points, respectively).

Keywords agriculture, lending, government policy, expenditures, agricultural market, financing, optimization, impact, structural modeling, panel regression

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INTRODUCTION

Government policies play a crucial role in shaping the dynamics of consumer markets, particularly in sectors like agriculture where regulation directly impacts food production, distribution, and consumption. Understanding the influence of government policies on regulating the consumer market in the agricultural sector is imperative for policymakers, researchers, and stakeholders to ensure sustainable development, food security, and economic growth. An essential element of the government policy for the development of the agricultural sector is maintaining a balance: On the one hand, to reduce the financial pressure on the state budget, it is important to gradually reduce the amount of state expenditures and reorient farmers to the use of agricultural credit instruments; on the other hand, the reduction of state expenditures should not lead to a deficit in the agricultural sector consumer market.

According to the OECD report, in 2019–2021, the total financial support of the agricultural sector in 54 countries amounted to USD 817 billion. This value is 13% more than in 2018–2020 (USD 720 billion) (OECD, 2022). The European Union and the United States received two-thirds of the allocated total volume. However, there is also a tendency to increase non-state financial support for the agricultural sector of developing countries. Usually, the burden of supporting agriculture in such countries falls on the state, and due to the lack of budget funds, there is a need to attract credit resources.

The balance between government expenditure and crediting to the agricultural sector ensures agriculture's stability, growth, and sustainability while supporting the livelihoods of farmers and rural communities (Joao & Castro, 2023). Government intervention in the agricultural sector is essential for supporting farmers, improving agricultural infrastructure, and enhancing productivity. Therefore, it is crucial to explore the trade-offs and synergies between government spending and lending in the agricultural sector and their impact on agricultural production.

1. LITERATURE REVIEW

Government policies in agriculture cover a wide range of initiatives, including price controls, subsidies, trade regulations, and food safety standards. Zolkover et al. (2022) and Tiutiunyk et al. (2023) emphasize the importance of coherence between tax administration, macroeconomic stability, and economic growth to achieve sustainable agricultural development. Various scientists were engaged in the search for the optimal ratio between government spending and crediting of agriculture. In particular, Paspie et al. (2022), using the example of the Philippines, developed a model of the relationship between the level of agricultural production and the volume of public spending. At the same time, a direct positive relationship between the studied determinants was revealed. Similar results were obtained only for India and Nigeria (De, 2018; Ken & Bidemi, 2016).

Besides, a practical government policy supporting agriculture should also achieve a balance between promoting agricultural productivity and comprehensive financial security as a key component of innovative development of the agricultural sector (Khalatur et al., 2023a). However, there may be many structural obstacles that can prevent this; in particular, we are talking about risks associated with weather conditions and climate change (Ali, 2021), imperfect legislation, moral wear and tear of equipment (Tomilin et al., 2023; Rakotoarisoa & Mapp, 2023), and structural problems caused by the spread of corruption and illegal schemes (Kaya, 2023; Bouchafaa et al., 2023).

Governments of countries usually direct agricultural subsidies to support farmers and producers of agricultural products, stabilize commodity prices, and ensure food security. However, the effectiveness of using these subsidies in regulating consumer markets remains a subject of debate (Zhghenti, 2023). Although government subsidies help increase agricultural productivity and lower consumer prices in the short term, agricultural investments and credits play an equally important role in supporting efficient market mechanisms in the agricultural sector (Leonov et al., 2014; Tiutiunyk et al., 2022). In addition, the impact of government subsidies on small farmers needs to be more thoroughly investigated compared to large agribusiness (Kaya, 2023; Njegovenović, 2023; Mullens & Shen, 2023). To avoid the destabilization of the consumer agricultural market, which can provoke a shortage of farm products, the governments of countries should develop a state policy that would take into account the specifics of the natural conditions and resource provision of the country and activation of the process of non-state lending to the agricultural sector (Ngobeni & Muchopa, 2022). Jambo and Traub (2023), using the example of three African countries (Zambia, Malawi, and South Africa), for which the issue of food security is particularly acute, recommend that governments change the priority of public spending in favor of the production of those crops that contribute to more significant growth.

State trade policy and agricultural loans significantly affect market dynamics in the agricultural sector, influencing the concentration and efficiency of resource redistribution, stakeholder expecta-

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tions (Kuzior et al., 2021, 2023), tariffs and trade agreements due to the synchronization of financial, business and trust cycles (Kuzior et al., 2022) in the context of the functioning of the digital economy (Melnyk et al., 2019). Trade liberalization policies, while promoting market efficiency and international competitiveness, can threaten the development of shadow schemes and expose farmers to global market risks, potentially affecting the formation of local food systems and not taking into account consumer preferences (Kobiyh & El Amri, 2023; Kobiyh et al., 2023).

Ensuring the safety of food products and the free access of all segments of the population to the possibility of their consumption (Guliyev, 2017; Lyeonov et al., 2021b; Gentsoudi, 2023) is the primary concern of governments to protect the health of consumers and maintain trust in agricultural products. High product quality standards and regular inspection protocols are an essential part of ensuring a country's food security and, as a result, maintaining consumer confidence (Atashov, 2005; Richardson, 2023).

Government policy aimed at ensuring the sustainable development of agriculture in the context of the formation of a favorable business environment (Brychko et al., 2023; Vasilyeva et al., 2022; Khalatur et al., 2023b) and environmental protection plays a crucial role in the formation of consumer preferences and market demand for environmentally friendly products (Singh & Pandey, 2023). Initiatives such as certification of organic products, agro-ecological subsidies, environmental incentives, and the formation of green brands among agricultural products (Starchenko et al., 2021; Lyeonov et al., 2021a) encourage farmers to use methods that contribute to reducing the degree of damage to the environment and reduce carbon emissions. and nitrate emissions (Ray, 2023), which have become especially relevant in the period of development of the additive economy (Sotnyk et al., 2012; Sineviciene et al., 2019). The development of modern information digital technologies allows not only the implementation of technology transfer strategies in agrarian businesses but also reformatting of traditional ways of conducting agriculture in more ecological directions; especially this is noticeable in industrial regions where the problem of environmental production is in the foreground (Kuzior & Lobanova, 2020; Pakhnenko & Kuan, 2023). Increasing consumer awareness of social engineering principles and eco-labeling schemes contributes to strengthening the impact of environmental policies by empowering consumers to make informed choices (Heiko & Yurochko, 2023) and associated farmers to improve ethical behavior and respect society (Bhandari, 2023).

The government's policy for developing the agricultural sector must strike a delicate balance between reducing state expenditures and ensuring the sector's stability and growth. In addition, a balanced state government's support for agriculture must consider several features (economic, social, ecological, and resource) to prevent a shortage of certain agricultural products.

Thus, this paper aims to develop proposals for transforming the government policy of financing the agricultural sector, taking into account the determined optimal ratio of government expenditures and credits in the agricultural industry and the dependence of the dynamics of the production of agricultural products on government financing.

2. METHODS

The information base for this study is the statistical data of ten countries of the world (Azerbaijan, Georgia, Germany, Israel, Italy, Russian Federation, Turkey, Ukraine, the United Kingdom of Great Britain and Northern Ireland, and the United States of America). Belonging to groups with different income levels (as classified by the World Bank) is represented by various regions of the world, the necessary statistical information for which is presented in the FAOSTAT database of the Food and Agriculture Organization (FAO) of the United Nations. This organization provides free access to food and agriculture data for over 245 countries and territories and covers all FAO regional groupings from 1961 to the most recent year available. The research period is 2004–2021. The list of input data is presented in Table 1.

The method of structural modeling based on "path analysis" and "path diagrams" involves the analysis of the information environment, which is formed based on the interaction of latent variables (Tsvetkov, 2012, 2014). Using the terminol-

Table 1. Input data description

No.	Indicator designation	The full name of the indicator
1	Gen_gov	Total Expenditure (General Government), million USD
2	Tot_cred	Total Credit, million USD
3	Agric	Agricultural Production Index
4	Cer	Cereals Production Index
5	Crops	Crops Production Index
6	Liv	Livestock Production Index
7	Meat	Meat indigenous Production Index
8	Milk	Milk Production Index
8	Non Food	Non Food Production Index
9	Sugar	Sugar Crops Primary Sugar Crops Primary

ogy of the indicators that are the basis of this study, when determining the optimal ratio between the government expenditure and crediting to the agricultural sector, it is necessary to build a structural model based on three indicators: Gov, Cred, and Agro, which are conditioned based on explicit indicators from Table 1 (Gen_gov, Tot_cred, Agric). An illustration of a simplified structural model for these indicators is shown in Figure 1.

Before building a structural model, the explicit indicators x must be standardized using the values of the mathematical expectation μ and the root mean square deviation *σ*. The data standardization formula has the following form (1)

$$Z = \frac{x - \mu}{\sigma}, \quad (1)$$

where Z – normalized value of the indicator; x – initial value of the indicator; μ – mathematical expectation of the indicator; σ – standard deviation of the indicator.

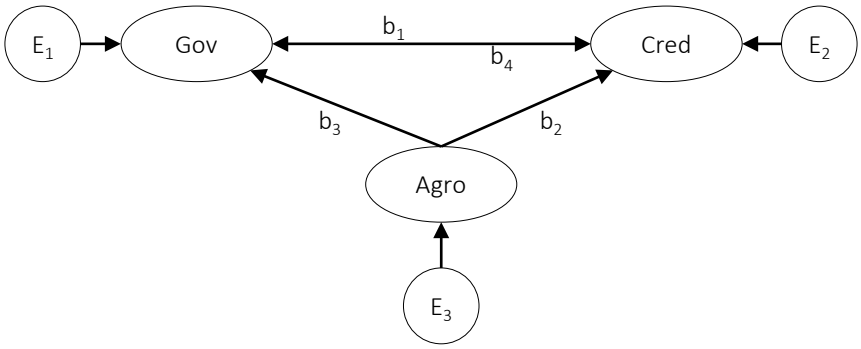
Structural modeling will result in the obtaining of two systems of simultaneous structural equations of the type, equations (2) and (3).

$$\begin{cases} Cred = b_2 Agro + b_1 Gov + E_2 \\ Gov = b_3 Agro + E_1 \\ Gen\_gov = Gov + \varepsilon_1 \\ Tot\_cred = Cred + \varepsilon_2 \end{cases}, \quad (2)$$

$$\begin{cases} Gov = b_3 Agro + b_4 Cred + E_2 \\ Cred = b_2 Agro + E_1 \\ Gen\_gov = Gov + \varepsilon_1 \\ Tot\_cred = Cred + \varepsilon_2 \end{cases}. \quad (3)$$

The optimal simulated values of the amount of government expenditure (Gov_{calc}) and credits ($Cred_{calc}$) of the agricultural sector are determined by equations (4) and (5).

$$\begin{cases} Cred = b_2 Agro + b_1 Gov + E_2 \\ Cred^* = \dfrac{Gen\_gov}{Cred} \cdot 100\% \\ Cred_{calc} = \dfrac{Gen\_gov}{Cred^* / 100} \end{cases}, \quad (4)$$



Note: b_1, b_2, b_3, and b_4 – structural parameters of the model, E_1, E_2, and E_3 – random components.

Figure 1. General graphic representation of the structural model

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$$\begin{cases} Gov = b_3 Agro + b_4 Cred + E_2 \\ Gov^* = \dfrac{Tot\_cred}{Gov} \cdot 100\% \\ Gov_{calc} = \dfrac{Tot\_cred}{Gov^*/100} \end{cases} . \quad (5)$$

The second stage of the study identifies state regulation's influence on the agricultural sector's consumer market. For this, a panel regression model of type 6 must be built, where Agricultural Production Indices will alternately perform the role of the dependent variable from Table 1 and the role of the independent variable – *Gen_gov*.

$$y_{it} = \alpha + Gen\_gov_{it}\beta + v_{it}, \quad (6)$$
$$i = 1,...,N, \quad t = 1,...,T,$$

where i – number of the indicators; t – year of the study; α – free member; β – regression coefficient; v_{it} – regression error.

$$v_{it} = u_i + \varepsilon_{it}, \quad (7)$$

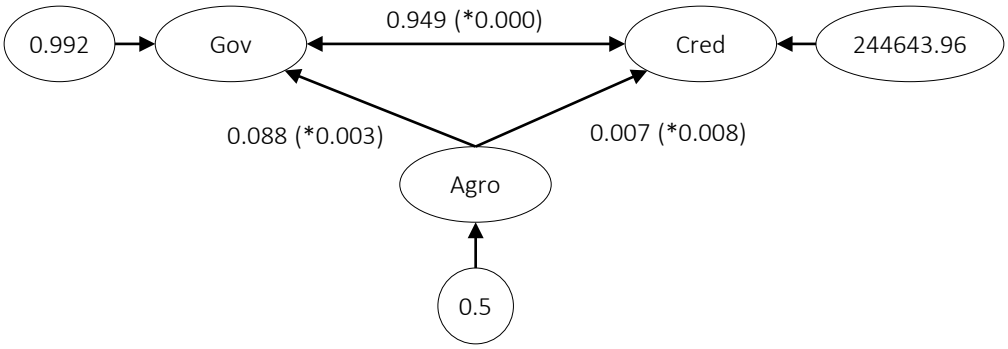
where u_i – individual effects of observations; ε_{it} – residuals of the model.

All calculations were carried out based on the software complex Stata/SE 18.0.

3. RESULTS AND DISCUSSION

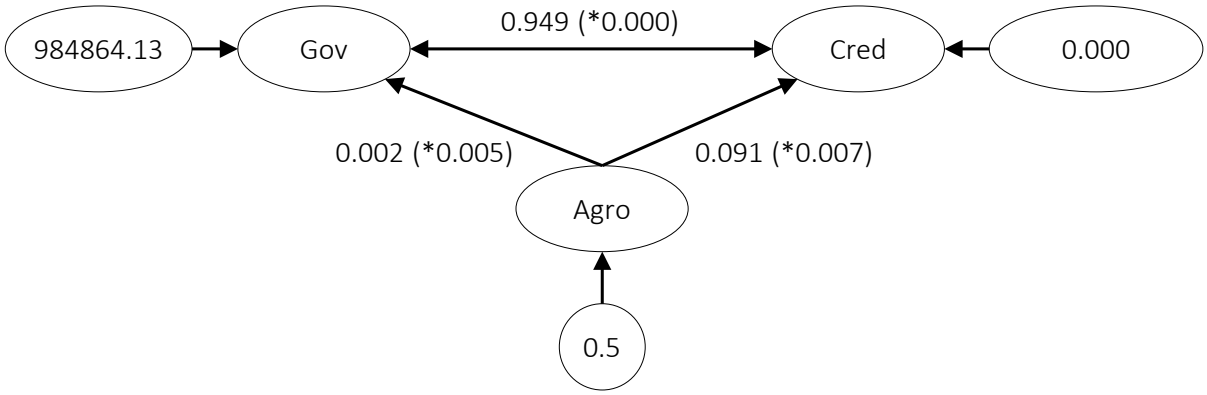
Graphically, structural models have the following forms (see Figures 2 and 3).

The obtained parameters of both structural models were used to build systems of structural equations (8) and (9).



Note: * level of statistical significance 0.05.

Figure 2. First structural model



Note: * level of statistical significance 0.05.

Figure 3. Second structural model

$$\begin{cases} Cred = 0.007\,Agro + 0.949Gov + 244643.96 \\ Gov = 0.088\,Agro + 0.992 \\ Gen\_gov = Gov + 0.000 \\ Tot\_cred = Cred + 0.5 \end{cases}, \quad (8)$$

$$\begin{cases} Gov = 0.949\,Agro + 0.002Cred + 984,864.13 \\ Cred = 0.091Agro + 0.992 \\ Gen\_gov = Gov + 0.000 \\ Tot\_cred = Cred + 0.5 \end{cases}. \quad (9)$$

The quality of the built structural model is evaluated according to two main criteria: the maximum cosine of the residuals and the RMS index, and it is based on the conformity of the distribution of the residuals to the normal law. The criterion of the maximum cosine of the residuals demonstrates a measure of the quality of the iteration process convergence. If the criterion value approaches zero, the process has converged successfully; the RMS index helps assess the quality of model fit. When the index is less than 0.05, the simulation results are qualitative.

The maximum cosine residual criterion for both models is 0.447, and the RMS index is 0.141. These values confirm the adequacy of the parameters of the obtained structural equations. A graphic representation of the distribution of the simulation residuals for both structural models confirms compliance with the normal distribution (Figure 4).

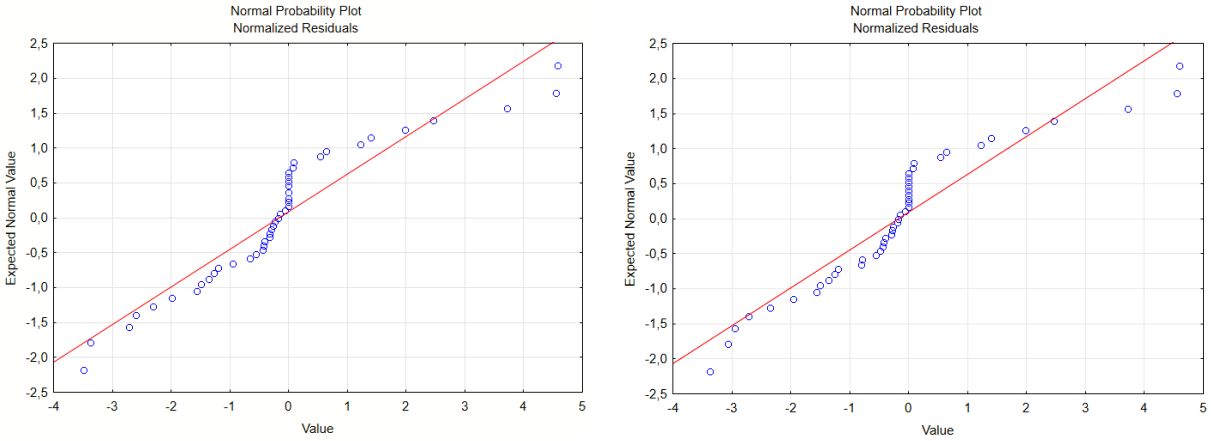
Since the results of the simulated structural models are statistically significant, the simulated values of the agricultural sector's volume of government expenditures (Govcalc) and credits (Credcalc) can be calculated according to the following ratios (equations (10) and (11)).

$$\begin{cases} Cred = 0.007\,Agro + 0.949Gov + 244,643.96 \\ Cred^* = \dfrac{Gen\_gov}{Cred} \cdot 100\% \\ Cred_{calc} = \dfrac{Gen\_gov}{Cred^*/100} \end{cases}, \quad (10)$$

$$\begin{cases} Gov = 0.949\,Agro + 0.002Cred + 984,864.13 \\ Gov^* = \dfrac{Tot\_cred}{Gov} \cdot 100\% \\ Gov_{calc} = \dfrac{Tot\_cred}{Gov^*/100} \end{cases}. \quad (11)$$

Table 2 presents current and simulated values of the ratio between the volume of government expenditure (Gov_{calc}) and credits ($Cred_{calc}$) of the agricultural sector.

Considering the results obtained for all the studied countries, there is a general trend of reorientation between the amount of government expenditure and credits to the agricultural sector, adjusted for the country's income level. A regularity is observed – the higher the income level in the country, the fewer funds from the state budget are spent on supporting agriculture, and the more credit resources are attracted. For example, the ratio be-



First structural model

Second structural model

Figure 4. Graphic representation of the distribution of simulation residuals for the first and second structural models

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Table 2. Current and simulated values of the ratio between the volume of government expenditure (Gov_{calc}) and credits ($Cred_{calc}$) of the agricultural sector, %

Country	Government Expenditure	Total Credit	Government Expenditure (calc)	Total Credit (calc)	Recommendations
Azerbaijan (UMI)	66.6	33.4	14.3	85.7	Targeted subsidy reduction, efficiency improvements of the agricultural sector, shift to market-based mechanism, investment in the agricultural infrastructure
Georgia (UMI)	89.7	10.3	60.7	39.3	
Ukraine (LMI)	57.4	42.6	52.7	47.3	
Germany (HI)	48.8	51.2	74.7	25.3	Budget allocation prioritization in the agricultural sector, policy reforms, government support for smallholder farmers
Israel (HI)	32.7	67.3	74.7	25.3	
Italy (HI)	49.2	50.8	60.0	40.0	
Russian Federation (UMI)	50.9	49.1	58.1	41.9	
Turkey (UMI)	50.5	49.5	57.4	42.6	
United Kingdom (HI)	24.9	75.1	81.4	18.6	
USA (HI)	49.0	51.0	62.8	37.2	

Note: LMI – Lower middle income, UMI – Upper middle income, HI – High income.

tween the average level of government expenditure and crediting of agriculture in Azerbaijan is 66.6% and 33.4%, respectively; in Israel – 32.7% and 67.3%; in the USA – approximately the same, 49% and 51%. Using structural modeling, a different ratio was obtained between the average level of government expenditure and agricultural crediting, taking into account the level of agricultural development in these countries: Azerbaijan – 14.3% of public expenditure and 85.7% crediting, Israel – 74.7% and 25, 3%, respectively, the USA – 62.8% and 37.2%, respectively. Figures 5 to 7 show the actual and simulated volume of redistribution of budget and credit funds in the agricultural economy of all ten countries from 2004 to 2021.

The relationship between the level of state financing of agriculture and key production indices of agricultural products (Table 3) must be checked using panel regression modeling.

Considering the results of the panel regression model, the level of state financing of agriculture has the most significant influence on the agricultural production indices: Crops Production Index, Meat indigenous Production Index, and Milk Production Index. With an increase in government support by USD 1 million, the Crops Production Index will increase by 4.5 points, the Meat Indigenous Production Index by 3.47 points, and the Milk Production Index by 3.79 points.

The average influence of the volume of state support is carried out on indicators such as the Cereals Production Index and Sugar Crops Primary Sugar Crops Primary. With an increase in government support by USD 1 million, the Cereals Production Index will increase by 2.69 points, and the Sugar Crops Primary Sugar Crops Primary by 2.11 points.

Table 3. Results of panel regression modeling of the relationship between the level of state financing of agriculture and key production indices of agricultural products

Independent variable	Dependent variable	Regression coeficient	p-value	Type of model
Gov	Cer	*2.69	0.00	Fixed-effects
	Crops	*4.50	0.00	
	Liv	*1.53	0.04	
	Meat	*3.47	0.02	
	Milk	*3.79	0.04	
	Non Food	*0.001	0.00	
	Sugar	*2.11	0.03	

Note: * – level of statistical significance 0.05. Fixed-effects mean that a fixed-effects model was used to construct panel regression.

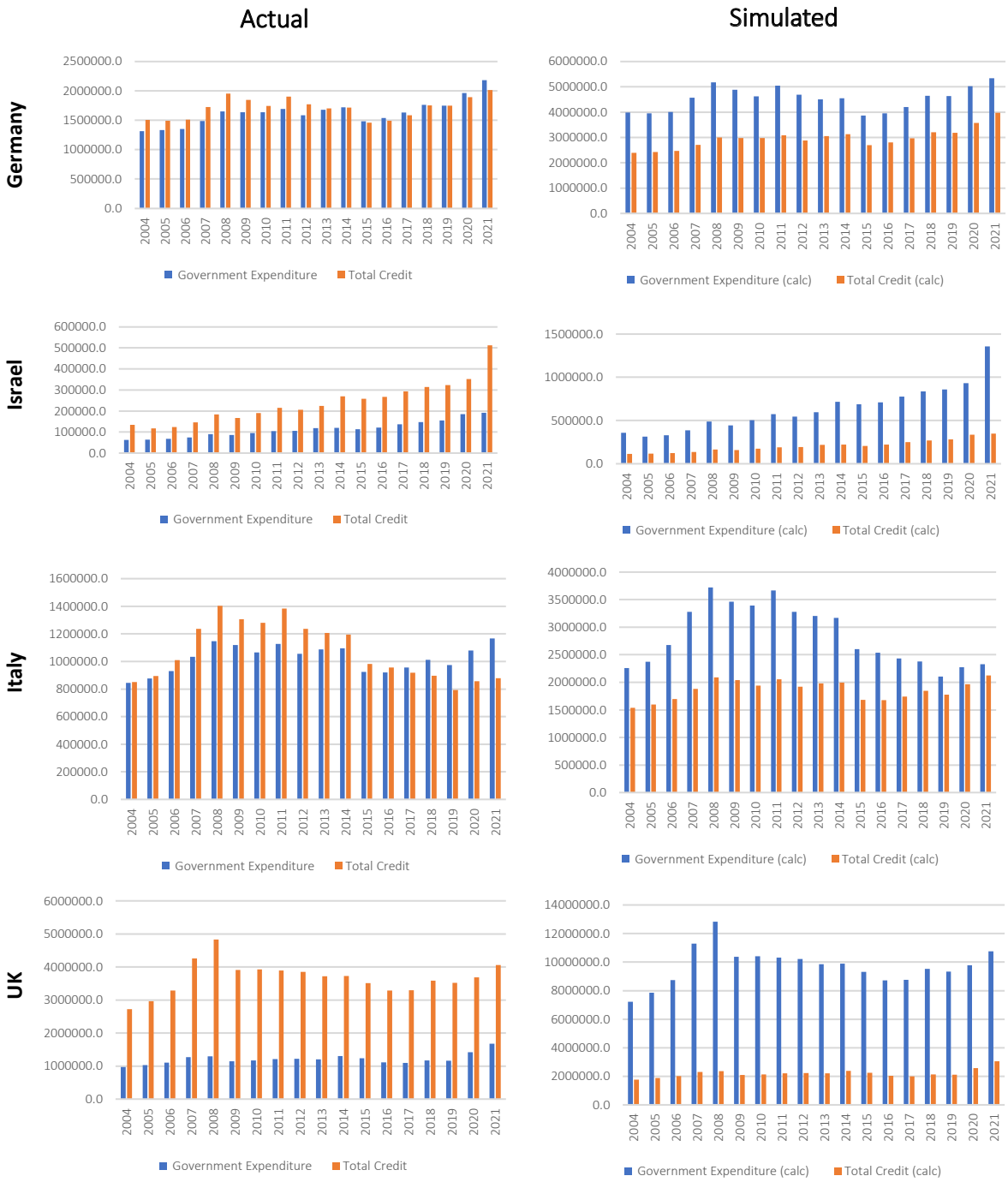

Figure 5. Graphic representation of the actual and simulated relationship between the level of government expenditure and agricultural credits in Germany, Israel, Italy, and the UK in 2004–2021, % (an increase in government spending on the agricultural sector is necessary)

The amount of state support has the least influence on indicators such as the Livestock Production Index and Non-Food Production Index. With an increase in government support of USD 1 million, the Livestock Production Index will increase by 1.53 points and the Non-Food Production Index by 0.001 points.

Chikov et al. (2023) developed a systematic approach to modeling a synthetic indicator of agricultural enterprises' competitiveness based on neural networks. The obtained quantitative indicator is a linguistic assessment of agricultural enterprises' competitiveness. The developed approach is used to track and control changes in the development of

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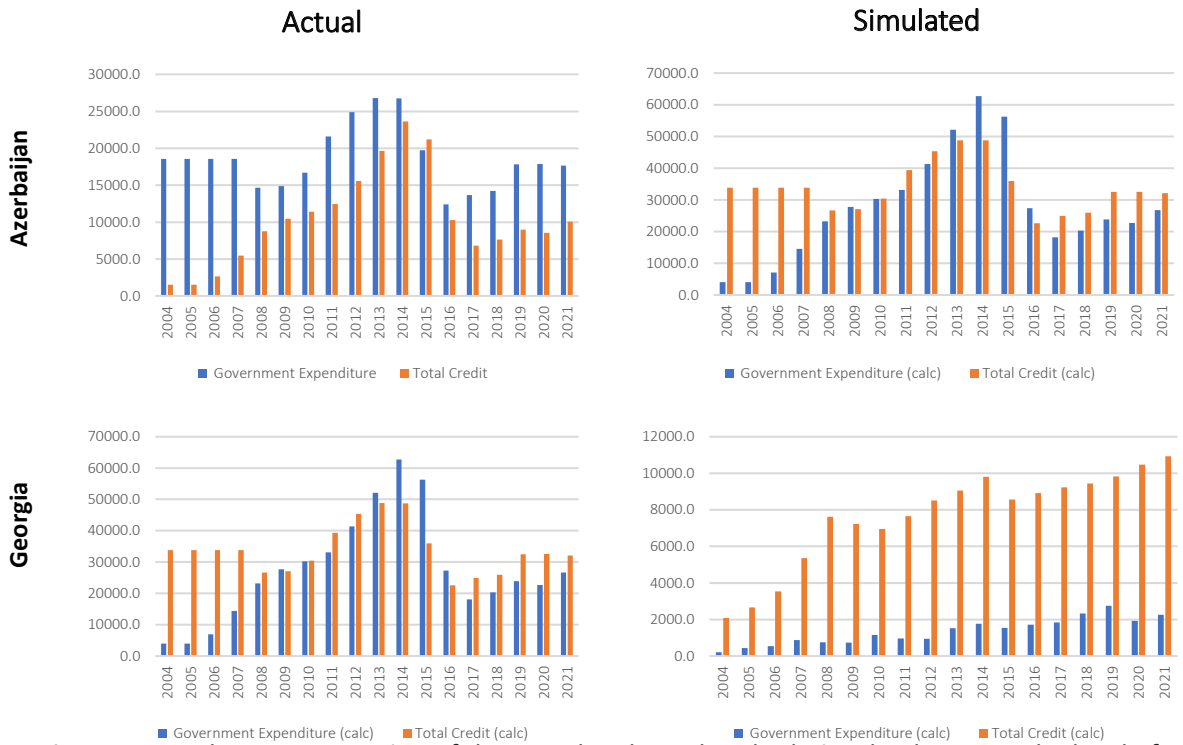

Figure 6. Graphic representation of the actual and simulated relationship between the level of government expenditure and agricultural credits in Azerbaijan and Georgia in 2004–2021, % (a decrease in government spending on the agricultural sector is necessary)

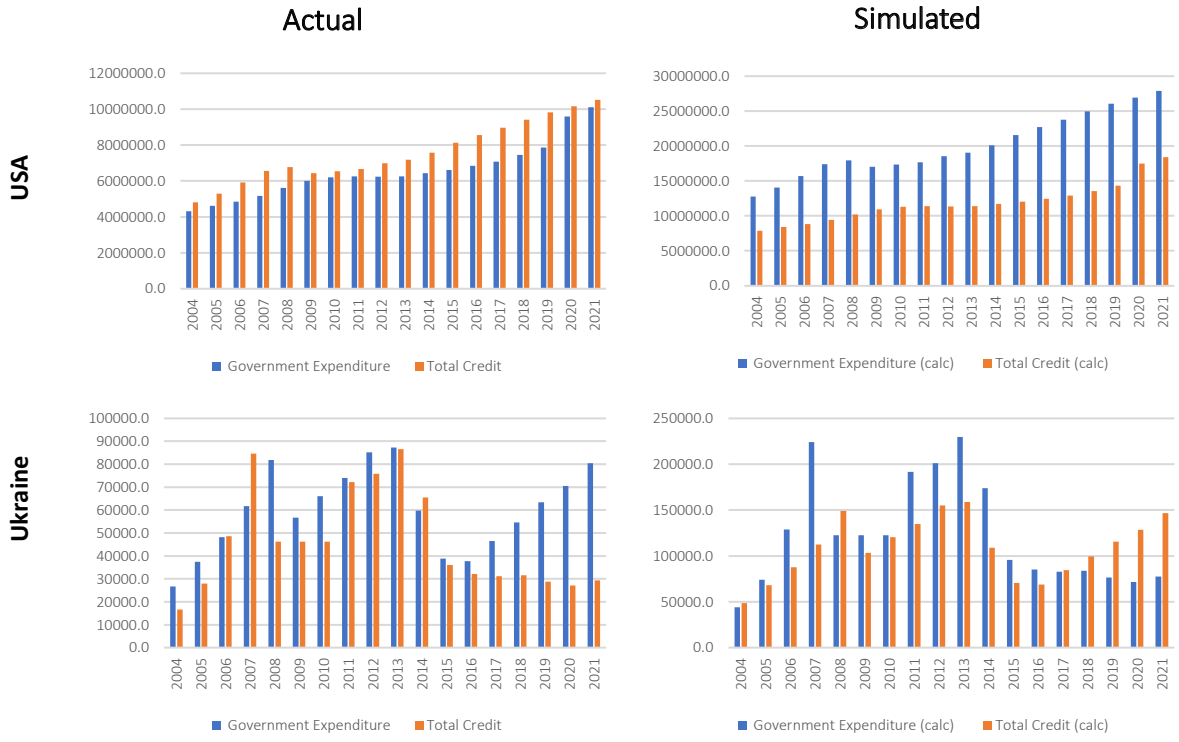

Figure 7. Graphic representation of the actual and simulated relationship between the level of government expenditure and agricultural credits in the USA, Ukraine, Turkey, and Russian Federation in 2004–2021, % (government spending on the agricultural sector is approximately at the same level)

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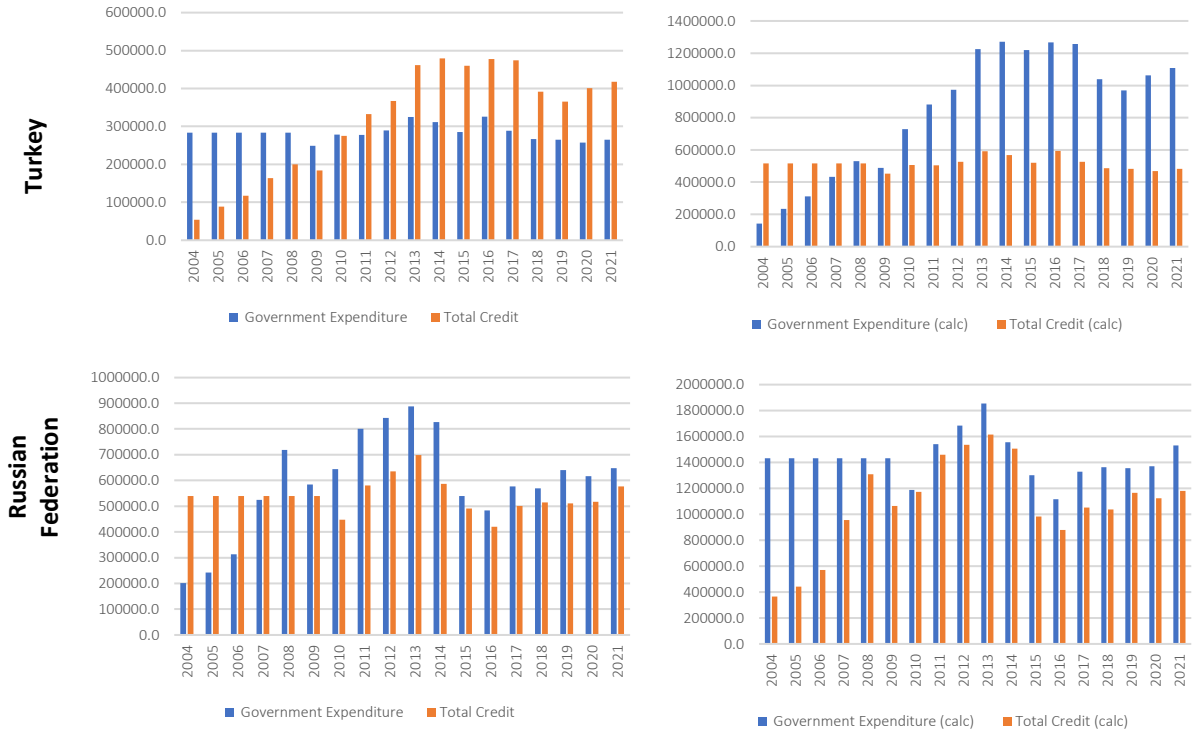

Figure 7 (cont.). Graphic representation of the actual and simulated relationship between the level of government expenditure and agricultural credits in the USA, Ukraine, Turkey, and Russian Federation in 2004–2021, % (government spending on the agricultural sector is approximately at the same level)

the agricultural sector and helps to assess agricultural enterprises' competitiveness. It expands their activity opportunities but needs to consider the influence of state and non-state support, which creates appropriate conditions for creating a competitive environment in the studied sector.

CONCLUSION

This paper develops proposals for transforming the government policy of financing the agricultural sector, considering the determined optimal ratio of government expenditures and credits in the agricultural industry. The dependence of the dynamics of agricultural production on government funding has been established using the example of ten countries of the world with different levels of economic development.

According to the modeling results, Ukraine needs to reduce its share of state support and increase the volume of agricultural lending by 4.7%. Azerbaijan, Georgia, the Russian Federation, and Turkey also need to reduce the volume of state financing and increase the level of lending by 52.3%, 29%, 7.2%, and 6.9%, respectively. On the contrary, Germany, Israel, Italy, the United Kingdom, and the USA need to increase the share of state funding and reduce the amount of credit to agriculture by 25.9%, 42%, 10.8%, 56.5%, and 13.8%, respectively.

State regulation significantly influences three production indices (the Crops Production Index, the Meat Indigenous Production Index, and the Milk Production Index). With an increase in government support by USD 1 million, the Crops Production Index will increase by 4.5 points, the Meat Indigenous Production Index by 3.47 points, and the Milk Production Index by 3.79 points. It means that these areas of the agricultural sector are critical from the point of view of state support. In the event of a signifi-

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cant reduction in their state funding and untimely support at the expense of other financial resources, their deficit may be threatened. On the other side, the amount of state support has the least influence on the indicators of the Livestock Production Index and Non-Food Production Index. With an increase in government support by USD 1 million, the Livestock Production Index will increase by 1.53 points and the Non-Food Production Index by 0.001 points. Thus, the production of Livestock and Non-Food can become the basis for reforming the financing of the agricultural sector towards intensifying agricultural lending and thus reducing the financial pressure on the country's budget.

Thus, the obtained results allow us to confirm the relevance of reviewing the volumes and sources of financing of a country's agriculture, taking into account their economic level of development and Agricultural Production Indices and lay the foundation for future research on the assessment of the effectiveness and fairness of a country's state and credit policy, which would contribute to ensuring food security safety and stable well-being of consumers.

AUTHOR CONTRIBUTIONS

Conceptualization: Bayali Atashov, Sabina Valiyeva, Nizami Gafarov.
Data curation: Nizami Gafarov.
Formal analysis: Bayali Atashov, Sabina Valiyeva.
Funding acquisition: Bayali Atashov, Nizami Gafarov.
Investigation: Bayali Atashov.
Methodology: Bayali Atashov, Sabina Valiyeva, Nizami Gafarov.
Project administration: Sabina Valiyeva.
Resources: Sabina Valiyeva.
Software: Bayali Atashov, Nizami Gafarov.
Supervision: Sabina Valiyeva.
Validation: Bayali Atashov, Nizami Gafarov.
Visualization: Bayali Atashov, Nizami Gafarov.
Writing – original draft: Sabina Valiyeva, Nizami Gafarov.
Writing – review & editing: Bayali Atashov.

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