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Research Article

Diagnosis of sustainable development of the agro-industrial complex in the context of ensuring food security

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ABSTRACT

Assessing the level of food security requires a detailed analysis of the effectiveness of government policies to support the agro-industrial complex and determining the nature of the analyzed socio-economic processes in order to determine the key factors that influence on them, identify weaknesses and potential problem situations that have a negative impact on food security. The result of the construction of indicative systems is the possibility of interpreting the results obtained in order to develop a state program for ensuring food security and assessing the effectiveness of the proposed measures of influence. For modeling purposes, the method named as "Partial Least Squares Path Modeling" or "Projecton Latent Structures Path Modeling" was used based on panel data from the regions of southern Russia for 2014-2016. The obtained results confirm the possibility of using indicative models for constructing multivariate forecast estimates for the influence of scenario variants of the state support policy concerning the agro-industrial complex on the level of competitiveness of domestic producers and resistance to negative external influences, as well as modeling of general or partial equilibrium conditions in food markets in order to assess the appropriateness of state impact in case if some indicators overcame critical values and food security reduced.

Keywords: food security, model, state support, indicator,

INTRODUCTION

It is an important step for each state in ensuring economic security in the food sector to perform a well-founded selection of indicators that characterize the current state of individual components of food security, taking into account the existing dynamic and spatial characteristics. This is due to the fact that food security is an ntegral part of economic security; therefore, food security should also be characterized by a set of criteria and indicators. It is also necessary to take into account the current global trends in the development of world food markets [18] and long-term priorities for ensuring food security [14].

Indicators are targets that allow quantitative and qualitative characteristics of negative effects of ongoing processes to represent, and to signal about a possible further deterioration of the situation, as well as about a decrease in the global level of national security, what allows neutralizing the possible consequences [3]. The criterion of food security is the threshold (limiting) level of an indicator; it is the limit beyond which the food situation in the country (region) is considered dangerous [1]. Limit values of indicators characterize the marginal limits, below (above) which a certain economic (social or ecological) system leaves the equilibrium state, becomes unbalanced and passes into a zone dangerous for the further functioning and development. Limit values are usually taken from the international benchmarks of economically developed countries, from the best values for the aggregate of regions,

countries, from recommendations of international organizations, international and domestic experts, own expert assessments, maximum (minimum) of the totality of indicators. In foreign scientific literature, there are about 200 definitions and 450 indicators of food security [16].

Assessment of the food security level requires a detailed analysis of the effectiveness of government policies to support the agro-industrial complex, taking into account the specifics of the country's foreign trade policy, and the general economic situation [19]. The inclusion of macroeconomic indicators into the system of indicators makes it possible to assess their influence on the meso-level systems and the possible consequences for the long-term development of the subjects of the Russian Federation.

For the purposes of the study and analysis and assessment of trends in the development of the agro-industrial complex that directly affect the level of food security, the following [7, 9] should be taken into account:

– Determination of essence of the socio-economic process being under analysis with the aim of determining the key factors affecting them;

– Determination of the functioning specifics of territorial agro-industrial complexes of the regions, identification of weaknesses and potential problem situations that have a negative impact on the level of food security;

– Forecasting in short and long periods of the consequences of the formed trends in the agro-industrial complex;

– The possibility of interpreting the results obtained in order to develop a national program for ensuring food security and assessing the effectiveness of the proposed measures of impact.

Methodology for building an indicative system for assessing food security

As the analysis showed, there is no unified position among Russian researchers on the system of criteria and indicators characterizing the level of food security, allowing a comprehensive assessment of the state of the agro-industrial complex and agricultural markets development. At the macro level, an indicative system for assessing food security has been developed [1], but it does not take into account the existing territorial asymmetry of the socio-economic development of the regions, what requires expanding the list of indicators and clarifying the criteria for taking into account the specific functioning of meso-level systems in the context of achieving an acceptable level of food security.

The methodology for assessing the level of economic security includes three classical approaches of indicative analysis [2]:

– The only effective indicator should be determined, which acts as the main indicator, as well as a number of factor ones the values of which can act as a constant, and have a variable structure;

– Having analyzed the degree of influence of factor characteristics on the main indicator, it is possible to determine the optimal way to achieve the maximum possible planned value, taking into account a possible compromise in the conditions of available resource limitations;

– Construction of integrated indicators that allow us to assess the level of economic security with a view to further identifying priority of development directions.

All indicators characterizing economic processes can be divided into three main groups: leading, coinciding and lagging indicators [4]. Based on the first group, it is possible to predict the dynamics of the development of socio-economic processes, what makes it possible to create a basis for the development of strategic development programs. First of all, they should include indicators that reflect the investment activity of economic entities. Coincident indicators have the same name, since their dynamics coincide with the main macroeconomic trends taking place in the national economy. Their use makes it possible to assess the current level of economic security on the basis of such indicators as output, unemployment, average salaries, and so on. On the basis of lagging indicators, it is possible to assess the degree of adaptation of the industry or individual economic entities to the existing economic situation. First of all, this group includes indicators characterizing the financial and economic stability of territorial and sectoral complexes or individual economic entities.

The use of threshold values for assessing the level of food security makes it possible to more accurately quantify the socio-economic processes

which take place in the agro-industrial complex. The presented grouping of indicators for assessing the level of food security makes it possible to form a dynamic system of characteristics which are the basic elements of the functioning of the agro-industrial complex. However, the specific nature of the analysis of economic security and its food component requires consideration of its structure, in addition to assessing the dynamic characteristics of the economic system [20]. For this purpose, it is expedient to use a combination of relative and structural indicators such as the rate of growth or growth, the specific weight, and so on.

The proposed grouping of indicators for assessing the level of security of economic security and its food component requires further adjustment, taking into account the need for analysis in the context of the subjects of the Russian Federation. Most of the existing methods allow assessing the level of food security at the country level. However, in O. L. Taran's opinion, upon the existing differentiation of regions according to the level of socio-economic development it is necessary to consider a multitude of differently directed and difficultly comparable indicators, what makes interpretation of the results difficult [11]. However, assessment of the food security level with a breakdown into the subjects of the Russian Federation makes it possible to form a minimally necessary final system of indicators, since the analysis will principally concern territorial agro-industrial complexes [5].

A. I. Tatarkin identifies the following methods of state influence on the development of territorial and branch complexes: "planning, forecasting, use of the fiscal system and other regulatory tools" [12]. The use of these tools, being a prerequisite for the formation of an effective system for ensuring an acceptable level of food security, requires the use of indicators that can be integrated into the mechanism of state regulation of economic processes. Diagnosing the economic security and its food component requires identifying bottlenecks and flaws in the market system, the level of technical and technological development of the agro-industrial complex, the quality and efficiency of the current system of public administration. [15] All this predetermines the need to use indicators of food security. Particular attention should be paid to the need to develop such a system of indicators, which will correspond to the long-term goals of the country's socio-economic development [17]. The selection of indicators requires consideration of a number of factors affecting the level of food security [13]:

– Sustainable development of the agro-industrial complex requires the provision of an extended type of reproduction using advanced technologies;

– The achievement of an acceptable level of food security should be accompanied by an increase in the well-being of the population;

– The growth of globalization and foreign trade restrictions require an increase in the competitiveness of domestic producers in world agricultural markets;

– Food security should be provided in stages from production to the final sale of food products;

– It is necessary to create institutional prerequisites for increasing investment activity in the agro-industrial complex.

Indicative model for assessing the level of food security

The selection of indicators for assessing food security requires consideration of methodological specifics, and the indicators themselves meet a number of requirements. The main thing is that indicators should be as specific as possible and sufficient in their totality to conduct a comprehensive analysis of potential threats to the national economy, the actual level of socio-economic status of regions, territorial and sectoral complexes, or nationwide socio-economic status. In conditions of considerable spatial differentiation of regional development, the system of indicators should be suitable for carrying out comparative analysis and determining the strengths and weaknesses of sectors and territories.

In accordance with these requirements in the capacity of the basic principles for selecting indicators that characterize the level of food security, we have modernized the criteria proposed by Sh. M. Salikhov [10]. The selected indicators should be reliable, economically and mathematically sound, have the maximum coverage in retrospective for possible forecasting and assessment of the dynamics of economic security indicators. They should be easily verifiable, therefore indicators should be based on official statistical information, what will also

ensure the accuracy and objectivity of the estimates obtained. The number of indicators should be minimally possible and allow assessing the dynamic and spatial characteristics of economic security and its food component.

Based on these principles, we propose to use the following rules for selecting indicators for assessing economic security and its food component:

– Quantitative measurability and verifiability of indicators;

– Minimization of the number of indicators (5-7) due to the use of econometric methods and their integration into complex criteria that characterize certain components of food security;

– The ability to determine the dynamic characteristics and structure of the economic system as part of food security;

– An opportunity for drawing up concepts and strategies for ensuring economic security and forming targets;

– The possibility of their use on the macro and meso-levels;

– The ability to conduct comparative analysis in the context of the subjects of the Russian Federation and territorial and sectoral complexes;

– The need to use a complex of absolute, relative and structural indicators.

On the basis of the considered specific nature of assessing the economic security level of the agro-industrial complex, let us first select explicit indicators that will be grouped into corresponding blocks that will be hidden variables.

The list of factors is presented in Table 1. The interconnection between hidden variables is the external part of the model, while the factor "Economic security" acts as an effective feature, and the "social", "public policy" "financial-economic" and "technical and technological" variables are factor. The dependencies of hidden variables on explicit variables describe the outer part of the model.

Hidden Variables	Explicit Variables	Notation
The ratio of the average wage in the sector to the average wage for the region	Share of environmental costs	ZEK
	Unemployment rate in the sector	UBR
	Number of high-performance jobs created	VPR
Share of imported food products	The volume of public expenditures within the framework of import substitution and support programs for the agro-industrial complex	GRI
	Sectoral tax burden	ONN
	The share of costs for imported raw and consumable materials in the costs of purchasing raw and consumable materials for production and sales of products	ONZ
Share of innovatively active organizations	Power availability per 1worker	ETR
	Power capacity per 100 hectares	EMR
	Coefficient of equipment renewal	KOT
	Production of agricultural products enrolled to fixed assets in the reporting period	OSP
	Depreciation of fixed assets	RIS
The level of profitability of products sold	Share of unprofitable enterprises	DUP
	The ratio of tax debt to tax revenue	NZP
	Working capital financed by equity to total assets ratio	RPR
	Current liquidity ratio	RPZ
Share of investments in the volume of shipped products	Balance of export of agricultural products	ESP
	The volume of agricultural production in relation to 2013	PSP
	Growth rate of organizations	KPO
Economic security	The level of profitability of products sold	RPR
	Share of innovatively active organizations	OPS
	Share of imported food products	OIP
	Share of investments in the volume of shipped products	OOI
	The ratio of the average wage in the industry to the average wage for the region	SZP

Table 1 - The ratio between explicit variables with breakdown into blocks that characterize the economic security of the agro-industrial complex

As a basis, the use of the PLS-PM method (Partial Least Squares Path Modeling) was proposed. This method was developed in the 70s of the XX century, G. Vold is considered to be the founder of this direction [21]; he proved the expediency of its use in applied economic research.

Econometric analysis based on panel data has a number of advantages that are crucial for selecting factors and subsequent assessment of the economic security level for the agro-industrial complex. Classical econometric models use spatial samples or time series as the initial arrays of statistical data. Their use for assessing economic security is not always justified and does not allow them to develop effective recommendations for improving the level of economic security. This is due to the fact that the coefficients of regression found from individual equations for aggregated source data, lead to bias errors since they do not take into account the specifics of the socio-economic development of individual regions.

The initial array of data presented in the panel sample for the subjects of the SFD and the NCFD for a certain period of time (2014-2016) allows the formation of a prolonged spatial sample and allows analysis from several observations for each factor selected in the model.

Thus, panel analysis of data for selecting factors and assessing the level of economic security of the agro-industrial complex gives the following advantages [8]:

– Increases the number of observations, what automatically leads to an increase in the number of degrees of freedom and reduces the level of interfactor dependence, as well as standard errors in the econometric model;

– Makes it possible to carry out a complex analysis, what is impossible for cases when the initial array of statistical information is spatial data or time series to analyze a variety of economic issues that cannot be addressed to time series and spatial data separately;

– Prevents estimation bias when aggregating data;

– Allows assessment of the impact of individual characteristics on the level of economic security of the agro-industrial complex in space and time;

– Reduces the influence of specification errors which arise from ignoring certain factors.

The source blocks of the original data X_j are related to the hidden variables LP_j and are immeasurable quantities. Then their evaluation is based on the use of formula (1):

$$LP_j = Y_j \quad (1)$$

All available relations among variables can be conditionally divided into two groups. The external model is the relations between the hidden variables and the blocks of the original data X_j, and the internal model consists of hidden inter-dependencies.

The endogenous model is a classical system of linear equations (2):

$$LP_j = \delta_0 + \sum_{i \to j} \delta_{ji} LP_i + \varepsilon_j \quad (2)$$

Where LP_i are implicit variables that directly or indirectly affect the structure of the latent variable LP_j;

δ_{ji} are "path coefficients" which allow estimating the tightness and direction of the relation between LP_i and LP_j;

δ_0 - free term;

ε_j – random error.

To be able to interpret the simulation results, the system of econometric equations must meet a number of requirements:

– The system of linear equations must be recursive;

– The endogenous model and the individual equations of the system are regression ones;

– The residual sequence must be independent of the variables being explained [6].

Exogenous model determines the relationship between hidden and explicit variables. To assess the level of economic security of the agro-industrial complex, it is advisable to use the "reflective model" which is a kind of external models where a hidden variable acts as a factor variable with respect to the explicit one, i.e., the so-called "reflection" of hidden variables via explicit ones takes place.

$$X_{jk} = \gamma_{0jk} + \gamma_{jk} LV_j + \varepsilon_{jk} \quad (3)$$

Where γ_{jk}- load factors;

γ_{0jk} - free members;

ε_{jk} - random errors.

Formulas (2) and (3) allow us to derive the coefficients of the models considered using the parameters of the hidden variables LP_j based on regression analysis for each equation of the system, which are linear relationships between the corresponding explicit variables that allow us to assess the level of economic security of the agro-industrial complex.

$$LP_j = Y_j = \sum_k w_{jk} X_{jk} \quad (4)$$

Where w_{jk} are exogenous weighting coefficients of the model.

The assessment of the economic security level of the agro-industrial complex based on the use of the PLS-PM type model includes the following stages:

– Finding latent variables by finding coefficients and obtaining estimates of hidden variables (w_{jk});

– Finding the "path coefficients" of the endogenous model and determining the nature of the relationship between factors affecting the level of economic security (γ_{ji});

– Finding the parameters of the exogenous model (γ_{jk}) and the final assessment of the economic security level of the agro-industrial complex on the basis of selected external factors and the degree of their impact on the outcome.

Simulation results

Empirical results were obtained using MS Excel and Statistika software on the basis of data from a single interdepartmental information and statistical system (EMISS) for selected factors in the context of SFD and NCFD regions from 2014 to 2016, according to the following algorithm:

– Internal matching on hidden variables of the model;

– The estimation of statistical significance of explicit variables in the external model;

– Estimation of the multicollinearity of factor attributes (hidden and explicit) both within and between blocks;

– Assessment of the adequacy of the endogenous model obtained;

– Assessment of the adequacy of the model taking into account the influence of exogenous factors;

– Optimization of the model.

The results obtained according to the hidden variable that characterizes the social aspects of economic security in the agro-industrial complex (the ratio of the average wage in the sector to the average wage for the region) indicate a statistical insignificance of the explicit variable "the number of high-performance jobs created" and the presence of a weak correlation with the "Share of environmental costs". The effectiveness of the state policy on supporting the domestic agricultural producer is estimated based on the hidden indicator "The share of imported food products". Its importance is not influenced by the sectoral tax burden, and the amount of state support for import substitution projects in the agro-industrial complex and the share of imported raw materials in expenditures has a relatively low impact, but both indicators are statistically significant.

An important component of the economic security of the agro-industrial complex is the technical and technological component, the analysis of which is based on the hidden variable "The share of innovation-active organizations". Among the explicit variables that describe this indicator, there is a multicollinearity between the following pairs of indicators: "Power availability per 1 worker" and " Power capacity per 100 hectares", as well as "Coefficient of equipment renewal" and "Depreciation of fixed assets". The indicator "Production of agricultural products enrolled to fixed assets in the reporting period" turned out to be statistically insignificant, which is most likely due to the fact that only livestock and green plantations are related to this product. Thus, after eliminating the multicollinearity and statistically insignificant factors, two indicators remained: "Power capacity per 100 hectares" and "Coefficient of equipment renewal". The profitability level of the products sold, which characterizes the financial component of the economic security of the agro-industrial complex, has a significant feedback with the indicator "The ratio of tax debt to tax revenues" and a direct close relationship with the indicator "Working capital financed by equity to total assets ratio"; the remaining explicit indicators in this block were statistically insignificant. In the last block, only the indicator "Growth rate of organizations" was statistically significant.

The final endogenous model describing the economic security of the agro-industrial complex will take the following form:

$$LP_{EBAPK} = 0{,}33LP_{SZP} + 0{,}61LP_{OIP} + 0{,}20LP_{OPS} + 0{,}47LP_{RPR} + 0{,}54LP_{OOI} + \varepsilon_{EBAPK} \quad (5)$$

Hidden variables are expressed in terms of explicit ones as follows:

$$\begin{gathered} LP_{SZP} - 0{,}14X_{ZEK} - 0{,}59X_{UBR} \\ LP_{OIP} = 0{,}22X_{GRI} + 016X_{ONZ} \\ LP_{OPS} = 0{,}62X_{EMR} + 0{,}73X_{KOT} \\ LP_{RPR} = 0{,}39X_{NZP} + 0{,}69X_{DUP} - 0{,}22X_{DUP} \\ LP_{OOI} = 0{,}32X_{KPO} \end{gathered} \quad (6)$$

The results of the simulation demonstrate that the influence of individual blocks on the overall level of economic security of the agro-industrial complex is different. The maximum influence is exerted by factors characterizing the level and effectiveness of state support for the agro-industrial complex, which, in our opinion, is primarily connected with the start of the program for import substitution of agricultural products, as well as with the general specifics of the functioning of the sector, what requires constant support of agricultural producers.

Financial stability of economic entities and their investment activity should also be taken into account when assessing the level of economic security in the agro-industrial complex.

The need to take them into account is primarily due to the need to increase the competitiveness of domestic producers, which is impossible without the implementation of capital investments in the modernization of fixed assets, the purchase of new equipment, etc.

The relatively weak influence of factors characterizing the social orientation can be explained by the fact that in the agro-industrial complex the low level of wages is partially compensated by the presence of personal subsidiary plots.

The proposed methodology for assessing the economic security level of the agro-industrial complex can be used for comparative analysis of indicative figures both within the blocks in the territorial aspect and in retrospect, and also to form a system of endogenous factors, which makes it possible to reduce the dimensionality of the model.

In our case, when assessing the level of economic security of the agro-industrial complex, two possible options should be considered:

– Estimations of the hidden variables that form individual blocks of the current period, have a tend to decrease, i.e., a stable trend of reducing economic security is formed;

– Estimations of the hidden variables have an upward trend, which indicates an increase in the level of economic security, but its final value does not reach the optimum and fluctuates near threshold values, and it can reach critical minima by certain criteria.

CONCLUSIONS

Thus, the solution of the actual problem of ensuring food security in conditions of negative external influences and sanctions pressure requires the development and further use of adaptive and adequate economic and mathematical models. The complexity of this problem predetermines the need for using indicative systems for diagnosing the level of food security. In this case, the main value in its solution is the ability to obtain dynamic characteristics for the purpose of constructing accurate forecasts and constructing transparent methods for determining key indicators of sustainable development in the agro-industrial complex.

The proposed economic and mathematical model which diagnoses the level of food security is comprehensive and can be supplemented further in the following areas:

– Construction of multivariate forecasted assessments for the influence of scenario variants of the agro-industrial complex state support policy on the competitiveness level of domestic producers and resistance to negative external influences;

– Modeling and formalization of the technical and technological modernization processes in the agro-industrial complex;

– Modeling of general or partial equilibrium conditions in food markets in order to assess the appropriateness of government impact in case of overcoming individual critical indicators and reducing food security;

– Building a model of foreign food trade and the necessary technical and technological resources for the agro-industrial complex, the use of which is necessary and for which import substitution is impossible in the short term;

– Modeling of inter-sector relations in the agro-industrial complex in the context of assessing the effectiveness of state support measures for key and priority sectors, taking into account their retrospective and current status. In this connection, they should be represented by static and dynamic inter-branch models, and be based on the mass of statistical information provided by Rosstat (Russian Federal State Statistics Service)

Another positive aspect of the proposed economic and mathematical model for assessing the level of food security is the possibility of conducting a

comparative analysis, since there are the indicators used similar to indicators in international statistical databases.

As it was noted earlier, one of the main directions of increasing the level of food security is the emergence of new foodstuffs competitive in global markets in terms of quality and price characteristics; therefore it is advisable to supplement the developed indicative evaluation system with the toolkit for two-criterion analysis.

Achieving the necessary level of food security is impossible without the establishment of an effective monitoring system for the functioning of the agro-industrial complex. The organization of such a system is the prerogative of the state and should signal about potentially possible negative scenarios for the development of the agro-industrial complex, the growth of social tension in the countryside, and a reduction in the level of food security. The developed model can be used as the basis of the system for monitoring key indicators of socio-economic development in the agro-industrial complex. To diagnose the competitive advantages of the agro-industrial complex and to search for potential growth points that will contribute to improving food security, it is advisable to expand the list of traditional indicators in the following areas:

– Operative analysis of the competitiveness level for large agro-holdings with the aim of adjusting the measures of state support for their development;

– Analysis of the technical and technological modernization process for the agro-industrial complex in the existing logistic chains, as well as the restoration of the material and production base of agricultural producers, which contributes to the growth of labor productivity and the expansion of the assortment of food products that are competitive in terms of price and quality criteria;

– Evaluation of effectiveness of the regulatory framework governing the activities of economic agents in the agro-industrial complex on unification of Russian and international quality standards, what will stimulate the output of domestic products to global markets.

Thus, the development and implementation of indicative models of assessing the level of economic security and its food component requires the consideration and analysis of a multitude of differently directed criteria that must correspond to the current strategies and concepts of Russia's long-term socioeconomic development, have a flexible structure of indicators, and contribute to the formation of stable upward trends growth of the agro-industrial complex, including for the development of foreign trade activities and access to new global markets for agricultural products.

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