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Food Security: State Financial Support Measures for Sustainable Development of Agriculture in Russian Regions

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ABSTRACT

In the context of global economic instability, the problem of ensuring food security and sustainable development of agriculture at the international, national and regional levels becomes urgent. Existing methods for assessing the state of food security and sustainable development of agriculture, as a rule, have two main drawbacks: first, they are often static, and second, they include a scattered list of indicators that are difficult to systematically interpret in the analysis. Therefore, the **aim** of the study is to develop an adequate methodology for assessing the food security of the constituent entities of the Russian Federation. The construction of a thematic index is carried out in three stages: 1) a system of indicators is formed; 2) the values of indicators are normalized; and 3) sub-indices are calculated. The analysis of domestic and foreign literature on food security provided the **methodological basis** of the study. The system of indicators was clarified, which were combined into three groups (numerical indicators of the sphere of production, distribution, consumption, and food). The authors extended the retrospective assessment of food security at the meso-level by ranking and clustering Russian regions using hierarchical analysis and a new data filtering algorithm. The hierarchical procedure is based on a system of mathematical filtering of data, which is fundamentally different from existing methods for analyzing hierarchies. The authors replaced the fuzzy "what if" logic with a clear subordination of ranked indicators (subindices). The group of leaders was selected considering the accepted priority of indicators, the rest of the regions were united into a new subgroup, among which leaders and outsiders were singled out. At each new stage, new groups are ranked after excluding leaders and outsiders, they are in the "center of the circular convolution of data", the procedure for stopping the procedure is the presence of two groups. This is a fundamental feature, scientific novelty, and value of the mathematical apparatus for multidimensional ranking of Russian regions in terms of food security. The authors **concluded** that in modern Russia the problem of food security has not yet been resolved due to the insufficient use of general economic and special levers to increase the stability of the food system. The results of the study can be applied in the process of updating the state policy in the field of ensuring the sustainability of food systems at the macro- and meso-level of management.

Keywords: food security; regions of Russia; financial state support; Agriculture; index method; hierarchical analysis

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INTRODUCTION

The processes of globalization taking place in the economy have led to population growth, changes in consumption, production and trade patterns, and also significantly influenced the well-being of people around the world. Currently, the concepts of sustainable agricultural development and food security are dominant among many theories of socio-economic and environmental development.

World practice has developed many methods and a rather complex mechanism of state support and stimulation of the development of agriculture, which includes: a system of regulation of the agrarian market and agricultural production, various instruments of influencing the incomes of various agricultural producers, as well as the rural social structure, inter-sectoral and inter-farm relations. Empirical experience shows the dependence, in which the higher the level of government regulation, the higher the degree of self-sufficiency of the country in food. A critical analysis of modern concepts of the state's regulatory impact on agribusiness indicates the existence of a differentiated state policy even in economically developed countries. For example, the EU countries take a socially and environmentally friendly approach, while the US applies strict regulation [1–5].

In this context, a number of new questions arise about the role of the state in providing affordable and high-quality food for various segments of the population living in both urban and rural areas. At the same time, it should be noted that, in general, there are few and little-known global studies that assess food systems using several indicators of sustainability [6, 7]. There is only a partial understanding of how systems function at different levels of government, which prevents decision-makers from influencing food quality. At the same time, a review of scientific works indicates a lack of agreement among researchers regarding the need for certain indicators (justification for their choice is not provided) in the system of thematic assessment [8, 9]. The consequence of this is a high level of risk of cross-correlation between indicators, which ultimately can lead to distortion of the assessment results.

The sanctions pressure on the Russian economy from the EU countries and the United States made the issue of ensuring food security and sustainable development of agriculture urgent. The study of various aspects of food security and sustainable development of agriculture plays an important role in improving state policy in relation to the country's agro-industrial complex. In turn, this policy involves the development of effective measures of state support for domestic agricultural producers, primarily of a financial nature, considering the positive foreign experience. In modern conditions, this is impossible without an objective assessment of the results achieved (based on competitive benchmarking methods) using modern high-precision methods of economic and mathematical modeling. The foregoing predetermined the objectives of the study, which consists of developing an adequate methodology for assessing the food security of the constituent entities of the Russian Federation and systematizing measures of state financial support for sustainable agricultural development. To achieve the set objectives, it is necessary to address a number of tasks:

- analyze and classify food security assessment studies;
- build a food security index with methodological features;
- use it to conduct a retrospective assessment of the food security of the regions of Russia;
- to rank and cluster the constituent entities of the Russian Federation by the level of food security using the author's hierarchical procedure;
- to study the positive foreign experience of state financial support for sustainable agricultural development.

THEORETICAL AND METHODOLOGICAL ASPECTS OF ASSESSMENT OF FOOD SECURITY OF THE COUNTRY AND ITS REGIONS

Research on food security and sustainable agricultural development is a relatively new direction in economics that emerged at the end of the 20th century. This problem in a changing economy is complex and multifaceted, and it receives increased attention both in foreign and domestic literature. A significant number of works are devoted to issues directly or indirectly related to the research topic, which may be divided into several groups.

The first group includes few, but relevant works devoted to assessing the impact of economic globalization on the food security process as a result of the impact of a number of factors (population growth, changes in consumption patterns, production and trade patterns). For example, foreign authors [10] from the University of Athens and the UK Business School discuss the following issues: how globalization affects state policy in the field of food security; what is the degree of influence of global chains on the value creation process (*GVC*); dominance in trading markets; the role of investment and international markets for agricultural products. According to their hypothesis, there is a strong relationship between food security and globalization, which is characterized by the volume of investments and financing models of the agri-food sector of the economy.

The second group includes numerous international researches devoted to the study of the factors in the multi-indicator assessment of global food systems. For example, in the work of modern scientists from Switzerland and the USA [11], a multi-indicator assessment of the sustainability of global food systems is presented. The system of indicators proposed by them makes it possible to comprehensively assess the food security of the country and clarify the directions of development of the country's agriculture. It should be noted that the number of indicators required for assessment may vary from country to country depending on their geographic location, the quality of life of the population, and national dietary habits.

In the work of an international group of researchers from the International Center for Tropical Agriculture of Columbia, University of California, scientists from France, and the University of Denver, USA [12], a global map of food system sustainability was presented for the first time based on the analysis of data from 156 countries using 25 indicators combined into 7 groups. The study proposes an assessment of the development of food systems using such groups of indicators as nutrition, environment, food availability, socio-cultural well-being, sustainability, food safety, and the level of food spending.

The third group of scientific works includes studies of regulatory measures and support for the agri-food sector of the economy of European countries. For example, in [13], the authors considered the factors affecting the economic stability of agriculture, the impact of support policies on production efficiency, and the opportunities for economic growth. Their calculations demonstrate the effectiveness of the EU's Common Agricultural Policy in subsidizing agriculture.

The fourth group of investigated problems of theoretical substantiation and empirical measurement of the concept of sustainable development [14, 15].

And, finally, the fifth group of studies includes scientific works of Russian agricultural economists A. I. Altukhova [16], I. N. Buzdalova [17], G. I. Panaedova [18], N. Shagayda [19, 20], and a number of others [21–23] who study the problems of the state agraricultural policy of the Russian Federation. They provide data on the current state and directions of development of the agricultural sector in our country and focus on the need to adapt the accumulated world experience to the changing economic situation in Russia.

There is growing interest among researchers and analysts in the ability to define and empirically measure the resilience of food systems. Therefore, we focus on the methodological side of the issue. In our opinion, the approach can be implemented in five stages.

First stage. The theoretical aspects of food security include the definition of the required list of peer-reviewed articles, documents, and reports of expert groups and international development agencies, which discuss indicators of the sustainability of the food system.

The ***second stage*** includes a review of more than 80 documents, which shows that the literature on food systems typically distinguishes four dimensions of sustainability: economic, social, food security, and environmental. For example, the group of economic indicators includes the degree of openness of the economy, the level of debt, the budget deficit, the balance of export-import trade operations, GDP, GNI, etc. In turn, social indicators include unemployment rate, Gini coefficient, life expectancy at birth, health care costs, etc.

Third stage. To assess food security, the economic literature contains a large number of indicators that measure various aspects of economic sustainability.

The ***fourth stage*** in assessing food security is based on comparing the dynamics of investment and agricultural production. The impact of the size of budget funding on the results of agricultural production and food security is assessed.

Fifth stage. In the course of the study, the materials of the official websites of international organizations, regulatory legal acts, materials of ministries and departments, forms of state support, and trends in its development in the EU countries, the USA, China and the Russian Federation were analyzed.

Based on a review of thematic literature to assess the food security of a country and its regions, we consider it possible to apply a food security index, which includes three sub-indices and is calculated using the formula below:

$$I\,FP = f(P, D, C), \quad (1)$$

where *I FP* is Food Provision Index;

P — production, D — distribution and C — consumption are, respectively, the numerical indicators of the sphere of production, distribution, and consumption, as well as food production.

For example, production indicators that must be considered when analyzing the sphere of production are indicators of the output of various types of agricultural products and the level of self-sufficiency in food. Indicators characterizing food distribution may include:

- food price index;
- the magnitude of the change in the real money income of the population;
- the level of unemployment and the proportion of the population with incomes below the subsistence minimum.

Among the indicators characterizing the sphere of food consumption, it is proposed, in particular, to highlight the share of food expenditures in the structure of consumer spending and the volume of food consumption in accordance with rational consumption standards.

Thus, within the framework of the study, the assessment of food security of the constituent entities of the Russian Federation involves not only an analysis of the production capabilities of the agricultural sector of the regional economy but also considers the financial capabilities of the population for the consumption of basic (essential) food items.

RETROSPECTIVE ASSESSMENT OF FOOD SECURITY OF CONSTITUENT ENTITIES OF THE RUSSIAN FEDERATION

As part of the study, a retrospective assessment of the food security of the constituent entities of the Russian Federation

is carried out on the basis of the author's approach using the previously considered food security index. The information base for the thematic assessment is the data of official (regional) statistics for 2016–2018.[1] Before proceeding with the assessment of food security of the constituent entities of the Russian Federation, we will briefly describe the methodological features of constructing the index in the author's interpretation. To conduct a thematic assessment, we have developed a system of indicators. Its initial version consists of 43 indicators, grouped into three (presented in *Table 1*).

Such indicators are expressed in different units of measurement. Consequently, the correct convolution of indicators presupposes a preliminary normalization of their values. For most indicators (with the exception of the subgroup of indicators characterizing the per capita actual consumption of food), it is carried out using a minimax method:

$$x = \begin{cases} \dfrac{X - X_{\min}}{X_{\max} - X_{\min}}, \text{if the growth} \\ \text{of the indicator value is assessed positively;} \\ \dfrac{X_{\max} - X}{X_{\max} - X_{\min}}, \text{the opposite situation,} \end{cases} \quad (2)$$

where X, $X_{\max}$, $X_{\min}$ are, respectively, the actual (for each year separately) the largest and smallest values (for the analyzed period of time) of any indicator from the system.

Normalization of the values of indicators from the previously indicated subgroup is carried out according to the formulas below:

$$x = \begin{cases} \dfrac{X}{X_n} \text{IIIIIIIIIIIII} \\ \text{IIIIIIIIIIIII} \\ \text{of the indicator within the normal range,} \\ \dfrac{X_{\max} - X}{X_{\max} - X_n}, \text{the opposite situation,} \end{cases} \quad (3)$$

where X_n is the rational rate of food consumption (in the context of their groups according to the recommendations of the Ministry of Health of the Russian Federation[2]).

The value of both the index and the three sub-indices is calculated by calculating the simple arithmetic mean, i.e., provided that all indicators from the system are equivalent.

The original system of indicators is specified (some factors are eliminated) according to the results of the calculation and analysis of the paired Pearson correlation coefficients. First, for a number of correlation coefficients (all factors with an effective indicator), their statistical significance is checked using the Student's t-test. During the test, it was found that the paired correlation coefficients of the effective indicator with factors 17, 18, 25, 26, 28, 30, and 42 are statistically insignificant. Therefore, these factors are not included in the final system of indicators for assessing the food security of the constituent entities of the Russian Federation. Secondly, the initial information was checked for multicollinearity (the phenomenon is considered established if the value of the pair correlation coefficient for any combination of factors exceeds 0.85). It has been experimentally proven that there is no multicollinearity in the initial data (an array of normalized values of indicators and index).

Appendix 1 presents not only the final results of the retrospective assessment of food security of the constituent entities of the Russian Federation (index calculation) but also their decomposition (in the context of three sub-indices). We analyze the variability of the data set (in the spatio-temporal context) of the above four indicators based on the calculation and interpretation of the values of the coefficient of variation. In 2016 and 2018 the spread in the values of the food security index of the constituent entities of

[1] Russian regions. Socio-economic indicators. 2019: col. art. M.: Rosstat; 2019.

[2] Recommendations for norms of food consumption that meet modern requirements for a healthy diet (approved by order of the Ministry of Health of the Russian Federation of August 19, 2016, No. 614).

Table 1

The system of indicators of food security of the constituent entities of the Russian Federation

Indicators	Assessment of the growth of the indicator value
Numerical indicators of production	
Agricultural production indices (in farms of all categories; in comparable prices; % to 2015):	
1. Crop production	Positive
2. Livestock	Positive
Yield (in farms of all categories; hundred kilograms per hectare of harvested area):	
3. Cereals and legumes (in weight after processing)	Positive
4. Sugar beet	Positive
5. Sunflower	Positive
6. Fiber flax	Positive
7. Potatoes	Positive
8. Vegetables	Positive
9. Milk yield per cow in agricultural organizations (kg)	Positive
10. Average annual egg production of laying hens in agricultural organizations (pcs.)	Positive
11. Average annual shearing of wool from one sheep in agricultural organizations (in physical weight; kg)	Positive
The ratio of food products produced and consumed by the population (%):	
12. Meat and meat products	Positive
13. Milk and dairy products	Positive
14. Potatoes	Positive
15. Vegetables and food melons and gourds	Positive
16. Eggs	Positive
Numerical indicators of distribution and consumption	
17. Indices of consumer prices for food products (December of the analyzed year to December 2015; %)	Negative
18. Ratio of average per capita money income of the population to the cost of a fixed set of consumer goods and services (%)	Positive
The ratio of the average monthly accrued wages of employees of organizations with the size of the subsistence minimum (%)	Positive
20. The ratio of the average size of assigned pensions to the size of the subsistence minimum (%)	Positive
21. The size of the population with monetary incomes below the subsistence minimum (% of the total population of the subject)	Negative
22. Unemployment rate (%)	Negative
23. Purchase of food products in the structure of household consumption expenditures (based on the results of a sample survey of household budgets; %)	Negative
Average per capita actual food consumption (% of the rational consumption rate):	
24. Meat and meat products	Within the norm – positive
25. Milk and dairy products	Within the norm – positive
26. Potatoes	Within the norm – positive
27. Vegetables and food melons and gourds	Within the norm – positive
28. Eggs	Within the norm – positive
29. Sugar	Within the norm – positive
30. Vegetable oil	Within the norm – positive
31. Bread	Within the norm – positive
Numerical indicators of food products	
Average per capita gross fee (kg per person):	
32. Grains (in weight after processing)	Positive
33. Beets	Positive
34. Sunflower seed	Positive
35. Flax fiber	Positive
36. Potatoes	Positive
37. Vegetables	Positive
38. Fruits and berries	Positive
Average per capita production of livestock products:	
39. Livestock and poultry for slaughter (slaughter weight; kg per person)	Positive
40. Milk (kg per person)	Positive
41. Eggs (pcs. per person)	Positive
42. Wool (in physical weight; kg per person)	Positive
43. Honey (kg per person)	Positive

Source: compiled by the authors.

the Russian Federation was 18.7%, and in 2017 — 19.5%. This means that during the analyzed period of time, there was a dispersion of the thematic index above the average. At the same time, if there was a deviation from the average for the sub-index of numerical indicators of consumption and distribution (more than 10, but less than 12%), then for the sub-indices the numerical indicators of the sphere of consumption, production, and food — a significant spread, amounting to about 27–29 and more 68%.

Thus, we can conclude that the differences in food security in the regions of Russia are mainly associated with different production capabilities of their agricultural sector of the economy.

To develop differentiated measures of state support for agricultural producers in the context of the constituent entities of the Russian Federation, it is necessary not only to rank the regions of Russia according to the achieved level of food security but also to carry out multidimensional clustering using modern methods of economic and mathematical modeling. As part of the study, multidimensional (nonlinear) data processing (simultaneously for three sub-indices) is carried out with the linking of indicators to the ranking center.

RATING AND CLUSTERING OF CONSTITUENT ENTITIES OF RUSSIAN BY FOOD SECURITY LEVEL

The thematic approach is described in detail in [24, 25]. The research uses an improved author's ranking technique, taking into account a set of initial data (sub-indices) and a fundamentally new filtering algorithm. Before carrying out computational experiments, we briefly describe the features of the approach and its step-by-step implementation. Regions-leaders and outsiders are filtered at each stage, the group of "average" regions is subjected to a new analysis, the leaders and outsiders of the second level are singled out, the former are below the leaders of the first level, the latter are above the outsiders of the first level, but below all leaders of the second level. Compression continues until the number of groups reaches two, then priority ranking (selected sub-index) is performed, the algorithm ends. The substantiation of the hierarchical procedure is contained in the system of mathematical filtering of data, which is fundamentally different from the existing methods of analyzing hierarchies, the fuzzy logic "what-if" is replaced by a clear subordination of ranked indicators (sub-indices). The group of leaders was selected considering the accepted priority of indicators, the rest of the regions were united into a new subgroup, among which leaders and outsiders stand out. At each new stage, new groups are ranked after excluding leaders and outsiders, they are in the "center of the circular convolution of data," the procedure for stopping the procedure consists in the presence of two groups. This is the fundamental feature, novelty, and value of the mathematical apparatus for the multidimensional ranking of Russian regions from the point of view of food security. So, within the framework of the study, in contrast to the aforementioned author's works on indexing and rating, when constructing a rating at the first level of hierarchical data analysis, ranking numbers for the initial indicators of regions obtained on the basis of their simple processing and initial filtering of information.

To construct an integral rating, three sub-indices (PDC) are used in descending order of priority, i.e. taking into account the previously conducted assessment of the variation of their values. Such indicators for the i-th region are denoted by, p_i, d_i и c_i, respectively.

Average values of indicators p_i, d_i и c_i for $i=(1,\ldots,N)$ are calculated using the formulas below:

$$\overline{p}=\frac{1}{N}\sum_{i=1}^{N}p_i;\ \overline{d}=\frac{1}{N}\sum_{i=1}^{N}d_i;\overline{c}=\frac{1}{N}\sum_{i=1}^{N}c_i. \qquad (4)$$

The methodology for constructing an integral food security rating of the constituent entities of the Russian Federation (IFSR) is carried out in several stages. At the first stage of the analysis, Russian regions are divided into groups according to the priority of sub-indices *C*, *P* and *D*: the first group has the highest priority (leaders), groups *P* and *D* follow in descending order of importance, and the last group includes outsiders. The regions of Russia that fall into the first group will have competitive advantages in relation to the subjects of the Russian Federation from other groups (second, third, etc.). We denote the number of groups by *m*, there are from two to eight groups. Initially, for the algorithm, we assume that $m = 8$. Next, we apply the procedure.

Stage 1. All the constituent entities of the Russian Federation are divided into 8 groups according to the following principle:

Group 1 — Russian regions *i*, for which $p_i < \overline{p}, d_i < \overline{d}, c_i < \overline{c}$;

Group 2 — Russian regions *i*, for which $p_i < \overline{p}, d_i \geq \overline{d}, c_i < \overline{c}$;

Group 3 — Russian regions *i*, for which $p_i \geq \overline{p}, d_i < \overline{d}, c_i < \overline{c}$;

Group 4 — Russian regions *i*, for which $p_i \geq \overline{p}, d_i \geq \overline{d}, c_i < \overline{c}$;

Group 5 — Russian regions *i*, for which $p_i < \overline{p}, d_i < \overline{d}, c_i \geq \overline{c}$;

Group 6 — Russian regions *i*, for which $p_i < \overline{p}, d_i \geq \overline{d}, c_i \geq \overline{c}$;

Group 7 — Russian regions *i*, for which $p_i \geq \overline{p}, d_i < \overline{d}, c_i \geq \overline{c}$;

Group 8 — Russian regions *i*, for which $p_i \geq \overline{p}, d_i \geq \overline{d}, c_i \geq \overline{c}$.

Stage 2. At each stage, the closing groups of the first and last are important, if there are more than two groups, then the regions of Russia that fall into the first and last group are ranked (above and below the circle, respectively, are excluded, and then the analysis continues in a narrower circle, returning to the beginning of the algorithmic procedure).

We will restrict ourselves to conducting computational experiments using the example of the formation of the first and last groups of constituent entities of the Russian Federation, which include, respectively, the leading regions and outsiders in food security.

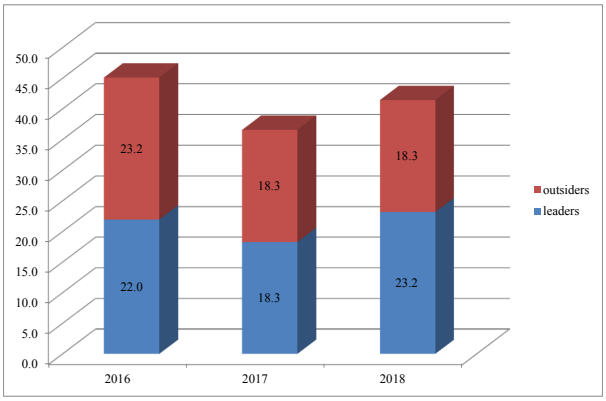

Fig. **Fragment of the cluster structure of Russian regions by the level of food security for 2016–2018**

Source: compiled by the authors.

Appendix 2 presents the results of ranking and clustering of Russian regions according to the achieved level of food security using the example of the above two groups.

During the analyzed period of time, there have been changes in the food security rating of the constituent entities of the Russian Federation. First, the competitive positions of most regions of Russia, not only in the overall ranking but also within clusters, are dynamically strengthening or weakening. Secondly, as a rule, the number of the constituent entities of the Russian Federation included in the group of leaders and outsider regions changed annually. All this is reflected in the cluster structure of Russian regions in terms of food security (shown in the *Figure*).

So, in particular, in 2018 (compared to 2016), there were positive changes in the cluster structure of the constituent entities of the Russian Federation, while the share of leading regions increased and the share of outsider regions decreased.

The results of ranking and clustering of Russian regions obtained in the course of the study can serve as a scientific basis for justifying federal and regional measures (primarily of a financial nature) of state

Table 2

The level of state support for agriculture in the EU, USA, China and the Russian Federation in 2018, USD

Countries	GDP, USD billion	State financial support for agriculture	
		Volume, USD billion	Level, % of GDP
EU	15800	57.9	3.4
USA	20237	139.6	6.8
China	13040	342.8	3.6
Russia	1652	3.4	2.1

Source: China statistical yearbook. URL: http://www.stats.gov.cn/tjsj/ndsj/2018/indexeh.htm; The official website for Food and Agriculture Organization of the United Nations. URL: http://faostat.fao.org; Government finance statistics — Summary tables. Luxembourg: Publications Office of the European Union. URL: https://ec.europa.eu/ eurostat/ web/agriculture/data/database (accessed on 23.03.2021).

Table 3

State budget expenditures of the EU countries, the USA, China and the Russian Federation for the development of agriculture in 1990–2019, billion dollars

Countries	1990	2000	2010	2013	2015	2016	2017	2018	2019
EU	24.9	37.7	71.8	72.4	79.8	62.8	54.4	58.0	56.0
USA	45.9	75.1	135.8	155.9	139.1	138.1	138.9	139.6	141.2
China	20.0	25.0	150.0	250.0	325.0	358.7	349.2	342.8	335.8
Russia	4.9	2.0	7.6	13.0	5.9	4.0	4.4	3.4	3.3

Source: cEconomic Research Service of U.S. Department of Agriculture. URL: https://www.ers.usda.gov/; OECD — Total support estimate. URL: https://stats.oecd.org/Index.aspx (accessed on 23.03.2021).

support for agricultural producers, which, in turn, will contribute to an increase in the level of food security of the constituent entities of the Russian Federation.

Currently, the EU countries, the USA and China are not only the world's largest producers of agricultural products but are also characterized by an effective system of state support for the agricultural sector of the economy. Therefore, the study ends with a brief description of their positive experience, which can be applied in Russia.

STATE FINANCIAL SUPPORT MEASURES FOR SUSTAINABLE AGRICULTURE DEVELOPMENT

Based on the methods of competitive benchmarking, we briefly characterize the level of state support for agriculture in the EU countries, the USA, China, and the Russian Federation (*Table 2*).

Thus, in the United States, government funding for agriculture is 6.8%, in China — 3.6%, and in the EU countries — 3.4% of gross domestic product. Among developed countries, the highest level of financing for agriculture is typical for Norway — 58%, Switzerland — 55%, Japan — 52% of gross revenue, which is explained by unfavorable climatic conditions, limited land resources, and a high standard of living. In Russia for 2010–201, the budget allocations for the development of agriculture amounted to about 0.37–0.57% of national GDP, in 2019–2.1%, while according to experts, they should be 3–3.5% of GDP.

A comparative analysis of budget expenditures for state financial support for agriculture in the EU countries, the USA, China, and Russia in dynamics for 1990–2019 is carried out. The data in *Table 3* shows that China is the world leader in total financial support from a budget, with funding in 2019 of

more than US$ 335 billion. Also, a significant amount of state support for agriculture from a similar source of financing is typical for the United States — US$ 141.2 billion and EU countries — US$ 56 billion.

In Russia, on the contrary, the volume of state financial support for agricultural producers from budgetary funds is insignificant and amounts to only US$ 3.3 billion. When the country entered the World Trade Organization, this problem was one of the main topics of negotiations, and the Russian Federation established the amount of state financial support for agriculture of US$ 89 billion. However, it was gradually reduced to US$ 36 billion, and then to US$ 16 billion. By the time of Russia's accession to the WTO by 2012, the volume of state financial support from budgetary funds was only US$ 9 billion. In addition, the obligations included requirements for its further reduction to US$ 4.4 billion by 2017, which was 20 times less than the declared volume.

The world's largest agricultural producer is the EU countries, which account for about 11% of the global volume. They have the most effective system of state support for agriculture within the framework of the Unified Agrarian Policy in three main directions:

- direct payments that ensure income stability and stimulate environmentally friendly agricultural production, rural development;
- the application of market measures necessary to deal with difficult market situations, such as a sudden drop in demand or a fall in prices as a result of oversupply;
- a set of rural development and support measures within the framework of the implementation of national and regional programs, to address the specific needs and problems of rural areas.

To implement these directions, the EU government applies various measures of state regulation of agriculture: import duties, quotas for imports and production, government intervention, and collection of taxes for non-use of land.

Funding for the Common Agricultural Policy in the EU is gradually decreasing. So, if in 1970 it accounted for 89% of the entire EU budget, then in the 1980s about 70% of the expenditure side, in 1990 it dropped to 50% on average and in subsequent years decreased to 42%. The downward trend continues, with agricultural funding expected to account for 27% of the EU budget by 2027. In 2018, the EU allocated over 58 billion euros to support farmers and develop agriculture. In addition to the European one, national co-financing of the agricultural sector is carried out: for example, Austria allocates 44% of its total income, and France — 17%. In total, the total amount of support is over 100 billion euros per year.

State support of the EU countries is carried out from two sources of funding: the European agricultural guarantee fund and the European agricultural fund for rural development. For example, direct payments to farmers are made by the European agricultural guarantee fund based on the area of agricultural land. The volume of financing from this fund is about 75% of the overall budget of the European Union. However, in order to receive subsidies, agricultural producers must strictly adhere to government conditions, which include certain standards (so-called cross-compliance). Also, the rules contain requirements for the preservation of soil and habitat, and the use of water.

The second source of funding (the European agricultural fund for rural development) accounts for about 25% of the payments of the European Union and is aimed at developing rural areas that have demographic problems and are prone to climate change. At the same time, the main goal of the fund is to create safe jobs and ensure a high quality of life in rural areas.

The United States is another major global agricultural producer and a leading player in the international food trade, accounting for about 10% of global agricultural production.

Also, the United States is the leader in food production per capita. The system of state financing of the agricultural sector in the country is carried out mainly within the framework of the "green box" activities. More than 80% of its volume is domestic food assistance to low-income groups of the population with an average monthly payment per person of about US$ 120. The second-largest public funding program for green box support is "general services", which accounts for 9.6%. Subsidized payments to support "untied" income and environmental programs are approximately the same at 3.8% on the volume of the "green box". Since 2014, the traditional budget aid has been replaced at the legislative level by another instrument — risk insurance with a budget of US$ 956.4 billion, as a result of which over several decades there has been an increase in public funding of the US agricultural sector from 4.4%. up to 6.8% of all budget funds appropriations.

When studying the foreign experience of state support for agriculture, in our opinion, the experience of China is of considerable interest. The country, pursuing a targeted protectionist policy of the state and consistent agrarian reforms, has made it possible to significantly increase the volume of agricultural production and become one of the largest producers in the world food market.

In China, both administrative and economic methods of state regulation and support of agriculture are used. But for the modern period, the priority has become to address environmental problems, improve the quality of life of the rural population, and increase the competitiveness of products. An analysis of agricultural subsidies in China showed that while maintaining the structure of state support in the country, the volume of direct and indirect public investment increased significantly. In particular, in 2018, 2.8% of funds from the national budget were directed to support agriculture in China. In the expenditures of subnational budgets of the provinces, a significant share is made up of expenditures on agriculture — 11% and mainly the use of "green box" measures.

Modern China is characterized by the innovative development of agricultural science, the introduction of borrowed and its own advanced agricultural technologies, which implies a further increase in funding for agricultural science, stimulation, and implementation of advanced technologies. By 2020, the Agricultural Development Bank of China plans to allocate 3 trillion yuan (or US$ 450 billion) to modernize the country's agricultural sector. The study of the experience of state support for the agricultural sector in China allows us to conclude that due to the similarity of climatic, economic, and political processes, it can be applied in Russia.

CONCLUSIONS

Foreign experience in ensuring food security and sustainable development of agriculture indicates that increasing the competitiveness of the relevant sector of the national economy is impossible without an effective mechanism of state support for agricultural producers. A systematic study of various aspects of ensuring the long-term sustainability of the food system is important for improving the state policy for the development of the agricultural sector of the country and its regions. And this requires constant monitoring of the situation.

The vector of development of Russian state support for domestic agricultural producers corresponds to the changes taking place in the countries of the world. At the same time, a review of scientific literature indicates that not all global trends are reflected in the methods for assessing the food security of the country and its regions, which indicates the need (relevance) for their improvement. Therefore, within the framework of the study, the goal was set and achieved to fill this gap in the scientific literature.

To assess the food security of the constituent entities of the Russian Federation, it is proposed to use the index of the same name,

which is based on the analysis of the numerical indicators of production, distribution, consumption, and food production. It allows, in close interconnection, to study not only the production capabilities of the agricultural sector of the constituent entities of the Russian Federation but also, for example, the degree of satisfaction of the population's need for essential foods, considering their financial capabilities. Statistical processing of the values of the thematic index and three sub-indices for 2016–2018 indicates that the differentiation of the constituent entities of the Russian Federation in terms of food security is largely due to the spread in the numerical indicators of food production.

For ranking and subsequent clustering of Russian regions based on the achieved level of food security, a modified author's approach is used, which involves a hierarchical data analysis with a fundamentally new filtering algorithm. In the course of computational experiments, a significant part of the constituent entities of the Russian Federation was correctly divided into two groups (regions — leaders and outsiders). Despite the fact that in 2018 (compared to 2016) there were positive changes in the cluster structure of Russian regions in terms of food security, currently, more than 18% are included in the group of outsider regions. Therefore, for the leadership of the country and its regions, the issue of not only strengthening the competitive positions of outsider regions in dynamics but also ensuring their transition in the future to a cluster characterized by a higher level of food security remains relevant. The study may be used as a scientific basis for improving state policy in the field of supporting domestic agricultural producers. In particular, the decomposition of the final results of the retrospective assessment, considering the ranking and clustering of the constituent entities of the Russian Federation, makes it possible, on the basis of competitive benchmarking methods, to quickly identify the reserves of the country's sustainable development of the food production system for the control at the meso-level.

Analysis of various sources allowed us to conclude that in modern Russia three main directions of state support for the agricultural complex can be distinguished: budget financing; provision of subsidies to producers and compensation of production costs, payment of transfers to consumers. Such support measures contribute to the entry of the Russian Federation into the number of countries characterized by relatively high-quality nutrition and an average level of affordability of food for the population.

However, according to a number of important indicators, the problem of food security in the country has not yet been resolved. For the Russian agricultural sector of the economy, the current stage is characterized as the period of meeting the WTO requirements and the transition from direct government funding to indirect investments. Analysis of the dynamics of expenditures of the federal budget of the Russian Federation shows that in the last years of the study period, expenditures increased, but insignificantly. At the same time, there is no connection between the measures of state support and its results. Considering the foreign experience of the EU countries, the USA and China, it can be concluded that the country does not widely use various general economic and special levers to increase the stability of the food system of the Russian Federation.

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Appendix 1

Index (and sub-indices) of food security of the constituent entities of the Russian Federation for 2016–2018

The constituent entity of the Russian Federation	P			D			C			I FP		
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
1. Belgorod Region	0.531	0.586	0.540	0.655	0.597	0.623	0.389	0.382	0.388	0.519	0.526	0.514
2. Bryansk Region	0.572	0.602	0.606	0.658	0.631	0.667	0.242	0.257	0.268	0.493	0.504	0.518
3. Vladimir Region	0.325	0.318	0.325	0.689	0.652	0.661	0.094	0.090	0.096	0.345	0.332	0.339
4. Voronezh Region	0.488	0.488	0.490	0.632	0.601	0.613	0.320	0.318	0.319	0.473	0.465	0.468
5. Ivanovo Region	0.347	0.307	0.323	0.677	0.648	0.668	0.070	0.069	0.073	0.345	0.319	0.333
6. Kaluga Region	0.321	0.350	0.365	0.739	0.703	0.727	0.094	0.106	0.116	0.356	0.364	0.379
7. Kostroma Region	0.339	0.354	0.356	0.697	0.666	0.678	0.132	0.130	0.121	0.365	0.363	0.365
8. Kursk Region	0.455	0.475	0.483	0.591	0.540	0.534	0.349	0.366	0.363	0.457	0.458	0.459
9. Lipetsk Region	0.451	0.460	0.473	0.625	0.586	0.601	0.319	0.332	0.346	0.454	0.452	0.467
10. Moscow Region	0.295	0.335	0.321	0.660	0.621	0.653	0.038	0.036	0.036	0.308	0.315	0.317
11. Oryol Region	0.398	0.401	0.426	0.687	0.623	0.628	0.280	0.279	0.288	0.434	0.419	0.434
12. Ryazan Region	0.427	0.434	0.440	0.664	0.619	0.615	0.179	0.186	0.188	0.411	0.405	0.407
13. Smolensk Region	0.354	0.350	0.370	0.577	0.555	0.556	0.179	0.172	0.154	0.356	0.347	0.351
14. Tambov Region	0.429	0.455	0.444	0.593	0.533	0.555	0.342	0.380	0.381	0.443	0.451	0.452
15. Tver Region	0.321	0.318	0.346	0.620	0.594	0.618	0.144	0.121	0.135	0.341	0.327	0.349
16. Tula Region	0.458	0.470	0.480	0.727	0.683	0.683	0.127	0.132	0.133	0.424	0.420	0.425
17. Yaroslavl Region	0.396	0.386	0.420	0.713	0.678	0.681	0.170	0.160	0.181	0.406	0.390	0.412
18.Moscow	0.210	0.203	0.190	0.719	0.704	0.720	0.001	0.001	0.001	0.273	0.267	0.265
19. Republic of Karelia	0.191	0.184	0.196	0.605	0.573	0.608	0.026	0.024	0.026	0.244	0.233	0.247
20. Komi Republic	0.306	0.271	0.312	0.685	0.654	0.684	0.032	0.028	0.030	0.317	0.292	0.319
21. Arkhangelsk Region	0.292	0.270	0.289	0.691	0.674	0.684	0.032	0.029	0.032	0.312	0.297	0.309
22. Vologda Region	0.395	0.366	0.390	0.683	0.644	0.669	0.168	0.136	0.156	0.398	0.365	0.388
23. Kaliningrad Region	0.348	0.257	0.277	0.628	0.588	0.599	0.093	0.086	0.091	0.340	0.287	0.301
24. Leningrad Region	0.439	0.454	0.465	0.727	0.701	0.717	0.183	0.184	0.186	0.433	0.433	0.443
25. Murmansk Region	0.204	0.213	0.221	0.739	0.722	0.738	0.005	0.005	0.006	0.277	0.277	0.284
26. Novgorod Region	0.390	0.350	0.373	0.695	0.653	0.654	0.161	0.142	0.154	0.396	0.362	0.376
27. Pskov Region	0.320	0.316	0.317	0.603	0.580	0.591	0.110	0.113	0.120	0.327	0.320	0.325

Appendix 1 (continued)

The constituent entity of the Russian Federation	P			D			C			I FP		
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
28.Saint Petersburg	0.000	0.000	0.000	0.817	0.793	0.802	0.000	0.000	0.000	0.204	0.198	0.200
29. Republic of Adygea	0.345	0.315	0.354	0.646	0.605	0.623	0.155	0.156	0.155	0.362	0.339	0.360
30. Republic of Kalmykia	0.291	0.299	0.273	0.540	0.523	0.518	0.114	0.122	0.109	0.299	0.301	0.284
31. Republic of Crimea	0.384	0.386	0.344	0.581	0.582	0.594	0.098	0.089	0.086	0.346	0.345	0.328
32. Krasnodar Region	0.449	0.449	0.437	0.628	0.579	0.577	0.217	0.217	0.208	0.423	0.410	0.402
33. Astrakhan Region	0.408	0.437	0.459	0.632	0.588	0.585	0.137	0.151	0.176	0.381	0.387	0.404
34. Volgograd Region	0.435	0.455	0.447	0.711	0.663	0.668	0.189	0.194	0.196	0.429	0.427	0.426
35. Rostov Region	0.451	0.479	0.443	0.733	0.692	0.698	0.207	0.220	0.202	0.447	0.453	0.433
36. Sevastopol	0.180	0.181	0.173	0.725	0.692	0.725	0.012	0.010	0.010	0.265	0.257	0.261
37. Republic of Dagestan	0.323	0.331	0.358	0.427	0.373	0.409	0.121	0.126	0.125	0.287	0.279	0.300
38. Republic of Ingushetia	0.294	0.271	0.275	0.408	0.375	0.398	0.061	0.059	0.067	0.251	0.232	0.242
39. Kabardino-Balkar Republic	0.432	0.451	0.464	0.570	0.514	0.508	0.253	0.285	0.297	0.412	0.416	0.424
40. Karachay-Cherkess Republic	0.416	0.418	0.436	0.568	0.554	0.562	0.185	0.167	0.161	0.383	0.375	0.384
41. Republic of North Ossetia – Alania	0.274	0.258	0.312	0.653	0.592	0.614	0.082	0.079	0.090	0.310	0.287	0.320
42. Chechen Republic	0.295	0.301	0.284	0.555	0.533	0.544	0.055	0.059	0.053	0.287	0.285	0.279
43. Stavropol Region	0.491	0.468	0.448	0.674	0.636	0.644	0.201	0.197	0.184	0.448	0.427	0.416
44. Republic of Bashkortostan	0.381	0.397	0.413	0.705	0.669	0.673	0.161	0.164	0.166	0.394	0.394	0.402
45. Republic of Mari El	0.359	0.339	0.390	0.596	0.563	0.580	0.169	0.156	0.182	0.360	0.339	0.374
46. Republic of Mordovia	0.514	0.524	0.530	0.643	0.584	0.582	0.320	0.310	0.314	0.487	0.474	0.477
47. Republic of Tatarstan	0.496	0.519	0.510	0.749	0.702	0.726	0.201	0.206	0.204	0.469	0.469	0.471
48. Udmurt Republic	0.450	0.445	0.444	0.761	0.726	0.722	0.213	0.216	0.206	0.455	0.445	0.440
49. Chuvash Republic	0.413	0.403	0.410	0.705	0.664	0.675	0.139	0.133	0.138	0.402	0.386	0.393
50. Perm Region	0.304	0.303	0.360	0.673	0.659	0.695	0.083	0.081	0.089	0.328	0.324	0.361
51. Kirov Region	0.403	0.380	0.413	0.670	0.628	0.646	0.150	0.143	0.160	0.393	0.370	0.394
52. Nizhny Novgorod Region	0.402	0.422	0.423	0.755	0.700	0.695	0.110	0.115	0.120	0.401	0.398	0.398
53. Orenburg Region	0.363	0.381	0.363	0.742	0.701	0.696	0.204	0.220	0.201	0.409	0.412	0.397
54. Penza Region	0.395	0.411	0.418	0.699	0.666	0.681	0.215	0.212	0.214	0.416	0.414	0.421
55. Samara Region	0.343	0.354	0.291	0.709	0.685	0.707	0.093	0.093	0.098	0.358	0.357	0.336

Appendix 1 (continued)

The constituent entity of the Russian Federation	P			D			C			I FP		
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
56. Saratov Region	0.410	0.429	0.416	0.718	0.668	0.693	0.204	0.207	0.215	0.424	0.421	0.424
57. Ulyanovsk Region	0.362	0.386	0.386	0.683	0.643	0.660	0.132	0.131	0.130	0.372	0.372	0.376
58. Kurgan Region	0.356	0.354	0.348	0.675	0.628	0.634	0.149	0.190	0.156	0.372	0.372	0.361
59. Sverdlovsk Region	0.356	0.343	0.359	0.686	0.651	0.673	0.073	0.073	0.078	0.352	0.338	0.352
60. Tyumen Region	0.332	0.351	0.418	0.686	0.660	0.676	0.072	0.077	0.076	0.341	0.345	0.378
61. Chelyabinsk Region	0.334	0.346	0.342	0.721	0.690	0.711	0.090	0.093	0.091	0.356	0.354	0.358
62. Altai Republic	0.308	0.280	0.236	0.564	0.522	0.553	0.102	0.099	0.097	0.309	0.285	0.273
63. Republic of Tuva	0.193	0.243	0.256	0.511	0.490	0.527	0.045	0.045	0.047	0.227	0.244	0.260
64. Republic of Khakassia	0.278	0.305	0.331	0.714	0.675	0.689	0.091	0.092	0.092	0.330	0.332	0.347
65. Altai Region	0.493	0.494	0.478	0.572	0.532	0.536	0.284	0.278	0.276	0.449	0.437	0.431
66. Krasnoyarsk Region	0.355	0.342	0.337	0.733	0.699	0.707	0.103	0.097	0.098	0.372	0.356	0.356
67. Irkutsk Region	0.342	0.356	0.346	0.696	0.674	0.680	0.085	0.086	0.085	0.352	0.353	0.350
68. Kemerovo Region	0.333	0.325	0.330	0.707	0.685	0.724	0.081	0.081	0.080	0.350	0.341	0.352
69. Novosibirsk Region	0.349	0.367	0.368	0.680	0.644	0.653	0.103	0.108	0.107	0.356	0.357	0.360
70. Omsk Region	0.449	0.467	0.459	0.684	0.662	0.681	0.216	0.219	0.205	0.436	0.440	0.437
71. Tomsk Region	0.365	0.400	0.367	0.692	0.654	0.656	0.080	0.080	0.074	0.359	0.366	0.350
72. Republic of Buryatia	0.302	0.292	0.309	0.652	0.630	0.628	0.053	0.047	0.048	0.314	0.302	0.309
73. Republic of Sakha (Yakutia)	0.221	0.220	0.235	0.582	0.549	0.566	0.044	0.045	0.046	0.257	0.249	0.260
74. Zabaykalsky Krai	0.234	0.244	0.248	0.649	0.612	0.638	0.078	0.078	0.079	0.290	0.285	0.294
75. Kamchatka Region	0.288	0.288	0.298	0.702	0.722	0.733	0.032	0.034	0.034	0.313	0.319	0.326
76. Primorsky Krai	0.286	0.303	0.299	0.653	0.629	0.647	0.085	0.091	0.090	0.316	0.320	0.322
77. Khabarovsk Region	0.276	0.277	0.287	0.721	0.699	0.708	0.033	0.035	0.034	0.313	0.309	0.315
78. Amur Region	0.345	0.347	0.309	0.640	0.623	0.669	0.102	0.100	0.097	0.344	0.341	0.335
79. Magadan Region	0.142	0.158	0.160	0.637	0.658	0.671	0.023	0.025	0.025	0.229	0.242	0.247
80. Sakhalin Region	0.276	0.288	0.297	0.789	0.768	0.799	0.045	0.046	0.048	0.334	0.334	0.346
81. Jewish Autonomous Region	0.172	0.179	0.187	0.567	0.560	0.575	0.123	0.100	0.139	0.256	0.250	0.269
82. Chukotka Autonomous Region	0.245	0.247	0.245	0.712	0.644	0.608	0.005	0.004	0.005	0.289	0.272	0.262

Source: compiled by the authors.

Appendix 2

Fragment of the rating of food security of the constituent entities of the Russian Federation for 2016–2018

Cluster name	Cluster composition	Ranking place	Number of regions in a cluster
2016			
Regions-leaders	Republic of Tatarstan, Stavropol Region, Rostov Region, Udmurt Republic, Omsk Region, Leningrad Region, Volgograd Region, Ryazan Region, Saratov Region, Kirov Region, Oryol Region, Yaroslavl Region, Vologda Region, Penza Region, Novgorod Region, Republic of Bashkortostan, Orenburg Region and Kurgan Region	1–18	18
Regions-outsiders	Kaliningrad Region, Amur Region, Republic of Dagestan, Tver Region, Pskov Region, Republic of Altai, Republic of Buryatia, Chechen Republic, Moscow Region, Republic of Ingushetia, Republic of Kalmykia, Primorsky Krai, Republic of North Ossetia-Alania, Zabaykalsky Krai, Republic of Sakha (Yakutia), Republic of Tyva, Republic of Karelia, Jewish Autonomous Region and Magadan Region	64–82	19
2017			
Regions-leaders	Bryansk Region, Republic of Tatarstan, Rostov Region, Stavropol Region, Omsk Region, Volgograd Region, Leningrad Region, Udmurt Republic, Saratov Region, Penza Region, Chuvash Republic, Republic of Bashkortostan, Yaroslavl Region, Orenburg Region and Vologda Region	1–15	15
Regions-outsiders	Amur Region, Moscow Region, Republic of Dagestan, Tver Region, Pskov Region, Chechen Republic, Republic of Kalmykia, Republic of Altai, Republic of Ingushetia, Republic of North Ossetia — Alania, Kaliningrad Region, Zabaykalsky Krai, Republic of Tyva, Republic of Sakha (Yakutia) and Republic of Karelia	68–82	15
2018			
Regions-leaders	Bryansk Region, Republic of Tatarstan, Tula Region, Leningrad Region, Omsk Region, Stavropol Region, Volgograd Region, Udmurt Republic, Rostov Region, Nizhny Novgorod Region, Yaroslavl Region, Penza Region, Saratov Region, Kirov Region, Republic of Bashkortostan, Chuvash Republic, Vologda Region, Novgorod Region and Orenburg Region	1–19	19
Regions-outsiders	Tver Region, Pskov Region, Republic of North Ossetia — Alania, Republic of Buryatia, Chechen Republic, Kaliningrad Region, Republic of Ingushetia, Republic of Kalmykia, Republic of Tyva, Zabaykalsky Krai, Chukotka Autonomous Region, Republic of Altai, Republic of Sakha (Yakutia), Republic of Karelia and Jewish Autonomous Region	68–82	15

Source: compiled by the authors.

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