Analysis of indicators of food security and import substitution based on the methods of economic and mathematical modeling

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Abstract. The paper assesses the indicators of import substitution of food products in the Russian Federation. Data on the dynamics of food imports to the territory of the Russian Federation, the volume of production of the main types of import-substituting food products in Russia and the regions of the South federal district (SFD) are analyzed. Groups of indicators of food security in the context of implementation of import substitution policy are analyzed on the example of the regions of SFD. For this purpose, the author uses the method of analysis and integrated assessment of food security, taking into account the indicators of economic and physical availability of food, food self-sufficiency. Based on the analysis, it was found that there is a steady increase in the production of import-substituting food products, in particular dairy and meat products, while the share of imported products on the Russian food market is decreasing. The effectiveness of the import substitution policy is determined by a set of measures to develop the infrastructure of the agricultural sector and the food market, technical modernization of agricultural enterprises through the implementation of state programs for the purchase of agricultural machinery and equipment. As promising area of research and development of assessment models, we recommend methods of fuzzy economic and mathematical modeling that will optimize and improve the effectiveness of food security assessment.

1. Introduction

In the conditions of implementing the import substitution policy, achieving the goal and doing the tasks of the Russian Food Security Doctrine, a special role is assigned to the assessment of food security and food security indicators. In any economic system, the issues of providing food and achieving a given level of self-sufficiency for key groups of food products are priorities. Accordingly, it is necessary to analyze the indicators of food import substitution in order to determine the priority directions of the state socio-economic policy to maintain an optimal level of food security.

The results of the implementation of the state agrarian policy in the field of food security are characterized by A.I. Altuhov [1], V.V. Miloserdov [2], P.M. Taranov [3] and a number of other researchers. In the works of foreign scientists R. Capone, H. Bilali, Ph. Debs [4], food security is determined by the availability of food suppliers, the population’s income and access to food supplies.

A number of theoretical provisions and practical issues of food security assessment need to be analyzed and generalized in relation to the requirements of the modern period. In this regard it is theoretically and practically significant to develop methodological tools for analyzing food security in order to monitor and assess the state of food security in Russian regions.
2. Methods

2.1. Fuzzy economic and mathematical modeling of food security

When developing a methodology for assessing food security, the following analysis methods can be used. To substantiate the groups of factors of food security indicators, it is advisable to use an expert method of analyzing hierarchies, which allows the formation of the structure, relationships and membership functions of fuzzy cognitive maps based on the obtained system of indicators [5; 6]. For parameterization of cognitive maps, as a rule, the construction of infological and information models that provide justification for the structure of the relational database of selected statistical indicators is used. The construction and verification of a family of predictive econometric models can be implemented on the basis of specific indicators for food groups.

2.2. Integrated assessment of food security

In accordance with the Food Security Doctrine [7], the author’s methodology has been developed (table 1), which allows evaluating the level of food security in points as optimal (9-10 points), acceptable (5-8 points) or low (less than 5 points).

| Table 1. Food security indicators [8]. |
|--------------------------------------|
| Criterion | Indicator | Indicator value* |
|-----------|-----------|------------------|
| 1. Food self-sufficiency | $C_s = \frac{q}{n \cdot q_p}$ | $C_s \leq 0.5$ – low; $0.5 < C_s \leq 0.9$ – acceptable; $0.9 < C_s$ – optimal |
| 2. The degree of satisfaction of the population’s physiological needs in food | $C_{fc} = \frac{q_{fact}}{q_{rate}}$ | $C_{fc} \leq 0.5$ – low; $0.5 < C_{fc} \leq 0.95$ – acceptable; $0.95 < C_{fc} \leq 1$ – optimal |
| 3. Economic accessibility of food: | | |
| - the share of the population with incomes below the subsistence minimum; | | $C_p \geq 0.4$ – high; $0.2 < C_p \leq 0.4$ – acceptable; $C_p \leq 0.2$ – optimal |
| - the share of food expenditures in the structure of household expenditures; | | $C_p > 0.5$ (or >50%)– high; $0.25 < C_p \leq 0.5$ – acceptable; $C_p < 0.25$ – optimal |
| - the degree of inequality in the distribution of the population by income level | | $C_G > 0.5$ – high; $0.3 \leq C_G < 0.5$ – acceptable; $C_G < 0.3$ – optimal |

* the optimal value corresponds to the assessment – 2 points, the acceptable – 1 point, low and high values – 0 points.

3. Results

In the face of sanctions from a number of countries, the issue of food self-sufficiency is becoming more urgent for Russia, especially in relation to regions with developed agricultural production [9]. Among the imported food products to the territory of the Russian Federation, the largest share is accounted for various types of dairy and meat products, including canned ones, vegetable and animal oils. As of 2018, the share of imported food products in the total volume of the corresponding categories of commodity resources in the Russian Federation was beef (40.7%), milk powder and cream (37.4%), vegetable oils (18.1%), and cheeses (29%). It should be noted that in comparison with the indicators of 2013, the share of beef imports decreased by 11.7%, cheese by 19%, milk powder and cream by 23.1% (table 2).
Table 2. The share of imports of specific products in their product resources, %.

| Name of food products | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|-----------------------|------|------|------|------|------|------|
| Beef, including byproducts | 59.0 | 57.3 | 48.1 | 40.0 | 40.9 | 40.7 |
| Pork, including byproducts | 31.0 | 16.6 | 12.5 | 9.6  | 9.6  | 2.2  |
| Poultry, including byproducts | 12.8 | 10.0 | 5.5  | 5.0  | 4.4  | 4.3  |
| Cheese | 48.0 | 37.3 | 23.3 | 28.2 | 27.3 | 29.0 |
| Vegetable oils | 19.0 | 14.4 | 17.4 | 16.7 | 14.7 | 18.1 |
| Milk powder and cream | 60.5 | 49.4 | 56.4 | 59.1 | 52.6 | 37.4 |
| Sugar | 8.2  | 7.4  | 6.2  | 5.5  | 3.9  | 5.1  |

In general, the share of imported food products in the commodity resources of retail food trade in 2018 was 24%, in 2019 – 25%, respectively [10]. The implementation of the import substitution policy in Russia contributed to the growth of production of import-substituted food products, which resulted in a decrease in the share of imported products on the Russian food market. If during 2005-2014 the share of imported food products averaged 33-36%, then, starting from 2015, there is a gradual decrease in the share of food imports (Figure 1).

![Import share in the volume of retail commodity resources in the Russian Federation](image-url)

**Figure 1.** Import share in the volume of retail commodity resources in the Russian Federation.

The leaders among the countries importing food products and agricultural raw materials to the Russian Federation are traditionally the EU countries, China, Turkey, Brazil, Argentina, Chile, Ecuador, and Belarus among the CIS countries. So as of December 2019, the share of EU countries accounted for 24.6% in the structure of imported food products, the share of Belarus – 14.1%, China – 5.8%, Turkey – 4.4%, and Ecuador – 4.3% [10]. The volume of production of the main types of import-substituting food products in the Russian Federation increased in 2018, as beef and chilled veal was
received more by 10.7%, pork by 11%, fish by 11.8%, fruit and berries by 6.41%, while the volume of vegetable production decreased by 11.03% at the end of the year (table 3).

**Table 3.** Production of the main types of import-substituting food products in the Russian Federation, thousand tons.

| Name of food products                                      | 2017 | 2018 | Change value thousand tons | %  |
|-----------------------------------------------------------|------|------|---------------------------|----|
| Chilled meat (beef and veal), including for baby food      | 205  | 227  | 22                        | 110.73 |
| Chilled pork, including for baby food                      | 2171 | 2410 | 239                       | 111  |
| Poultry                                                   | 4839 | 4877 | 38                        | 100.78 |
| Sausage products, including sausage products for baby food | 2259 | 2282 | 23                        | 101  |
| Fish, including fillets, smoked                            | 58.4 | 65.3 | 6.9                       | 111.81 |
| Frozen crustaceans                                         | 69.9 | 82.4 | 12.5                      | 117.88 |
| Vegetables (except potatoes) and frozen fungi              | 62.6 | 55.7 | 6.9                       | 88.97 |
| Fruits, berries and nuts, fresh or frozen                  | 15.6 | 16.6 | 1                        | 106.41 |
| Milk                                                      | 5390 | 5466 | 76                        | 101.41 |
| Cheese                                                    | 464  | 467  | 3                        | 100.64 |

4. Discussion

According to official statistics, the share of the South Federal District (SFD) in the total output of all agricultural producers in Russia in 2019 was 17.52%. According to preliminary results of 2019, the volume of agricultural production in the SFD, largely determined by crop production indicators, increased by 7.1%. Farmers in the macroregion increased the gross harvest of grain by 14%, remaining the leaders in grain production, and forming more than a quarter of the Russian crop (33.2 million tons). The growth of grain production was noted in all regions of the district.

Russian agricultural producers in 2019 collected 14 million tons of vegetables, which is 2.5% higher than last year level, including 4 million tons, or 29% of the Russian volume, with an increase of 5%, accounted for the regions of the South Federal District. The positive dynamics in the district is provided by agricultural producers in almost all territories, except Adygea and Sevastopol.

Let us note that, despite the high share of imported products, the SFD is a major exporter of agricultural products. The volume of exports for 2016-2018 increased by $ 3201 million, while the volume of imports increased by only $ 342 million. Plant-based products account for about 30% of the macroregion total exports [11].

As for the import of food products imported to the SFD, it is also dominated by products of the category “products of plant origin” – 21% of the volume of imported goods. Imports to the SFD of goods from the group “products of plant origin” for the period 2016-2018 amounted to 5.35 billion dollars. Fruits and nuts (55%), vegetables (16%) were mainly imported. In the structure of imports by country, Turkey is on the first place (21%), and Ecuador is on the second place (14%). In 2017, imports of the analyzed group of goods increased by 0.39 billion dollars (392 thousand tons), but already in 2018, the indicator of imported plant products began to decline.

The agro-industrial complex of the SFD is an important sector of the economy of the macroregion, which has a significant impact on its socio-economic development. As agriculture is one of the main elements of the food supply system, the region faces the task of developing rural areas that perform key production, economic, socio-demographic and other functions, including the function of creating conditions for ensuring the implementation of the import substitution policy. Most of the regions of
the SFD have favorable natural and climatic conditions and great potential for the development of the food market, agricultural production and agriculture in general. Over the period from 2010 to 2018, the volume of agricultural products produced showed an expressed positive dynamics. The only exception was in 2017, when production was produced by 7470 million rubles less than in the previous 2016, which generally corresponded with the indicators for the Russian Federation.

Among the main directions of food supply in the macroregion, it is necessary to note the direct participation of the state in improving the efficiency of the agro-industrial complex with the involvement of state support and investment [12]. In 2020, significant financial support by the state is planned for agricultural producers, including for the purpose of developing the food market in terms of import substitution. According to available data, as of May 2020, the total financing of the agro-industrial complex of the SFD will amount to 18 billion 230 million 626 thousand rubles. For several years, the SFD has been on the third place in terms of financial state support for the agricultural sector and the agro-industrial complex as a whole.

The most important factor in the development of the agro-industrial complex of the macroregion is the availability of modern equipment and technologies, seed material, plant protection products, etc. to farmers. Thus, the effectiveness of the agro-industrial complex in the region also depends on the support of the regional and federal authorities. Among the areas of prospective development of the agro-industrial complex of the SFD are: the formation of conditions for ensuring food security in the region; the implementation of technical and technological modernization of agricultural sectors; increasing the financial stability of the agro-industrial complex; improving the material base for the sustainable development of dairy cattle, the widespread use of advanced biotechnologies.

The development of the regional food market of the SFD in the conditions of implementation of the import substitution policy fraught with risks and threats that are expedient to be classified according to the directions of the macroeconomic, foreign trade, technological and climatic risks constraining the development of agricultural production in the region. Through the implementation of a set of agrifood policy measures, there are opportunities to minimize or almost completely eliminate the impact of negative factors, and reduce the level of risks and threats to food security.

The mechanism for regulating the food supply system is based on the interaction of state authorities at the federal and regional levels, in order to implement legal and financial regulatory instruments effectively. At the macroregion level of the SFD, the organizational and management mechanism is implemented by the Ministry of Agriculture through legal acts that are the basis for the development of food markets in the agro-industrial complex.

We will apply the integrated assessment methodology to analyze food security in the SFD (table 4).

| Indicator value | Number of points |
|-----------------|------------------|
| $K_c = 1.02$    | 2                |
| $K_{dp} = 1.12$ | 2                |
| $K_r = 0.14$    | 2                |
| $K_n = 0.37$    | 1                |
| $K_{sc} = 0.403$| 1                |
| **Total:**      | **8**            |

In the conditions of the implementation of the import substitution policy, the food security of the SFD meets the acceptable level. Among the trends of development of agricultural industry of the SFD they offer to consider: infrastructure development of agriculture and food market of the region, including processing, supply and marketing; the growth of production volumes of import-substituting food products, particularly dairy and vegetables; increase in the number of small farms in the structure of agricultural producers of the region; technical modernization of agricultural enterprises through the implementation of state programs for the purchase of agricultural machinery and equipment.
5. Summary
For the successful development of the food market of the macroregion of the SFD, a number of long-term strategies and targeted programs should be developed and implemented in the future, aimed at developing the market in modern conditions of import substitution, in order to ensure food independence and security in general. This requires a preliminary assessment of food security, identifying threats to its provision in modern conditions, based on analytical information on the selected assessment indicators.

A priority element of the process of regulating food markets and ensuring food security is the assessment of food market parameters, which involves the development of a methodology for analysis, determining the evaluation parameters and interpreting the obtained results, in order to identify the forecast values of the evaluated factors for making strategic decisions in the field of food security.

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