

Modeling the Impact of Agricultural Production on Food Security Taking Into Account Import Substitution

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Abstract. The assessment of such a multidimensional concept as food security involves the analysis of a number of indicators characterizing the food production sector, the food market, food availability for the population, the influence of external factors, in particular import substitution. The use of integral or aggregated indicators when carrying out such an assessment is rather difficult, since it involves the determination of relative weights for different indicators and the interpretation of the values of the composite indicator. In modern studies on the topic of food security, attempts are made to analyze the various categories of the population, distinguished by social and demographic, territorial criteria or type of agricultural activity. As an effective assessment methodology, the use of cognitive economic and mathematical modeling is proposed, which allows for analyzing groups of statistical indicators and assessing the impact of various factors on changes in food security. The recommended method can also be used to predict the level of food security.

1 Introduction

Food security issues are relevant for all states, but they are most urgent in the developing countries of the world, most of which are characterized by low incomes and poverty still remaining a significant threat to food security. Food insecurity is a situation where households have limited access to wholesome, nutritious and safe food, or limited ability to purchase essential food in socially acceptable ways. Thus, incomes of the population play a key role in reducing the likelihood of food insecurity. Food insecurity leads to hunger, poor health and high mortality rates. Furthermore, food insecurity has a negative impact on the economy and health care system, as poor health conditions increase the incidence of illness in the population and an increase in the number of days off work due to illness. Thus, labor productivity decreases, the quality of human capital deteriorates, the volume of use of medical services increases, and the overall burden on the healthcare system increases.

In the developing world of the world, food insecurity is usually analyzed in the broader context of poverty and deprivation. From a categorical point of view, a number of case

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studies use the term “food poverty” to characterize food scarcity, for which household budgets, daily food expenditures based on disposable monthly income, and the minimum consumer basket are analyzed [1]. Since food poverty is measurable, it is viewed as a scalar that has both spatial and temporal characteristics.

2 Materials and Methods

Of particular interest are the studies that analyze food security in relation to certain categories of the population, identified according to various criteria, for example, social and demographic (migrants, students), geographic (urban population), diversification of agricultural activities (e.g., farms, specializing in animal husbandry or engaged in both animal husbandry and crop production).

Y. J. Sin Wei and Le Q, analyzed the factors affecting the food security of migrants in Tasmania [2]. Migrants tend to always have a higher risk of food insecurity than the local population. Various factors are believed to affect migrants' food security, including language barriers, length of stay in the host country, social and economic status, geographic location and cultural factors. Each of the factors can hinder migrants from achieving food security, which indirectly affects their health and well-being in the host country.

L. Bidiger-Friedman and B. Sanchez studied food buying behavior and food insecurity among college students, using the example of the University of Texas at San Antonio [3]. The results showed that almost a third of the students were classified as having very low (11.6%) or low (19.4%) food security. Food insecurity is common among college students and indicates inadequate access to food due to a lack of personal income.

Evaluation of consumer behavior in the purchase of food and beverages made it possible to obtain an objective assessment of the diet and identify trends in high consumption of fatty foods, sugary soda, fast food by college students and limited consumption of fruits, vegetables, and dairy products. Only 6% of college students consumed the recommended daily allowances for fruits and vegetables. A decline in nutritional quality leads to serious health problems, including weight gain as a result of calorie imbalances and a shift in diet from fruits and vegetables to high consumption of fatty foods and sweetened beverages.

For a number of developing countries of the world, the solution of issues of food provision of the population and food security is associated with the development of agriculture, including within the city. In particular, urban agriculture is increasingly seen as a potential panacea for urban food insecurity. The article by Jn. Crush, B. Frayne analyzed the relationship between the development of urban agriculture and food security of the urban population of Lesotho [4].

The idea that the urban poor people should and could grow their own food became particularly popular in the 1990s. At the same time, supporters of the development of urban agriculture believe that the solution to the problem of food security in cities lies in the production and physical accessibility (availability) of food, not taking into account other aspects of food security such as access to food (economic accessibility, purchase), quality and safety of food products. As a result, food insecurity is commonly viewed as an agricultural efficiency issue requiring increased production and productivity of small-holder farmers. Thus, the development of household plots in urban areas can contribute to the food security of urban households [4].

In Zimbabwe, urban agriculture, which is a predominantly rural economic activity, is emerging as a profitable livelihood strategy used to overcome urban food insecurity. Rapid urbanization leads to increased poverty due to high unemployment rates, low incomes below the minimum baseline poverty line and deteriorating quality of life in urban areas, which prompts urban residents to engage in urban agriculture.

In many African countries, urban agriculture is quite widespread, it involves the use of free, even small, areas and territories between other types of land use in urban space. Urban agriculture is of particular importance to poor people as it helps them cope with food shortages and hunger and is often a significant source of income.

Among the obvious advantages of urban agriculture, there is an increase in the level of food security, due to the production of additional agricultural products in urban agriculture, and including a decrease in the cost of transporting food, a reduction in poverty, due to the receipt of additional income by the urban population from the sale of agricultural products. However, it is necessary to take into account a number of problems associated with the presence of urban agriculture, first of all, a threat to the ecological state of the urban environment. Furthermore, urban agriculture is illegal in terms of urban land use policy and is not legally recognized in many cities. [5]

In a study by E. Pedzisai and P. Kowe it is noted that for the poor, urban agriculture is a general livelihood strategy that helps to ensure subsistence even at extremely low incomes [6]. The income received from the sale of agricultural products is mainly used to meet the basic needs of households, the purchase of basic necessities: clothing, shoes, payment for medical services. It is clear that urban agriculture is an important activity for the population of a number of developing countries, from which certain social and economic benefits can be obtained.

Analysis of food security of farms with different types of specialization (livestock or a combination of livestock and crop production) showed that there is no significant difference in the degree of food insecurity among families that practice only livestock farming and those that combine livestock production with crop production in grazing areas [7].

3 Results and Discussion

The implementation of the import substitution policy in Russia contributed to the growth in the production of import-substituting food products, which was reflected in the 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 has been a gradual decrease in the share of food imports [8].

Assessment of the integral level of food security is possible with the help of cognitive maps. Cognitive maps provide modeling of the main areas of formation of the level of food security, with the receipt of an integral indicator. When constructing cognitive maps, the results of the analysis of groups of factors and indicators that affect the formation of the level of food security are used, in particular, the influence of the growth in the production of import-substituting food products can be taken into account [9].

The task of managing a modeled system in cognitive maps can be stated as follows. The factors that significantly affect the development of the modeled system, can be controlling and controlled, their change is the direct goal of control. The controlling solution determines the choice of a certain subset of the controlling factors, defining the control strategy. A conceptual model of a fuzzy cognitive map for assessing and predicting the level of food security is shown in Figure 1.

Pulse modeling of the system under study is carried out according to the dependence:

$$x(t) = (I + A + A^2 + \dots + A^t)x(0), \tag{1}$$

where $A = \|a_{ij}\|$ is the adjacency matrix of dimensionality $n \times n$,
 t is the number of the temporal modeling pulse.

A sign of instability of the adjacency matrix A , in which the time processes for some factors will diverge, is the excess of the moduli of the eigenvalues of its elements of 1. In

this case, it is recommended to transform the original matrix A into a stable one by multiplying the elements of each row of matrix A by a factor of:

$$Nn = 1/(s_i + \varepsilon), \tag{2}$$

where s_i is the number of nonzero elements of the i -th column (row); ε is a small number.

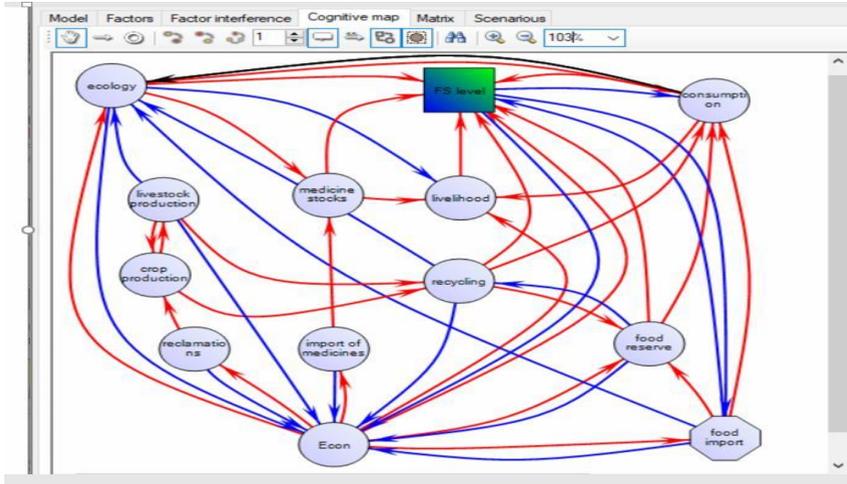


Fig. 1. Conceptual model of the mutual influence of food security factors.

The numerical implementation of impulse modeling of the system, the structure of which was described by the conceptual model of the cognitive map, is shown in Figure 2.

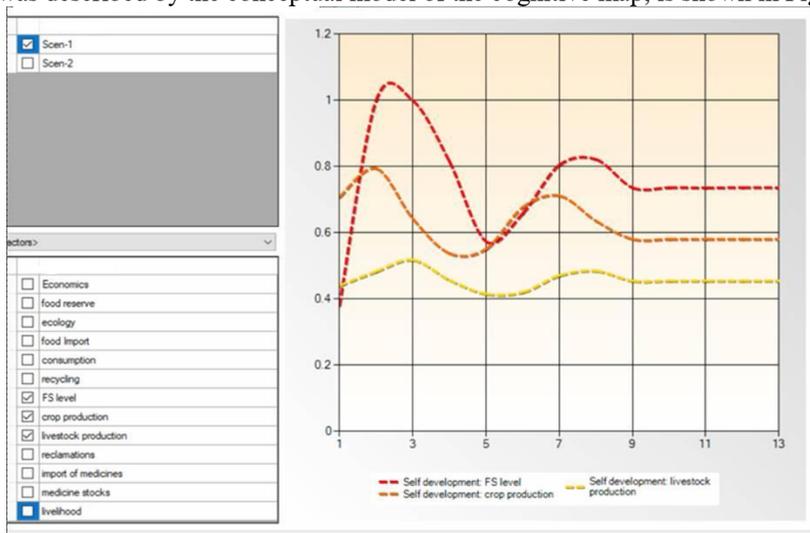


Fig. 2. The dynamics of changes in food security according to the 3-factor cognitive map.

The results of the numerical study of the obtained cognitive model can be used in the scenario analysis of the choice of a strategy for the development of regional agricultural production. The relevance of the problem of creating an intelligent cognitive system for predicting food security is due to the fact that the optimization of the ratio of production and consumption of food products, as well as their imports and rational stocks in the

context of import substitution requires substantiation taking into account the rational structure and consumption rates. The solution to the problem of the insufficiently optimal ratio of production and consumption of high-quality and environmentally friendly food products, rational volumes of their reserves, as well as forced imports for a number of food groups, which has developed in Russia, is possible with the help of multi-criteria mathematical modeling and optimization with a high dimension of input factors. As limitations of the task, it is necessary to take into account the rational structure and norms of consumption, as well as a number of other indicators listed in the national Food Security Doctrine [10].

4 Conclusions

Cognitive modeling of food security makes it possible to take into account the influence of a number of factors, including import substitution: the share of imports and the dynamics of production volumes of import-substituting agricultural products. Conducting cognitive analysis also allows us to assess the impact of large groups of conceptual factors of food security, including production, stocks, consumption of food products, the share of food imports, ecology, etc. The main directions of improving the software and hardware for assessing and predicting the level of food security are increasing the reliability and performance of such systems.

Acknowledgments

The article was prepared with the financial support of RFBR under the project 19-07-01132 “Creation of an intelligent system for assessment and forecasting of food security in the conditions of import substitution based on fuzzy cognitive approach”.

References

1. D. Lomeling, R. Wani, J. of Food Security, **3** (2015)
2. Y. J. Sin Wei, Le Q., McManamey, J. of Food Security, **4** (2015)
3. L. Biediger-Friedman, B.Sanchez, J. Guan, Z. Yin, Journal of Food Security, **4** (2016)
4. Jn. Crush, B. Frayne, C. McCordic, J. of Food Security, **2** (2017)
5. L.O. Oganessian, E.N. Fedyunina, Series: Advances in Economics, Business and Management Research, **47** (2019)
6. E. Pedzisai, P. Kowe, C.H. Matarira, A. Katanha, R. Rutsvara, Journal of Food Security, **2** (2014)
7. V. Nderumaki, F.X. Mkanda, J. Saria, J. of Food Security, **1** (2016)
8. T. V. Shlevkova, E. N. Antamoshkina, E. V. Kuzmina, Competitive, Sustainable and Secure Development of the Regional Economy: Response to Global Challenges, Series: Advances in Economics, Business and Management Research, **39** (2018)
9. A. Rogachev, E. Antamoshkina, *IOP Conference Series: Earth and Environmental Science*, 403 (2019)
10. Food Security Doctrine of the Russian Federation the Presidential Decree from 30.01.2010, Rossiyskaya Gazeta, 5100 (2010)