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THE SIMPLE ADDITIVE WEIGHTING METHOD APPLICATION IN FOOD SECURITY ASSESSING

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Abstract: raditionally the problem of food security was the center of attention in domestic and foreign economic science and practice that was connected with challenges of world development and increase of global contradictions. Food security is an important element of economic and national security of the state in general. It is one of the necessary conditions of sustainable development in the region. Regional features influence safety of the region and as a consequence the safety of the country in general. The methodical approach based on an expert pair comparison method and the SAW method was developed for assessing the food security condition in the regions. The Volga Federal District (VFD) and the Republic of Tatarstan (RT) were chosen as a research object. The received method was applied to assessing the level of ensuring food security in regions of Volga Federal District and the largest regions of the Republic of Tatarstan. This technique allows to fully estimate stability of the food sphere in the economic security of the region in general and the territorial subjects of the Russian Federation which are its part, as well as to reveal strong points and weaknesses of the region and its subjects for the purpose of increasing the management efficiency and proving measures of the operating influence, directed to its increase.

Keywords: food security, assessment, SAW method, expert method, criteria of ensuring food security**.**

Introduction

Assessing the food security condition defines need of developing the system of objective criteria and methods

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of its quantitative measurement at the international and intra economic levels, as well as at the level of the region, area, and social population group. Food security contains three aspects (quantitative, qualitative and social-and-economic); it is means that assessing the problem of food security has to be carried out within these aspects. The first is focused on ensuring sufficient volume of food; the second characterizes providing people not just with food, but food safe and qualitative. The third aspect provides increase in the income of the population or its separate groups to the level providing real (economic) access to food [1].

Today in order to estimate food security various statistics and dynamics are usually calculated [2, 3]. We offer an algorithm of assessing the regional food security. The developed model is based on a technique of assessing the food security at the regional level of economy. This method is universal and allows carrying out the food security level assessing by regions of the country in comparison. This model studies food security of regions, using criteria for evaluation of food security in the region.

Methods

During the research we applied an expert pair comparison method to define the priority importance of ensuring food security criteria [4, 5]. This method allows analyzing relation between the considered elements. Priorities of criteria concerning their importance to each other are defined as follows. They are compared with each other on their superiority [6, 7]. The scale of the relative importance for comparison of criteria is presented in table 1.

Table 1: Scale of the criteria relative importance

Importance	Definition	Explanation
0	Are incomparable	The expert is at a loss in comparison
1	Equal importance	Equal contribution
3	Moderate superiority of one over another	One criterion surpasses over another a little

5	Essential or strong superiority	One criterion strongly surpasses over another
7	Significant superiority	One criterion is largely more significant than the another
9	Very strong superiority	One criterion very strongly surpasses another
2,4,6,8	Intermediate values between two similar judgments	Compromise solutions

We make a matrix on the following algorithm. Let comparison be made for criterion, being in the left column, concerning criterion, being in the top line. When comparing criteria which have the equal importance therefore the elements standing on the main diagonal of this matrix are equal to 1. The elements received at the return comparison of the same criteria are given the corresponding inverse values: 1, 1/3..., 1/9. The received matrix is a matrix of paired comparisons.

Let's say *n* of criteria is considered. Experts establish criteria values by pair comparison method. Paired comparison – is the most expressive way for detection of elementary preferences. The pair comparison method is convenient; experts can compare indicators among themselves which is important having a large number of indicators. Investigating information obtained from experts by statistical methods it is necessary to estimate coherence of their opinions.

We will designate an indicator of the priority criteria values through d_{ij} $(i, j = \overline{1, n})$. This indicator designates the relation of the importance *of i* and *j* of criteria. Let results of paired comparison be reduced in a matrix *of D*

$$D = \begin{pmatrix} d_{11} & d_{12} & \dots & d_{1n} \\ d_{21} & d_{22} & \dots & d_{2n} \\ \dots & \dots & \dots & \dots \\ d_{n1} & d_{n2} & \dots & d_{nn} \end{pmatrix}.$$

Elements of a matrix D are set as follows:

$$d_{ij} = 1, \quad d_{ji} = \frac{1}{d_{ij}} \qquad \left(i, j = \overline{1,n}\right).$$

Then the matrix of D has an appearance:

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$$D = \begin{pmatrix} 1 & d_{12} & \dots & d_{1n} \\ \frac{1}{d_{12}} & 1 & \dots & d_{2n} \\ \dots & \dots & \dots & \dots \\ \frac{1}{d_{1n}} & \frac{1}{d_{2n}} & \dots & 1 \end{pmatrix}.$$

Further we calculate a vector of priorities on this matrix. Its coordinates are calculated by a formula $\sqrt[n]{\prod_{j=1}^{n} d_{ij}}$ where $i, j = \overline{1,n}$. Further we normalize the received vector, i.e.

$$g_i = \frac{\sqrt[n]{\prod_{j=1}^{n} d_{ij}}}{\sum_{i=1}^{n}\sqrt[n]{\prod_{j=1}^{n} d_{ij}}}, \quad (i = \overline{1,n}).$$

(1)

g_i number $(i = \overline{1,n})$, calculated by a formula (1), are numerical value of the importance of *i* criterion $(i = \overline{1,n})$.

For application of a pair comparison method, we use the expert method and a way of coherence check for expert opinions offered by L. Evlanov [8]. This technique is as follows.

Let there is *k* of experts. Under each questionnaire indicators of the importance of subjects to comparison are received. Let q_{ij} - ranks i subject to comparison of j by the expert $\left(i = \overline{1,n},\ j = \overline{1,k}\right)$. Results of expert poll can be entered in the following table.

Table 2:Results of expert poll

Subjects to comparison	Experts					Sum of ranks	Average rank
	1	2	3	…	k		
X_1	q_{11}	q_{12}	q_{13}	…	q_{1k}	$\sum_{j=1}^{k} q_{1j}$	$\overline{q_1}$
X_2	q_{21}	q_{22}	q_{23}	…	q_{2k}	$\sum_{j=1}^{k} q_{2j}$	$\overline{q_2}$
X_3	q_{31}	q_{32}	q_{33}	…	q_{3k}	$\sum_{j=1}^{k} q_{3j}$	$\overline{q_3}$
…	…	…	…	…	…		
X_n	q_{n1}	q_{n2}	q_{n3}	…	q_{nk}	$\sum_{j=1}^{k} q_{nj}$	$\overline{q_n}$

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The average rank is calculated by a formula

$$\overline{q_i} = \frac{1}{k}\sum_{j=1}^{k} q_{ij} \quad (i = \overline{1,n}).$$

If there are coherent ranks, then reliability of examination can be expressed through concordat coefficient:

$$W = \frac{S}{\frac{1}{12}\kappa^2(n^3 - n) - k\sum_{j=1}^{k} T_j},$$

where S - the sum of squares of assessment deviations in results of each efficiency indicator expressed on the following formula:

$$S = \sum_{i=1}^{n}\left[\sum_{j=1}^{k} q_{ij} - \frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{k} q_{ij}\right]^2,$$

T_j - an indicator of coherent ranks in estimates *of j* of the expert

$$T_j = \frac{1}{12}\sum_{l}^{L_j}(t_l^3 - t_l) \quad (2)$$

.

In a formula (2) L_j - number of sheaves (types of the repeating elements) in estimates *of j* of the expert $(j = \overline{1,n})$, t_l - quantity of the repeating elements in *l* to a sheaf for the expert's *j*.

If the connected ranks are absent, then $Tj=0$ $(j = \overline{1,n})$ and coefficient of a concordat is calculated by a formula:

$$W = \frac{S}{\frac{1}{12}\kappa^2(n^3 - n)}. \quad (3)$$

The concordat coefficient equals 1 if all rankings of experts are identical, and equals 0 if all of them are various. This coefficient represents a random variable [9]. For definition of assessing the importance of concordat coefficient we will calculate criterion of Pearson's coordination:

$$\chi^2 = \frac{S}{\frac{1}{12}kn(n+1) + \frac{1}{n-1}\sum_{j=1}^{k} T_j}. \quad (4)$$

If $\chi^2 > \chi^2 table$ where $\chi^2 table$ - the tabular value depending on number of freedom degrees and the accepted significance value, a hypothesis of expert opinions coherence in ranking is accepted. Otherwise, when $\chi^2 < \chi^2 table$, it is considered that expert opinions are not coordinated and significantly differ. The recommended significance value when checking a hypothesis of expert opinions coherence 0,05 [10].

The SAW method (method of simple additive weighing) is applied to

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definition of assessing the ensuring food security in this work [11].

SAW method algorithm.

1. Let's consider *n* of regions which will be estimated by *m* criteria. Let's use for this purpose a scale for determination of level for criterion of ensuring food security in regions (tab. 3).

Table 3:Scale for determination of level of criterion of ensuring food security

Importance	Definition
1	The highest category of quality
3	High category of quality
5	Satisfactory category of quality
7	Low category of quality
9	Unprofitable category of quality
2,4,6,8	Intermediate values between the next values of a scale

According to the obtained data we make a decision-making matrix

$$B = \begin{pmatrix} b_{11} & b_{12} & \dots & b_{1n} \\ b_{21} & b_{22} & \dots & b_{2n} \\ \dots & \dots & \dots & \dots \\ b_{m1} & b_{m2} & \dots & b_{mn} \end{pmatrix},$$

where b_{ij} – value of *i* indicator for *j* region ($i = \overline{1, m};\ j = \overline{1, n}$).

2. We find the best values of each indicator. If indicators of efficiency are minimized, then the best value of each indicator is calculated by a formula

$$b_i^* = \min_{1 \le j \le n} b_{ij}, \quad (i = \overline{1, m});$$

if are maximized, then by a formula

$$b_i^{**} = \max_{1 \le j \le n} b_{ij}. \quad (i = \overline{1, m}).$$

3. We calculate the normalized matrix $\overline{B}$. Its elements are on formulas:

$\bar{b}_{ij} = \frac{b_i^*}{b_{ij}}$, if indicators of efficiency are minimized;

$\bar{b}_{ij} = \frac{b_{ij}}{b_i^{**}}$, if indicators of efficiency are maximized.

4. We calculate a matrix of the weighed efficiency indicators $\tilde{B}$. Elements of every line of the normalized matrix $\overline{B}$ are multiplied by

corresponding sizes of the importance of efficiency indicators $g_1, g_2..., g_m$.

5. Using a matrix of the weighed efficiency indicators $\tilde{B}$, the criterion of efficiency of each region is defined:

$$K_j = \frac{1}{m}\sum_{i=1}^{n}\tilde{b}_{ij}, \qquad (j = \overline{1,n}).$$

The optimal variant of the made decision and ranks (preference of alternatives) of possible decisions are established in value K_j. In case indicators of efficiency are minimized, then the rank "1" is appropriated to the region which has the greatest criterion of efficiency; a rank "2" - to the region which has the second-large criterion of efficiency; etc. A rank of "n" - to the region which has the smallest. If indicators of efficiency are maximized, then the rank "1" is appropriated to the region which has the smallest efficiency criterion, and a rank of "n" - to the region which has the greatest, i.e. in ascending order of efficiency criteria to the region.

Results

In this research the following criteria of ensuring food security were considered [1]:

1. daily energy value of a diet of the person (X1);
2. providing diet of the person with main types of products (X2);
3. sufficiency of grain reserves in the state resources (X3);
4. economic availability of products (X4);
5. differentiation of food cost on social groups (X5);
6. capacity of domestic market for separate products (X6);
7. food independence on separate products (X7);
8. physical availability of foodstuff (X8);
9. stability of the food market (X9);
10. safety and quality of foodstuff (X10);
11. level of developing the agrarian sector (X11);
12. natural and resource potential and efficiency of its use (X12);
13. food independence of separate types of food (X13);
14. self-reliance level main types of food (X14);
15. volume of the state stocks of food (X15);
16. balance of foreign trade in food products (X16).

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For finding the numerical values of the importance of the considered criteria in ensuring food security we interviewed 17 experts. After processing the questionnaires in which it was offered to compare in pairs criteria of ensuring food security, determined a matrix of pair comparisons for objects (criteria of ensuring food security) with estimates by T. Saati's scale according to the scheme considered above and carried out mathematical calculations. Using a formula (1), the following numerical g_i values are received $(i = \overline{1,16})$:

Table 4:The normalized assessment of a priority vector (g)

Criteria of ensuring food security	Normalized a vector
X1	0,050959
X2	0,079615
X3	0,055445
X4	0,088309
X5	0,090942
X6	0,053635
X7	0,041874
X8	0,074332
X9	0,055333
X10	0,09567
X11	0,024916
X12	0,03757
X13	0,055207
X14	0,051049
X15	0,060234
X16	0,084907
$\sum$	1

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Numerical values of the criteria values of ensuring food security $_{gi}$ $(i=\overline{1,16})$ are presented in Figure.

Fig. 1. Numerical values of the importance for ensuring food security criteria

When checking coherence of opinions of the 17 experts the concordat coefficient (3) for finding the numerical values of the criteria values of ensuring food security made 0,8658 that means rather high coherence of this expert group.

Calculated according to (4) value $\chi^2 = 202{,}692$ there is more tabular value at significance value α=0,05 and to number of freedom degrees ν=n-1=15 $\chi^2_{табл} = 25$. The hypothesis of expert opinions coherence means is accepted.

On the basis of the SAW method we calculated criteria of optimality and defined ranks for regions of Volga Federal District. This method allows estimating the level of ensuring food security of these regions.

As a result of poll of the same 17 experts mentioned above for assessing the level of ensuring food

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security criterion the decision-making matrix was drawn**.** In this case when checking coherence of opinions of 17 experts the concordat coefficient made 0,9171 that means rather high coherence of this expert group.

Calculated according to (4) value $\chi^2 = 202{,}6791$ there is more tabular value at significance value α=0,05 and to number of degrees of freedom ν=n-1=14-1=13 $\chi^2_{табл} = 22{,}4$. The hypothesis of expert opinions coherence means proved itself.

Using numerical values of the priority importance of the criteria for ensuring food security found by means of a pair comparison methods with use of a scale of Saati (tab. 4) the efficiency criteria were calculated and ranks of each region (tab. 5) are defined.

Table 5:Level assessment of criterion for ensuring food security in the regions of Volga Federal District

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Republic of	Republic Mary-Al	Chuvash Republic	Perm Krai	Kirov region	Nizhny Novgorod	Orenbursky region	Area Penzenskya	Samara region	Saratov region	Ulyanovsk region	Republic of Mordovia	Republic of Tatarstan	Udmurt Republic
K	0,0535	0,0188	0,0135	0,0198	0,0101	0,0234	0,0266	0,0164	0,0297	0,0254	0,0103	0,0141	0,0510	0,0185
Rank	1	8	12	7	14	6	4	10	3	5	13	11	2	9

So, assessing the level of criteria for ensuring food security in the regions of Volga Federal District is presented in the Figure.

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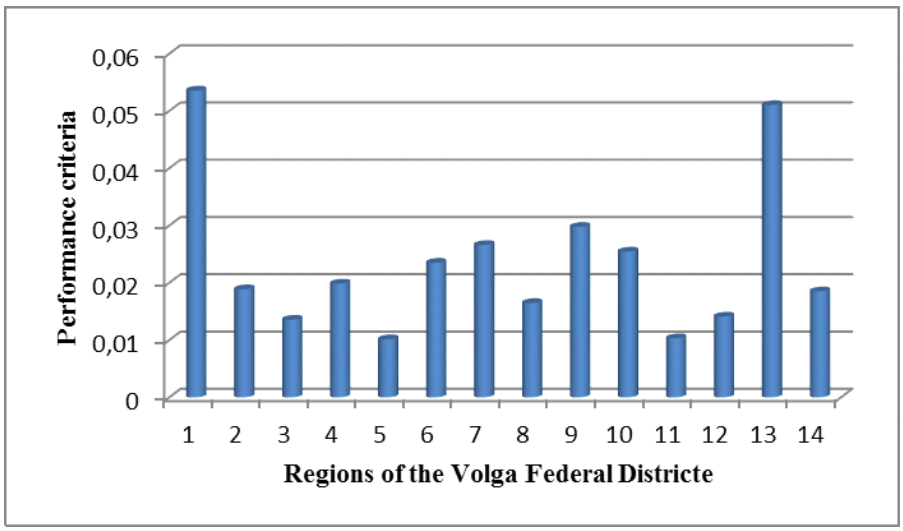

Fig. 2. Level of ensuring food security in the regions of Volga Federal District

The submitted chart demonstrates levels of ensuring food security in the regions of Volga Federal District.

By means of the economic-mathematical model constructed on the basis of the SAW method we also carried out the analysis of assessing the level of ensuring food security in the largest regions of the Republic of Tatarstan. Level assessment of ensuring food security in the largest regions of the Republic of Tatarstan is presented in table 6.

Table 6:Assessing the level of criterion for ensuring food security the largest regions of RT

	1	2	3	4	5	6	7
	Almetyevsk district	Bugulma district	Yelabuga district	Zelenodolsk district	Leninogorsk district	Nizhnekamsk district	Chistopolsky district
K	0,04603	0,04183	0,04487	0,04220	0,04178	0,04627	0,04377
Rank	2	6	3	5	7	1	4

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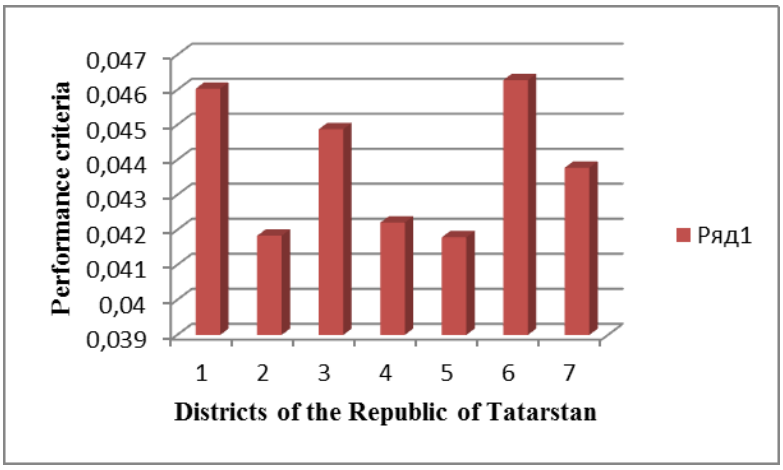
Assessing the level of criterion for ensuring food security of the largest regions of RT is given in the Figure.



(row)

Fig. 3. Assessing the level of criterion for ensuring food security of the largest regions of RT

In this case we interviewed 15 experts. Professors and associate professors of the Kazan higher educational institutions acted as experts. When checking coherence of opinions of these experts the concordat coefficient made 0,8891 that means rather high coherence of this expert group.

Calculated according to (4) value $\chi^2 = 80{,}019$ there is more tabular value at significance value α=0,05 and to number of freedom degrees ν=n-1=7-1=6 $\chi^2_{табл} = 12{,}6$. The hypothesis of expert opinions coherence means is accepted.

Discussion

The results on Volga Federal District presented in fig. 2 demonstrate that the level of ensuring food security in the Republic of Bashkortostan and the Republic of Tatarstan is at s rather high level. The lowest levels of ensuring food

security are in the Kirov and Ulyanovsk regions.

The results received by us on RT demonstrate that the level of food security has the highest assessment in the following regions of RT: Almetyevsk, Nizhnekamsk. This results from the fact that these areas are in big dependence on the petrochemical, oil processing and power generating industry of Tatarstan from which they receive the majority of the budgetary receipts.

Conclusions

Component organization of ensuring food security is important in assessing the ensuring food security of the region.

The model of assessing the ensuring food security offered above allows to define in management process of regional economic system regions with the low level of food security and to take measures in improvement of this question. It increases effective process management of ensuring food security. Such approach in estimation of ensuring food security in regions allows to reveal shortcomings and to eliminate them.

On the basis of elements of the economic-mathematical modeling the method of estimating ensuring food security on the example of the Volga Federal District and the Republic of Tatarstan which helps to reveal regions with the low level of food security and by that to take measures for improvement of a situation in these regions is developed.

Summary

Thus, application of methods of economic-mathematical modeling allowed to present objective assessing the level of sustainable development by the food sphere of economic security on the example of the regions of Volga Federal District and municipalities which are a part of the Republic of Tatarstan that allowed proving the maintenance of measures for the operating influence.

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