Economic Mathematical Modeling of Agrarian Industry Development by Cluster Analysis

Sergey I. Tkachev[1]
Ekaterina V. Berdnova[2]
Svetlana N. Rubtsova[3]
Tatiana Vl. Pakhomova[4]
Julia Vl. Lazhauninkas[5]
Lyudmila An. Sleptsova[6]

1. Saratov State Vavilov Agrarian University. Email: tkachevsi@sgau.ru
2. Saratov State Vavilov Agrarian University. Email: berdnovsn@mail.ru
3. Saratov State Vavilov Agrarian University. Email: sveta.rub-2014@yandex.ru
4. Saratov State Vavilov Agrarian University. ptw5@yandex.ru
5. Saratov State Vavilov Agrarian University. Email: lazhauninkas@yandex.ru
6. Saratov State Vavilov Agrarian University. Email: sla-7@yandex.ru

Abstract: 1. Purpose. The main kind of encouraging the development of agrarian industry is financial backing. The state allocates the means to the regions, while the regions distribute them for various needs as planned. In this case a subjective approach to solving the problem in question is possible. To make this process more objective, the scientific method of distributing investments is suggested. 2. Methods. The economic mathematical modeling of agrarian industry development by cluster analysis is suggested for the scientific distribution of investments. 3. Results. The key function of commercial activities in agrarian industry is the income from introducing research (innovations) characterized by respective parameters (arguments). In crop farming they include efficient rotation, fertilizers, seed fund, weed control. In stock raising they include immunologic prophylaxis problems, ensilage conservation, etc. Eventually, the investments optimally distributed in the Saratov oblast' included 635,271 thousand rubles for crop farming and 915,227 thousand rubles for stock raising. The specific result is that the investments are distributed in the region up to a specific amount by the scientific method with the help of cluster analysis. 4. Conclusion. The goal set forth to determine the scientific method has been achieved, which is proven by the specific data on crop farming and stock raising. The specific conclusion is that the problem with distributing investments in the studied region is solved scientifically. The distribution of population across the studied territory is a factor difficult to consider in terms of investments distribution. There are no convincing average arithmetic and statistic figures. This is why, cluster analysis was used instead. In this procedure the population's need for investments is tied to clusters of homogeneous communities (towns) and the weighted average condition by clusters is determined graphically (see Fig. 1). The further distribution of investments is planned proceeding from this condition. **Keywords:** economic mathematical model, cluster analysis, key function, crop farming, stock raising, farming innovations.

1. Introduction

The success in developing agrarian industry is determined by turnout. The activities most typical of this industry are crop farming and stock raising, processing included.

The development of agrarian industry does have distinct features depending on the region but has a lot of common features as well.

The State Program for Agricultural Development and Regulating Agricultural Commodities, Raw Materials, and Foodstuffs Markets in 2013-20 was adopted by Russian Government Decree 717 on June 14, 2012 [22] and set forth real goals and objectives for the national agricultural industry for this period.

In terms of agriculture the Saratov oblast' is one of the leading regions in Russia. The region's share in the total national cost of agricultural commodities is 2.4 % [21]. The specialization areas of the region's agricultural industry are crop and stock production (65.4

and 34.6 % of the total cost of agricultural turnout in the region, respectively). The cost analysis of the region's agricultural production yields the following results: in 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, and 2017 the cost amounted to 64.1, 70.7, 89.5, 89.2, 91.8, 109.6, 119.1, 112.3, and 133.5 billion rubles, respectively. The gain in 2010 on 2009 was ((70.7 – 64.1)/64.1) * 100% = 10.3%, whereas in 2011, 2012, 2013, 2014, 2015, 2016, and 2017 it was 26.6, (-1.7), 2.9, 19.4, 8.7, (-5.7), and 18.9%, respectively. The statistical annual average gain was (10.3 + 26.6 – 1.7 +2.9 + 19.4 + 8.7 – 5.7 + 18.9)/8 = 9.92% « 10%. It is seen that the annual average value for eight years was 10% and the variations ranged from 26.6 to (-5.7%). The results are governed by the Law on Strategic Planning in the Saratov Oblast' adopted in 2015 [7] and by the Saratov Oblast' Government Decree on Agricultural Development in the Saratov Oblast' in 2014-20 [14].

The success in developing the region's agricultural industry depends on such factors and objects as the size and distribution of population across the region, conditions significantly affecting the region's economy, and the region's innovative potential.

2. Methods

The term "cluster analysis" was first used by mathematician R. Tryon [37]. Cluster analysis is a multidimensional statistical procedure consisting of retrieval of data with information about choosing objects and arranging them in relatively homogeneous groups, which is followed by processing these data by the function cluster method in Excel tables. The objective of cluster analysis is to use these data as basic for elaborating the economic mathematical development model of agrarian industry.

The formation of such groups involves splitting (clusterizing) them in typologies, studying useful concept patterns of object grouping, and generating hypotheses on the basis of data exploration. Work by A. I. Popova [12] is an example work on ensuring financial sustainability of agricultural enterprises, taking account of seasonal production variability, work by O. V. Nikulina and I. S. Pankina [10] is an example work on economic clusterization of food industry, and work by S. A. Belousov [2] is an example work on clusterization in stock raising. Some of the pivotal issues of cluster analysis are exposed in book by Leonid Gittis [5]; however, the main emphasis in the book is put on one of the image recognition methods, which points at the diverse opportunities for applying cluster analysis. There is another book by Gitis [6], where he exposes the application fields of the theory in mining, economic, sociological, and other studies. Another trend in cluster analysis is dedicated to regional competition, regional strategy, and regional economy and presented in book by T. V. Uskova [18]. Two more books worth mentioning are works by A. I. Berg and Yu. Dmitriev [4] and M. V. Klyuchnikov [8] on using cluster analysis in analyzing competition in the field of banking. The enumerated sources expose the large potential of cluster analysis, whereas the results presented in this work expose its efficiency in a particular case.

The reliability of the used methods consists in their mathematical base, whereas the influence on the results consists in the commercial feasibility of investments distributed, taking account of cluster peculiarities of population groups from different regions.

The section titled "Mathematical Model of Commercial Component of Agrarian Activities in Saratov Oblast'" exposes the commercial parameters that shall bring income in both, crop farming and stock raising. These parameters allowed obtaining specific results, taking account of the cluster-like distribution of population. In terms of commercializability, for example, 9,964,950.23 rubles out of the 635,271 thousand rubles of crop farming investments shall be doled out on efficient rotation, 34,042,816 rubles shall be doled out on science-based soil processing systems and fertilizers, etc., whereas 230,868,843.3 rubles out of the 915,227 thousand rubles of stock raising investments shall be doled out on immunologic

prophylaxis control, 297,024,000 rubles shall be doled out on treatment of mass-scale viral infections among cattle, etc.

3. Results and discussion

Grouping and Arranging Towns of Saratov Oblast' by Population Size

The population involved in agricultural labor, especially in processing, tends to lean toward urban life.

The towns of the Saratov oblast' are ranked below by population size in '000 people as of January 1, 2008: 1) Saratov – 836.1; 2) Engels – 204.4, 3) Balakovo 198.7; 4) Balashov – 92.5; 5) Volsk – 68.6; 6) Rtishchevo – 43.2; 7) Pugachev – 42.7; 8) Marx – 32.7; 9) Petrovsk – 32.3; 10) Atkarsk – 27.5; 11) Krasnoarmeysk – 24.8; 12) Ershov – 23.4; 13) Kalininsk -18.7; 14) Novouzensk – 16.9; 15) Krasny Kut – 14.7; 16) Arkadak – 13.6; 17) Khvalynsk – 13.5; 18) Shikhany – 6.2.

The statistic average population size is (836.1+204.4+198.7+92.5+68.6+43.2+42.7+32.7+32.3+27.5+24.8+23.4+16.7+16.9+14.7+13.6+13.5+6.2)/18= 95,028 residents.

The cities and towns divided in groups relatively similar by population size are classified as

($W_{1)}$ Saratov (W_{11}) ~ 900K people,

(W_2) Engels (W_{21}), Balakovo (W_{22}) ~ 200K people,

(W_3) Balashov (W_{31}), Volsk (W_{32}) ~ 80K people,

(W_4) Rtishchevo (W_{41}), Pugachev (W_{42}), Marx (W_{43}), Petrovsk (W_{44}), Atkarsk (W_{45}), Krasnoarmeysk (W_{46}), Ershov (W_{47}), Kalininsk (W_{48}), Novouzensk (W_{49}), Krasny Kut (W_{410}), Arkadak (W_{411}), Khvalynsk (W_{412}), Shikhany (W_{413}) ~ 30K people.

Let us make a graphologic analysis. Assume that there are two vertical axes separated from one another by a conventional unit. Mark out both axes from 0 to 1 000, with points W_1 = 900 and W_2 = 80 plotted on the right vertical line and W_3 = 200 and W_4 = 30 - on the left vertical line. Then draw one straight line to connect W_1 and W_4 and another to connect W_2 and W_3. The resulting straight lines intersect in W= 179K people.

These reasonings reveal a shift. Whereas the statistic average value is 95K people, the cluster average is 179,393≈179K people. The discrepancy is insignificant but allows determining the key point of reference in economic mathematical studies of the regions.

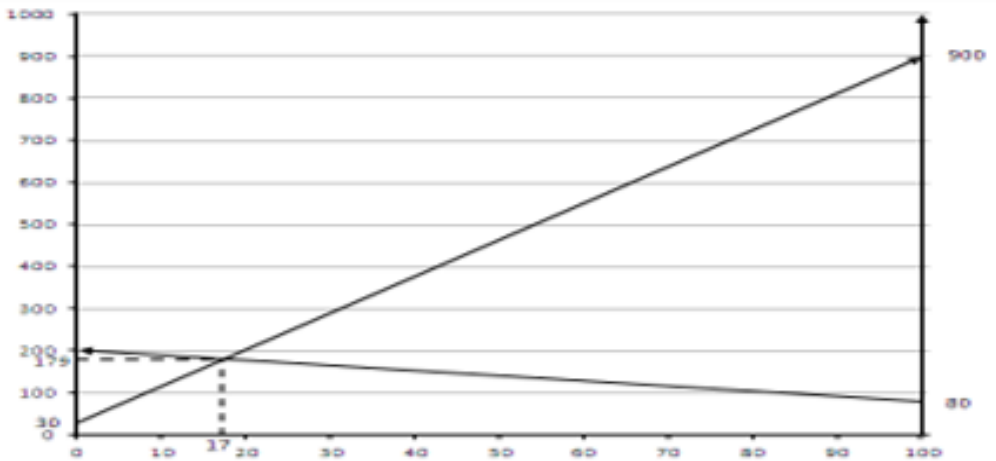

Fig. 1. Grouping and collation of agrometeorological conditions in the Saratov oblast'

Agrometeorological conditions can be both, positive factors encouraging an increase in crop yield and risk factors leading to its decrease. That said, an important indicator is gain in agricultural output. Let us correlate risk figures with gain in output.

In 2010 the gain was 10.3 % given that two districts suffered from drought and 1 600 peasant and farm enterprises were damaged. The area of agricultural crop losses covered 1 million ha. Unfortunately, however, there are other factors of damage as well. For example, the relative fire area in a given period tends to increase year-on-year: in 2007, 2008, 2009, and 2010 that area was 244.7/63 = 3.88 per fire, 501.28/108 = 4.64, 1 521.77/214 = 7.1, and 6 238.51/386 = 16.16 ha per fire, respectively. Other factors of damage are road accidents and other manmade losses, and the damage amounts to 2.6 billion rubles.

In 2011 the gain in agricultural output was 26.6 % as that year was quite good in all respects; in 2012 the gain was (-1.7 %) due to drought in two districts, a damage of 1.5 billion rubles, and failure of sugar beet, sunflower, and some other crops; in 2013 the gain was only 2.9 % due to failure of sugar beet, and low yield of wheat and other crops; in 2014 the gain was 19.4 % as that year was relatively good; in 2015 the gain was only 8.7 % due to drought in two districts and a damage of 2 billion rubles. In 2016 the gain was (-5.7 %): according to the Saratov Center of Hydrometeorology and Monitoring of Environment (HME), a branch of the Volga Department of HME, the region suffered from unfavorable weather conditions (UWC) that led to an accumulation of hazardous substances in the atmosphere and caused damage to the agriculture and public health. The unfavorable environmental conditions in summer caused 57 fires in various localities across the region.

In 2017 the gain was 18.9 %. The unfavorable conditions fell on the ripening stage of corn and sunflower when they suffered from rainfalls. The harvesting of sunflower was impossible, which is why the crop was harvested only in the mid-January of 2018 when frosty weather came. However, the quality of the ice-covered seeds was low. The harvesting of crop was postponed until the spring of 2018 for similar reasons. The damage was about a billion rubles.

Let us consider the agrarian industry of the Saratov oblast' in terms of crop farming and stock raising as the two key branches.

Crop farming

The cultivation of each crop has its distinct features; however, it is possible to distinguish the principles of making up a set of cultivation methods common to all crops. The set includes efficient rotation; science-based soil treatment systems and fertilizers; selection of varieties (hybrids with the most valuable commercial biological properties in local edaphoclimatic conditions); using HQ seed grain; right arrangement of plants across planting acreage (optimal planting dates and methods, planting rates and depth); careful handling of seedings and weed, disease, and pest control; timely and HQ harvesting and also primary product processing. The ultimate goal of crop farming is to discover reserves for increasing agricultural crop production at minimal costs.

Innovative processes in crop farming shall be aimed at increasing crop farming product output by improving soil fertility; improving crop productivity and product quality; overcoming degradation and destruction of natural environment and ensuring more ecofriendly production; reducing energy sources consumption and making crop farming productivity more independent from natural factors; using irrigated and drained land more efficiently; saving labor and material costs; maintaining and improving environmental ecology. In this context the innovative policy of crop farming shall rely on improving selection methods, i.e., creating new agricultural crop varieties with high productive potential, and adopting science-based arable and seed farming systems.

Stock raising

In the current context of unstable stock raising development and sharp decline in stock raising production the measure highly significant to improving the branch's production potential is to implement the biological set of innovations and advancements in Russian and global selection; these advancements highlight a major trend in improving selection genetic potential that directly determines the productivity of animals, efficient use of fodder supplies, adoption of resource-saving technologies intended for making stock raising production more efficient and intensive.

The main problems with cattle breeding have to do with immunologic prophylaxis, treatment of mass-scale viral cattle diseases, and conserving hi-pro grass ensilage with biological preparations. At the same time, it is observed that the cost of fodder procurement is high and the purchasing price of stock raising (meat and dairy) products is low [23]. Thus, the problems in stock raising and crop farming are closely related.

One of the main innovative directions is biotechnological animal husbandry systems making use of genetic and cell engineering methods. These systems are aimed at creating and using new types of transgenic disease-resistant animals with improved productivity characteristics.

Another no less important role in developing the innovation process in stock raising is played by technology, scientific, and engineering groups of innovations closely related to industrialization of production, manufacturing automation and mechanization, production revamping, adoption of high technologies, and workforce productivity increase that determine the efficiency of stock raising production.

The amount of money necessary for solving the indicated problems depends on payback related to using innovations.

Innovations

This section considers innovations applicable to solving the indicated problems. The essence of innovations consists in adopting novelties (new research, discoveries, technologies). The process shall develop in sequence. First of all, scientific information sharing is necessary. For example, according to the futurological report "Envisioning the Future of Veterinary Medical Education" by doctor Danny Osbourne, dean of California School of Veterinary Medicine, people shall be ready for outbreaks and pandemics of viral infections among animals. In this context, an important role is played by the economic efficiency of using targeted drugs for immunologic prophylaxis and mass treatment of viral infections in cattle, comparative anatomic characteristic of morphological adaptations of pelvic waist in contemporary animals, and also by evaluation of embryotoxic and teratogenic properties of complex preparation Viapen, and conservation of hi-pro grass ensilage with biological preparations. The enumerated problems indicate the points that required being concentrated upon. Thus, primary information is the key to searching for innovations. The second step is to search for solutions of the stated problems. The third step is to make up a research program when it is seen that the final result has not been obtained yet.

Mathematical Model of Commercial Component of Agrarian Activities in Saratov Oblast'

The key function of commercial component Z is the income from adopting research (innovations) characterized by respective parameters. The commercial parameters meant to be profitable will be referred to as x_{ji}. The x_{ji} for crop farming will be x_{1i}, which includes x_{11} standing for efficient rotation; x_{12} standing for science-based soil treatment systems and fertilizers; x_{13} standing for selection of varieties (hybrids with the most valuable commercial biological properties in local edaphoclimatic conditions); x_{14} standing for using HQ seed grain;

x_{15} standing for proper arrangement of plants across planting acreage (optimal planting dates and methods, planting depth and rate); x_{16} standing for careful maintenance of seedings and weed, disease, and pest control; x_{17} standing for timely and high-quality harvesting and also primary product processing. The x_{ji} for stock raising are will be x_{2i}, which includes x_{21} standing for solving immunologic prophylaxis problems; x_{22} standing for treatment of mass viral infections in cattle; x_{23} standing for conservation of hi-pro grass ensilage with biological preparations. The commercial parameters meant to be profitable will be referred to as

y_{ji}. The y_{ji} for crop farming will be y_{1i}, which includes y_{11} standing for the agroclimatic component and y_{12} standing for the agrometeorological component. The y_{ji} for stock raising will be y_{2i}, which includes y_{21} standing for the agroclimatic component and y_{22} standing for the agrometeorological component.

Assume that the average amounts of per capita crop farming and stock raising investments in the Saratov oblast' are 3 549 and 5 113 rubles, respectively, whereas the cluster average number of residents in the region is 179K people. Then, Z_1 = RUB 3 549/cpt*179K ppl. = RUB 635,271 thousand, Z_2 = RUB 5 113/cpt*179K ppl. = RUB 915,227 thousand. With these designations, the target crop farming and stock raising functions will be recorded as $Z_1 = \sum_{i=1}^{7} x_{1i} \cdot a_{1i} + \sum_{i=1}^{2} y_{1i} \cdot b_{1i}$ and $Z_2 = \sum_{i=1}^{7} x_{2i} \cdot a_{2i} + \sum_{i=1}^{2} y_{2i} \cdot b_{2i}$, respectively. Parameters a_{1i}, b_{1i}, a_{2i}, b_{2i} depend on those characteristics that will be determined for each of the commercial parameter in the course of research. The calculated values of Z will characterize the commercial attractiveness of each study.

The results are: Z_1 = RUB 635,271 thousand (635,271,000), Z_2 = RUB 915,227 thousand (915,227,000), a_{11}= 52,350, a_{12}= 35,116, a_{13} = 1 16,345, a_{14} = 256,365, a_{15} = 53,236, a_{16} = 68,745, a_{17} = 78,695, a_{21} = 32,310, a_{22} = 37,128, a_{23} = 12,434, b_{11} = 35,243, b_{12}= 25,216, b_{21}= 23,235, b_{22}= 32,511.

The limitations are: $855<x_{11}<1055$, $870<x_{12}<1070$,

$800<x_{13}<1000$, $680< x_{14}<880$,$840<x_{15}<1040$,$820<x_{16}<1020$,

$830<x_{17}<1030$, $875 <y_{11}<1075$, $880<y_{12}<1080$.

$6000<x_{21}<8000$, $7000<x_{22}<9000$, $2000<x_{23}<4000$, $4000<y_{21}<6000$,

$6000<y_{22}<8000$. In this case the respective equations for Z_1 and Z_2 are

$635{,}271{,}000 = 52{,}350\, x_{11} + 35{,}116\, x_{12} + 116{,}345\, x_{13} + 256{,}365\, x_{14} + 53{,}236\, x_{15} + 68{,}745\, x_{16} + 78{,}695\, x_{17} + 35{,}243\, y_{11} + 25{,}216\, y_{12}$ and $915{,}227{,}000 = 32{,}310\, x_{21} + 37{,}128\, x_{22} + 12{,}434\, x_{23} + 23{,}235\, y_{21} + 32{,}511\, y_{22}$.

Each of these equations can be solved in a lot of ways but the restrictions for x_{ji} and y_{ji} minimizes their number. Let us use the simplex method to solve each of the equations together with the respective systems of inequations.

The set of the unknowns meeting the above described equations for Z_1 and Z_2 and the system of inequations is found using the Solution Search function in MSExcel as

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2		Z_1										
3		635271000,00										
4												
5			a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}	a_{17}	b_{11}	b_{12}	
6			52350	35116	116345	256365	53236	68745	78695	35243	25216	
7												
8			x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	y_{11}	y_{12}	
9			954,4403169	969,439	898,746	776,888	953,669	940,172	931,513	969,328	978,055	
10												
11			855	870	800	680	840	820	830	875	880	
12			1055	1070	1000	880	1040	1020	1030	1075	1080	
13												

Fig.2

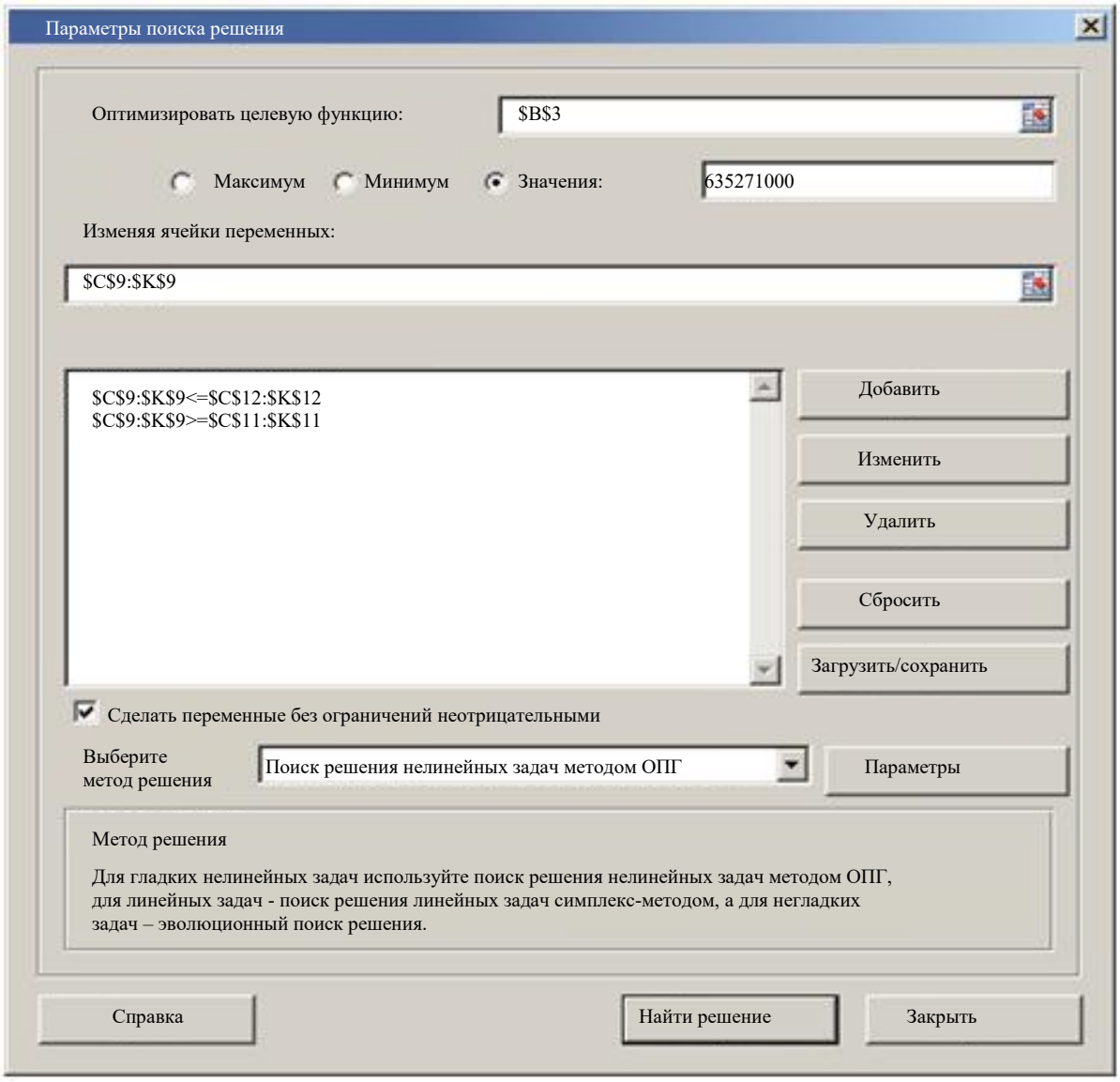

Fig.3

	A	B	C	D	E	F	G	H
1								
2		Z_2						
3		915227000,00						
4								
5			a_{21}	a_{22}	a_{23}	b_{21}	b_{22}	
6			32310	37128	12434	23235	32511	
7								
8			x_{21}	x_{22}	x_{23}	y_{21}	y_{22}	
9			7145,434486	8000	2749,81	5138,48	7189,89	
10								
11			6000	7000	2000	4000	6000	
12			8000	9000	4000	6000	8000	
13								

Fig.4

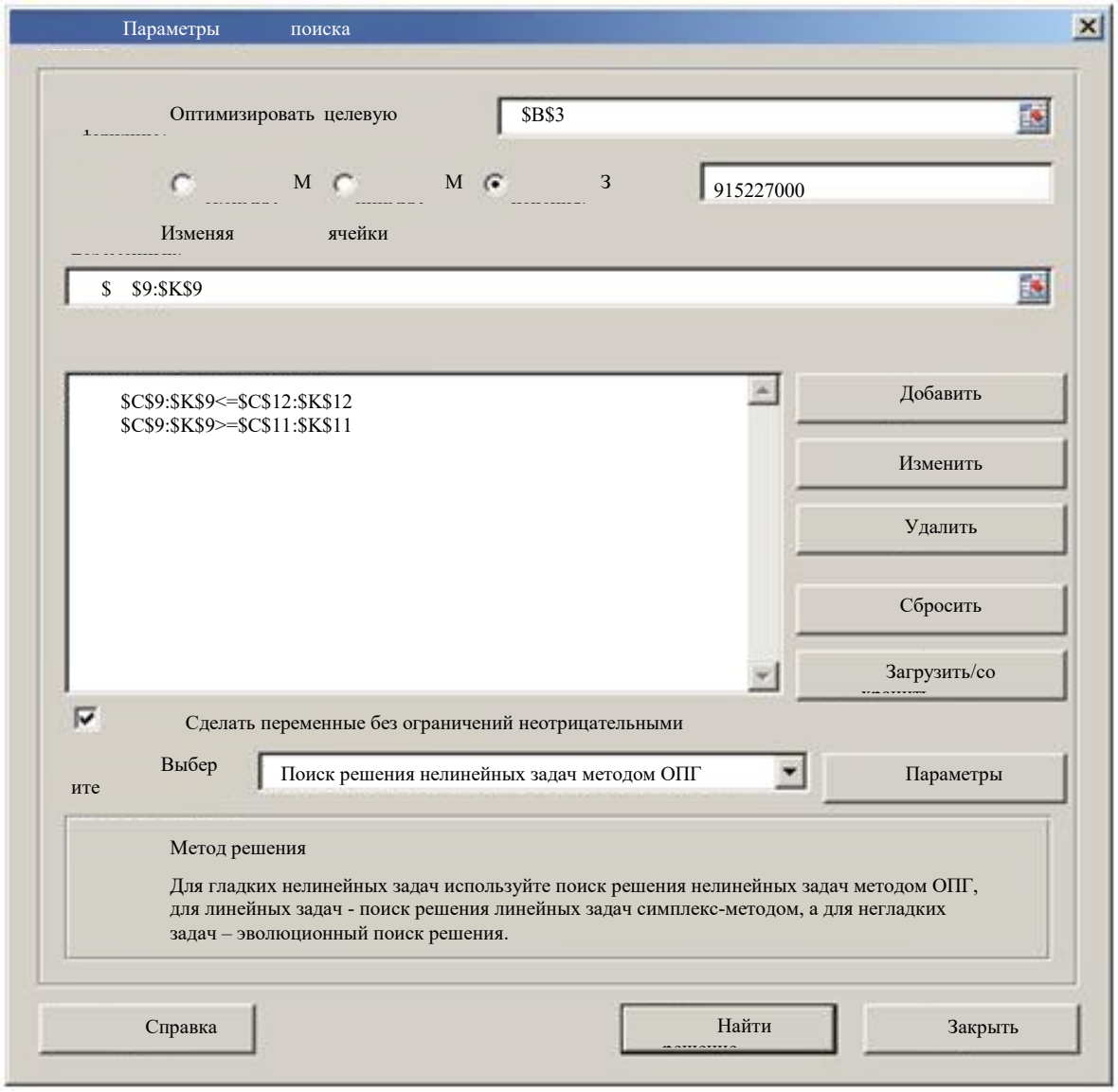

Fig.5

Table 1.

X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	Y_{11}	Y_{12}
954,44031	969,43889	898,74610	776,88809	953,66924	940,17191	931,51252	969,32836	978,05476
X_{21}	X_{22}	X_{23}	Y_{21}	Y_{22}				
7145,43	8000	2749,81	5138,48	7189,89				

Thus, x_{11} = 954.44 means that the subventions required for efficient rotation out of the RUB 635,271 thousand doled out on crop farming are found as

$x_{11}*a_{11}$= 954.44031*52,350= RUB 49,964,950.23, subventions for science-based soil treatments systems and fertilizers are found as $x_{12}*a_{12}$=969.43889*35,116= RUB 34,042,816.06; subventions for selection of varieties (hybrids with the most valuable commercial biological properties in local edaphoclimatic conditions) are found as $x_{13}*a_{13}$=898.7461*116,345= RUB 104,564,615; subventions for using HQ seed grain are found as $x_{14}*a_{14}$=776.88809*256,365= RUB 199,166,915.2; subventions for proper arrangement of

plants across planting acreage (optimal planting dates and methods, planting depth and rate) are found as $x_{15}*a_{15}$=953.66924*53,236= RUB 50,769,535.66;

subventions for careful maintenance of seedings and weed, disease, and pest control are found as $x_{16}*a_{16}$=940.17191*68,745= RUB 64,632,117.95; subventions for timely and high-quality harvesting and also primary product processing are found as $x_{17}*a_{17}$=931.51252*78,695= RUB 73,305,377.76, subventions for agroclimatic component are found as $y_{11}*b_{11}$=969.32836*35,243= RUB 34,162,039.39; subventions for the agrometeorological component are found as $y_{12}*b_{12}$= 978.05476*25,216= = RUB 24,662,628.83.

In sum, the result is $x_{11}*a_{11}+ x_{12}*a_{12}+ x_{13}*a_{13}+ x_{14}*a_{14}+ x_{15}*a_{15}+ x_{16}*a_{16}+ x_{17}*a_{17}++y_{11}*b_{11}+ y_{12}*b_{12}$= 954.44031*52,350+969.43889*35,116+898.7461*116,345+ +776.88809*256,365+953.66924*53,236+940.17191*68,745+931.51252*78,695+ +969.32836*35,243+978.05476*25,216=RUB 635,271 thousand.

By the same token, x_{21}=7 145,434 means that the subventions required for solving the immunologic prophylaxis issue out of the RUB 915,227 thousand doled out on stock raising are found as $x_{21}*a_{21}$=7 145.43*32,310= RUB 230,868,843.3; subventions required for treatment of mass viral infections in cattle are found as $x_{22}*a_{22}$=8 000*37,128= RUB 297,024,000; subventions for conservation of hi-pro grass ensilage with biological preparations are found as $x_{23}*a_{23}$=2 749.81*12,434= RUB 34,191,137.54; subventions for the agroclimatic component are found as $y_{21}*b_{21}$=5 138.48*23,235= RUB 119,392,582.8; subventions for the agrometeorological component are found as $y_{22}*b_{22}$=7 189.89*32,511=RUB 233,750,513.8.

In sum, the result is $x_{21}*a_{21}+ x_{22}*a_{22}+ x_{23}*a_{23}+ y_{21}*b_{21}+ y_{22}*b_{22}$=7 145.43*32,310+ +8 000*37,128+2 749.81*12,434+5 138.48*23,235+7 189.89*32,511=RUB 915,227.

Thus, the scientific method has helped determine the distribution of financial means for solving the specific problems of crop farming and stock raising.

The suggested solution is not integral. Agrarian industry is affected by a lot of factors. For example, a fairly negative effect resulted from Russia's joining the WTO (see, e.g., articles by Uzun [17] and Barsukova [1]). Meanwhile, the influence of state-run programs (see, e.g., Russian Government Decree [13] and article by Ushachev [19]) as well as regional programs of agrarian development (see, e.g., Saratov Oblast' Government Decree 520-P of October 2, 2013 [14] and Concept of Developing the Agrarian Industrial Complex of the Rostov Oblast' [9] is efficient and positive. At the same time, each specific case requires a specific approach. This approach is exactly the one described in the case in question.

The suggested method is also acceptable in other regions; that said, however, one should consider all essential differences between the new and the given region. If to take Moscow with its 12.5 million residents and Saint-Petersburg with 5.3 million residents, such studies will not make sense. In case of Novosibirsk (1.6 mln.), Yekaterinburg (1.5 mln.) and Nizhniy Novgorod (1.3 mln.) it will be necessary to introduce a corrective factor of about 1.5 when analyzing key points by populated localities. For other millionaire cities, including Kazan, Chelyabinsk, Omsk, Samara (1.2 mln.), Rostov-on-Don, Ufa, and Krasnoyarsk (1.1 mln.), Perm, Voronezh, Volgograd (1 mln.) this calculation can be the most proximate because Saratov taken together with Engels (≈ 1.1 mln.) is nearly at the same level with these cities by population size. If to consider climatic and resource conditions, the cities most similar to each other will be Kazan, Samara, Voronezh, Volgograd. At the same time, this category should encompass such cities as Krasnodar (0.9 mln.), Izhevsk (0.7 mln.), Ulyanovsk and Yaroslavl (0.6 mln.), Orenburg, Ryazan, Astrakhan, and Penza (0.5 mln.).

There is quite a lot of literature about economic mathematical methods and models, e.g., works [3, 11, 15, 16, 20]. At the same time, they pay extremely little attention to using cluster analysis and simplex method. In the case in question the strong point of using them is the clear

unambiguous answer about the distribution of budget means for each of the problems within allowable tolerance limits (inequations on the left and right) for each parameter.

The suggested method is applicable to solving other similar tasks; that said, however, it is necessary to take into account the distinct features of each region.

It should be noted that cluster analysis becomes increasingly popular. The idea of clusterization was invented by R. Trayon when he studied the behavior of lab rodents whom he classified by the level of intelligence. The subsequent development of cluster analysis had to do chiefly with biology, psychology, healthcare, and anthropology. The history of developing cluster analysis in economy hearkens back to the 1990s when Denmark, Finland, and the Netherlands became the pioneers in cluster programs development [24]. An increasing number of countries and territories have used cluster analysis since the mid-2000s for economic development in light of efficient implementation of cluster programs in various regions. According to Sweden's VINNOVA agency of innovative systems, cluster analysis allows operatively managing the implementation of cluster policy, evaluating efficiency and performance in certain periods, having feedback on government meddling, and determining the influence of cluster programs on the development of regional innovative systems.

At the same time, cluster programs are seldom exposed to evaluation [36]. The involvement of manpower, material and financial resources leads [31] entails significant financial expenditures. It is necessary, therefore, to investigate the internationally known theoretical methodological basics of cluster policy performance evaluation.

According to Sölvell Ö., evaluation means the consistent application of procedures from various kinds of studies for the purpose of analyzing the conceptualization and implementation of policies, programs, projects, or other objects [36].

At present, foreign analytical reports on results of implementing cluster programs expose the results of analyses in such areas as [32] evaluation of cluster productivity and its evolution over time, analysis of steps taken as part of cluster initiatives, evaluation of the influence of government meddling with cluster development. The objects evaluated in cluster policy are cluster initiatives, groups of clusters, single clusters, and also particular aspects of their work [33]. Evaluations of cluster initiatives in real-time mode have recently gained in popularity [29]. It is commonly recognized that the evaluation process shall involve the group of stakeholders in cluster policy, including participants in the cluster, cluster structure managers, government agencies, cluster employees, and consumers [31]. The cluster policy evaluation indices can also be supplemented with the group of indices presented in works by Andersen [25], Jappe-Heinze [29], Rosenfeld [34].

The indices distinguished by the authors are divided in two groups, including the efficiency indices of the cluster organization and management system and the indices of cluster operation results (number of staff involved in R & D works, expenses on R & D, research funding level). The methods applicable in the process of cluster policy efficiency studies are presented in works by Schmiedeberg C. [35].

The connection of cluster analysis with market economy and intelligent research began to develop later.

In one of the early articles on the topic R. Baptista and P. Swann [26] seek to find out what businesses are more prone to innovations. In this case not only such variables as market share and employment dispersion (Hirschman index) were used but also, like in our case, the population size meaning the overall number of residents in the region, where firms operated from 1971 to 1981.

The proneness of businesses to innovations in and outside clusters was also evaluated in 2003 by Beaudry C., Breschi S. [27]. The authors used empirical analysis to study operational results of firms in the UK and Italy.

Study by Malmberg A. and Power D. [30] is aimed at finding evidence showing that being in clusters allows companies to exchange, acquire, and generate new knowledge as the foundation of competitiveness.

Wennberg K. and Lindqvist G. [38] consider the influence of clusters on survival and operation of new firms, where clusters are defined as regional agglomerations of related branches. The authors analyze the data about 4 397 Swedish firms from 1993 to 2002 in such branches as telecommunication systems and consumer electronics, financial services, information technologies, medical facilities, drugs and pharmaceutical industry. Among various standpoints of research two main cluster formation theories are distinguished that describe various ways in which enterprises, business and government entities as well as representatives of academic community join efforts in a production cluster. The first theory is based on M. Porter's theory [28] about the ability of economic subjects to organize themselves in clusters on their own account under the influence of free market trends. This approach formed back in the 1980s-1990s and is also referred to as classical or liberal. In addition, Delgado M., Porter M., and Stern S. [28] consider the influence of clusters on entrepreneurship. The authors focus on the various roles of convergence and agglomeration in the increase in the number of firms as well as on the hiring process in these new firms. The second theory was invented in France in 2006 and is based on the idea of poles of competitiveness. This approach stems from the public-private collaboration principle. In this theory public authorities collaborate with businesses and support companies joining effort in clusters to make the national economy more competitive. Public-private collaboration is not analyzed in this work. The main result is that cluster analysis has helped distribute financial means for solving specific crop farming and stock raising problems. In this case the distribution of investments by sorting preferences and counting the number of votes cast in their favor is replaced with the scientific method. Thus, it is not a particular firm or region winning in this case but science (objective reality). The consequences of making this step in practice are that investments made by the scientific method have to do not with petitions by interested persons but with actual circumstances.

4. Conclusions

The goal set was to elaborate the scientific method of distributing investments, and it has been achieved. The cluster analysis of the Saratov oblast' has helped calculate the optimal amount of investments necessary for crop farming (RUB 635, 271 thousand) and stock raising (RUB 915,227 thousand). That said, the respective shares for solving each specific problem have been determined: in crop farming these problems include efficient rotation (RUB 49,964,950), fertilizers (RUB 34,042,815), seed bank (RUB 104,564,615), etc.; in stock raising these problems are immunologic prophylaxis (RUB 230,868,843), treatment of mass viral diseases in cattle (RUB 297,024,000), ensilage conservation (RUB 34,191,137), etc.

References

Barsukova S. Inevitable Losses and Potential Benefits for National Agribusiness from Russia's Joining WTO [Prisoyedineniye Rossii k VTO: neizbezhnyye poteri i vozmozhnyye priobreteniya dlya agrobiznesa]. Voprosy statistiki. 2013. No. 3. Pp.77-79.

Belousov S. A. Creation of Stock Raising Cluster as Means of Making AIC Attractive for Investments: Case Study of Lipetsk Oblast' [Sozdaniye klastera zhivotnovodstva kak instrument formirovaniya investitsionnoy privlekatel'nosti APK (na materialakh Lipetskoy oblasti). Menedzhment v Rossii i za rubezhom (Management in Russia and Abroad). 2011. No. 6. Pp. 63-67.

Belolipetskiy A. and Gorelik V. Economic Mathematical Methods [Ekonomiko-matematicheskiye metody]. Moscow: Academia, 2010.

Berg A. I. and Dmitriev Yu. A. Cluster Approach to Providing Competitiveness to Subjects of Socioeconomic Activities [Klasternyy podkhod v obespechenii konkurentosposobnosti sub"yektov sotsial'no-ekonomicheskoy deyatel'nosti]. Sovremennaya konkurentsiya (Modern Competition). 2012. No. 5 (35). http://readly.ru/book/16741.

Gitis L. Cluster Analysis in Classification, Optimization, and Prediction Tasks [Klasternyy analiz v zadachakh klassifikatsii, optimizatsii i prognozirovaniya]. Moscow: Moscow State Mining University, 2001.

Gitis L. Statistical Classification and Cluster Analysis [Statisticheskaya klassifikatsiya i klasternyy analiz]. Moscow: Moscow State Mining University, 2003.

Saratov oblast' Law 56-ZSO of April 28, 2016 "On Strategic Planning in Saratov Oblast'" [O strategicheskom planirovanii v Saratovskoy oblasti] adopted on April 22, 2015 by the Saratov oblast' Duma according to Federal Law 172-FZ of June 28, 2014 "On Strategic Planning in Russian Federation".

Klyuchnikov M. V. Technology of Cluster Analysis of Financial Figures of Banks [Tekhnologiya klasternogo analiza finansovykh pokazateley bankov]. Prikladnaya informatika (Applied Informatics). 2006. No. 1. https://www.litres.ru/m-v-kluchnikov/tehnologiya-klasternogo-analiza-finansovyh-pokazateley-bankov/

Concept of Developing Agrarian Industrial Complex of Rostov Oblast' up until 2020 [Kontseptsiya razvitiya agropromyshlennogo kompleksa Rostovskoy oblasti na period do 2020 goda] adopted on May 23, 2012 by Rostov Oblast' Government Decree 424. http://www.don-agro.ru/FILES/KONC2020/koncepciya-razvitiya-APK-2020.pdf.

Nikulina O. V. and Pankina I. S. Economic Clusterization As Efficient Form of Developing Innovative Activities on Foodstuff Industry Enterprises: Case Study of Krasnodar Kray [Klasterizatsiya ekonomiki kak effektivnaya forma razvitiya innovatsionnoy deyatel'nosti predpriyatiy pishchevoy promyshlennosti (na primere Krasnodarskogo kraya]. Regional'naya ekonomika: teoriya i praktika (Regional Economics: Theory and Practice). 2012. No. 32(363). Pp. 9-17.

Popov A. M. and Sotnikov V. N. Economic Mathematical Methods and Models [Ekonomiko-matematicheskiye metody i modeli]. Moscow: Yurait, 2017.

Popova A. I. Ensuring Financial Sustainability of Agricultural Organizations, Taking Account of Seasonal Production Variability: Modeling Potential for Economic Development [Obespecheniye finansovoy ustoychivosti sel'skokhozyaystvennykh organizatsiy s uchetom sezonnosti proizvodstva: modelirovaniye potentsiala ekonomicheskogo razvitiya]. Regional'naya ekonomika: teoriya i praktika (Regional Economics: Theory and Practice). 2012. No. 37(368). Pp. 58-70.

Russian Government Decree 717 of July 14, 2012 "On State-Run Program of Agricultural Development and Regulating Agricultural Commodities, Raw Materials, and Foodstuff Markets in 2013-20" [O gosudarstvennoy programme razvitiya sel'skogo khozyaystva i regulirovaniya rynkov sel'skokhozyaystvennoy produktsii, syr'ya i prodovol'stviya na 2013-2020 gody]. Rossiyskaya gazeta. 2012. No. 5832.

Saratov Oblast' Government Decree 520-P of October 2, 2013 "On State-Run Program of Agricultural Development and Regulating Agricultural Commodities, Raw Materials, and

Foodstuff Markets in Saratov Oblast' 2014-20 (As Amended on December 24, 2018) [O gosudarstvennoy programme Saratovskoy oblasti «Razvitiye sel'skogo khozyaystva i regulirovaniye rynkov sel'skokhozyaystvennoy produktsii, syr'ya i prodovol'stviya v Saratovskoy oblasti na 2014-2020 gody» (s izmeneniyami na 24 dekabrya 2018 goda)].http://docs.cntd.ru/document/977400942

Husnutdinov R. Economic Mathematical Methods and Models. Study Guide [Ekonomiko-matematicheskiye metody i modeli. Uchebnoye posobiye]. Moscow: Infra-M, 2016.

Stepanov V. And Terpugov A. Economic Mathematical Modeling [Ekonomiko-matematicheskoye modelirovaniye]. Moscow: Academia, 2009.

Uzun V. Russian Policy of Supporting National Agricultural Industry and Need for Its Modification upon Joining WTO [Rossiyskaya politika podderzhki sel'skogo khozyaystva i neobkhodimost' eye korrektirovki posle vstupleniya v VTO]. Voprosy ekonomiki. 2012. No. 10. Pp.132-149.

Uskova T. V., Barabanov A. S., Ilyin V. V., Iogman L. G., Popova O. I. Production Clusters as Means of Improving Regional Competitiveness [Proizvodstvennyye klastery kak instrument rosta konkurentosposobnosti regiona]. Vologda: Vologda Research Center of the Russian Academy of Sciences. 2009.

Ushachev I. Scientific Support of State-Run Program of Agricultural Development and Regulating Agricultural Commodities, Raw Materials, and Foodstuff Markets in 2013-20 (Following Report on General Meeting of Russian Academy of Agricultural Sciences on February 14, 2013) [Nauchnoye obespecheniye Gosudarstvennoy programmy razvitiya sel'skogo khozyaystva i regulirovaniya rynkov sel'skokhozyaystvennoy produktsii, syr'ya i prodovol'stviya na 2013-2020 gg. (po materialam doklada na Obshchem sobranii Rossel'khozakademii 14 fevralya 2013 goda)]. APK: ekonomika, upravleniye (AIC: Economics and Management). 2013. No. 3. Pp.13-26.

Shilovskaya N. A. Financial Mathematics: Manual and Practical Course [Finansovaya matematika. Uchebnik i praktikum]. Moscow: Yurait, 2017.

Agriculture in Saratov Oblast' in 2001-15: Analytical Essay [Sel'skoye khozyaystvo Saratovskoy oblasti (po sostoyaniyu na 2001 – 2015 gody) - analiticheskaya stat'ya]. Expert and Analytical Center of Agribusiness "AB Center". http://ab-centre.ru/page/selskoe-hozvavstvo-saratovskoy-oblasti (Accessed February 3, 2018).

State-Run Program of Agricultural Development and Regulating Agricultural Commodities, Raw Materials, and Foodstuff Markets in 2013-20. Adopted by Russian Government Decree 717 of July 14, 2012 [Gosudarstvennaya programma razvitiya sel'skogo khozyaystva i regulirovaniya rynkov sel'skokhozyaystvennoy produktsii, syr'ya i prodovol'stviya na 2013-2020 gody. Utverzhdena postanovleniyem Pravitel'stva ot 14 iyulya 2012 goda № 717]. http://government.ru/programs/208/events

Pressing Problems of Stock Raising and Potential Ways of Solving Them [Ostryye problemy v zhivotnovodstve i vozmozhnyye puti ikh resheniya]. https://agrarnyisector.ru/zhivotnovodstvo/ostrye-problemy-v-zhivotnovodstve-i-vozm puti-ikh-resheniya.html. (Accessed November 6, 2012).