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SYSTEMS APROACH FOR RISK MANAGEMENT IN REGIONAL SYSTEMS

INTRODUCTION

Regional policy takes an important place in economic policies of developed countries and countries with transition economy.

Developed countries show many examples of effective decision of regional problems that are actually for Ukraine regions [1, 2]. Policies and programmers' that promote regional development are formed. Within the framework of them the necessity of active participation and interference of country in regional policy development about stimulation of competitor-capable regions development, contribution of dialogue between central and local authorities about ensuring of economic and social regions development in globalization, innovation policy development is recognized. Budget expenses on regional policy and regional territorial development makes about 30% of budget. The higher development level of country is, the larger accent in regional development policy is made on „problem" of depression and lesser on backward regions and the other way round.

One of the main strategic directions of policy touches upon the problem of selection between policies, directed on maximum straightens of social-economic development levels of all regions of country and policy, directed on receiving of maximum return from each region. Determination of political stimulation measures of overcoming depression of each territory is a process, that needs elaboration of goal-directed programmers' of development, that have to count up a lot of contradictory conditions, factors and resource restrictions from system analysis point of view.

MONITORING AND REGIONAL MANAGEMENT

Monitoring results and results of value of depression territory conditions, territory classification by the level of development is the reason for giving goal-oriented

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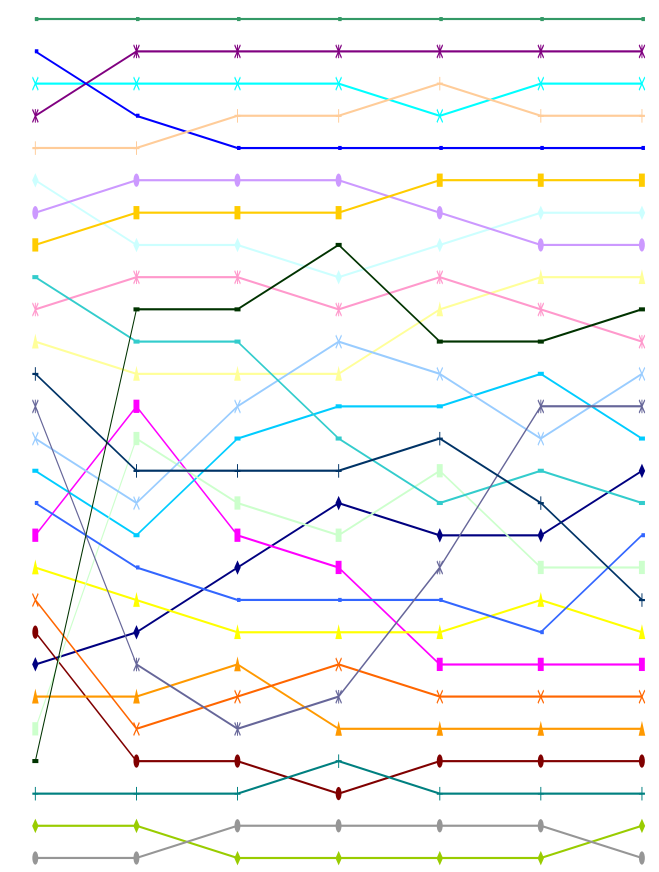
Table 1. Ranks of Ukrainian regions in 2000-2006 years

<table>
<tr><th colspan="7">Rank change by years</th><th rowspan="3">Region that had proper rank in 2006 year (color of Pareto layers for period 2002-2006 years)</th></tr>
<tr><th colspan="4">Gross added value counting on 1 person (in factual prices), grn.</th><th colspan="3">Gross reginal product counting on 1 person (in factual prices), grn.</th></tr>
<tr><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th></tr>
<tr><td colspan="7" rowspan="27"></td><td>Kyiv city</td></tr>
<tr><td>Donetsk region</td></tr>
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<tr><td>Sevastopol city</td></tr>
<tr><td>Lviv region</td></tr>
<tr><td>Ivano-Frankivsk region</td></tr>
<tr><td>Chernihiv region</td></tr>
<tr><td>Kirovograd region</td></tr>
<tr><td>Sumy region</td></tr>
<tr><td>Crimea</td></tr>
<tr><td>Cherkasy region</td></tr>
<tr><td>Rivne region</td></tr>
<tr><td>Volyn region</td></tr>
<tr><td>Vinnitsa region</td></tr>
<tr><td>Khmelnitsky region</td></tr>
<tr><td>Kherson region</td></tr>
<tr><td>Zhytomyr region.</td></tr>
<tr><td>Transcarpathian region</td></tr>
<tr><td>Chernivtsi region</td></tr>
<tr><td>Ternopil region.</td></tr>
</table>

financial, legislative and technology help to such territories to lead them out of crisis position. Therefore it is necessary to range regions by certain criterion for accurate account of depressiveness and work facilitation of division helping for territories.

In Ukraine the stimulation of regional development is realized due to redistribution of national budget from successful regions to backward regions with the purpose of development investment territory attraction, their industrial infrastructure, increasing of population life level.

Estimation of development condition of territories and definition of possible purposeful actions of government stimulating of regional development are considered as compound elements of single system methodology of investigation problems of depressing for four types of territories: regions, industrial regions, rural regions, cities of regional (republican in Crimea) significance.

On Table 1. three Ukraine region ratings are represented: from 2000 year till 2006 year.

Critical infrastructure of region is a very important part of regional policy. Technological risk has always been associated with negative consequences for environment causing very serious problems for industrial societies. It has influenced human life as well as psychological and material state of an individual and society as a whole. Recently the problem has become even more urgent due to wide-scale practice of dangerous technologies operation. It is worthwhile to mention just a few technological processes which cause significant threat to the environment: nuclear and thermal power plants, natural gas and oil pipelines, large pump stations, processing industries, chemical and petro-chemical factories, etc. Consequences of technological catastrophes and accidents not only affect adjacent regions but also cause the so-called spill-over effect for the entire world in form of acid rains, water and air pollution, nuclear contamination, etc. [4, 5]. Therefore, large environmental impacts which are associated with technological accidents may lead to irreversible ecological processes.

The problem of regulation and management of these hazardous operations is directly associated with the problem of technological risk reduction. In order to solve this problem it is necessary to design a system of probability evaluation of an accident as well as costs necessary for risk reducing measures. Of course, the solution will require significant investment. However, the objective of safe environment and risk reduction is an international problem because it involves different countries and regions as well as economic and ecological systems, technological and psychological factors of different societies. That is why the solution to the problem of management of regional systems based upon system analyses approach and system principles [6, 7].

MODELS AND METHODS OF DECISION MAKING FOR ANALYSIS OF THE RESULTS OF MONITORING OF THE REGIONAL SYSTEMS

Classical mathematical models and methods of multicriteria optimization problem and expert evaluation of alternatives are widely used in systems analysis in investigating technical, ecological and economic systems, regional and social systems [6, 8, 9].

Applying these methods to investigate the depressive problem in Ukraine on the basis of the Law allows the ordering of alternatives (the territories of the region[10]), identifying them as the solution of multicriteria optimization problems, followed by division into groups (clusters) in which the alternatives are close to each other by integral indicators.

To improve the quality of research uses the principle of diversity [7], when simultaneously several methods (three methods) of decision-making for each of the groups and areas are used and the most close (in some sense) territories to potentially depressed areas are defined (fixed („ideal" alternative) territory, which has a worst-case values simultaneously on all the criteria for the respective periods of monitoring).

Use of mathematical methods for decision-making involves the construction of mathematical models that formally describe the problem situation of choosing a solution from the set of alternatives A, $A = \{\alpha\}$, taking into account the criteria [6].

Indicate $f_i(\alpha)$, $i \in I = \{1, 2, ..., m^*\}$ as a criteria (maximized, minimized), that are taking into account in selection of alternatives. Criteria define the essential properties (characteristics) of the solutions and the „intensity" and are given in a certain scale (number line, a set of values, etc.). Alternatives characterized by different values of criteria (numerical characteristics, indicators of the usefulness or effectiveness, cost, etc.).

Criterion value can be either a positive number (gross domestic product, unemployment rate) or negative. Criteria values may be restricted from above (below) by some fixed values (constraints), for example, the number of employees in the industry.

A widely known method for solving multicriteria optimization problems based on the construction of the convolution (generalized vector criterion) which is constructed from selected criteria and their weights with the fixation of the importance of each individual criterion.

Importance or weight of the criteria can be obtained using the methods of expert estimation [6]. The disadvantage of this method is the fact that the convolution of criteria is not possible in solving problems with qualitative and quantitative criteria, and a large number of criteria make it difficult to form the weights of criteria by experts.

A special case of convolution method is the rating assessment, where „rate" is some integral estimation. Rating agencies and international organizations provide different ratings according to different indicators for the formation of the level of economic development in different countries, the quality of training at universities, etc., which stimulates the development and use of scientific methods of statistical data analysis and formation ratings based on these ratings.

Reaction of many countries was a desire not only to determine its place in a single world rating scale, but also to understand the situation and the state of economic development inside the country concerning various areas and regions. Regional policy and regional rankings are useful, first, to better understand the general trends of economic development, and secondly, they allow individual regions „to look at ourselves", to define its place in a single national scale. Third, we can directly affect the economic development of the region (since the possibilities of obtaining investment largely determine the prospects for socio-economic development of the region).

Each alternative $\alpha \in \mathrm{A}$ is wholly characterized by appropriate (vector) *estimation* that is a vector $f(\alpha) = (f_1(\alpha), f_2(\alpha), ..., f_{m*}(\alpha))$. Choosing of the best alternative α^* from the set of alternatives A comes to choosing the optimal estimation of the set of acceptable estimations $Y(\mathrm{A}) = \{y \mid y = f(\alpha),\ \alpha \in \mathrm{A}\}$.

In general, the multicriteria optimization problems is [6]:

$$f_i(\alpha) \to \max,\ \ i \in I_1,$$

$$f_i(\alpha) \to \min,\ \ i \in I_2,$$

$$\alpha \in \mathrm{A},$$

where $I_1 = \{1,...,m\}$ – the index set of criteria that is maximized, and $I_2 = \{m+1,...,m^*\}$ – the index set of criteria that are minimized, the index set of all criteria is $I = I_1 \cup I_2, I_1 \cap I_2 = \varnothing$.

Subject to the structure of set A and properties of criteria multicriteria optimization problems are considered in a discrete setting, with a finite number of alternatives and linear or monotone criteria.

We consider the formalization of multicriteria optimization problem which solution determines the set of areas close to depressed. Large number of indicators that should be considered in the study of the level of development areas indicates the need for grouping the indicators and determining the weights for a group of indicators.

Let $\mathrm{A}_j = \left\{\alpha_1^j, \alpha_2^j, ..., \alpha_{n_j}^j\right\}$, $j \in J = \{1,2,3,4\}$ as a set of alternatives that correspond to areas of the j type. Let A_1 – a set of alternatives (areas) that are associated with regions, A_2 – with industrial areas, A_3 – with rural areas, A_4 – with the towns of regional importance (Republic in the Crimea).

Indicate $f_{it}^j(\alpha)$ as an i indicator (criterion) $i \in I_j = \{1,...,m,...,m^*\}$, which is a characteristic of the development level of the territory $\alpha \in \mathrm{A}_j$ of j type in a period $t \in T_j$ (for example, the value of gross regional product (gross extra cost for 2004 year) per 1 person (at current prices), USD, 2004 year). $I_j^1 = \{1,...,m\}$ – index set of indicators $f_{it}^j(\alpha)$, the worst value of which corresponds to the maximum value, and $I_j^2 = \{m+1,...,m^*\}$ – the index set of indicators, the worst value of which corresponds to the minimum, where the set of indexes is $I_j = I_j^1 \cup I_j^2, I_j^1 \cap I_j^2 = \varnothing$. For the regions is $I_1^1 = \varnothing, I_1^2 = \{1,...,5\}$ and for industrial districts $I_2^1 = \{1,2\}$, set $I_2^2 = \{3,4\}$.

When monitoring and investigating the problem of depression according to the Law the duration period T is determined. This period estimates the number of years and statistics data on them, which are used in the calculations. For regions that period is five years, that is $T = \{1,....,5\}$, and for industrial and rural areas and towns of regional (Republic Crimea) importance this period is three years, that is $T = \{1, 2, 3\}$.

Task of assessing the state of development of regions and territories of Ukraine on statistical indicators have a number of characteristics:

– for each type of area used a different set of indicators;

– consider the values of indicators for several years (five for the regions, three for other groups of territories);

– indicators have different units and scales of measurement;

– indicators have different directions of optimization (minimized, maximized).

Therefore, in solving this class of problems must be considered:

– different dimension indicators (units on the scale);

– the dynamics of change indicators (temporary);

– the ideal and the initial state of the territories (condition, with which it is possible to compare other alternatives).

As the monitoring and analysis of depressive areas is carried out by different indicators, which have different qualitative characteristics, dimension, take the values at different intervals, it is necessary to use a monotonic transformation (normalization of values), which lead their values to the dimensionless form. Monotone transformations must satisfy the following conditions [6]:

– take into account the need to minimize the deviation of the values of indicators of development areas for each indicator for all periods;

– have a common start point of counting all values for all the territories, as well as order of changing of their values;

– to save preference relations that are set when comparing alternatives, taking into account a number of different indicators.

Such a transformation, which meets the requirements, for example, has the following monotonic transformation [6]:

$$w_{it}^{j}(\alpha) = \begin{cases} \dfrac{f_{it}^{j0} - f_{it}^{j}(\alpha)}{f_{it}^{j0} - f_{it(\min)}^{j}} & i \in I_j^1, \\[2ex] \dfrac{f_{it}^{j}(\alpha) - f_{it}^{j0}}{f_{it(\max)}^{j} - f_{it}^{j0}} & i \in I_j^2, \end{cases}$$

where f_{it}^{j0} – the optimum (maximum for $i \in I_j^1$, minimum for $i \in I_j^2$) index value of the i type for the period t, $f_{it(\min)}^{j}$ – the minimum index value of the i type for the period t; $f_{it(\max)}^{j}$ – the maximum index value of type i for the period t.

The principal feature of multicriteria optimization problems is that not every pair of solutions (alternatives) can be compared on a set of criteria, as pairs of solutions not always are the best solutions for the set of criteria. Therefore, the problem of finding efficient (Pareto optimal) solutions of special algorithms of multicriteria optimization arises.

In order to find compromise solutions the method of „ideal point", which does not use additional information from decision making person about preferences on the set of criteria, is used. In this case, the assumption of the existence of the so-called „optimal" or „ideal" solution of the multicriteria optimization problem, which can be found by transforming the multicriteria optimization problem in the corresponding one-criterion problem, is done. The rule for choosing a compromise variant in this method consists in finding an alternative that has the estimate closest to the ideal point in a given metric. The ideal is a point in space estimates, whose coordinates correspond to the optimal values of the criteria. The Euclidean metric is used:

$$w_1^*(\alpha) = \sqrt{\sum_{j \in J_k} \sum_{t \in T_{jk}} \left(w_{jt}(\alpha) \right)^2}, \ \alpha \in A_k, \tag{1}$$

where A_k – a set of alternatives (territories) in the k problem (for the k type of territories), j - is a criteria, J_k – the set of criteria for the k problem (indicators of development for the k type areas), T_{jk} – the set of periods (years), in which investigated j criterion (indicator) in k problem, $V_{jt}(\alpha)$ – the value of the j criterion (indicator) in t period for the alternative α.

Also the following measure of closing to „depressed" alternative is used

$$w_2^*(\alpha) = \frac{1}{n_k} \sum_{j \in J_k} \sum_{t \in T_{jk}} w_{jt}(\alpha), \ \alpha \in A_k, \tag{2}$$

where $n_k = | A_k |$ – number of alternatives (territories) in k task.

In order to find compromise solutions of multicriteria discrete optimization problem the method of restrictions, which use the values $V_{jt}(\alpha)$ (from the ideal point method), with measure of approximation to the „depressed" alternatives for different types of areas, is used:

$$w_0^*(\alpha) = \max_{j \in J_k,\, t \in T_{jk}} \left\{ \rho_j \cdot w_{jt}(\alpha) \right\}, \ \alpha \in A_k, \tag{3}$$

where ρ_j - weights, $\rho_j > 0, \sum_{j \in J_k} \rho_j = 1$. For the equivalent criteria weightings ρ_j - are the same. The problem of finding compromise areas that are close to the potentially depressive is reduced to the following multicriteria optimization problem:

$$w^*(\alpha) \to \min, \tag{4}$$

$$\alpha \in \mathrm{A}, \tag{5}$$

where instead of the criterion $w^*(\alpha)$ one of the measures under consideration (1) – (4) is used, and the set of alternatives corresponds to one of the groups of territories.

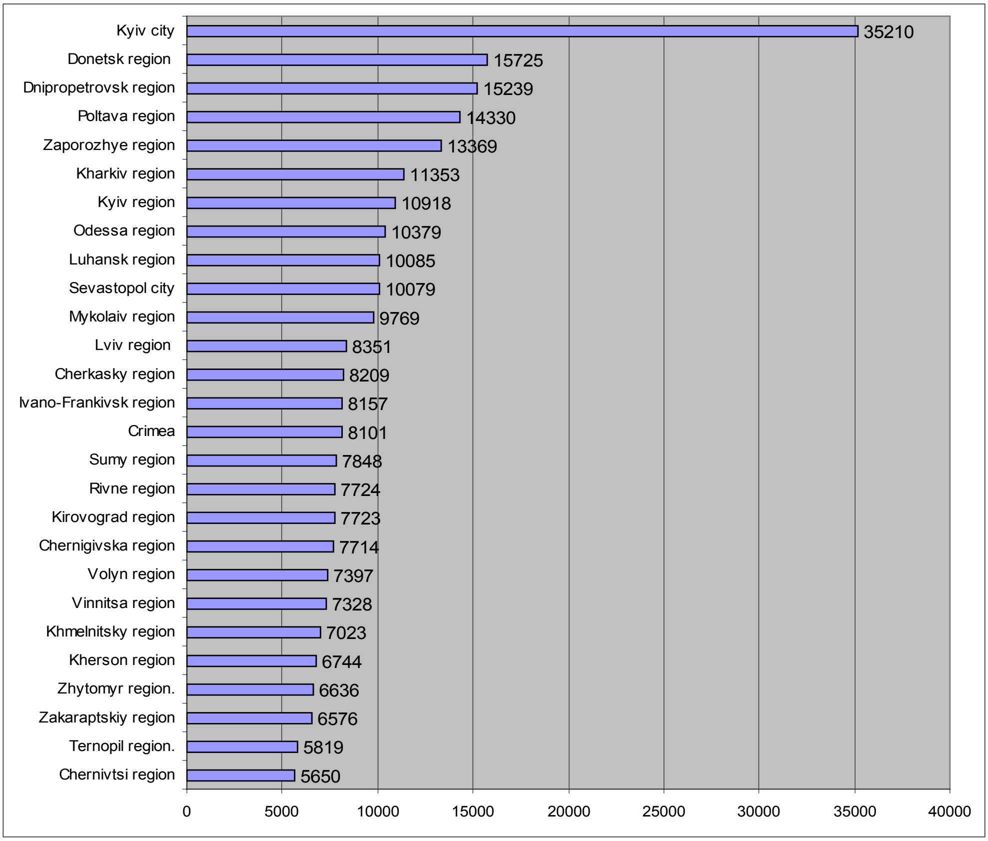

Figure 1. Ordered gross regional product in 2006 year

On Figure 1. the gross regional product per capital for 2006 for the regions (ordered by the decrease in the index) is represented. It should be noted a significant disproportion between the values of the regions.

On Figure 1. it is possible to see the ranks of the region for three consistent phases of research the problem of depressed regions (five years from2000 to 2006) as well as lines that represent the change in rank of the region between years. With different colors a set of equivalent alternatives (the fibers) are marked. The best alternatives are painted in green; the worst (crisis area) are colored red. It should be noted that a large number of alternatives, 2/3 of all the alternatives are yellow that means that many areas have roughly the same values of integrated index. However, this is a reflection of the statistical indicators of development areas.

RISKS ANALYSES IN REGIONAL SYSTEM

Risk-management in regional system reflects paradigm changes, on what business rely on while operating uncertainty factors that prevent to achieve financial, operating, strategic goals of region. It is necessary to reveal risks before regional system starts to realize risk-management program, because effective operation in modern conditions demands from regional system goal-oriented efforts for revealing all considerable risks. These risks are necessary to be ranged by certain scale with accounting of their significance or terms of money [3].

Consider large-scale territorial-distributed regional systems (e. g., a set of regions as set of *n* subdivisions) that continuously participate in system and for them in time periods $t_0 \ldots t_m$ ratings are defined [8, 9].

The observations of subdivisions behavior is described in matrix: $X_{nm} = \{x_{ij} \mid i \in I, j \in J\}, I = \{1, 2, ..., n\}, J = \{0, 1, ..., m\}$, whose elements x_{ij} by columns defined subdivisions ratings (ordinal numbers) in fixed time period. On basis of matrix X_{nm} for each i subdivision it is possible to generate matrix F_i (incidence matrix), whose elements f^i_{jk} indicate the number of times subdivision i move from state j to state k in period of $t_0 \ldots t_m$.

For describing transitions between states of the whole large-scale territorial-distributed systems use matrix $F = [f_{jk}]_{j \in J, k \in I}, f_{jk} = \sum_{i \in I} f^i_{jk}, f_j = \sum_{k \in I} f_{jk}$, whose elements are summed elements of matrix $F_i, i \in I$. Than $P = [p_{jk}]_{j \in J, k \in I}$ – transition matrix, whose elements $p_{jk} = p_{k \setminus j} = \frac{f_{jk}}{f_j}$ – are conditional probabilities, and f_j - sum of the rows of this matrix. Distributions p_{jk} contain information about ordinal transitions in system and matrix is Markov matrix since $p_{j.} = \sum_{k \in I} p_{jk} = 1$ and $p_{.k} = \sum_{j \in J} p_{jk} = 1$. This matrix is doubly stochastic.

The entropy function allows the direct measure of the information that is in the observations which underlie the probability distributions describing regional system behavior. The average conditional entropy $E_{(k/j)}$ of regional system is:

$$E_{(k/j)} = -\sum_{j \in J} \sum_{k \in I} [\frac{p_{k/j} \ln(p_{k/j})}{n}]; p_{jk} \geq 0, \sum_{j \in J} p_{jk} = \sum_{k \in I} p_{jk} = 1,$$

where $E_{(k/j)}$ expresses the amount of information contained in observations on the system if the present subdivisions positions are known, $E_{(k/j)}$ is dimensionless unit of information. Entropy can be normalized with respect to the entropy of hypothetical system, for it $p_{k \setminus j} = 1/n$ is maximum average conditional entropy: $E^*_{(K/J)} = -\sum_{j \in J} \sum_{k \in I} \frac{\ln(1/n)}{n \times n} = \ln n$ and will be counted as $R = \frac{E_{(K/J)}}{E^*_{(K/J)}}$. R expresses the relative uncertainty of the system or risk in regional system.

The relative conditional entropy of a system reflects the average amount of information concerning a subdivision's (region's) transition between two consecutive states, given knowledge of the initial state. R ranges from 0 to 1. If the system is completely certain, that is, when the probabilities of all conditional outcomes are 0 or 1, then the entropy of the system, $E_{(K/J)}$, is 0. As the system entropy approaches the maximum possible entropy, $E^*_{(K/J)}$, R approaches unity. That is, as the probability of each of the transitions in the transition matrix approaches 1/*n,* its entropy approaches the maximum entropy (i. e., that of a random system).

In Table 2. rank added cost for 25 regions of Ukraine and two cities of regional importance is represented.

Table 2. Ukraine regions rating (added cost is a criterion)

		Added value						
№	Region	2000	2001	2002	2003	2004	2005	2006
1	Crimea	21	20	18	16	17	17	15
2	Vinnitsa region a	17	13	17	18	21	21	21
3	Volyn region	18	19	20	20	20	19	20
4	Dnipropetrovsk region	3	3	3	3	4	3	3
5	Donetsk region	4	2	2	2	2	2	2
6	Zhytomyr region	20	24	24	25	24	24	24
7	Transcarpathian region	25	25	25	24	25	25	25
8	Zaporozhye region	2	4	5	5	5	5	5
9	Ivano-Frankivsk region	15	17	14	13	13	12	14
10	Kyiv region	6	8	8	9	8	7	7
11	Kirovograd region	23	14	16	17	15	18	8
12	Luhansk region	11	12	12	12	10	9	9
13	Lviv region	14	16	13	11	12	14	12
14	Mykolaiv region	10	9	9	10	9	10	11
15	Odessa region	7	6	6	6	7	8	8
16	Poltava region	5	5	4	4	3	4	4
17	Rivne region	16	18	19	19	19	20	17
18	Sumy region	9	11	11	14	16	15	16
19	Ternopil region.	26	26	27	27	27	27	26
20	Kharkiv region	8	7	7	7	6	6	6
21	Kherson region	22	22	21	23	23	23	23
22	Khmelnitsky region	19	23	22	21	22	22	22
23	Cherkasy region	13	21	23	22	18	13	13
24	Chernivtsi region	27	27	26	26	26	26	27
25	Chernihiv region	12	15	15	15	14	16	19
26	Kyiv city	1	1	1	1	1	1	1
27	Sevastopol city	24	10	10	8	11	11	10

The value of risk for different period is: R^1 =0.29158 for period 2000–2004 years, R^2 =0.30267 for period 2000–2005 years and R^3 =0.31876 for period 2000–2006 years.

Results of the calculation of system risk in Ukraine for period of 2000–2006 years presented in diagram (Figure 2). For period 2000–2006 years' system risk in-

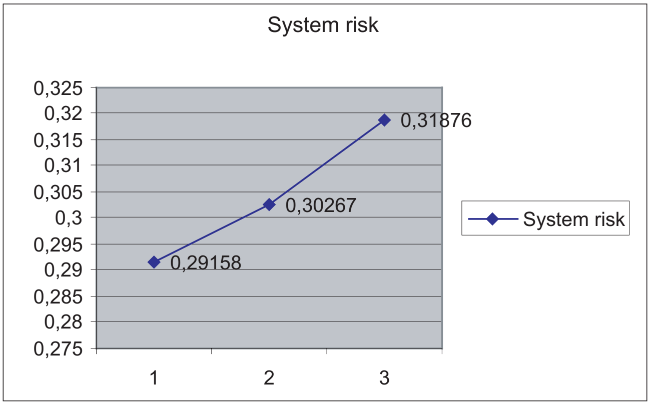

Figure 2. Value of system risk

creased on 10%. Risks of each region by criterion: added cost in calculation on 1 person (in UAH) for 3 periods: 2000-2004 years, 2000-2005 years, 2000-2006 years were calculated. Results are represented in tables.

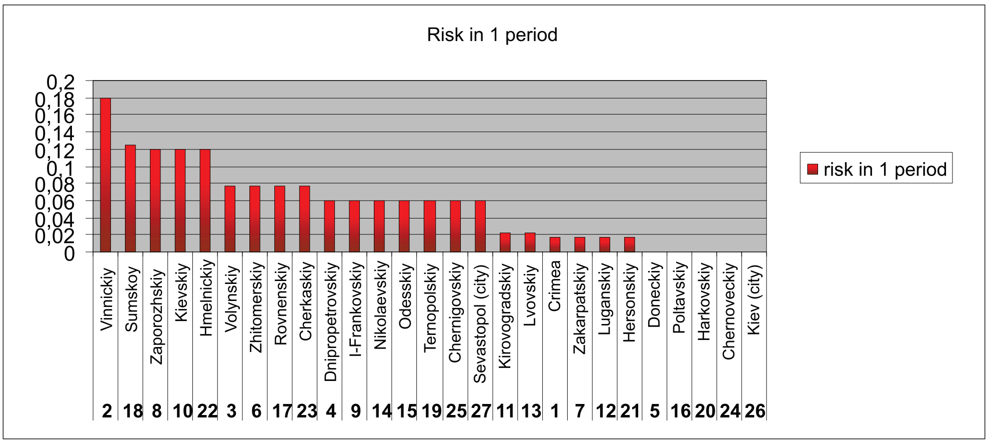

Figure 3. Risk of regions in 1 period 2000–2004

On Figure 3. risk of Ukrainian regions in 1 period (2000-2004 years) is represented. Most risky regions are Vinnickiy, Sumskoy, Zaporozhskiy, Kievskiy, Hmelnickiy.

On Figure 4. risk of Ukrainian regions in 2 period (2000-2005 years) is represented. Most risky regions are Vinnickiy, Sumskoy, Zaporozhskiy, Kievskiy, Odesskiy.

On Figure 5. risk of Ukrainian regions in 3 periods (2000-2006 years) is represented. Most risky regions are Sumskoy, Vinnickiy, Chernigovskiy, Zaporozhskiy, Kievskiy.

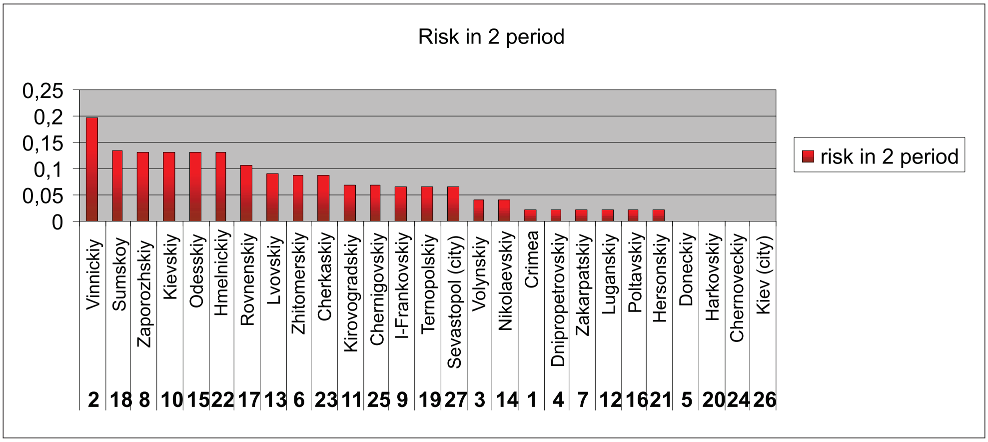

Figure 4. Risk of regions in 2 period 2000–2005 years

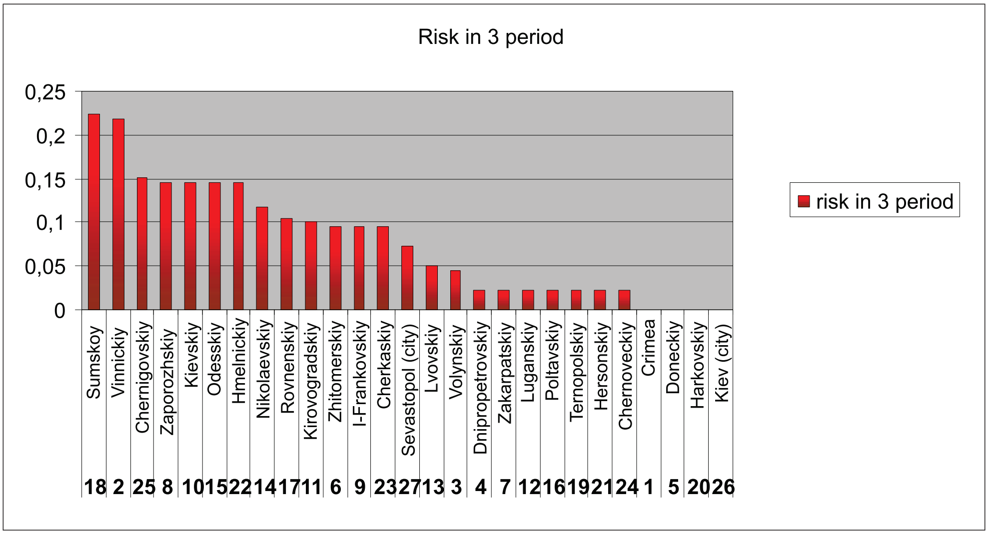

Figure 5. Regions risk in 3 periods 2000–2006 years

CONCLUSIONS

System risk research is an important question for different complex systems. Use of ranks and entropy allows finding system risk values for specified period of solution. Approach that we have considered in this article is applied for calculating risk of regional systems.

Results of calculation of Ukraine regional risk in period 2000-2006 years are represented in diagram (Table 1). For period 2000-2006 years' regional risk in-creased on 10%. Also was used multicriteria optimization method for measurement risk for regional system in Ukraine.

Results are given in Figures 3-5 for three periods. Results are important, while state stimulation efficiency of development of regions will be defined by accuracy of „diagnosis" and adequacy of the using toolbox. That is why so special attention spares to estimate level of territory development, appropriate identification of depressive or problem districts and determination of optimal mechanism of influence on this situation.

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