THE CREATION OF STRATEGY FOR INNOVATION DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS

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Abstract: *The creation the strategy of development of large socio-economic systems is based on the synthesis of the foresight methodology with the methodology of cognitive modeling, which opens up a unique opportunity in the framework of a single program-analytical complex to solve problems of strategic planning and rapid response.*

The model problem of innovative development of the recreational sector of the Southern coast of the Crimea is considered.

Keywords: *foresight methodology, cognitive modeling, sensitivity of the system, structural stability, sustainability of the perturbation, stability by value.*

ACM Classification Keywords: *H.4.2. INFORMATION SYSTEM APPLICATION: type of system strategy*

Introduction

A modeling of searching for the new ways of development of large socio-economic systems at the company, mega polis, large enterprise, and region level is a study of complex systems. A complex system is a holistic environment of a system research, which from the positions of achieving the goals is chosen, formed or created by a person and that allows to build the methodology of research and decision-making with regard to the development of the process of the object cognition in the mind of the researcher. Technological or organizational structure of such systems is hierarchical, multi-level system of interrelated same type or of different type's functional elements, which could be focused in some space or are separated for significant distances.

When creating the formalization of mathematical model of complex system it is necessary to take into account the complexity, nonformalizability, uncertainty, diversity of conceptual interconnections of organizational, technical, technological, economic and other objectives of the different phases of the life cycle of complex systems and the highest price of possible error. It follows the practical necessity of search of new concepts, principles, models and approaches to the creation of strategy of innovative development of large socio-economic systems. The most expedient is to solve the problem on the basis of the synthesis of different methodologies with modern information technologies.

Here for creation the strategy of development of large socio-economic systems is proposed the synthesis of the foresight methodology with the methodology of cognitive modeling, which opens up a unique opportunity in the framework of a single program-analytical complex to solve problems of strategic planning and rapid response.

1. Problem Formation

Methodology of foresight with high status has proven itself in many countries of the world. Application of the methodology allows answering the question "what will be, if...?" and create alternatives of scientifically-based scenarios. In accordance with the methodology of foresight [Zgurovsky M.Z., Pankratova N.D., 2005] at the last stage of the decision-making process, decision-makers are offered 3-4 scenarios that, in general, are complex semi-structured system. Currently in the framework of the foresight methodology a formalization of a number of methods of qualitative analysis (SWOT-analysis, the method of the hierarchy analysis and its modifications, methods of Delphi, cross-analysis, morphological analysis, and others), which became the basis of tools set of alternatives scenarios creation, is made [Zgurovsky M.Z., Pankratova N.D., 2011].

For a substantiated implementation of one kind or another scenario it is advisable to involve cognitive modeling, which allows on the basis of knowledge and experience to build cause-and-effect relationships, understand and analyze the behavior of a complex system and to offer science-based strategy for the implementation of the priority scenario.

Under cognitive modeling it is understood the solution of interrelated problems: the construction of cognitive models (maps'); analysis of the ways and cycles of cognitive models; substantiation of each step of stability modeling by the value, by the perturbation and structural stability; scenario analysis; solution of the inverse problems; decision-making including multifactor risks and uncertainties of different nature.

2. Technology of cognitive modeling

Technology of cognitive modeling is that on the basis of cognitive models to identify possible and rational way to manage the situation with the purpose of transition from the initial state to the desired one. The advantage of cognitive model is that it allows seeing the whole picture and details, to integrate logic and imagination, knowledge and experience.

In the modeling process at each stage of building a model the one of the important issues is substantiation of the reliability of its construction, which is achieved by mathematical justification stability of the model in the process of its creation [Zgurovsky M., Pankratov V.A., 2011]. When assessing the stability of cognitive models it is required that the system when reacting on the environmental changing had about the same equilibrium behavior for some period of time. For the assessment of stability of a complex system the following criteria is accepted:

1st criterion: the state of the system integrity is not output of trajectory of development of the system at the forecast interval of time from some set of safe operation conditions;

2nd criterion: almost monotonous growth of indicators - indicators of development of the object at the certain time interval, and then storing them in the preset interval of admissible values;

3rd criterion: putting of trajectory of development for a certain time in target set of the states;

4-th criterion: resistance to disturbance, including asymptotic stability of programmed and structural stability of the system.

Evaluation of the stability of the object development is carried out on the basis of the first two criteria. These criteria dictate the selection of specific indicators of economic stability of the object of a research, which describe and characterize the evolution of the studied object, the level of its quantitative and qualitative parameters in the system of statistics. The important means are not themselves indicators but their threshold values, i.e. limit values, the neglect values of which interfere with the normal process of various elements of reproduction, lead to the formation of negative, destructive tendencies of economic security.

The indicators used to define the threshold values are the system of indicators of economic stability. Ideally, stability is achieved under the condition that all indicators are set within the allowable limits of their threshold values, threshold values of a parameter is not achieved at the expense of others. All dependencies between sustainability indicators and their thresholds should be considered in the dynamics. In the case of massive "surge" inherent in the market, appear consistent patterns that need to be studied carefully.

The processes of propagation of the disturbances in the system are directly connected with the analysis of sensitivity of the system, its stability, adaptability; study the possibility of emergency situations in the system. That is the main issue in such trials is the question: whether the system behavior is changed significantly as a result of changes (desired, undesirable, unknown, unpredictable) in the mode of natural evolutionary development, as well as in the mode of management?

To develop recommendations for a stable development strategy the third and fourth criteria are used. The application of such criteria requires the involvement and knowledge of the theory of stability, well-developed technical and cybernetic systems and finds its application in studies of nonlinear economic systems from the second half of the 20th century. It is quite obvious that when you create a cognitive model the one of the possible approaches to the solution of the issue of determination of its «objective» is connected with the justification of model "stability".

In this work, when creation a cognitive model the following types of sustainability as structural stability, sustainability of the perturbation and stability by value (numerical stability) are considered.

To study structural stability the cognitive map in the form of a graph is considered. Cycles of the graph conform to the contours of feedback: cycles that characterize the growing tendency to diverge from this condition, meet the contours of positive feedback, and cycles that characterize the suppression of this trend, meet the contours of negative feedback. The cycle is a contour of a positive feedback (even cycle), if it contains an even number of arcs with a minus sign. Otherwise it is a contour of a negative feedback (odd cycle). The presence of the even cycle, having positive production of signs for all of the included arcs, testifies about the structural instability of the system, since it leads to unlimited growth of the values at the vertices of a graph. Changing of the values in any of the top of negative feedback has a negative production of signs for all of the included arcs and only leads to oscillation of tops parameters [Gorelova G.V., Zakharova E.N., Radchenko S.A., 2006], which points to the structural stability of the system.

Research on structural stability, i.e. to find all of the cycles of the graph, is carried out by a recursive search, all the vertices and all possible ways are searched, after which found cycles are investigated on parity. In the program window all the even cycles of the graph, as well as their number are displayed.

The stability of the graph by the perturbation and value is based on the concept of the process of propagation of perturbations of a graph. Determine the value at the top u_i at the moment of time t through $v_i(t), i \in [1, n], t = 0,1,\ldots$. Suppose that the value $v_i(t+1)$ depends on $v_i(t)$ and on the vertices adjacent to u_i. Thus, if a vertex u_j adjacent to u_i and if $p_j(t)$ represents the change in u_j at the moment of time t, it should be considered that the impact of this change on u_i at the moment of time $t+1$ will be described by the function $f(u_j,u_i)p_j(t)$, where through $f(u_j,u_i)$ the weight function of connection between the vertices u_j and u_i is denoted [4]. Thus, we have the following rule of perturbation propagation:

$$v_i(t+1) = v_i(t) + \sum_{j=1}^{N} f(u_j,u_i)\cdot p_j(t)\ \forall i = \overline{1,n}\ ,$$

$$p_j(t+1) = \nu_j(t+1) - \nu_j(t).$$

The vertex is called stable by perturbation, if the sequence $\{|p_j(t)|\}_{t=1}^{\infty}$ is limited. The vertex is called stable by value if the sequence $\{|\nu_j(t)|\}_{t=1}^{\infty}$ is limited. The graph is stable by perturbation (value), if all its vertices are stable.

Such a result: from the stability by value should be the stability by the perturbation.

Thus, the stability by value is reduced to a limited matrix series and the stability by the perturbation - to limited matrix sequence [Gantmakher F.R., 1967].

Thus, the stability by value is reduced to a limited matrix series $\sum_{t=0}^{\infty} A^t$, and the stability by the perturbation - to limited matrix sequence $M_t = \{A^t\}_{t=1}^{\infty}$ [5].

Take the following stability criteria by the perturbation and value.

Criterion 1. The system in the form of signed weighted directed graph G with the adjacency matrix A is stable by perturbation IFF the spectral radius of the adjacency matrix is $\rho(A) = \max_i |\lambda_i| \le 1$, where $\{\lambda_i\}_{i=1}^{M}$ — the eigenvalues A, and is the basis of eigenvectors.

Criterion 2. The system in the form of signed weighted directed graph G with the adjacency matrix A is stable by value IFF spectral radius of the adjacency matrix is $\rho(A) = \max_i |\lambda_i| < 1$, where $\{\lambda_i\}_{i=1}^{M}$ — characteristic numbers A, or $\rho(A) = 1$, but the Jordan form of the matrix is diagonal and there is no eigenvalue equal to 1.

3. Creation of the scenario of innovative development of the recreational sector of the Southern coast of the Crimea

Here the model problem of innovative development of the recreational sector of the Southern coast of the Crimea (SCC) is considered as an example. At the first stage of foresight methodology a SWOT analysis is involved to identify the following critical technologies of the recreation sector of the Southern coast:

Objects of research

V1 - atmosphere; V 2 - drinking water; V 3 - forests; V 4- soils.

Characteristic parameters (criteria)

V 5 - domestic waste; V 6 - sewage water; V 7 - industrial waste; V 8 - CO2 emissions; V9-transport; V10-industry; V 11 – trade; V 12–tourism; V 13 – restoration of resources; V 14 – waste recycling plants; V 15 – reorganization; V 16 – legislation.

At the next stage of the implementation of the process of foresight to identify quantitative characteristics, which are later used as the initial when using cognitive modeling, the Delphi method is involved [Pankratova N. D. and Malafeeva L. Y., 2012]. To assess different actions on objects of eco environment of Southern coast (atmosphere, drinking water, forests and soils) in accordance with the Delphi method a survey of experts was conducted, so that they express their views on selected objects of eco environment with the purpose of further ranking by selected criteria. Objects of eco environment, characteristic parameters (criteria) and their weights are given in table 1.

Table 1. Initial data

Objects of eco environment	Characteristic parameters (criteria)	Weights of characteristic parameters
$O = \{O_n \mid n = 1,4\}$	$I_n = \{I_{np} \mid p = 1,3\}$	$W = \{W_{np} \mid p = 1,3\}$
O_1 = «Atmosphere»	I_{11} = «Domestic waste»	W_{11} =0,35
	I_{12} = «Transport»	W_{12} =0,10
	I_{13} = «Recovered resources»	W_{13} =0,27
O_2 = «Drinking water»	I_{21} = «sewage water»	W_{21} =0,10
	I_{22} = «industry»	W_{22} =0,25
	I_{23} = «Waste processing plants»	W_{23} =0,35
O_3 = «Forests»	I_{31} = «Industry waste»	W_{31} =0,25
	I_{32} = «Trade»	W_{32} =0,30
	I_{33} = «Reorganization (structural change)»	W_{33} =0,30
O_4 = «Soils»	I_{41} = «Emissions of CO_2»	W_{41} =0,30
	I_{42} = «Tourism»	W_{42} =0,35
	I_{43} = «Legislation»	W_{43} =0,25

A priori defined coefficients:	
K = 0,9	Coefficient of accounting the weight of indicators of experts confidence
S^* = 0,65	The ultimate level of consistency
R^{T_1} = 0,3	Radius of the confidence interval

To ensure the reliability of expert assessment at the level of not less than 0.8, it is necessary to form a group with no less than 16 experts, each of which the indicator of competence in the subject area is reasonably obtained (table 2).

Table 2. Indicators of experts' competence

Expert	№ 1	№ 2	№ 3	№ 4	№ 5	№ 6	№ 7	№ 8	№ 9	№ 10	№ 11	№ 12	№ 13	№ 14	№ 15	№ 16
χ_k	0,61	0,61	0,94	0,63	0,99	0,94	0,99	0,61	0,99	0,61	0,94	0,61	0,83	0,99	0,99	0,99

On the basis of statistical researches, the available sources of information on the selected topic and reviews, proposed by each expert $E_k \in E$, in every cell of the questionnaire form expert puts his vision within the interval [0; 1]:

μ_{npk} – Expert evaluation of that criteria will take the specified value from the corresponding level $s = \overline{1,7}$;

ν_{npk} – Degree of expert confidence in each of the answer.

Experts fill out each section of the questionnaire form independently, without information on the evaluation of other experts.

The results of the expert assessment for the object «Atmosphere» on the criterion of «Resource Restoration» and the corresponding weights of indices (see Table. 1) are presented in table 3. Factor, allowing to take into account the weight of the indicators of experts confidence is taken as the following: K=0,8.

Table 3. The expert assessment for the object «Atmosphere» on the criterion of «Resource Restoration»

№	Expert	**Resources restoration**													
		1		2		3		4		5		6		7	
		Too low level		Very low level		Low level		Medium level		High level		Very high level		Too high level	
		μ_{k1}	ν_{k1}	μ_{k2}	ν_{k2}	μ_{k3}	ν_{k3}	μ_{k4}	ν_{k4}	μ_{k5}	ν_{k5}	μ_{k6}	ν_{k6}	μ_{k7}	ν_{k7}
1	Expert 1	0,05	0,99	0,16	0,83	0,38	0,94	0,67	0,63	0,62	0,94	0,97	0,83	0,46	0,94
2	Expert 2	0,83	0,94	0,91	0,83	0,74	0,83	0,45	0,83	0,20	0,94	0,09	0,99	0,04	0,61
3	Expert 3	0,40	0,99	0,54	0,61	0,53	0,83	0,58	0,63	0,55	0,63	0,38	0,63	0,20	0,83
4	Expert 4	0,97	0,99	0,86	0,94	0,55	0,99	0,26	0,83	0,09	0,61	0,03	0,99	0,01	0,63
5	Expert 5	0,85	0,61	0,98	0,63	0,85	0,61	0,55	0,94	0,27	0,61	0,10	0,63	0,03	0,94
6	Expert 6	0,47	0,63	0,59	0,99	0,55	0,83	0,56	0,99	0,50	0,61	0,32	0,61	0,16	0,83
7	Expert 7	0,37	0,94	0,62	0,94	0,75	0,83	0,67	0,83	0,45	0,94	0,31	0,83	0,19	0,99
8	Expert 8	0,35	0,83	0,55	0,61	0,64	0,63	0,55	0,61	0,49	0,63	0,39	0,83	0,22	0,63
9	Expert 9	0,19	0,94	0,39	0,63	0,58	0,61	0,64	0,83	0,53	0,99	0,45	0,63	0,33	0,94

10	Expert 10	0,24	0,61	0,55	0,94	0,83	0,63	0,95	0,61	0,83	0,99	0,55	0,61	0,29	0,83
11	Expert 11	0,10	0,83	0,23	0,99	0,51	0,61	0,79	0,99	0,91	0,99	0,80	0,63	0,54	0,94
12	Expert 12	0,68	0,94	0,78	0,83	0,63	0,99	0,37	0,99	0,17	0,94	0,06	0,94	0,02	0,83
13	Expert 13	0,43	0,99	0,63	0,63	0,67	0,61	0,53	0,83	0,44	0,63	0,32	0,63	0,17	0,63
14	Expert 14	0,99	0,63	0,93	0,94	0,68	0,61	0,37	0,94	0,16	0,61	0,05	0,63	0,01	0,94
15	Expert 15	0,90	0,94	0,99	0,99	0,83	0,83	0,53	0,83	0,25	0,63	0,09	0,94	0,03	0,83
16	Expert 16	0,45	0,61	0,49	0,61	0,61	0,83	0,67	0,83	0,54	0,63	0,32	0,83	0,14	0,63

According to the suggested formalizing of the Delphi method [Pankratova N. D.and Malafeeva L. Y., 2012] the process of formation of the coordinated expert assessments is carried out: interval estimates are built, the quality functional and cluster median are calculated, confidence interval is formed, the consistency of assessments in the cluster is analyzed.

Some expert results agreed by the number of experts' replies were held in trust set given in table 4.

Table 4. Agreed assessments of the expert estimation

Characteristic (criteria)	parameters	Objects of eco envionment			
		V1 Atmosphere	V2 Drinking water	V3 Forests	V4 Soils
V5	Domestic waste	0,36	0,93	0,93	0,21
V6	Sewage water	0,50	0,36	0,50	0,64
V7	Industry waste	0,50	0,36	0,50	0,36
V8	Emissions of CO_2	0,64	0,79	0,36	0,79
V9	Transport	0,83	0,71	0,8	0,61
V10	Industry	0,91	0,92	1,0	0,78
V11	Trade	0,84	0,70	0,78	0,82
V12	Tourism	0,81	0,70	0,98	0,84
V13	Resources restoration	0,62	0,73	0,76	0,79
V14	Waste processing plants	0,73	0,38	0,56	0,54
V15	Reorganization	0,55	0,77	0,64	0,72
V16	Legislation	0,74	0,63	0,82	0,80

Using the results of expert evaluation allowed building the initial adjacency matrix A for cognitive modeling, which is shown in table 5

Table 5. The initial adjacency matrix for cognitive modeling

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16
V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00
V4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00
V5	0.36	-0.93	-0.93	0.21	0.00	0.40	0.00	0.00	0.00	0.00	0.00	-0.50	0.00	0.30	0.00	0.00
V6	0.50	-0.36	-0.50	0.64	0.00	0.00	0.70	0.00	0.00	0.00	0.00	-0.60	0.00	0.00	0.00	0.00
V7	0.50	-0.36	-0.50	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.60	0.00	0.00	0.00	0.00
V8	-0.64	0.79	0.36	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.40	0.00	0.00	0.00	0.00
V9	-0.83	-0.71	-0.80	0.61	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
V10	-0.91	-0.92	-1.00	-0.78	0.80	0.60	0.60	0.70	0.00	0.00	0.50	0.20	0.00	0.00	0.00	0.00
V11	0.84	0.70	-0.78	0.82	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.40	0.00	0.00	0.00	0.00
V12	0.81	0.70	0.98	0.84	0.30	0.00	0.00	0.00	0.80	0.00	0.50	0.00	0.30	0.00	0.00	0.00
V13	0.62	0.73	0.76	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V14	0.73	0.38	0.56	0.54	-0.50	-0.50	-0.50	-0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V15	0.55	0.77	0.64	0.72	-0.50	-0.50	-0.50	-0.50	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
V16	0.74	0.63	0.82	0.80	0.40	0.40	0.40	0.40	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00

In table 5 elements of the matrix are: $a_{ij} = f(v_i, v_j)$ – the weight function that takes the value of the interval [-1;1]. It is equal to 0, if there are no relations between vertices V_i and V_j. The resulting cognitive graph is shown in figure 1.

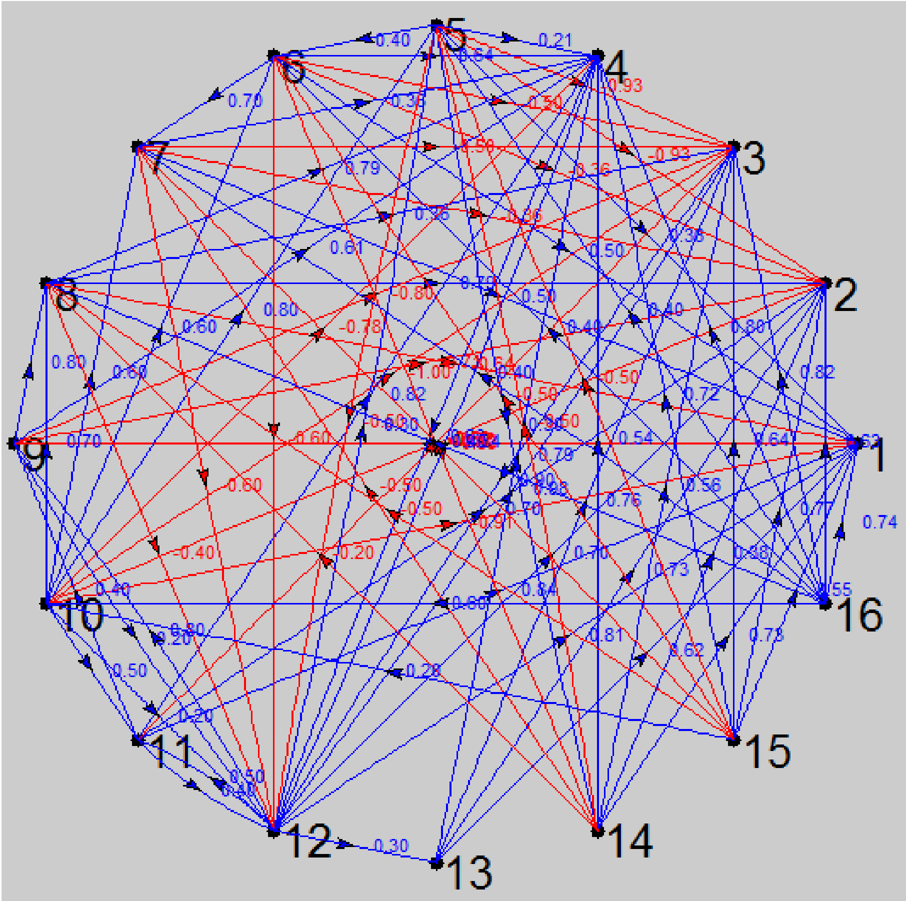

Fig. 1 The cognitive map is presented as the adjacency matrix according table 5

Substantiation of the reliability of building of cognitive maps is achieved by mathematical justification of the model stability in the process of its creation. This model is not stable by any of the considered criteria. For this model the spectral radius $\rho(A)$ **= 1.46118**, that requires a revision of the adjacency matrix to achieve the numerical stability. Considering structural stability **-** we have 26 paired cycles. To achieve structural stability is possible, if you add another factor:

Step 1. Note that we have cycles:

3-12-3 : Forests-Tourism-Forests

4-12-4 : Soils-Tourism-Soils

Improvement of forests leads to improvement of tourism. But improvement of tourism does not lead to the improvement (or deterioration) of forests. A similar situation is with soils. So here, we can remove the link. Obtain stability by the value, perturbation, numerical stability. The number of paired cycles is decreased to 7. The adjacency matrix and the cognitive map are shown in the table 6 and figure 2.

Table 6. The adjacency matrix after the 1st step of modeling

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16
V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V5	0.36	-0.93	-0.93	0.21	0.00	0.40	0.00	0.00	0.00	0.00	0.00	-0.50	0.00	0.30	0.00	0.00
V6	0.50	-0.36	-0.50	0.64	0.00	0.00	0.70	0.00	0.00	0.00	0.00	-0.60	0.00	0.00	0.00	0.00
V7	0.50	-0.36	-0.50	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.60	0.00	0.00	0.00	0.00
V8	-0.64	0.79	0.36	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.40	0.00	0.00	0.00	0.00
V9	-0.83	-0.71	-0.80	0.61	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
V10	-0.91	-0.92	-1.00	-0.78	0.80	0.60	0.60	0.70	0.00	0.00	0.50	0.20	0.00	0.00	0.00	0.00
V11	0.84	0.70	-0.78	0.82	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.40	0.00	0.00	0.00	0.00
V12	0.81	0.70	0.98	0.84	0.30	0.00	0.00	0.00	0.80	0.00	0.50	0.00	0.30	0.00	0.00	0.00
V13	0.62	0.73	0.76	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V14	0.73	0.38	0.56	0.54	-0.50	-0.50	-0.50	-0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V15	0.55	0.77	0.64	0.72	-0.50	-0.50	-0.50	-0.50	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
V16	0.74	0.63	0.82	0.80	0.40	0.40	0.40	0.40	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00

Step2. Note that we have cycles:

9-12-9 : Transport-Tourism-Transport

11-12-11 : Trade-Tourism-Trade

Now consider the transport, trade and tourism: improvement of transport leads to increase of tourists, which in turn increases the number of transport. The situation is similar with the trade. It is therefore proposed to introduce 17th factor that would connect these 3 factors: Tourism-Trade-Transport : Global development of IT technologies». Number of paired cycles is decreased to 5, and circle cycles are disappeared. The adjacency matrix and the cognitive map are shown in table 7 and figure 3.

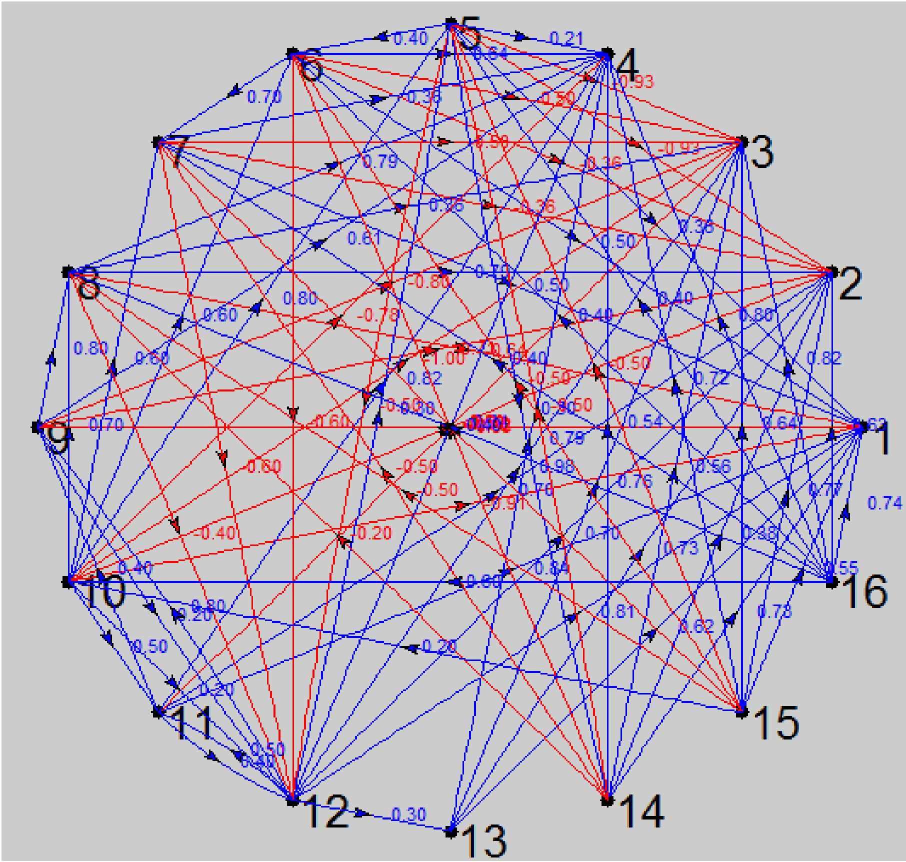

Fig. 2 The cognitive map after the 1st step of modeling

Table 7. The adjacency matrix after the 2nd step of modeling

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17
V1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V3	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0
V4	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0
V5	0.36	-0.9	-0.9	0.21	0	0.4	0	0	0	0	0	-0.5	0	0.3	0	0	0
V6	0.5	-0.4	-0.5	0.64	0	0	0.7	0	0	0	0	-0.6	0	0	0	0	0
V7	0.5	-0.4	-0.5	0.36	0	0	0	0	0	0	0	-0.6	0	0	0	0	0
V8	-0.6	0.79	0.36	0.79	0	0	0	0	0	0	0	-0.4	0	0	0	0	0
V9	-0.8	-0.7	-0.8	0.61	0	0	0	0.8	0	0	0	0.2	0	0	0	0	-0.4
V10	-0.9	-0.9	-1	-0.8	0.8	0.6	0.6	0.7	0	0	0.5	0.2	0	0	0	0	0
V11	0.84	0.7	-0.8	0.82	0	0	0	0	0.4	0	0	0.4	0	0	0	0	0
V12	0.81	0.7	0.98	0.84	0.3	0	0	0	0.8	0	0.5	0	0.3	0	0	0	0
V13	0.62	0.73	0.76	0.79	0	0	0	0	0	0	0	0	0	0	0	0	0
V14	0.73	0.38	0.56	0.54	-0.5	-0.5	-0.5	-0.2	0	0	0	0	0	0	0	0	0
V15	0.55	0.77	0.64	0.72	-0.5	-0.5	-0.5	-0.5	0	0.2	0	0	0	0	0	0	0
V16	0.74	0.63	0.82	0.8	0.4	0.4	0.4	0.4	0	0.6	0	0	0	0	0	0	0
V17	0	0	0	0.1	0	0	0	0	0	0.6	0	0.5	0	0	0	0	0

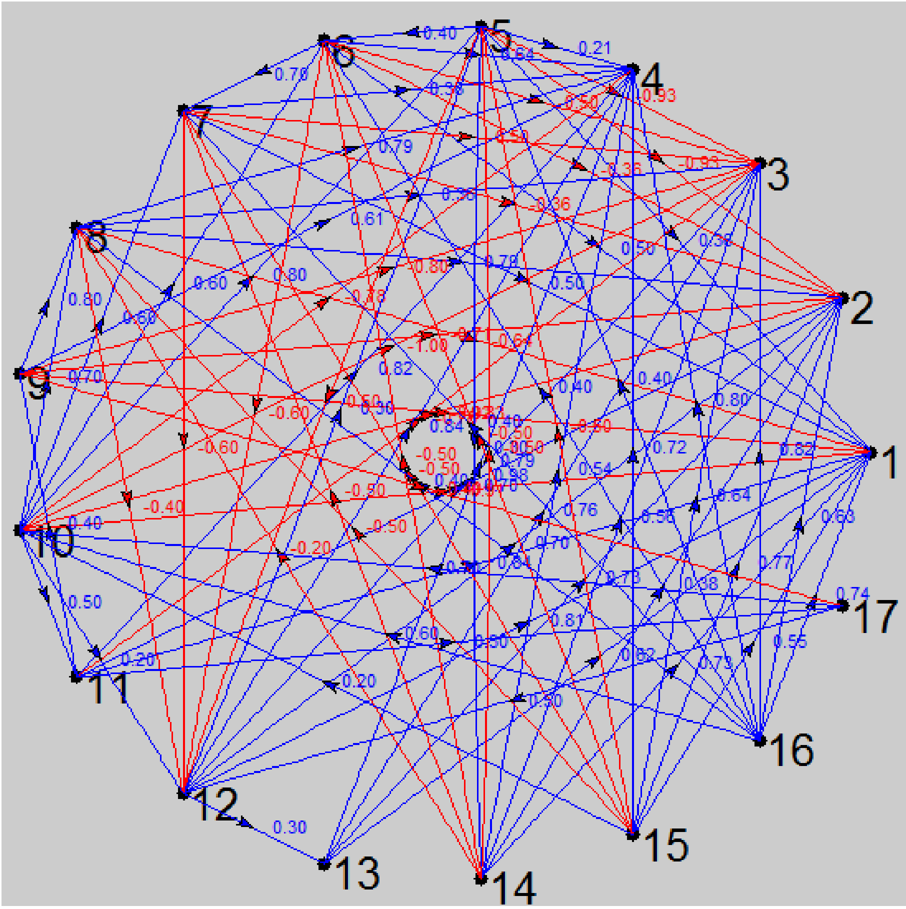

Fig. 3 The cognitive map after the 2nd step of modeling

Step 3. It can be noticed the dependency between «Waste processing plants» and «domestic waste». Domestic waste is treated at these plants. I.e. with the growing number of plants the amount of domestic waste will be decreased. On the other hand, the increasing of the amount of waste does not affect the development of factories, but simply consumes them. Therefore you can remove this link. In this case, the number of paired cycles is decreased to

1. The adjacency matrix and the cognitive map are shown in table 8 and figure 4.

Table 8. The adjacency matrix after the 3rd step of modeling

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17
V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V5	0.36	-0.93	-0.93	0.21	0.00	0.40	0.00	0.00	0.00	0.00	0.00	-0.50	0.00	0.00	0.00	0.00	0.00

V6	0.50	-0.36	-0.50	0.64	0.00	0.00	0.70	0.00	0.00	0.00	0.00	-0.60	0.00	0.00	0.00	0.00	0.00
V7	0.50	-0.36	-0.50	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.60	0.00	0.00	0.00	0.00	0.00
V8	-0.64	0.79	0.36	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.40	0.00	0.00	0.00	0.00	0.00
V9	-0.83	-0.71	-0.80	0.61	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.40
V10	-0.91	-0.92	-1.00	-0.78	0.80	0.60	0.60	0.70	0.00	0.00	0.50	0.20	0.00	0.00	0.00	0.00	0.00
V11	0.84	0.70	-0.78	0.82	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
V12	0.81	0.70	0.98	0.84	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
V13	0.62	0.73	0.76	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V14	0.73	0.38	0.56	0.54	-0.50	-0.50	-0.50	-0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V15	0.55	0.77	0.64	0.72	-0.50	-0.50	-0.50	-0.50	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V16	0.74	0.63	0.82	0.80	0.40	0.40	0.40	0.40	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.50	0.00	0.00	0.00	0.00	0.00

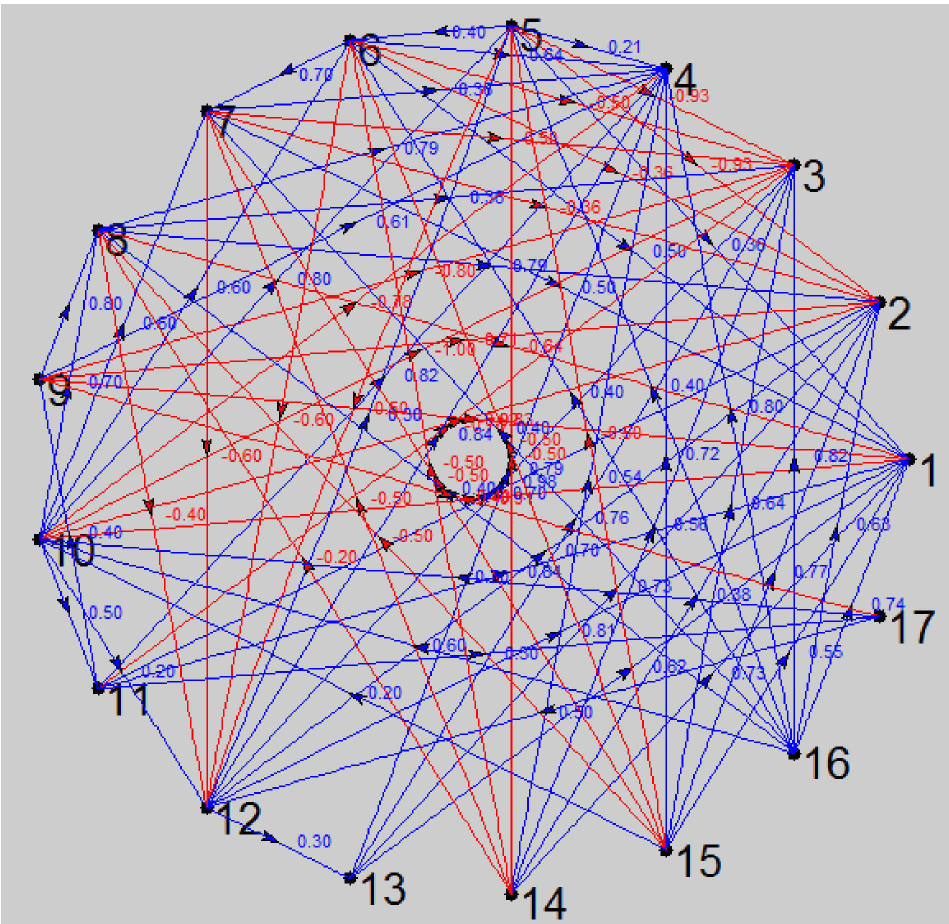

Fig. 4 The cognitive map after the 3rd step of modeling

Table 9. The adjacency matrix after the 4th step of modeling

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17
V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V5	0.36	-0.93	-0.93	0.21	0.00	0.40	0.00	0.00	0.00	0.00	0.00	-0.50	0.00	0.00	0.00	0.00	0.00
V6	0.50	-0.36	-0.50	0.64	0.00	0.00	0.70	0.00	0.00	0.00	0.00	-0.60	0.00	0.00	0.00	0.00	0.00
V7	0.50	-0.36	-0.50	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.60	0.00	0.00	0.00	0.00	0.00
V8	-0.64	0.79	0.36	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.40	0.00	0.00	0.00	0.00	0.00
V9	-0.83	-0.71	-0.80	0.61	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.40
V10	-0.91	-0.92	-1.00	-0.78	0.80	0.60	0.60	0.70	0.00	0.00	0.50	0.20	0.00	0.00	0.00	0.00	0.00
V11	0.84	0.70	-0.78	0.82	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.10
V12	0.81	0.70	0.98	0.84	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00
V13	0.62	0.73	0.76	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V14	0.73	0.38	0.56	0.54	-0.50	-0.50	-0.50	-0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V15	0.55	0.77	0.64	0.72	-0.50	-0.50	-0.50	-0.50	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V16	0.74	0.63	0.82	0.80	0.40	0.40	0.40	0.40	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00

Step 4. Paired cycle 11-10-17-10 is remained. In this link the relation between «Trade» and «Global development of IT technologies» is incoherent. Connect these dependencies, as the development of trade, in particular retail, may adversely affect global development of IT-technologies (Internet-shops are developing more slowly). So, the 4th step of modeling we have received a structural stability. The adjacency matrix and the cognitive map are shown in table 9 and figure 5.

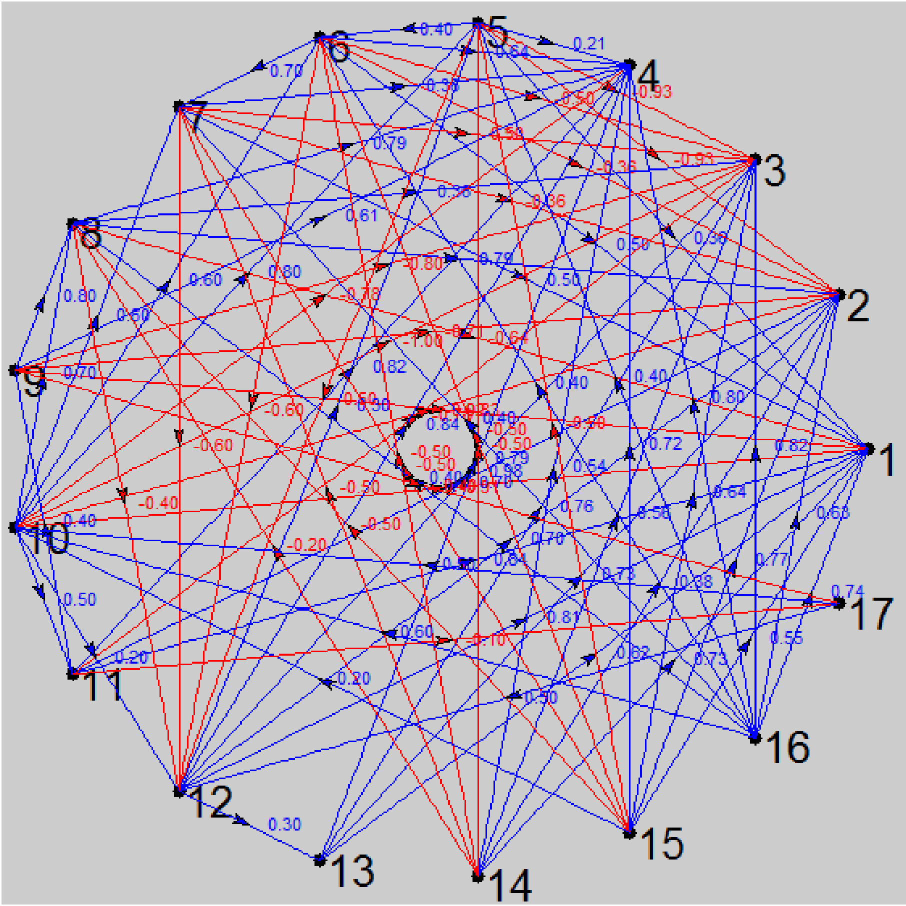

Fig. 5 Stable cognitive map

Thus, in the process of modeling a stable cognitive map, which is reasonable scenario of the appropriate innovative development of the recreational sector of the South coast, is received.

Conclusion

It is shown that the solution of complex unstructured problems must be created on the basis of synthesis of foresight methodologies and cognitive modeling.

Involvement of the process of modeling of foresight methodology at the first stage, which is sufficiently formalized, allows with the help of expert evaluation to identify the critical technologies and build the alternative scenarios with quantitative characteristic values. The obtained characteristics are the initial data for the initial iteration of cognitive modeling.

Using a model of cognitive graphs is expedient for obtaining reasonable decisions of a complex system behavior for the strategic prospects with a large number of interconnections and interdependencies. Of course, a real model, used in the framework of strategic planning, will include in consideration a greater number of important for the market factors and will require achieving its stability dozens of iterations of the modeling. A key advantage of cognitive graph models is the ability to use them for creation a reasonable scenario, which makes them an indispensable tool set in analytical support of strategic planning and development at the company, mega-polis and region level.

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