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INFORMATION TECHNOLOGY OF INTEGRATED RISK MANAGEMENT OF SCIENTIFIC PROJECTS UNDER UNCERTAINTY AND BEHAVIORAL ECONOMY

Abstract: The relevance of the topic is that currently the development of information technology allows to implement integrated risk management of scientific projects, which, in turn, expands the range of opportunities for project managers to manage integrated human risks, conflicts and factors of behavioral economics.

This study aims to develop the structure of the information base for integrated risk management of scientific projects under uncertainty conditions and behavioral economics.

To achieve this goal it is necessary to perform the following tasks:
- to analyze information technologies that can be used to create information bases for risk management of scientific projects;

- to develop a scheme for the implementation of information technology for integrated risk management of scientific projects under uncertainty conditions and behavioral economics;
- to develop an algorithm for filling the information technology for integrated risk management of scientific projects under uncertainty conditions and behavioral economics.

The information technology of integrated risk management of scientific projects in the conditions of uncertainty and behavioral economy which will be constructed on the basis of the developed structure of information base IRMSP is offered.

The research was conducted within the framework of project management methodology using information technology tools.

Thus, the structure of information technology of integrated risk management of scientific projects under uncertainty conditions and behavioral economics, as well as the scheme of its implementation was designed, which in turn will allow the head of the scientific project and his team to implement the IRMSP methodology developed by the authors in order to ensure the successful and timely implementation of the scientific project to meet the needs of its stakeholders.

Keywords: information technology, scientific project, integrated risk management, information base structure, uncertainty conditions, behavioral economics.

Introduction

The main purpose of information management technologies, in particular, anti-risk, is to meet the information needs of all stakeholders.

With the implementation of information technology, organizations have the opportunity to successfully manage projects, establish communication between project stakeholders, find and respond to deviations, report on all stages of the project and be able to quickly monitor them [1].

Information technology is a combination of procedures that implement the functions of collection, accumulation, storage, processing and transmission of data based on the use of a selected set of technical means with the participation of management staff [1]. To make decisions at the level of management control, information must be presented in an integrated form so that trends in data, causes of deviations and possible decisions allow to remain competitiveness in the conditions of global economy.

The author [2] makes a general conclusion that the concept of "Information Technology" (IT) extending to all areas of human activity, because information that is transformed into data, knowledge, information and software products, technological inventions - is an integral part of present time, and it is expedient to consider information technologies as an effective tool for ensuring the progressive functioning of the country's economy.

Therefore, there is a need to develop a structure of the information base of integrated risk management of scientific projects (IRMSP) under uncertainty conditions and behavioral economics, which would further implement the developed models [3, 4] and, in the future would be the basis for appropriate methodology.

Research of existing solutions of the problem

In the works [5, 6] a review of existing information technologies for business process management in organizations was conducted, but these IT products do not provide an integrated approach or separately manage human resources risks, conflicts and behavioral economics of scientific projects.

In [7] Teslya Yu.M. proposed an information technology to form a risk base for the construction of complex energy facilities, which can be used to collect information about the personnel

risks of scientific projects and by analogy with the conflicts and behavioral economics of these projects.

Danchenko O.B. in [8] developed information technology for integrated deviation management in projects, which can become the basis for the development of information technology for integrated risk management of scientific projects under uncertainty conditions and behavioral economics.

In [9] the author proposed information technology of value-oriented management of art projects, from which the part concerning the formation of the register of stakeholders and the risks associated with them can be used.

In [10] Chumachenko I.V. analyzed the tools of stakeholder's theory and showed the need to improve quantitative methods of analysis of project' stakeholders and their requirements, in particular, the need to implement multidimensional resource assessment. This study can be used to develop information technology for integrated risk management of scientific projects under uncertainty conditions and behavioral economics.

The purpose and objectives of the study

This study aims to develop the structure of the information base of integrated risk management of scientific projects under uncertainty conditions and behavioral economics.

To achieve this goal, it is necessary to perform the following tasks:

- to analyze information technologies that can be used to create information bases for risk management of scientific projects;
- to develop a scheme for the implementation of information technology of integrated risk management for scientific projects under uncertainty conditions and behavioral economics;
- to develop an algorithm for filling the information technology of integrated risk management for scientific projects under uncertainty conditions and behavioral economics.

Methods of research

The information technology of integrated risk management for scientific projects in conditions of uncertainty and behavioral economics is proposed to build on the basis of presented structure of IRMSP information base (Fig. 1), which includes:

0 – IRMSP reference database;

1 – information base of uncertainties and behavioral economics in scientific project;

2 – information base for estimating uncertainties and behavioral economics in scientific project;

3 – information base for managing uncertainties and behavioral economics in scientific project.

Reference database files of integrated risk management for scientific projects under uncertainty conditions and behavioral economics:

D1 – register of stakeholders for scientific project;

D2 – table of personnel risks groups for scientific project;

D3 – table of conflict groups for scientific project;

D4 – table of behavioral economics factors for scientific project;

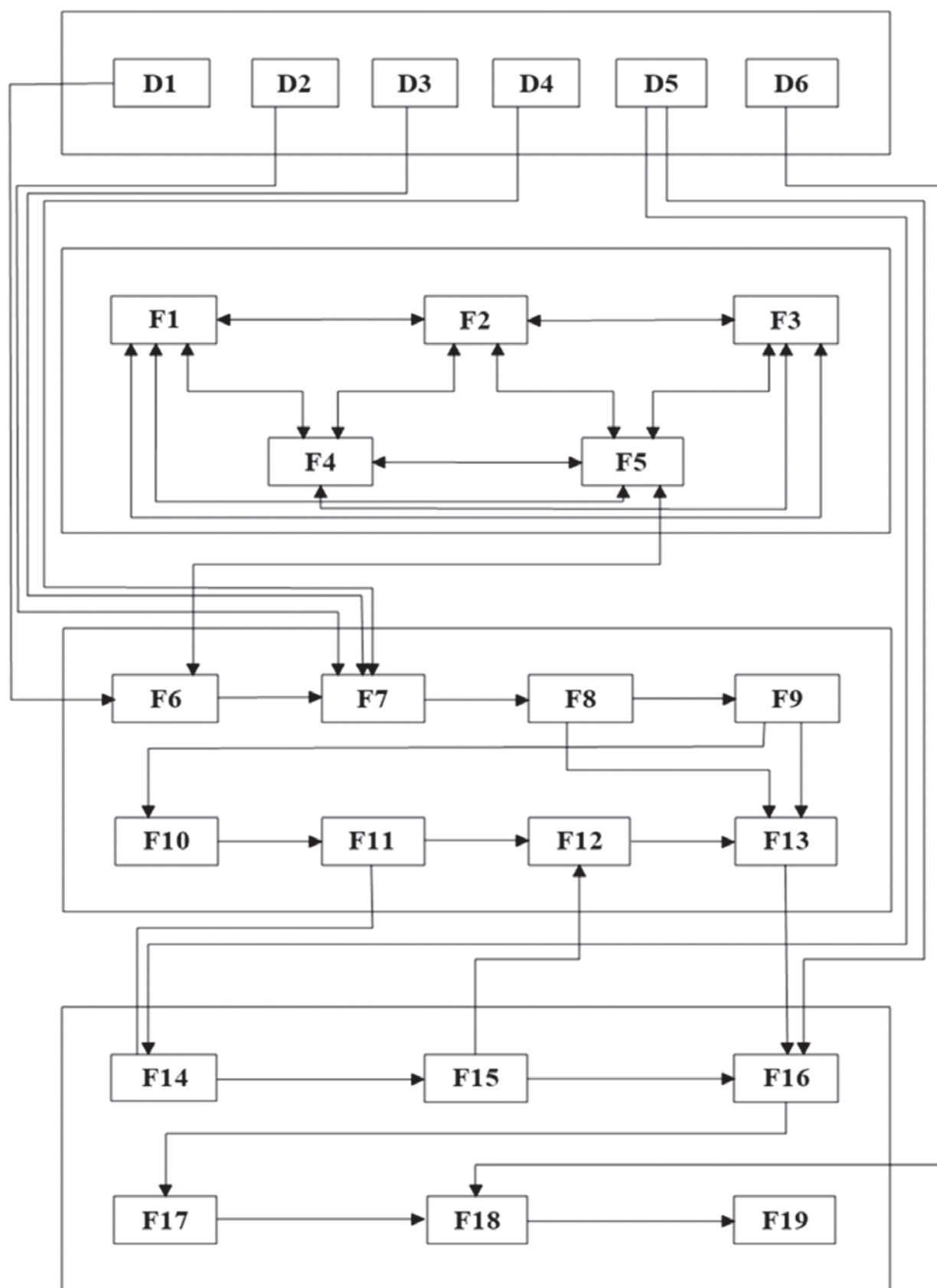D5 – IRMSP strategies;

D6 – IRMSP preventive measures.

Fig. 1. The structure of the information base of integrated risk management for scientific projects under uncertainty conditions and behavioral economics

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Files of the information base of uncertainties and behavioral economics in scientific project:

F1 – cognitive models of the effects of uncertainties and behavioral economics in scientific project;

F2 – cognitive maps of the effects of uncertainties and behavioral economics in scientific project;

F3 – causal model of integrated risk management of stakeholders for scientific project;

F4 – OLAP-cubes of uncertainties and behavioral economics in scientific project;

F5 – initial data for the calculation of the mathematical model of uncertainties and behavioral economics in scientific project (personnel risk groups, conflict groups, behavioral economics factors).

Files of the information base for estimating uncertainties and behavioral economics in scientific project:

F6 – preliminary register of stakeholders of scientific project;

F7 – personnel risk groups, conflict groups and behavioral economics factors associated with stakeholders of scientific project;

F8 – results of expert assessment of personnel risk groups, conflict groups and behavioral economics factors associated with stakeholders of scientific project;

F9 – results of cognitive modeling of interactions of personnel risk groups, conflict groups and behavioral economics factors associated with stakeholders of scientific project;

F10 – register of "toxicity" indicators of stakeholders in scientific project;

F11 – rating of stakeholders of the scientific project on "toxicity" indicators;

F12 – register of stakeholders in scientific project;

F13 – danger degrees' matrix of uncertainties and behavioral economics of stakeholders in scientific project;

Files of the information base for management of uncertainty and behavioral economics in scientific project:

F14 – measures to respond the impact of "toxicity" indicators of stakeholders in scientific project;

F15 – updated ratings of stakeholders in scientific project on the value of "toxicity" indicators, taking into account the developed measures;

F16 – IRMSP strategies;

F17 – actual parameters of uncertainties and behavioral economics of scientific project after application of IRMSP strategies;

F18 – preventive measures for uncertainties and behavioral economics of scientific project;

F19 – actual parameters of uncertainties and behavioral economics of scientific project after application of prevention.

Research results

To develop this information technology, the structure of information technology in integrated risk management for scientific projects under uncertainty conditions and behavioral economics, which is shown in Fig. 2 consists of the following elements:

1. The technology of filling the information base of uncertainties and behavioral economics in scientific project is implemented by monitoring the actual parameters of scientific project from the project documentation during the process of regular monitoring of its implementation.
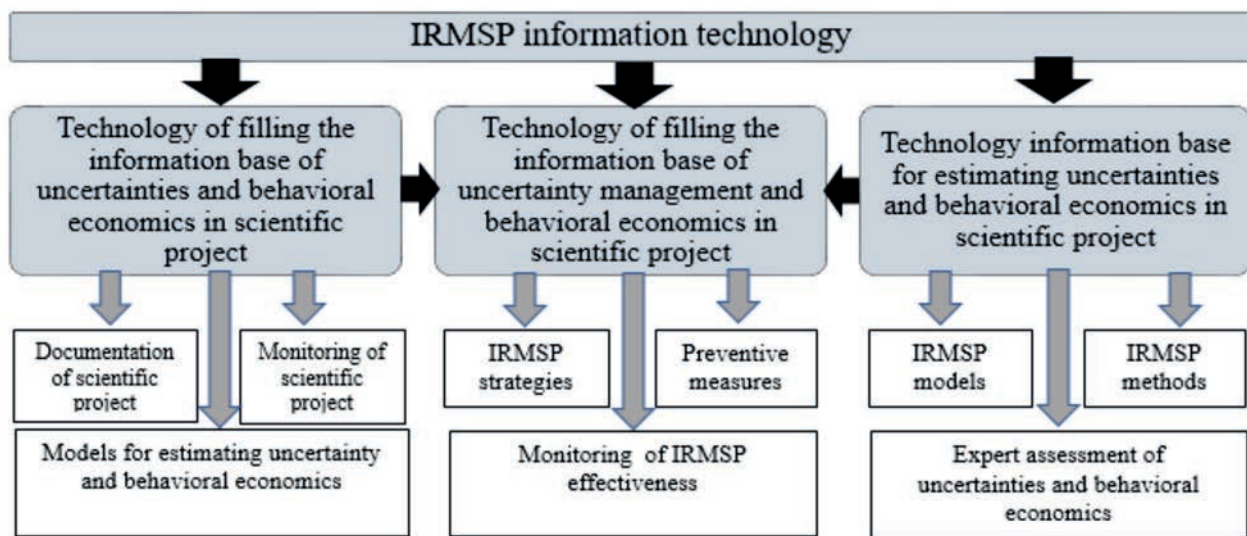
Fig. 2. The structure of information technology of integrated risk management of scientific projects under uncertainty conditions and behavioral economics

The developed models are used:
- cognitive models and maps of the effects of uncertainties and behavioral economics in scientific project;
- model of integrated risk management of stakeholders of scientific project;
- OLAP-cubes of uncertainties and behavioral economics in scientific project;
- mathematical models of uncertainties and behavioral economics in scientific project.

2. Technology of filling the information base for estimating uncertainties and behavioral economics in scientific project, which is implemented using the developed models and methods of integrated risk management of scientific projects under uncertainty conditions and behavioral economics, in particular, the identification of stakeholders and personnel risk groups, conflict groups and related behavioral economics; of cognitive modeling for interactions of personnel risk groups, conflict groups and behavioral economics factors related to stakeholders in scientific project; method of calculating "toxicity" indicator of stakeholders in scientific projects, in the process of which expert assessments of uncertainties and behavioral economics are used; method of integrated risk management of stakeholders in scientific projects under uncertainty conditions and behavioral economics; method of forming a register of stakeholders in scientific projects; method of integrated risk management of scientific projects under uncertainty conditions and behavioral economics.

3. The technology of filling the information base of uncertainty and behavioral economics management in scientific project, which consists of selecting and evaluating the effectiveness of integrated risk management strategies for scientific projects under uncertainty conditions and behavioral economics, prevention of uncertainties and behavioral economics and lessons learned, in particular: IRMSP strategies, prevention methods of uncertainty and behavioral economics, method of integrated risk management of scientific projects under uncertainty conditions and behavioral economics.

The scheme of information technology of integrated risk management of scientific projects under uncertainty conditions and behavioral economics is shown in Fig. 3.
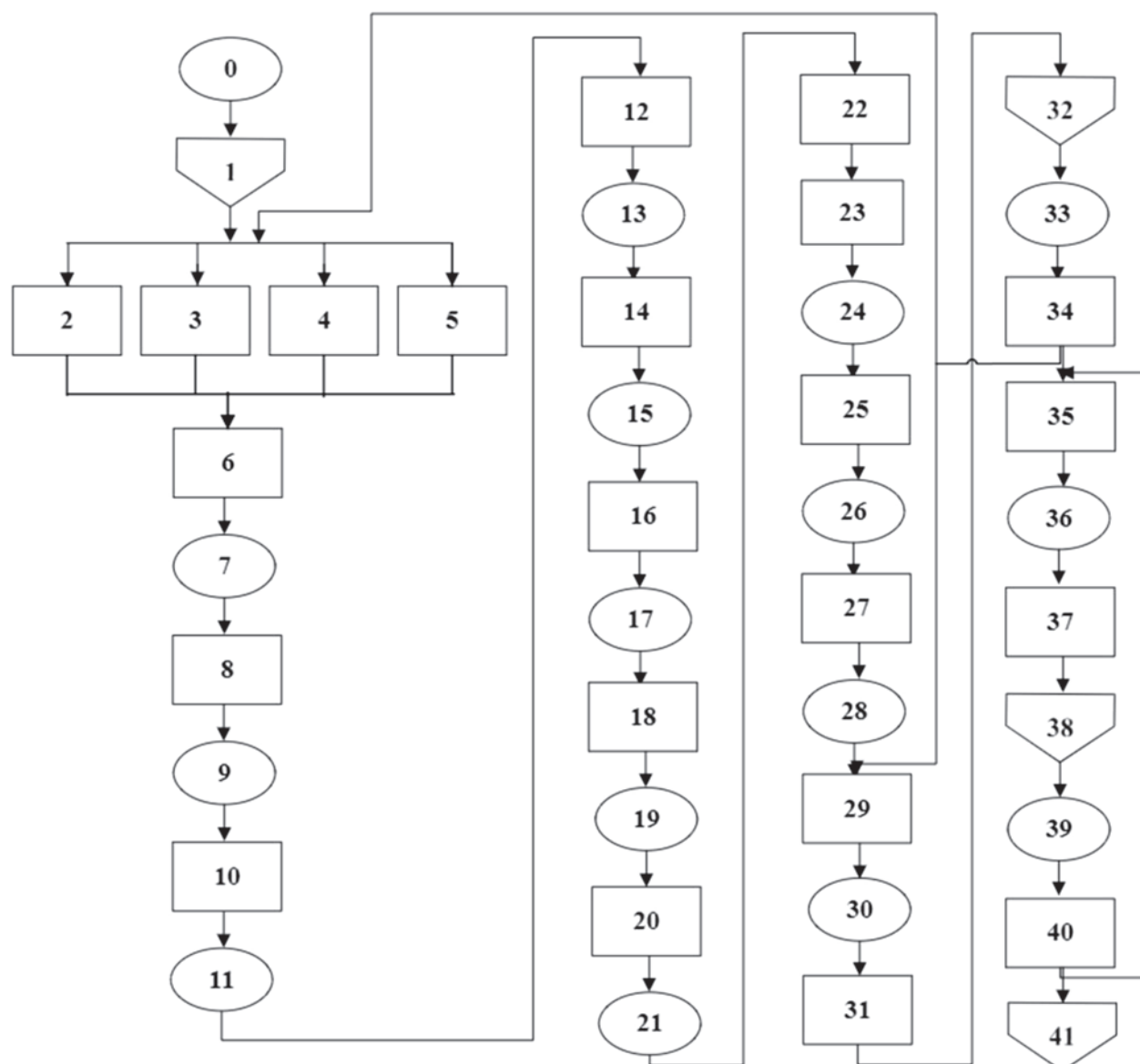
Fig. 3. The scheme of information technology of integrated risk management of scientific project under uncertainty conditions and behavioral economics.

The algorithm of filling of information technology of integrated risk management of scientific projects under uncertainty conditions and behavioral economy is offered:

0. Formation of a reference base of integrated risk management of scientific projects under uncertainty conditions and behavioral economics - filling data files [11-15]:

D1 – register of stakeholders for scientific project;

D2 – table of personnel risks groups for scientific project;

D3 – table of conflict groups for scientific project;

D4 – table of behavioral economics factors for scientific project;

D5 – IRMSP strategies;

D6 – IRMSP preventive measures.

1. As a result of regular control of the scientific project, weekly reports on the implementation of project work are received, in which the planned and actual indicators of project work (volumes, time and cost) are given, as well as deviations are calculated.

2. According to the data presented in the weekly reports, cognitive models of the effects of uncertainties and behavioral economics in scientific project are built [16].

3. According to the data provided in the weekly reports, cognitive maps of the effects of uncertainties and behavioral economics in scientific project are built [17].

4. According to the data provided in the weekly reports, a model of integrated risk management of stakeholders of scientific project under uncertainty conditions and behavioral economics is being built [18].

5. According to the data provided in weekly reports, OLAP-cubes of uncertainties and behavioral economics in scientific project are built.

6. In accordance with steps 2-5, a mathematical model of integrated risk management of scientific project under uncertainty conditions and behavioral economics by their types - groups of personnel risks, groups of conflicts and factors of behavioral economics - is developed [18].

7. Based on the data obtained in steps 2-6, filling in the information base of uncertainties and behavioral economics in scientific project, in particular: files F1 – F5.

8. According to the data provided in the information database of uncertainties and behavioral economics in scientific project (file D1), a preliminary register of stakeholders in scientific project is being built.

9. The results of step 8 are saved in the file F6.

10. For stakeholders identified in step 9 (file F6), personnel risk groups, conflict groups and related behavioral factors are identified from the IRMSP database (files D2 - D4).

11. The results of step 10 are saved in the file F7.

12. According to the data provided in files F6 and F7 (steps 9 and 11), an expert assessment of personnel risk groups, conflict groups and behavioral economy factors is performed.

13. The results obtained in step 12 are saved in file F8.

14. Based on the data obtained in paragraph 13, cognitive modeling of the interaction of personnel risk groups, conflict groups and behavioral economics factors associated with the stakeholders of scientific project is performed.

The scientific project is described by a set of values of characteristics, in particular: personnel risks (R1… R7), conflicts (K1… K6) and factors of behavioral economy (BEF1...BEF14). At the time of modeling, scientific project is in equilibrium, ie the current values of characteristics are constant in conditions of absence of external influence.

Normalize the characteristics, replacing them with dimensionless quantities, so that the current value of each characteristic corresponds to the initial value of $x_i(0)=1$ of the corresponding vertex of the oriented graph, as example, it is shown in Fig. 4-6. Thus, possible changes in values of vertices (or characteristics) will be determined as a fraction of current state [18, 19].
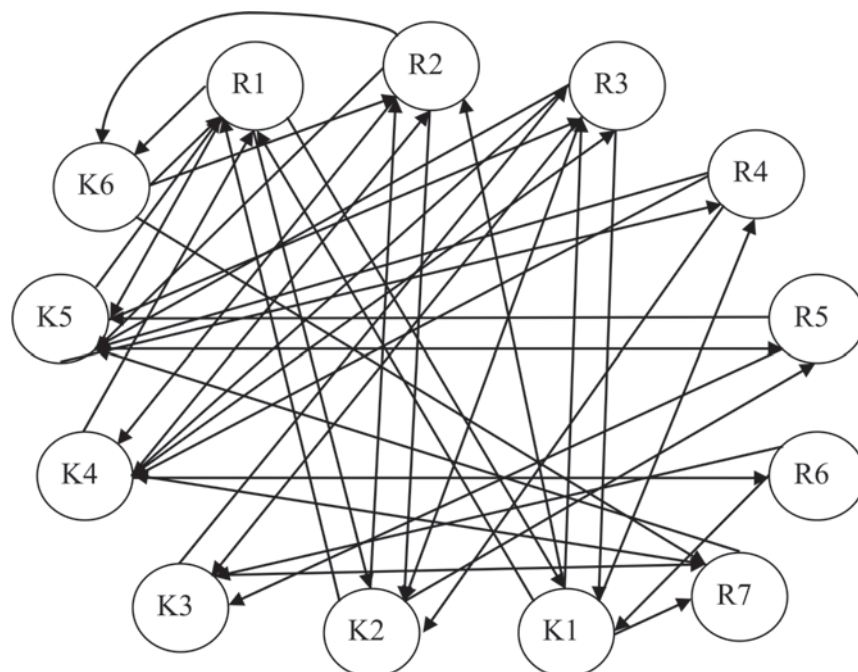
Fig. 4. Cognitive model of influences of personnel risks and conflicts in scientific projects

Oriented graph control is the purposeful change of one or more vertices. These changes are transmitted in arcs to neighboring vertices and then step by step.

To describe the changes in the values of the i-th vertex of the graph $x_i(k)$ on k-th step after exposure it is necessary to set the rule that determines the transition from $x_i(k)$ to $x_i(k+1)$ through the weight of the arcs a_{ij} [20, 21].

This uses the rule of the impulse process, which is often used in the modeling of any technical or economic systems. According to this rule, the change in the value of a vertex is determined by changes in the values of all its input vertices in the previous step.
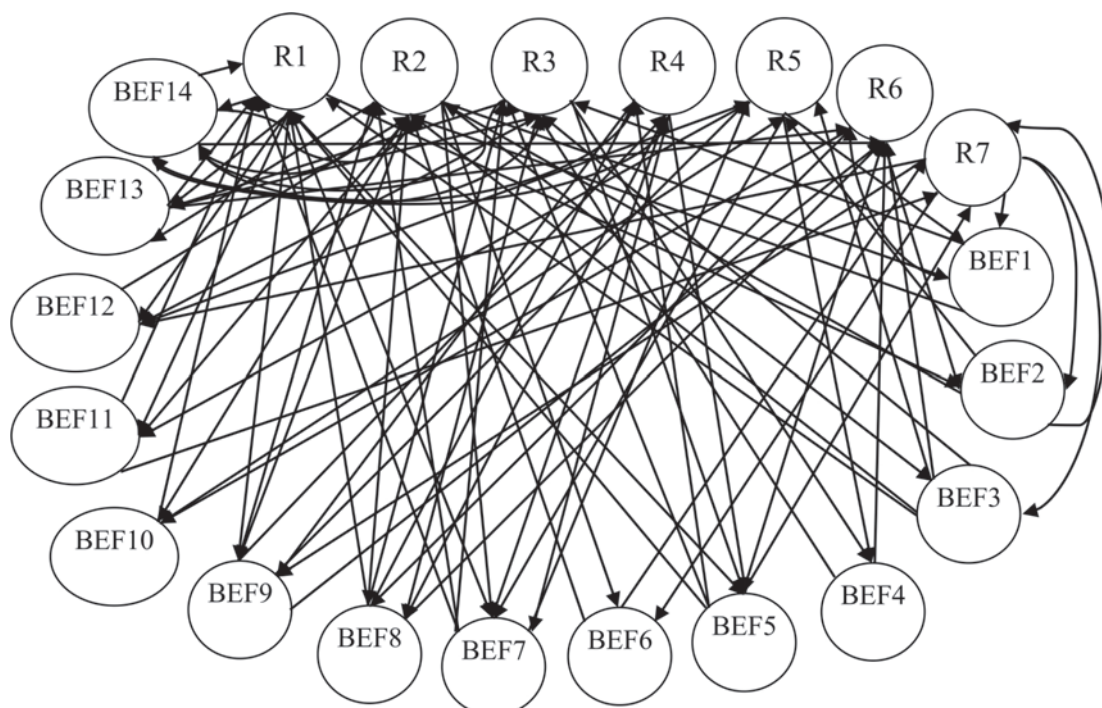

Fig. 5. Cognitive model of influences of personnel risks and factors of behavioral economics in scientific projects
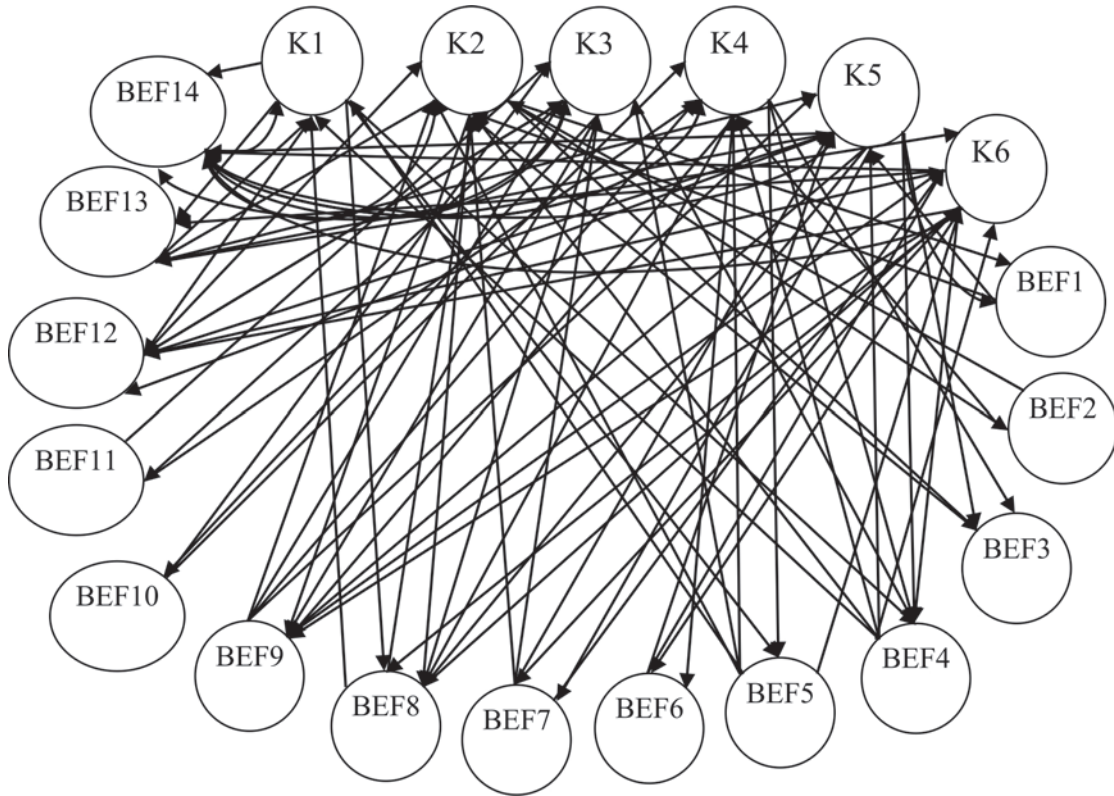
Fig. 6. Cognitive model of influences of conflicts and factors of behavioral
economy in scientific projects

At the same time changes of values of vertices accumulates. We can denote the change in the value of i-th vertex in k-th step, as (1) and name this value as impulse [22, 23, 24].

$$p_i(k) = x_i(k) - x_i(k-1) \qquad (1)$$

Let the weight of the arc a_{ij} show the ratio of values' increment for final vertex of an arc x_j, obtained by it in one step, to its increment, which was caused by initial vertex of an arc x_i.
Then the rule of changing the value is given by the formula (2):

$$x_i(k+1) = x_i(k) + \sum_{j=1}^{n} a_{ij}p_j(k), \qquad (2)$$

where $i = 1, \ldots, n$;
n – number of vertices in oriented graph.
We rewrite system (2) in the form (3) and assume that the initial pulses are known as $p_i(0)$, $i = 1, \ldots, n$.

$$p_i(k+1) = \sum_{j=1}^{n} a_{ij}p_j(k) \qquad (3)$$

Relation (3) is convenient to write in matrix form (4):

$$p(k+1) = p(k)A, \qquad (4)$$

where $p(k) = (p_1(k), \ldots, p_n(k))$,
$p(0) = (p_1(0), \ldots, p_n(0))$;
$A = (a_{ij})$ – the adjacency matrix of the oriented graph.

Thus,
$$p(1) = p(0)A = p(0)A,$$
$$p(2) = p(1)A = p(0)A^2,$$
$$\ldots$$
$$p(k) = p(0)A^k.$$

Returning to the variables $x(k) = \big(x_1(k), \ldots, x_n(k)\big)$, we obtain (5):

$$x(k) = x(0) + p(0)(A + A^2 + \cdots + A^k), \tag{5}$$

This rule allows to find values of vertices of the oriented graph through any number of steps after the initial exposure, that is, it makes it possible to predict the development of the system described by this oriented graph with a single initial pulse [17, 19, 21].

Let us call the reaction of oriented graph to initial impulse on k-th step the absolute change of values of vertices for k steps after the initial influence: $d(k) = x(k) - x(0)$.

Reaction of oriented weighted graph in the k-th step is determined by the formula (6):

$$d(k) = p(0)B(k), \tag{6}$$

where $B(k) = (B + B^2 + \cdots + B^k)$ – the adjacency matrix of oriented weighted graph.

One of the difficult tasks in the process of modeling systems in the form of a weighted digraph is to establish the weights of relationships. For this purpose, it is offered to use a method of expert estimations [24, 25]. Involvement of experts in system modeling takes place at both stages of digraph construction: when identifying factors that determine behavior of the system (in terms of scientific objectives), i.e. the construction of a sign digraph and when establishing relationships between factors, i.e. when determining the weights of arcs (construction of a weighted digraph).

15. The results obtained in step 14 are saved in the file F9 [16, 17].

16. Based on the data given in files F6 – F9, calculation of "toxicity" indicators for each stakeholder in scientific project is performed according to the method of calculation the "toxicity" indicator of stakeholder in scientific project [18].

17. The results of step 16 are saved in the corresponding file of the information database IRMSP - F10.

18. According to data obtained in step 17 and to the method of integrated risk management of stakeholders in scientific projects under uncertainty conditions and behavioral economics, the rating of stakeholders on "toxicity" indicators is formed.

19. The results of step 18 are saved in file F11 [18].

20. Based on the data provided in the file F11, as well as the reference file D5, the manager of scientific project selects measures to respond to the impact of "toxicity" indicators of stakeholders in scientific project [18].

21. The results of step 20 are saved in the file F14.

22. Relevant executors are implementing measures to respond the impact of "toxicity" indicators of stakeholders of scientific project.

23. According to data provided in the file F14, rating of stakeholders in scientific project is refined by the value of "toxicity" indicators, taking into account the developed measures [18].

24. The results of step 18 are saved in the file F15.

25. According to data provided in in steps 21 and 24, and also according to the method of stakeholders' register formation in scientific project, the register of stakeholders of scientific project is formed.

26. The results of step 25 are saved in the file F12 [18].

27. According to the data given in files F8 – F10 and F12, as well as the method of integrated risk management in scientific projects under uncertainty conditions and behavioral eco-

nomics, a matrix of danger degrees for uncertainties and behavioral economy of stakeholders in scientific project is under construction.

28. The data obtained in step 27 are saved in file F13.

29. Based on the data in file F13, the manager of scientific project selects IRMSP strategy for personnel risk groups, conflict groups and behavioral economics from all integrated risk management strategies for scientific projects under uncertainty conditions and behavioral economics (reference file D5).

30. The results of step 29 are saved in the corresponding file of the information database IRMSP – F16.

31. Implementation of measures to reduce the impact of personnel risk groups, conflict groups and behavioral economy factors by performers, in accordance with the selected IRMSP strategies.

32. Weekly reports on the implementation of scientific project, as well as on the applied IRMSP strategies.

33. According to the data obtained in step 32, the actual parameters of uncertainty and behavioral economics of scientific project after the application of IRMSP strategies are entered in the file F17.

34. Monitoring the results of reducing the impact of personnel risk groups, conflict groups and behavioral economics - if the application of selected strategies did not help to reduce negative effects of scientific project, move to step 2 or step 29 of IRMSP information technology, depending on the decision of scientific project manager.

35. In the case of successful implementation of integrated risk management in scientific projects under uncertainty conditions and behavioral economics, the project manager selects preventive measures to reduce the negative impact of scientific project from the reference file D6.

36. Information on the implementation of step 35 is saved in the file F18.

37. Application of selected preventive measures for uncertainties and behavioral economics by the executors of scientific project.

38. Receipt of weekly reports in scientific project on performed work and implemented prevention measures for uncertainties and behavioral economics.

39. The actual parameters of uncertainties and behavioral economics of scientific project after the application of preventive measures are saved in the file F19 of the IRMSP information base.

40. Control of the effects of uncertainties and behavioral economics on scientific project based on the data provided in file F19. If the impact is not reduced after the application of preventive measures, it is possible to repeat the choice of preventive measures – and return to step 35.

41. In case of successful application of preventive measures, the implementation of information technology is completed and the formation and printing of reports with IRMSP can be done.

Inference

1. Within the framework of scientific research, the structure of information base for integrated risk management in scientific projects under uncertainty conditions and behavioral economy is developed, which makes it possible to implement the IRMSP methodology in order to ensure the accumulation of statistical and expert information on the management of personnel risk groups, conflict groups and behavioral economics.

2. The structure of information technology of integrated risk management of scientific projects under uncertainty conditions and behavioral economy, and also the scheme of its

realization is developed, which, in turn, in conditions of uncertainty and behavioral economics will allow project manager and project team to implement IRMSP methodology to ensure successful and timely implementation of scientific project to meet the needs of its stakeholders.

3. Algorithm for filling the information technology of integrated risk management in scientific projects under uncertainty conditions and behavioral economics that was offered in the work, will allow to manage personnel risk groups, conflict groups and behavioral economics in accordance with the IRMSP methodology, which differs from modern approaches to the management of uncertainties and behavioral economics in the methodology of project and program management and will reduce the negative impacts on scientific project.

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