International Journal of Civil Engineering and Technology (IJCIET)
Volume 9, Issue 13, December 2018, pp.303–317, Article ID: IJCIET_09_13_031
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=13
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

MULTIFACTOR ASSESSMENT OF INDICATORS ON DYNAMIC MODELING OF PROGRAMS FOR MANAGING THE PERFORMANCE OF SCIENTIFIC LABOR

Olga V. Shinkareva, Viktor D. Orekhov, Petr V. Solodukha, Olga S. Prichina, Aliya Sh. Gizyatova
Russian State Social University
Wilhelm Pick St., 4, Bld., 1, Moscow, 129226, Russia

ABSTRACT

Based on the system analysis, the main subsystems of the weakly structured labor system of the research and development (R&D) specialists, which influence the efficiency of their labor, have been distinguished, and the key concepts included in these subsystems have been identified. Based on the experts' survey and using the decision support system (DSS), the concepts have been ranked, their system of interrelations has been determined, and a cognitive map of this system has been constructed.

The analysis of a fuzzy cognitive map showed that it generally had high consonance (degree of trust), but the group of mental concepts was characterized by lower consonance due to the weak influence of the system on these concepts.

The problem areas of the R&D work system, as well as the main components of the impact on the system: labor compensation, financing and provision with resources, demand for scientific developments, the R&D support system in the company, and the innovative business culture, have been defined.

A dynamic modeling of the system behavior under the impact of four types of control actions has been carried out. It is shown that the magnitude of improving the labor performance corresponds to the magnitude of the control action by order. The use of "Strategic Development Programs" and "Demand for R&D" concepts for management has provided threefold more rapid improvement of labor performance as compared to other two concepts.

The model of the R&D labor performance provides a systematic basis to develop recommendations on managing research activities.

Keywords: System Analysis, R&D, Cognitive Modeling, Critical Thinking, Mind Traps, Group Work, Labor Efficiency, GDP, Education.

Cite this Article: Olga V. Shinkareva, Viktor D. Orekhov, Petr V. Solodukha, Olga S. Prichina, Aliya Sh. Gizyatova, Multifactor Assessment of Indicators On Dynamic Modeling of Programs For Managing The Performance of Scientific Labor, *International Journal of Civil Engineering and Technology (IJCIET)* 9(13), 2018, pp. 303–317.
http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=13

1. INTRODUCTION

The R&D activity is an interrelated system of mental, socio-economic, industrial and other factors that dynamically change in accordance with the development of the society. According to G. Leibniz, the great mathematician, the goal of science is the following: "The welfare of the humanity, i.e. the multiplication of all that is useful for people, but not to idle afterwards, but to maintain virtue and expand knowledge".

The scientific and technological revolution that had taken place in the 20th century and the subsequent increase in the share of the human capital from 30 to 80 % of the national wealth of the largest developing and developed economies [1] contributed to the further increase in the importance of science in the world, and the humanity moved to the knowledge economy.

There is reason to believe that in the future the role of science will grow at an accelerating pace [2]. This is due to the fact that the potential for increasing the labor productivity is being exhausted due to the growing share of specialists who have higher education [3]. However, the increase in the contribution of science to the economic development only due to extensive factors is too resource-intensive. That is why it is important to comprehensively and systematically study the possibilities of improving the efficiency of the R&D specialists' labor through intensive technologies [4]. The theme of this work is to find solutions to this problem [5-7].

In order to systematically analyze the complex of factors that have impact on the performance of R&D specialists, this study uses the method of cognitive modeling [8-10].

The goal of this study is to develop recommendations on managing the labor system for R&D specialists who take decisions.

As part of the work to achieve this goal, the following tasks are supposed to be accomplished:

- To form a system of factors that influence the efficiency of R&D specialists' labor.
- To study this system of factors and to determine the main ones.
- To form a cognitive model of this system.
- To study the static parameters of the model, including its consonance characteristics.
- To study scenarios of behavior of the developed model in dynamics under various control impacts.
- To develop recommendations on managing this type of system for decision makers (DM).

2. METHODS

To study the R&D specialists' work system, the system analysis is used as the main methodology [11, 12]. Using its particular functions, it forms the structure of the study methods. The paper uses the functions of system analysis shown in Table 1 (approximately in the order of their use).

Table 1 System Functions Applied in the Study

No.	Function
1	Identifying the system, its boundaries and main subsystems – groups of elements of this problem area
2	Determining the supersystem where the system performs a useful function
3	Analysis of the function of this system in the supersystem and its value (efficiency)
4	Determining the main elements (here – concepts) of the system and their names
5	Determining the structure of relationships (interrelations) between concepts and ranking their strengths
6	Forming a model (digital) of the fuzzy system under study (cognitive matrix) and introducing it into a computer decision support system – DSS
7	Verification and visualization of the structure and integrity of the system – the lack of independent subsystems or the structure and degree of their independence
8	Modeling dynamic changes of system elements under the impact of managerial impulses focused on the target function
9	Determining the impact of the supersystem on this system and its role in the dynamics of the system
10	Determining points of the system it changes most quickly when influenced

The second technique used in the work (cognitive modeling) was proposed by Axelrod R., the American scientist [13], and is characterized by the fact that the digital model of the complex socio-economic system under study is formed based on the experts' subjective opinions about its structure in the form of Fuzzy Cognitive Map – FCM [14, 15].

The validity of this approach is due to the fact that the managerial decisions taken in practice are individualized, but they cannot take into account the complexity of the information used to take a decision due to the limited capabilities of the operating memory of the human brain. To correctly use it, it is necessary to fix this information on the carrier that does not depend on the brain and correctly process it. Next, the DSS uses the information transmitted by the DM or an expert and recorded in the form of a cognitive matrix.

It is called cognitive not occasionally, as by the form recorded in the database it is very close to the way of reflecting the information about the relevant thought processes in the human brain. It is just as fuzzy and weakly structured, but this is how a person thinks, and it is this universal presentation of information that allows him to really think.

Next, the FCM matrix is the carrier of information about the weakly structured system under study and the analysis allows us to obtain its static and dynamic characteristics by using the computer "Decision Support System" – DSS [16, 17]. In particular, the consonance matrix characterizing the degree of trust in various system concepts, the cumulative impact of the concepts on each other through the network of connections, the structure of the relations network, including the network integrity, system characteristics, and the dynamic behavior of the system, are studied [9, 15, 18].

3. RESULTS

3.1. Formation of the initial system of concepts

In accordance with the set goal, the system under study was defined as the labor system of R&D specialists, including the main factors affecting the efficiency of R&D (scientific) activity. Initially, the following main subsystems including 31 concepts were identified:

- Individual performance concepts,
- Critical thinking and mind traps,
- Positive group work concepts, and
- Negative and neutral concepts.

However, after working with experts on discussing the composition of concepts and subsystems, other subsystems (blocks) were formed:

- Measurable concepts,
- Mental concepts,
- External exposure, and
- Group work.

The Russian socio-economic system was considered as a supersystem where the system under consideration fulfilled a useful function.

In this work the main function of the R&D labor system (the term *scientific work* is also used) is an efficient R&D activity to increase the country's GDP.

At the stage of identifying the main elements, a list of concepts ($\mathbf{e_i}$) that influence the R&D efficiency was first formed by using materials from a wide range of studies in this area [19-25]. Then, their level of importance was determined according to the survey of 14 experts qualified in this area of activity. According to the results of the survey, four concepts with the lowest level of importance were withdrawn, and the subsystem of measurable concepts was supplemented with labor compensation and efficiency of scientific work, and a new group of concepts characterizing the external impact was formed.

Then the experts were surveyed again. This time they evaluated not only the level of concepts' importance, but also their level for Russia (initial values for cognitive modeling) in a ten-point rating system (here 4 was the minimum satisfactory rating and 6 was the average). Later, when forming a cognitive map, the concepts where no confident links with other concepts in this system had been found were excluded. The results of assessing the importance and level of the system of basic concepts for Russia (here M_i was the mathematical expectation, and S_i was the standard deviation) are given in Table 2.

The results of the survey are as follows: the average assessment of importance is 7.8, and 5.7 for Russia (approximately the average level). The following concepts were assessed as the most important: the R&D support system in the company – 8.7, the level of education – 8.3, and the demand for scientific research – 8.4. The following concepts were assessed as the least important: team work training – 6.8, innovative business culture – 7.0, and foreign languages skills – 7.0. The estimates for Russia are about 2 points less than the importance, as a whole. The standard deviation is 1.5 points on average, and varies from 0.5 to 2.0. The coefficient of variation for most concepts does not exceed 33 %, which indicates the homogeneity of the set of estimates. As for subsystems, the "external impact" has the greatest importance level, and it has the lowest rating for Russia.

Table 2 Significance of the Revised List of Concepts and its Values for Russia

Group	No.	**Concepts**	Significance	Level for Russia	Significance	Level for Russia
Measurable concepts	1	Education level	8.3	7.4	0.5	0.8
	2	Intelligence quotient (IQ)	7.7	7.1	2.2	1.4
	3	Communication skills, connections	7.2	6.0	1.5	2.2
	4	Foreign language skills	7.0	5.0	1.5	1.8
	5	Scientific performance		5.8		1.1
	6	Labor compensation	7.3	4.0	2.2	1.2
	7	Computer support	8.2	6.3	1.0	1.3
Mental concepts	8	Self-control, will	8.1	6.0	1.8	1.8
	9	Teaching critical thinking	7.6	5.5	1.3	1.8
	10	Training in new knowledge and skills	7.3	6.1	1.3	1.4
	11	Innovative methods of thinking	7.4	5.6	1.2	1.5
	12	Ability to identify and solve problems	7.7	5.5	1.6	1.1
	13	Ability to think systematically	8.0	6.0	1.3	1.1
External influence	14	Financing and provision of resource	8.2	4.6	0.8	1.3
	15	Demand for scientific developments	8.4	4.6	0.9	1.4
	16	Strategic development programs	8.0	5.6	1.7	1.5
	17	R&D support system in the company	8.7	4.9	0.9	1.1
	18	Innovative business culture	7.0	4.9	1.6	1.5
Teamwork	19	Agreed common goal	7.3	5.7	1.7	1.7
	20	Psychological climate in the group	7.4	6.0	1.3	2.0
	21	Teamwork training	6.8	5.9	1.0	2.0
	22	Competence variety	7.6	6.5	1.4	1.8
		Average value	**7.7**	**5.7**	**1.4**	**1.5**

3.2. Characteristics of Concepts

To coordinate expert assessments, it is important to interpret the main concepts.

The efficiency of scientific work is the main target concept in this study. It will be defined as the value of the contribution of a R&D specialist or a group of specialists in the country's GDP. It is not easy to assess such indicator in terms of quantity because there are many external effects of the scientific work [26]. This is due to the fact that in addition to the developer company, its customers, followers, R&D community and others get benefits from the introduction of new technologies. This is shown in Figure 1. A considerable part of a positive result through externalities turns into a strategic innovation resource of subjects of the innovation services industry.

Nevertheless, according to the estimates [3], the contribution of an R&D specialist to the country's GDP is 20 times more than the contribution of a specialist who has higher education. Since this work aims at developing recommendations on managing the R&D specialists' labor system, it is fundamentally wrong to use indirect indicators of scientific efficiency, such as publication activity because this can give completely inconsistent results. Actually, it is possible to develop a correct system for assessing the R&D specialists' labor efficiency based on the model presented in Figure 1. At the level of expertise, this indicator for the industry or other object can be measured by assessing the level of scientific achievements in this area.

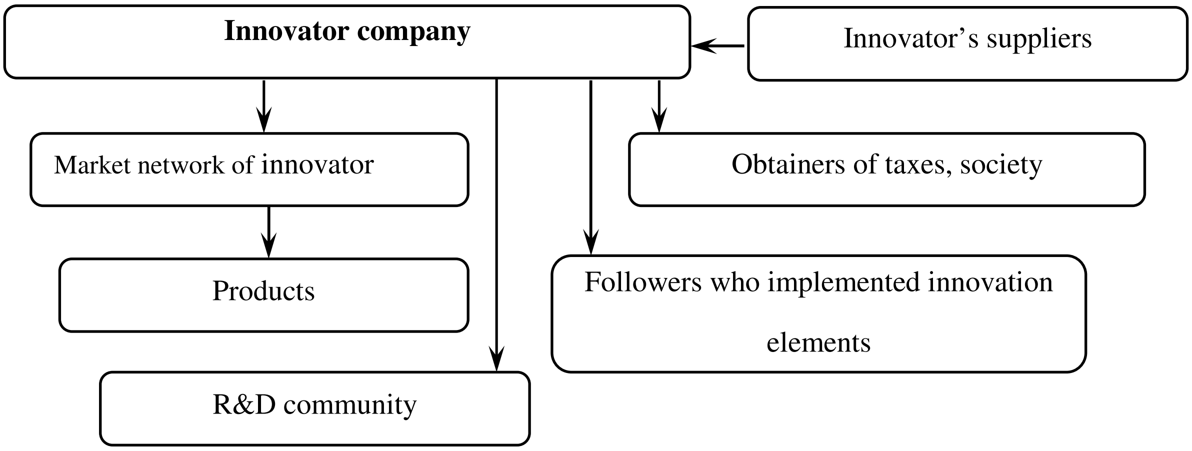

Figure 1. Areas of Obtaining Benefits from Implementing New Technologies

The level of education. This is the concept that has the most systemic impact on the efficiency of the scientific labor because the contribution to GDP exponentially depends on the number of years of study. In their work R.J. Barro and J.W. Lee [27] show that in various countries GDP per capita depends exponentially on the average number of years employees spend for their education. In his work V.D. Orekhov [3] shows that the average contribution of a specialist to the country's GDP exponentially depends on the number of his study years according to the formula (1)

$$\mathbf{G_L = K_L \cdot 10^{L/5},} \tag{1}$$

Here, L is the number of years of the specialist's study, and the coefficient $K_L \approx 125$ in international dollars for 2011 for the largest economies of the world. This formula makes it possible to determine the value of the contribution of specialists who have different levels of education to the country's GDP. It is also valid for researchers if their level of education is assumed to be about 6 years longer than for higher education. Such strong impact of education on the contribution to the country's GDP makes it a key systemic cause why the welfare of nations grows.

According to the level of employees' education, Russia is one of the leading countries [28]. The employees aged 25 to 64 years old who have occupational education make up 58 % of workers. However, according to The Global Competitiveness Report (2017 – 2018), the indicator "Higher education and professional retraining" is estimated at 3.6 points on the five-point scale, i.e. rather low. Such assessment could have been affected by the fact that in the conditions of weak financing and high equipment depreciation, training did not adequately correspond to the work with high-performance equipment. It is possible to manage the involvement of specialists with a high level of education in R&D by increasing their labor compensation. Nowadays, in Russia, specialists with a high level of education often prefer to work in business rather than in science [29].

Misperception in the mind. This concept was removed from the main list because it is difficult to assess it in terms of quantity. However, it is important for understanding the need to apply critical thinking. People have a lot of misperceptions in their minds that arise for various reasons. For example, these are stereotypes, outdated theories and incorrect interpretation of experience. Our consciousness perceives information much faster than the time required to check it. Therefore, in our memory there are often facts taken for granted. Their impact affects the efficiency of scientific labor. The book *Economics* contains a number of examples of such misperception, in particular, the transfer of the properties of the particular to the general. As a result, the true statement becomes false, and a causal link is defined incorrectly. In terms of the systems thinking, “There are three factors that can cause erroneous interpretation of one’s own experience when the reinforcing feedback occurs and makes the existing mental models stronger — regression, neglect of the time factor and one-sided interpretation of events”.

Critical thinking. The difficulty of identifying misconceptions is related to the fact that they are usually invisible until you make a detailed analysis of a certain area of your knowledge and mental models. In this case it is important to use the method of critical thinking [22]. Critical thinking is a system of judgments used to analyze events and to formulate reasonable conclusions. It helps make sound assessments, interpretations, and correctly apply the obtained results to situations and problems. Critical thinking begins with asking questions and defining the problems to solve. Many definitions of critical thinking are based on a reasonable, balanced approach to taking difficult decisions about actions or values. Despite the fact that critical thinking is based on independent judgment of the individual, it is also important to use a productive exchange of opinions for correct judgment.

The above brief analysis of the meaning of some important concepts in the R&D activity shows high complexity and ambiguity of their understanding. Therefore, they were discussed by experts iteratively, as surveys were conducted, and a common understanding was agreed.

3.3. Construction and analysis of a fuzzy cognitive model

As a result of the discussions, a fuzzy cognitive map was formed. It is presented in Table 3 as a cognitive matrix in quartiles (1 = 0.25, 2 = 0.5, 3 = 0.75, –2 = –0.5, where the second figure is the connection strength in fractions of a unit). To form FCM, “IGBA” DSS, the “Intellectual Generator of the Best Alternatives” [16], was used.

Table 4 shows the data on the consonance of the impact of concepts on the system (CS) and the system on concepts (SC). At the same time, the impact of the SC was defined as the sum of the impact of all concepts on the given system, and the impact of the CS – as the impact of the concept on all concepts of the system. The concepts that underwent the impact of other concepts by less than 50 % are in bold. It is vivid that for them the impact is SC < CS.

The analysis of the consonance impact showed that on average it was 72 %, i.e. quite high. In general, the matrix can be trusted. However, for three concepts (teaching critical thinking, communication skills, and foreign languages skills), the consonance of impact on them is much less than 50 %. This is a consequence of the fact that the connections that have impact on these concepts from all concepts of the system are not strong enough. The cognitive matrix shows it (Table 3).

The alpha-section of the impact consonance at the level of 90 % is shown in Fig. 2. It is clear that the most important concepts for consonance include system of supporting R&D in the company, innovative business culture, agreed common goal and teamwork training (5 – 7 connections of at least 90 % level with each component).

Table 3 Cognitive Matrix of Scientific Performance

	Concept, group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Education (years of study)				1	3	1		1														
2	Intelligence quotient (IQ)					1																	
3	Communication skills, connections					2																	
4	Foreign language skills			2																			1
5	Scientific performance						2							1			-2		1				
6	Labor compensation	3	1			1																	2
7	Computer support					2																	
8	Self-control, will					2														2			
9	Teaching critical thinking											2											
10	Innovative methods of thinking					1																	
11	Ability to identify and solve problems					2																	
12	Ability to think systematically					2																	
13	Financing and provision of resource					2	1									2	2						
14	Demand for scientific developments	2		1										3			2						
15	Strategic development programs														3								
16	Retraining of scientific personnel	1			1					2	1	1	2										1
17	R&D support system in the company						1	1									3						
18	Innovative business culture	1								1								2				1	
19	Agreed common goal					2													2				
20	Psychological climate in the group					1																	
21	Teamwork training			1																2	1		
22	Competence variety					2																	

Table 4 Consonances of Mutual Impact of the System and Concepts

Concepts	CS	SC	Concepts	CS	SC
Education (years of study)	0.73	0.49	Ability to think systematically	0.66	0.51
Intelligence quotient	0.66	0.91	Financing and provision of resources	0.64	0.92
Communication skills, connections	0,66	0,36	Demand for scientific developments	0.69	0.92
Foreign language skills	0,72	0,40	Strategic development programs	0.69	0.92
Scientific performance	0.64	0.89	Retraining of scientific personnel	0.90	0.50
Labor compensation	0.74	0.91	R&D support system in the company	0.64	0.92
Computer support	0.66	0.93	Innovative business culture	0.79	0.92
Self-control, will	0.71	0.51	Agreed common goal	0.68	0.73
Teaching critical thinking	0,68	0,19	Psychological climate in the group	0.66	0.92
Innovative methods of thinking	0.66	0.51	Teamwork training	0.70	0.92
Ability to identify and solve problems	0.66	0.50	Competence variety	0.66	0.48
Here **CS** is the consonance of the concept impact on the system, SC is the consonance of the system impact on the concept					

Fig. 3 shows the alpha-section of the mutually positive impact of concepts on the level of 50 %. The alpha-section includes 19 out of 22 concepts. The alpha-section does not include (with less impact): "Intelligence quotient", "Innovative methods of thinking", and "Psychological climate in the group". According to this version of the cognitive matrix (Table 3), these are the concepts that have the least impact on the target concept.

It is possible to see that the main component that undergoes the impact of other concepts is the target factor: "Efficiency of scientific work". "Demand for scientific research", "Agreed common goal", "Education", "Retraining of scientific personnel" and "Financing and provision with resources" are also important components of the impact on the system [30-31].

Thus, approximately half of the components related to influencing the system are found in the “External impact” subsystem, except for the target concept “Efficiency of scientific work” that was predetermined as the most important, as well as “Education” and “Coordinated common goal”.

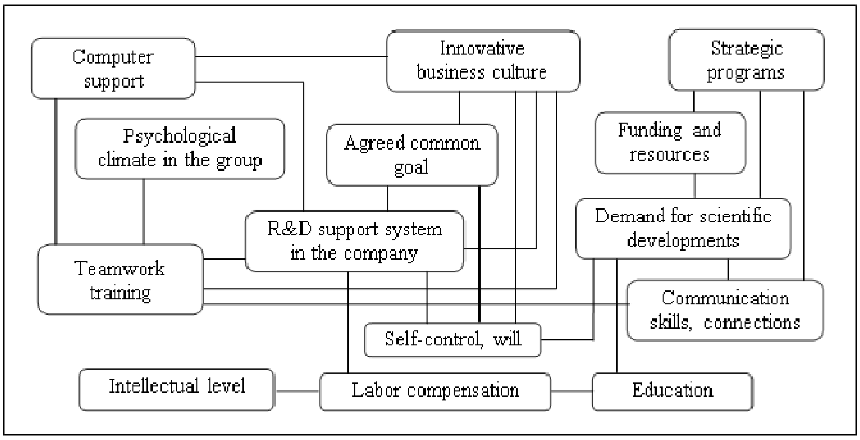

Figure 2. Alpha-section of the influence consonance at 90 %

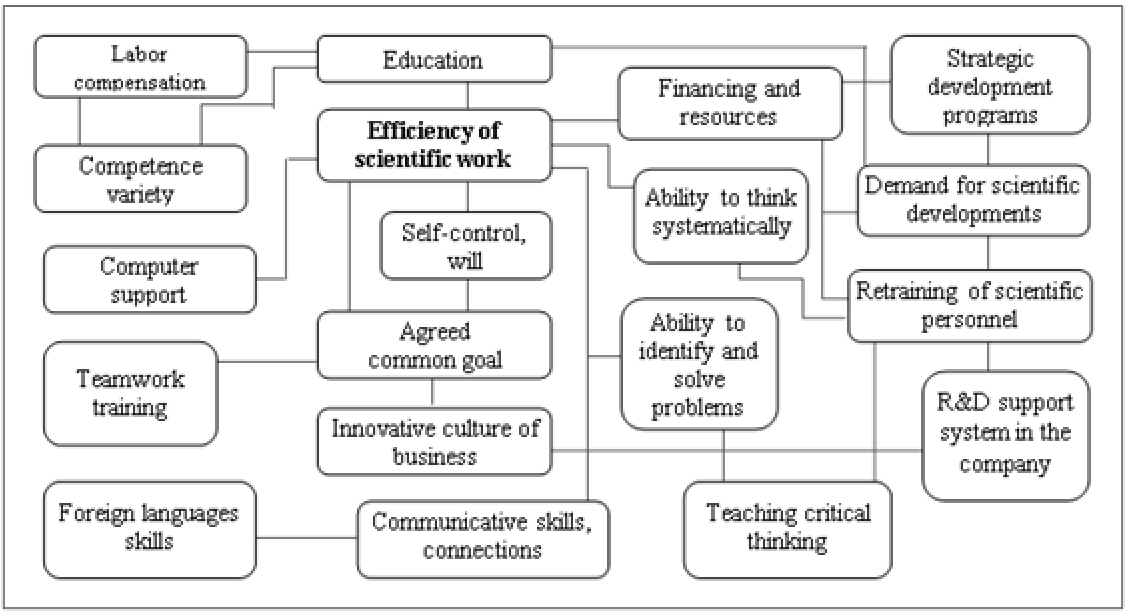

Figure 3. Alfa-review of Mutual positive Impact at 50 %

3.4. Modeling the dynamic behavior of the system

In case of dynamic modeling of the system development, the “Efficiency of scientific research” concept was used as a target level which is very high (100 %). The following concepts that can be efficiently managed were chosen as control parameters: “Labor compensation”, “Demand for scientific research”, “Strategic development programs”, “Retraining of scientific personnel”, and “Financing and provision with resources”. The initial values of the concepts, the level of which differed from the average (50 %), are shown in Table 5. The level of the initial impact of the controlling concept (mostly single effects were used) was chosen minimal (14 %) for each calculation. It varied when it was required.

Table 5 Initial Values of Concepts, %

Education (number of study years)	64	Financing and providing resources	36
Intellectual quotient (IQ)	64	Demand for scientific research	36
Computer support	64	Innovative culture of business	36
Self-control, will	64	Labor compensation	36
Innovational methods of thinking	64	Foreign language skills	36
Competences variety	64		

Fig. 4 shows the dynamics of a number of concepts of the R&D specialists' labor system when using the control action: "Labor compensation" (the increase by 14 %). It is possible to see that "Efficiency of scientific work" increases in 44 steps by 12.4 %, while the total labor compensation increases by 24.7 %. At the same time, "Financing and provision with resources" and "Strategic development programs" as well as "Demand for scientific research" (from 36 % to 83 %) are growing rapidly. "Psychological climate in the group", "Teamwork training" and "Computer support" are growing at the slowest pace (by 1 – 3 %). Mental concepts are growing by about 10 % in 44 steps ("Ability to think systematically" – by 19 %).

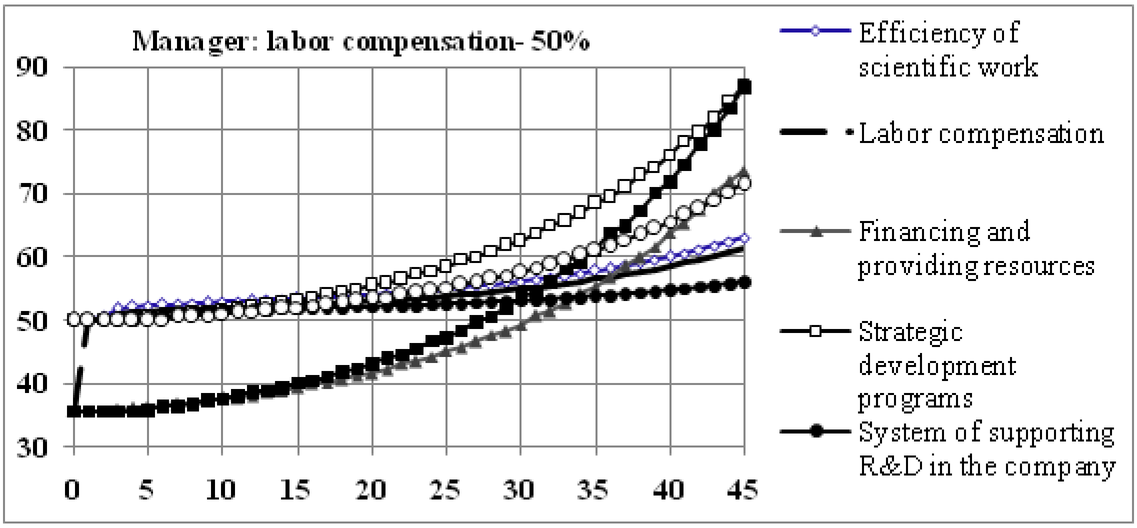

Figure 4. Impact of Labor Compensation on the Dynamics of the R&D Specialists' Work System

Fig. 5 shows the dynamics of the system concepts when using the control action: "Demand for scientific research" (the initial impulse is 14 %). At the same time, "Efficiency of scientific work" increases three times faster (15 steps) by 16 %, i.e. more than in the previous version of management, approximately one and a half times. In this case, the total labor compensation increases considerably less – by 14 %. The system changes about three times faster, and all parameters are overlooked as soon as the control parameter reaches 100 %. "Financing and providing resources" and "Strategic development programs" are growing rapidly. "Psychological climate in the group" and "Teamwork training" are the slowest (by 2 – 4 %). The growth of mental concepts is about 15 % ("Ability to think systematically" – by 30 %). In the context of managing the efficiency of scientific labor, this type of management in all respects is better than the increase in labor compensation.

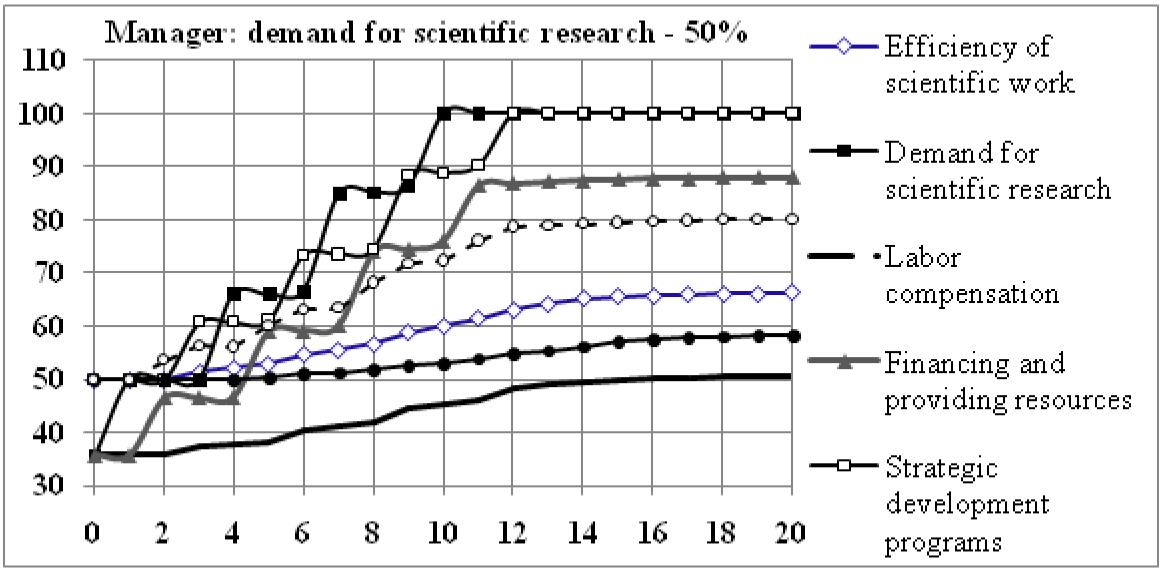

Figure 5. Impact of Demand for Scientific Research and on the Dynamics of the System

Fig. 6 shows the dynamics of the system concepts when using the control action: "Retraining of scientific personnel" (the initial impulse is 14 %). At the same time, "Efficiency of scientific work" increases in 44 steps by 14 %, while the labor compensation increases only by 11 %. In terms of speed, the system changes rather slowly like in case of the labor compensation increase.

"Financing and providing with resources" and "Strategic development programs" are growing rapidly, and "Demand for scientific research" is growing at the quickest pace. "Psychological climate in the group" and "Teamwork training" are growing as slowly (by 1 – 3 %). The growth of mental concepts is 10 – 18 % in 44 steps ("Ability to think systematically" – by 35 %). In the context of managing the efficiency of scientific work, this variant of management is a bit better than the increase in the labor compensation.

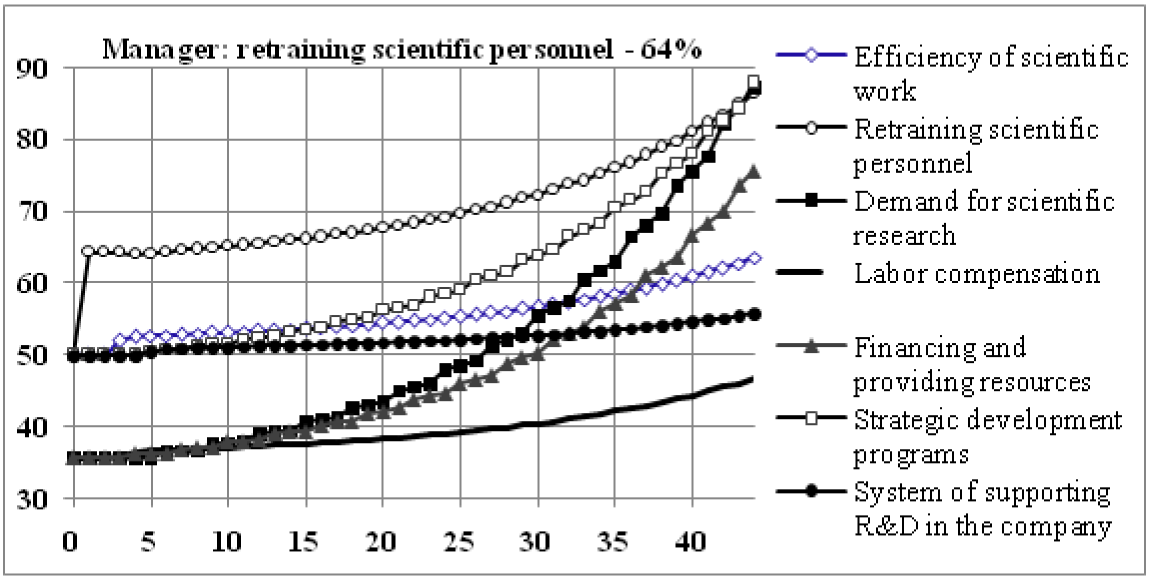

Figure 6. Impact of Retraining Scientific Personnel on System Dynamics

Fig. 7 shows the dynamics of the system under the impact of the "Strategic development programs" (the initial impulse is 14 %). At the same time, "Efficiency of scientific work" increases in 14 steps by 16 % like in case of the growth of the demand for scientific research.

In this case, the total labor compensation increases by 15 %. The system changes almost exactly as in the "Demand for scientific research" variant, but a bit quicker.

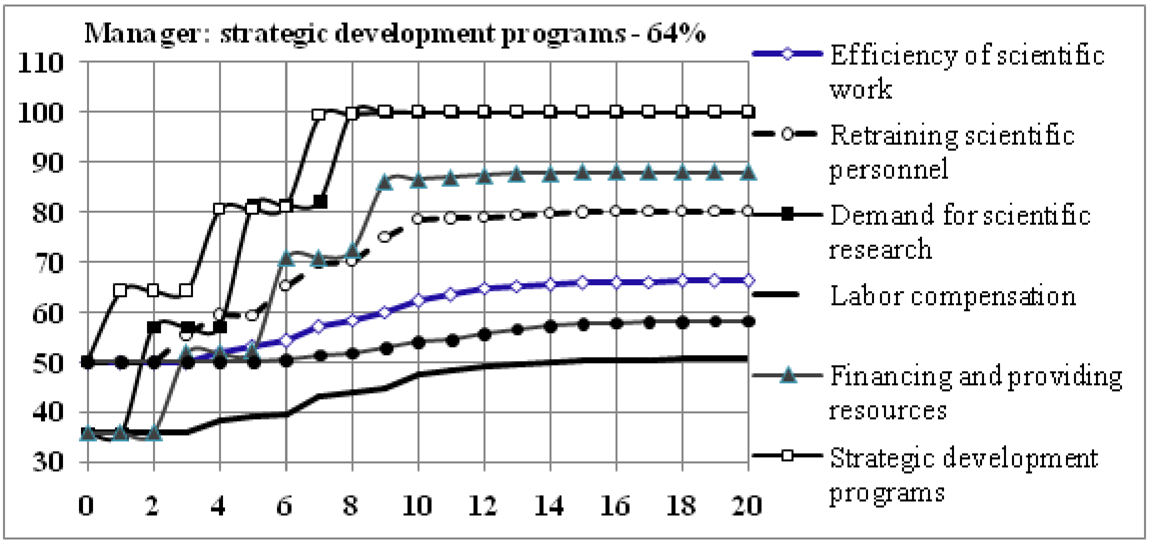

Figure 7. Impact of Strategic Development Programs on System Dynamics

Thus, two pairs of similar system behavior out of four variants of control actions were revealed. They approximately threefold differ in the speed of response to a control action. The main results of managerial impacts are shown in Table 6.

Table 6 Management Impact Results

Managing concept	Managing impulse	Growth of the scientific work efficiency	Labor compensation growth	Reaction time, steps
Labor compensation	From 36 to 50 %	12.4 %	24.7 %	44
Retraining scientific personnel	From 50 to 64 %	14 %	11 %	44
Demand for scientific research	From 36 to 50 %	16 %	14 %	15
Strategic development programs	From 50 to 64 %	16 %	15 %	14

If to correlate the studied control actions with the entrance and exit scheme of the scientific work system, it is possible to determine that the "Strategic development programs" refer to the entrance to this system, "Demand for scientific research" refers to the exit, and the other two administrative impacts are focused directly on the system. Thus, the strongest impact on the system is recorded at the entrance and exit from it, i.e. on external conditions, and the system itself is managed more slowly.

Summarizing the calculations, it is possible to recommend the DM to focus on the options of impacts: "Demand for scientific research" and "Strategic development programs", although complex impact on the managed system is also possible.

It was also revealed that the "Psychological climate in group" and "Teamwork training" concepts were growing at the slowest pace (by 1 – 3 % over the entire cycle). The growth of mental concepts is approximately 14 %, which corresponds to the magnitude of the control impulse and the growth of the scientific work efficiency. The "Ability to think systematically" concept is growing the most rapidly, up to 35 %.

4. DISCUSSION

One of the objectives of this work was to identify the impact of critical thinking and group work on the efficiency of scientific work. Although the consonance of impact for a number of mental concepts is less than 50 %, the dynamic modeling showed that under the impact of a controlling impulse they began to grow in accordance with the magnitude of this impulse and the level of growth of the scientific work efficiency (about 14 %).

It was a bit unexpected that “Psychological climate in a group” and “Teamwork training” concepts were growing at the slowest pace (by 1 – 3 % over the entire cycle), although this corresponded to the results obtained by R.M. Belbin [19].

It was interesting that the increase in the labor compensation happened to be the least efficient method for stimulating the growth of the scientific work efficiency, although this result was not unexpected for specialists in personnel management.

It is necessary to note that the work revealed the most preferable methods of management impact on the efficiency of scientific work, but the cost of these impacts may be completely different. That is why it is necessary to take into account this factor when choosing a management program. The results of this work provide quantitative reasons for this.

5. CONCLUSION

The main problem areas of the R&D work system have been identified. They are “Labor compensation”, “Financing and resources”, and “Demand for scientific research”. The main components of impact on the system are “Agreed common goal”, “Financing and resources”, “Demand for scientific research”, “Education”, and “Retraining scientific personnel” [32-34].

The dynamic modeling of the system’s behavior showed that three of four control factors used (except for “Labor compensation”) approximately proportionally improved the work efficiency of R&D specialists. The impact on the entry and exit of the system (“Strategic Development Programs” and “Demand for Scientific Research”) allow increasing the work productivity three times faster than the system itself (“Labor compensation” and “Retraining scientific personnel”).

The obtained information about the regularities of improving the efficiency of R&D work allows DM to take grounded decisions on managing the system of R&D activity.

REFERENCES

[1] Korchagin, Y. A. Russian human capital: the factor of development or degradation?: a monograph. Voronezh, 2005, pp. 1 – 252.

[2] Orekhov, V. D., Prichina, O. S., Shchennikova E.S. *World number of scientists in dynamic simulation for the past and the future.* Economic and Social Development Book of Proceedings. Varazdin Development and Entrepreneurship Agency; Russian State Social University. 2017. P. 69 – 81.

[3] Orekhov, V. New approach to assessing contribution of science and education to welfare of countries. Educational Researcher, *American Educational Research Association*, 45(9), 2016, pp. 625 – 635.

[4] Nakhratova, E. E., Ilina, I. Yu., Urzha, O. A., Kryukova, E. M., Potekhina, E. V. Minimum Living Wage as a Basic Aspect for Managing the Population’s Life Quality in Russia. *European Research Studies Journal*, 21(2), 2018, pp. 601 – 610.

[5] Ilina, I., Zotova, A., Kuznetsova, E., Nakhratova, E., Kryukova, E. Teachers of Russian higher educational institutions in the professional labor market. *Rupkatha Journal on Interdisciplinary Studies in Humanities*, 8(2), 2016, pp. 128 – 136.

[6] Ilina, I., Kryukova, E., Potekhina, E., Shadskaya, I., Abyzova, E. Russian lectures at the crossroads of reforms: strategies of survival and adaptation. *European Research Studies Journal,* 20(2), 2017, pp. 86 – 97.

[7] Ilina, I. Yu., Kryukova, E. M., Zotova, A. I., Chardymskiy, M. G., Skudareva, N. Z. Scientific Degrees As A Status Characteristic Of Russian University Teachers. *International Education Studies,* 8(5), 2015, pp. 165 – 172.

[8] Avdeeva, Z. K., Kovriga, S. V. *Cognitive analysis and management of situations*. Proceedings of the 6th International conference – CASC’2006. Moscow: Institute of management problems of RAS, 2006.

[9] Kulinich, A. A. Computer systems for modeling cognitive maps: approaches and methods. *Control Sciences*, 3, 2010, pp 2-16.

[10] Thibeault, I. V., Prichina, O. S., Goreliva, G. V. Cognitive Russian Modeling in the System of Corporate Governance. *Mediterranean Journal of Social Sciences*, 6(2), 2015, pp. 442 – 452.

[11] Bogdanov, A. A. *Tektologiya: vseobshchaya organizatsionnaya nauka* [Tectology: general organizational science]. Ed. 3. Moscow, 1989.

[12] Meadows, D. H. *Thinking in Systems*: a primer. Chelsea Green Publishing, Vermont, 2008, pp. 211.

[13] Axelrod, R. The Structure of Decision: Cognitive Maps of Political Elites. Princeton. NJ: Princeton University Press, 1976, pp. 404.

[14] Kosko, B. Fuzzy CognitiveMaps. *International Journal of Man-Machine Studies*, 1, 1986, pp. 65 – 75.

[15] Saaty, T. L. Relative Measurement and its Generalization in Decision Making: Why Pairwise Comparisons are Central in Mathematics for the Measurement of Intangible Factors – The Analytic Hierarchy/Network Process. *RACSAM (Review of the Royal Spanish Academy of Sciences, Series A, Mathematics)*, 102 (2), 2008, pp. 251 – 318.

[16] Podvesovskiy, A. G., Lagerev, D. G., Korostelev, D. A. Primeneniye nechetkikh kognitivnykh modeley dlya formirovaniya mnozhestva alternativ v zadachakh prinyatiya resheniy [Use of fuzzy cognitive models for the formation of a variety of alternatives in decision-making problems]. *Bulletin of Bryansk State Technical University*, 4(24), 2009, pp. 77 – 84.

[17] Isaev, R. A., Podvesovskiy, A. G. Generalized Model of Pulse Process for Dynamic Analysis of Sylov’s Fuzzy Cognitive Maps. CEUR Workshop Proceedings of the Mathematical Modeling Session at the International Conference Information Technology and Nanotechnology (MM-ITNT 2017), 1904, 2017, pp. 57 – 63.

[18] Gorshenin, V. P., Prichina, O. S., Orekhov, V. D. *Cognitive Technologies to Build Models for Operations of Business School.* Proceeding of the 29th IBIMA Conference – Education Excellence and Innovation Management through Vision 2020: From Regional Development Sustainability to Global Economic Growth, 2017, pp. 504 – 513.

[19] Belbin, R. M. *Management Teams. Why They Succeed or Fail*. Second edition. London, Elsevier, 2004, pp. 238.

[20] Goleman, D. *Emotional intelligence*. New York: Bantam Books, Inc., 1995.

[21] Muraven, M., Shmueli, D., Burkley, E. Conserving self-control strength. *Journal of Personality and Social Psychology,* 91, 2006, pp. 524 – 537.

[22] Temple, C. Critical thinking and critical literacy. *Change (Peremena)*, 2, 2005, pp. 15 – 20.

[23] Woodcock, M. *Team Development Manual*. Farnborough: Gower Press, 1979.

[24] Barabanov, D. D. *Razvitiye volevoy regulyatsii studentov* [The development of volitional regulation of students]. PhD Thesis. Moscow, Moscow State University, 2015

[25] *The Global Competitiveness Report 2017 – 2018*. World Economic Forum.

[26] Prichina, O. S., Orekhov, V. D., Esipova, E. Yu. Zakonomernosti trudovoy deyatelnosti kollektivov v oblasti R&D: faktory i rezervy povysheniya proizvoditelnosti truda [Regularities of teams' activity in R&D: factors and reserves for increasing labor productivity]. *Social policy and sociology,* 16, 6(125), 2017, pp. 25 – 35.

[27] Barro, R. J., Lee, J. W. International Data on Education Attainment: Updates and Implications. *Oxford Economic Papers*, 53(3), 2001.

[28] Yudina, T. N., Fomicheva, T. V., Dolgorukova, I. V., Kataeva, V. I., Kryukova, E. M. The value of happiness: well-being on a global scale. *International Journal of Engineering and Technology(UAE),* 7(3.14), 2018, pp. 455 – 460.

[29] Svetlov, N. M. Model konkurentsii nauki i proizvodstva za intellekt [Model of competition of science and production for intelligence]. Strategic planning and development of enterprises. Materials of the XVIII All-Russian Symposium. Moscow: CEMI RAS, 2017, pp. 822 – 825.

[30] Apanasyuk, L. A., Egorova, E. N., Kryukova, E. M., Makeeva, D. R., Mukhomorova, I. V. Formation of Pedagogical Experience of Newcomers to the University Teachers in the Process of Intercultural Interaction. *SGEM International Multidisciplinary Scientific Conference on Social sciences and Arts*, 5(3), 2017, pp. 193 – 200.

[31] Apanasyuk, L. A., Egorova, E. N., Kryukova, E. M., Mosalev, A. I., Mukhomorova, I. V. Socio-ecological education as a factor of economic development. *SGEM International Multidisciplinary Scientific Conference on Social sciences and Arts*, 1(3), 2017, pp. 971 – 978.

[32] Fomicheva, T., Sulyagina, Ju., Kataeva, V., Kryukova, E., Dusenko, S. Transformation of Values in Global Society: Managerial Aspect. *Espacios,* 38(33), 2017, pp. 31.

[33] Kryukova, E., Starostenkov, N., Krapotkina, S., Timoshina, E., Makeeva, D., Yudina, T. Socio-Economic Problems of Today's High School Students in The Context of Reforming The Educational System of The Russian Federation. *Journal of Advanced Research in Law and Economics,* 7(2), 2016, pp. 285 – 291.

[34] Dusenko, S., Oleynik, A., Sharikov, V., Polyakov, V., Kryukova, E., Melnichuk, A. Current State Of Innovative Activities In Education: The Use Of E-Learning In Russian Universities. *Research Journal of Pharmaceutical, Biological and Chemical Sciences,* 7(4), 2016, pp. 1629 – 1637.