INVESTIGATION OF MANAGED EXTERNAL - AND INTRIECONOMIC PROCESSES IN CONDITIONS OF GLOBAL AND UNCERTAINTY

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ABSTRACT

The work is devoted to the study and substantiation of the systemic possibilities of administrative influences on socio-economic processes in conditions of global and uncertainty. The program-targeted approach, from the point of view of the existing macroeconomic interrelationships in socio-economic processes, within which regional and microeconomic production, labor, information processes occur, is the basis for the study. The paper substantiates that, from the point of view of the stability of the interrelationships between natural and social processes, the priority of choosing strategic plans (programs) for the development of society is based on the key role of labor productivity growth and GDP per capita, as well as on increasing the share of human capital in the composition of national wealth. A critically important condition for the implementation of the innovative development program is to ensure a guaranteed reduction in the level of depreciation of fixed assets, as well as intensify activities in the field of R&D.

Keywords: *socio-economic processes, human capital, GDP per capita, STEP factors, labor productivity, depreciation of fixed assets, cognitive modeling, fuzzy cognitive matrix*

1. INTRODUCTION

The authors used the target-oriented approach to effectively apply the developed solutions to adapting the Russian labor market to the rising globalization requirements and uncertainty and determine the parameters of the developed strategy. Alternative options of strategic programs were developed by an economic and mathematical method: the cognitive modeling methodology. Previous research both by target-oriented and organic approaches enabled the authors to select a list of factors that provide for the most efficient achievement of the target GDP per capita parameters. The objective of the research is to study the problem of achieving the target GDP per capita parameters using cognitive modeling methods.

2. METHODOLOGY

The study of controlled economic processes is based on the general management theory, according to which the socioeconomic development system of a country develops in cycles with four to sixteen (depending on the level of detail) development stages.

The following classic stages (derived from the scientific organization of labor) are present within the management cycle:

1. Collecting information (in this case, the formation of a list of concepts that reflect the problem area of the actual state of the socioeconomic system in general).
2. Providing a comprehensive analysis of assessment of the collected indicators with account of the interconnected (interdependent) factors of the macroeconomic dynamics and constraining factors.
3. Building a system of scenario alternatives and their assessment (experience shows that it is the most reasonable for decision support systems to develop alternative options of strategic scenarios and uncommon managerial decisions with a focus on maintaining the mechanism of the socioeconomic system functioning).
4. Providing situational control of the process development under a directing control action.

The technology of cognitive modeling of the dynamics of a sophisticated, poorly structured system was used for the systematic study and consideration of the mutual influence of various factors in the field of socioeconomic activity (Kosco, B., 1986, pp. 65–75), (Saaty, T.L., 2008, pp. 251–318), (Kulinich, A.A., 2010), (Prichina, O.S., Goreliva, G.V., 2015, pp. 442–453), (Gorshenin, V.P., Prichina, O.S., Orekhov, V.D., Pechurochkin, A.S., Aliukov, S.V., 2017, pp. 504–513). The behavior modeling of the system under consideration was performed with the IGLA decision support system (Korostelev, D.A., 2008, pp. 329–336), (Podvesovsky, A.G., Lagerev, D.G., Korostelev, D.A., 2018). This publication continues the previous study (Melnik, M.S., V.D. Orekhov, O.S. Prichina, 2018, pp. 94–101) of the cognitive modeling of trends and regularities of human labor activities, in which the first two stages of those specified above were completed and the work on dynamic modeling was started. This study provides the detailed results obtained through dynamic modeling of the system development affected by single control concepts.

3. RESULTS

3.1. Selection of the set of socioeconomic development factors

At the first stage, experts isolated the main types of factors determining trends and regularities of human labor activity. As the factors were grouped, it became obvious that they were mostly STEP factors, though it is not a precise definition for some of them. The list of factors (concepts) is provided in Table 1. Columns 3 and 6 indicate their level L (1 for low, 2 for moderate, 3 for high) for Russia in 2015–2018 compared to the typical level in the developed countries. The Global Competitiveness Report (Schwab K., 2017, 1–398) served as the main source of data on the state of the system under consideration in the evaluation of the level of concepts. In addition, the data provided in (Twelve Solutions for the New Education, 2019, 1–106), (Labor Productivity in Russia, 2017, 1–44), (Russia and the EU Countries, 2017, 1–264), (Education at a glance, 2017, 1—452), (Word Globalization, 2018), (Sobolev, E.N., 2017, pp. 1–46), (Nesterov, L.I., 2003, pp. 103–110), (The Strategy of Innovative Development of Russia, 2011), (Koritsky, A.V., 2013, pp. 1–244) were used for evaluation. Table 1 shows that these factors cover the major part of directions of the socioeconomic development of Russia with an emphasis on the occupational activity. Issues of healthcare, not present explicitly, mostly refer to the ‘social and labor institutes’ concept.

3.2. Construction and analysis of a fuzzy matrix

At the next stage of the study, we revealed connections between concepts and determined their influence degree using the following scale: 1.0; 0.5; 0.5; 0.25; 0; –0.25; – 0.5; –0.75; – 1.0. In order to reduce the large cognitive table, we also represented it in quartiles (–4, –3, –2, –1, 0, 1, 2, 3, 4), with each portion equal to one fourth of the unit.

Table 1: Levels of the selected concepts

No.	Concept name	L	No.	Concept name	L
	Social factors		12.	Depreciation of fixed assets	3
1	Human capital	2	13.	Macroeconomic stability	2
2	Personnel education level	2	14.	Financial institutions and markets	1
3	Stimuli for education	2	15.	Expenditures for science	1
4	Business education	2	16.	Globalization	2
	Technological factors		17.	Expenditures for the higher vocational education system	1
5	Labor productivity	1			
6	Infrastructure	1	18.	Unemployment level	2
7	Innovative activity	1		***Political factors***	
8	Progress in science and technology	2	19.	Strategic programs	2
9	Research and Development	2	20.	Cross-border barriers	2
	Economic factors		21.	Defense expenditures	2
10.	GDP per capita	2	22.	Social and labor institutes	2
11.	Natural resources	3			

We used the determined connections and the IGLA decision support system to form a fuzzy cognitive map **(**FCM), which formalized the cause and effect relationship between concepts, as shown in Table 2 in quartiles (Melnik, M.S., V.D. Orekhov, O.S. Prichina, 2018, pp. 94–101). An analysis of the cognitive dissonance matrix that demonstrates the extent of trust in the FCM concepts shows that it has a low dissonance with the average value of 26%. The highest dissonance is observed for unemployment (65%), social and labor institutes (62%), stimuli for education (53%), business education (51%), and personnel education level (47%).

Table 2: Fuzzy cognitive matrix (quartiles)

	The concepts influenced																				
Influencing concepts	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
1. Human capital										**3**												
2. The level of the personnel education	**3**				**3**		**2**											**-1**				
3. Motivation for education		**3**		**2**																		
4. Business education					**3**		**2**															
5. Labor productivity										**3**												
6. Infrastructure	**1**				**3**																	
7. Innovative activities								**3**														
8. TD					**3**														**3**			
9. R&D								**3**			**1**								**1**			
10. GDP per capita						**3**						**-3**										**2**
11. Natural resources										**3**												
12. Depreciation of fixed assets			**-3**		**-3**					**-3**												
13. Macroeconomic stability							**2**							**3**				**-2**				**3**
14. Financial institutions and markets							**3**					**-2**										
15. Expenditure on scientific activities									**3**													
16. Globalization						**2**	**2**													**-2**		
17. Expenditure on the HVE system		**3**																				
18. Unemployment rate			**2**							**-2**												
19. Strategic programs						**2**						**-3**			**3**		**3**					**3**
20. Cross-country barriers										**-3**						**1**						**-3**
21. Expenditure on the defense capacity									**2**				**3**									
22. Social and labor institutions	**3**					**2**												**-2**				

An alpha section of the FCM consonance (Fig. 1) at 90% shows high trust in the concepts that are most important for this system: strategic programs, research and development, progress in science and technology, expenditures for science and higher vocational education, depreciation of fixed assets, etc.

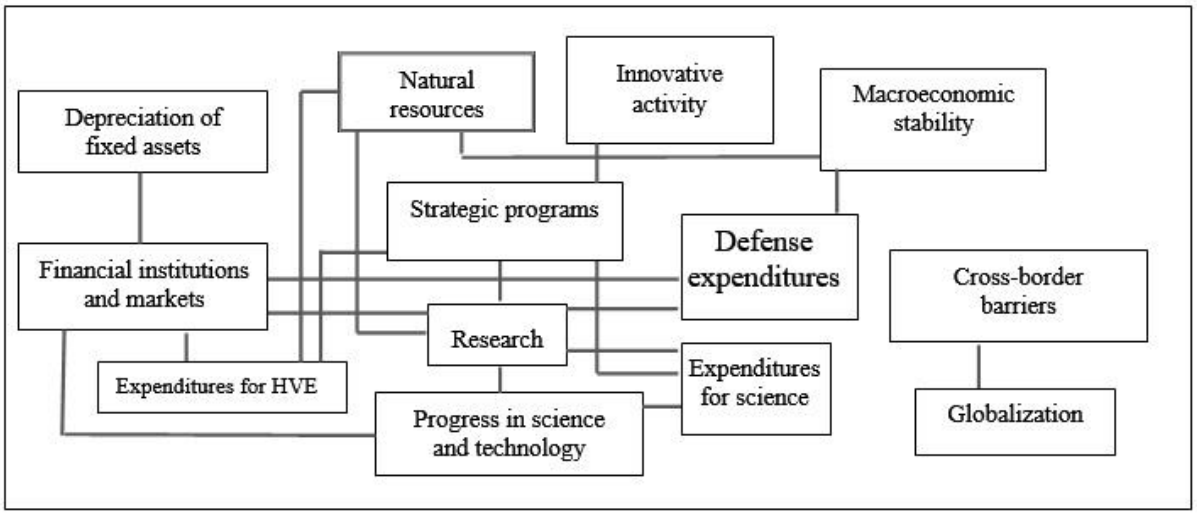

Figure 1: Alpha section of the mutual consonance of the FCM concepts (90%)

Figure 2 provides an alpha section of the concepts at 75% for the mutually positive influence. For a more integral representation of the relationship pattern, we provided the concepts associated with the negative effect in the diagram (those are highlighted with italics, and negative relationship is shown with a dashed line).

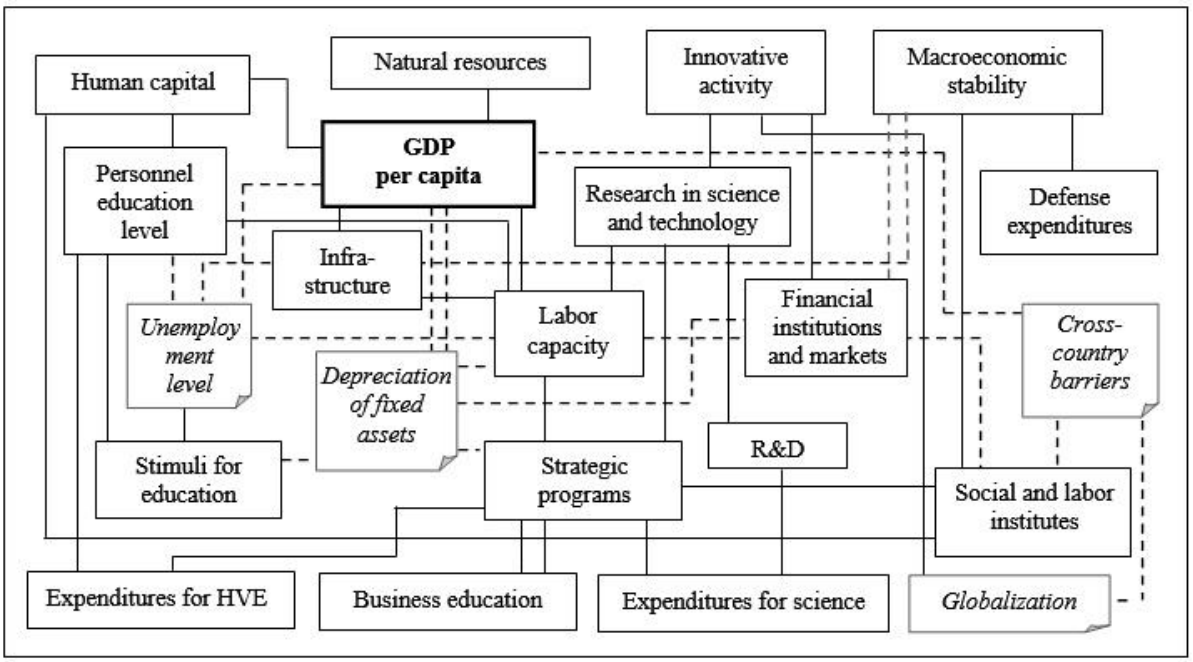

Figure 2: Diagram of the mutual influence of the FCM concepts

This diagram allows emphasizing the main nods of direct influence on the 'GDP per capita' target concept. Three mutually positive ones are: human capital, natural resources, labor productivity. Two mutually negative ones are: depreciation of fixed assets, cross-border barriers for obtaining knowledge and technology.

3.3. Modeling dynamic interaction

In dynamic modeling of the system development, we used GDP per capita with a very high target level (100%) as the target concept. And concepts that can be effectively controlled were chosen as the control parameters: strategic programs, innovative activity, business education,

and expenditures for the higher vocational education system. In the previous study (Melnik, M.S., V.D. Orekhov, O.S. Prichina, pp. 94–101), the dynamic modeling was performed with simultaneous variation of all of the control parameters and selection of the best management program option. Alternatives 63 and 167 turned out to be the best ones out of the 255 non-dominating options considered. The time dynamics of the target and control concepts for option 167 is provided in Figure 3. At the first step, the control pulse is obtained based on the conditional time of the concepts' values, and then a quick change in the control concepts takes place, followed by an increase in GDP per capita, which achieves the target value by Step 10.

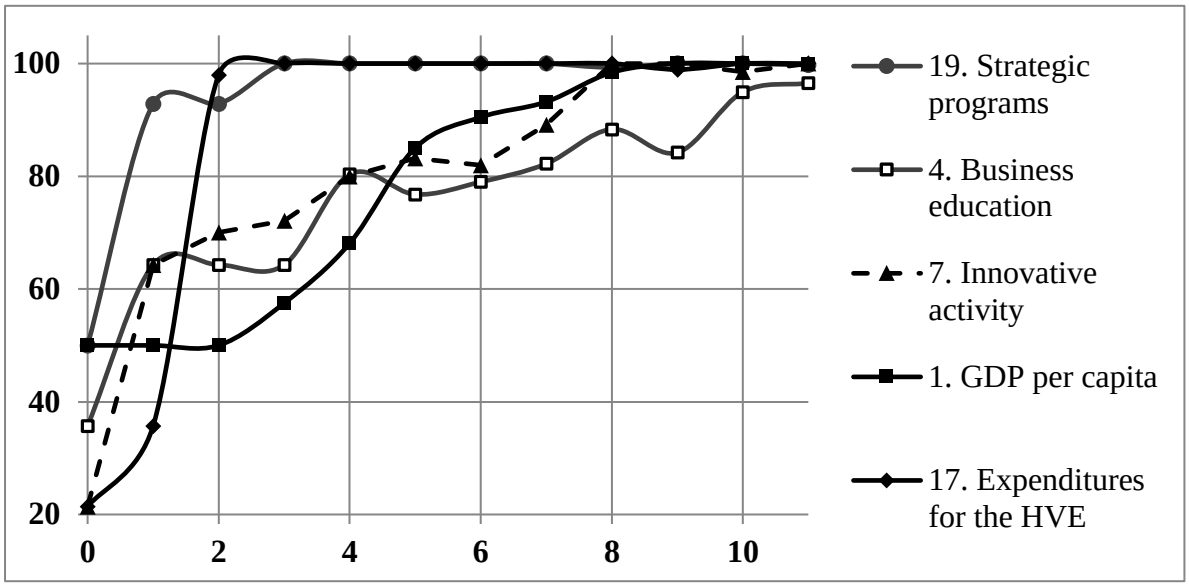

Figure 3. The dynamics of the controlling and target concepts (Alt. 167)

However, the best option is characterized by a very high control pulse, which in real life can be very costly or unfeasible; therefore, we considered other options to manage the socioeconomic process in this study. With this purpose, we considered the system's behavior under the effect of certain control pulses. For example, Figure 4 shows the dynamics of the target factor and a group of concepts, which could be the controlling ones, but in this case only the Innovative Activity concept was increased in pulses from 20% to 50%. It is evident that after the initial pulse the concepts start to grow quickly and then achieve the margin, with innovative activity reaching 87%, business education 70% and the others striving to achieve 100%. The target concept under such a control action reaches 100% by Step 14, instead of Step 9, as it did under a combined influence of factors. We should note that according to the cognitive map (Table 2), innovative activity affects progress in science and technology only, which in turn affects strategic programs. Subsequently, strategic programs influence on the whole set of concepts, including labor productivity, and result in their growth and achievement of the target value.

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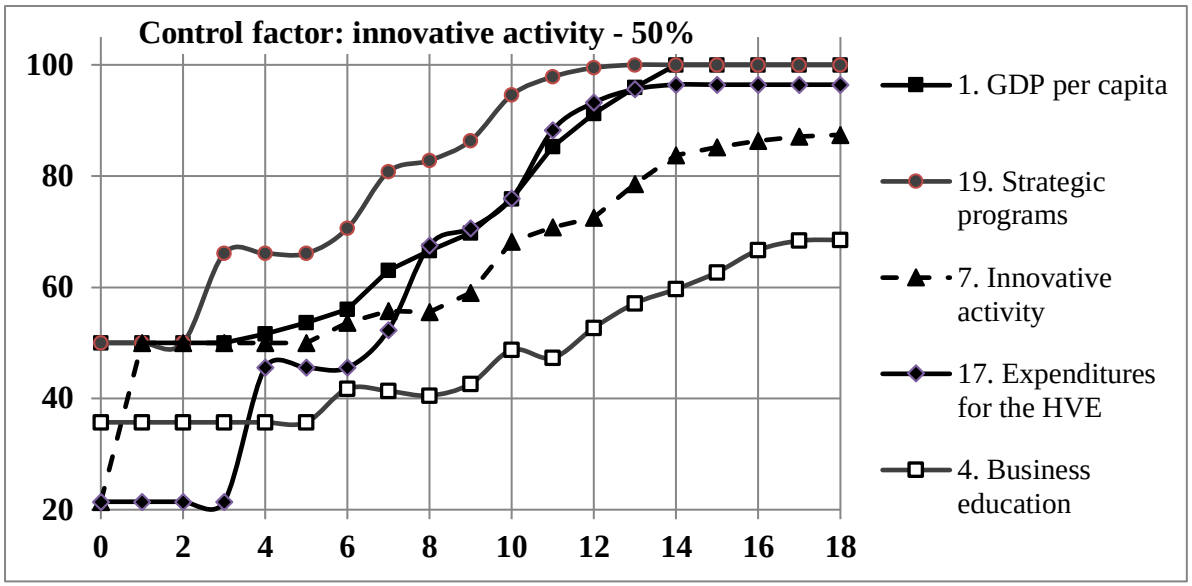

Figure 4: Effect of innovative activity on the system concepts

Figure 5 shows the behavior of the concepts associated with labor productivity, and Figure 6 shows those associated with progress in science and technology and social and labor relations with the same control action.

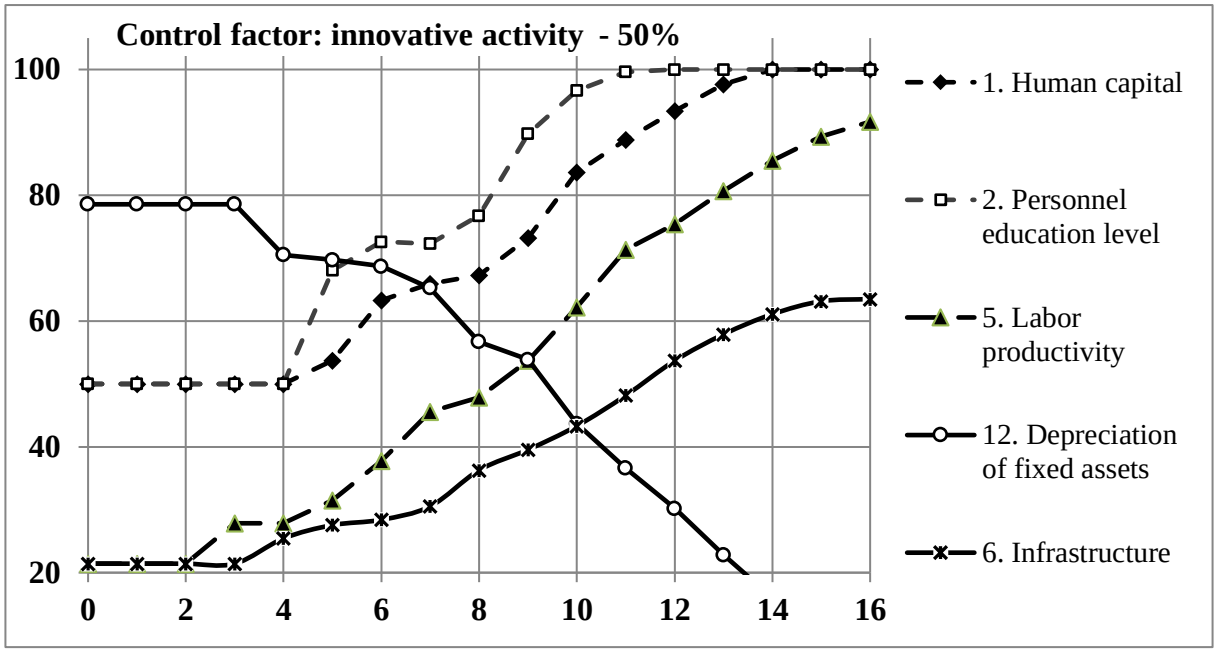

Figure 5: Dynamics of the concepts associated with labor productivity

It is evident that among the factors shown in Figure 5, Labor Productivity responds the most quickly (however, slower than Strategic Programs) to the control action, and is followed by Depreciation of Fixed Assets, Infrastructure, after which Education Level and Human Capital start growing. The dynamics of factors shown in Figure 6 demonstrates that progress in science and technology responds to the control action the most quickly, and the rest start changing from approximately Step 4, responding to the dynamics of strategic programs. It is characteristic that the dynamics of concepts in this case is of intermittent nature, which is due to delays in the control pulse for a number of concepts:
Innovative Activity →Progress in Science and Technology →Strategic Programs →…

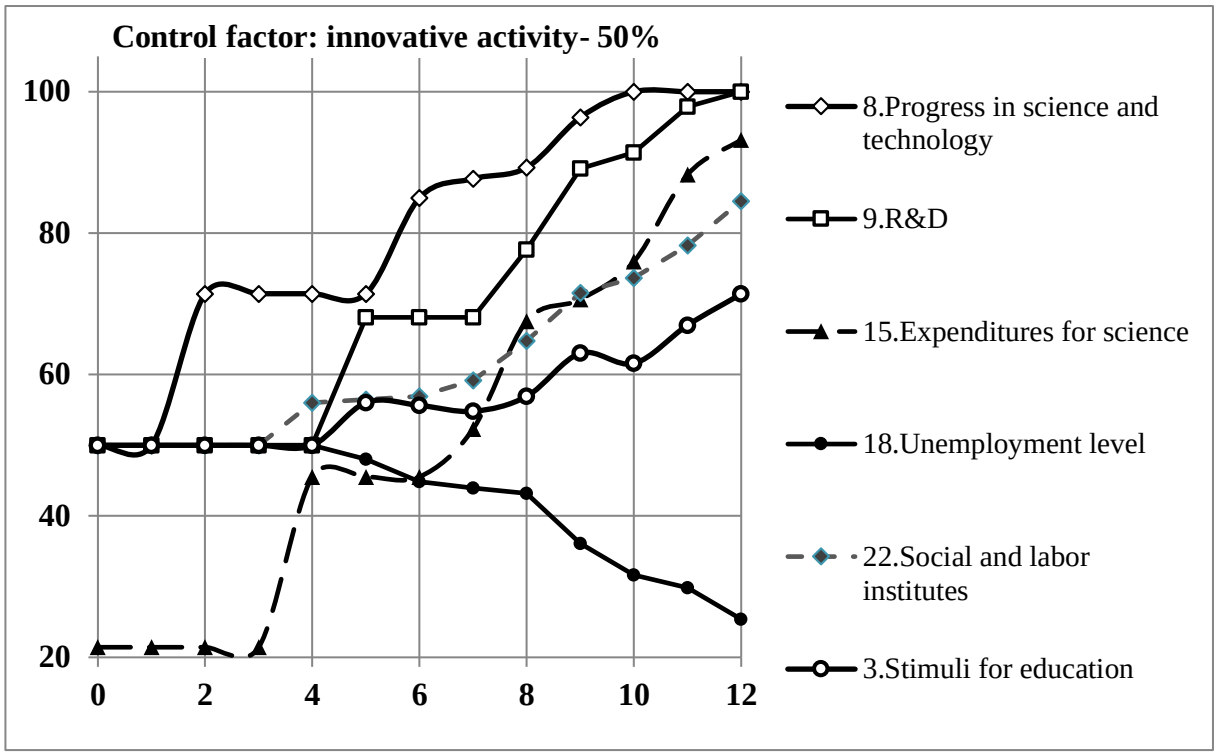

Figure 6: Dynamics of the 'Progress in Science and Technology' and 'Social and Labor Relations' concepts

Figures 7 and 8 show the behavior of the key concepts of the system under the effect of the 'Business Education' control factor, the control action of which consists in the growth from 36% to 50%.

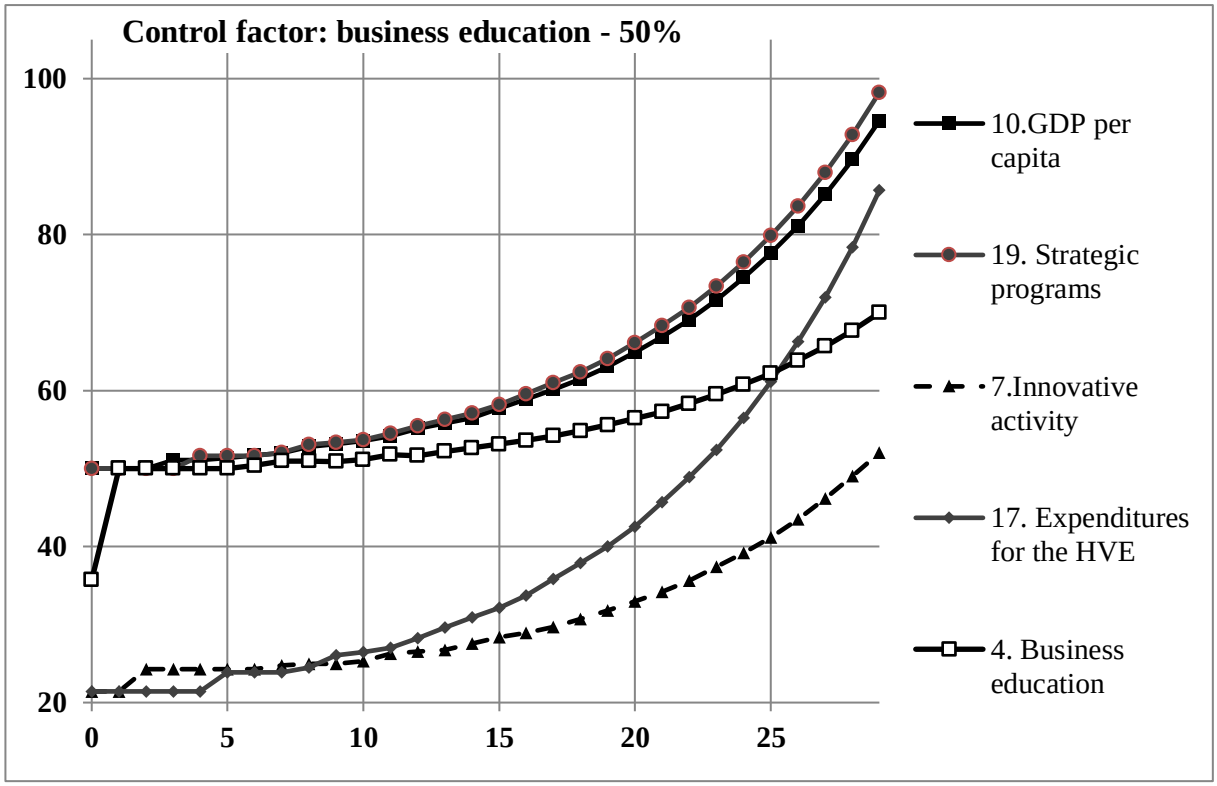

Figure 7: Influence of business education on the key parameters of the system

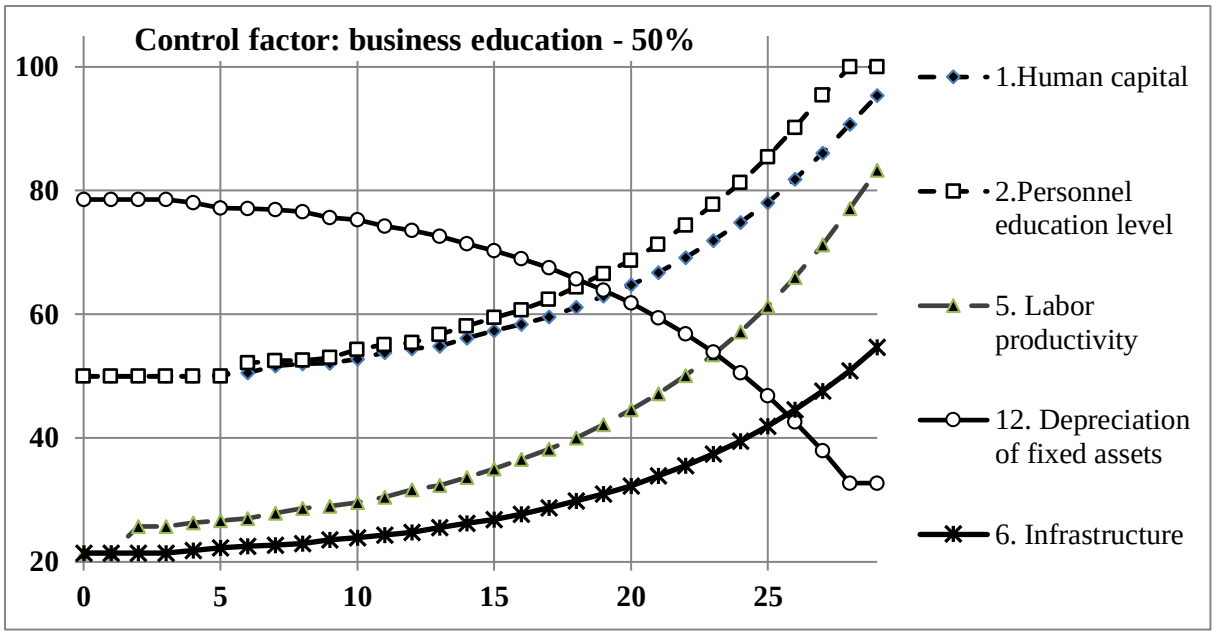

Figure 8: Influence of business education on the 'Labor Productivity' group concepts

It is obvious that the target factor in this case achieves the target value much slower, after Step 30. The system changes much more gradually. Probably, it is due the fact that business education influences labor productivity directly and significantly, and the latter significantly affects the target parameter. Figure 10 shows the effect of the 'Expenditures for the Higher Vocational Education System' control concept on the system dynamics.

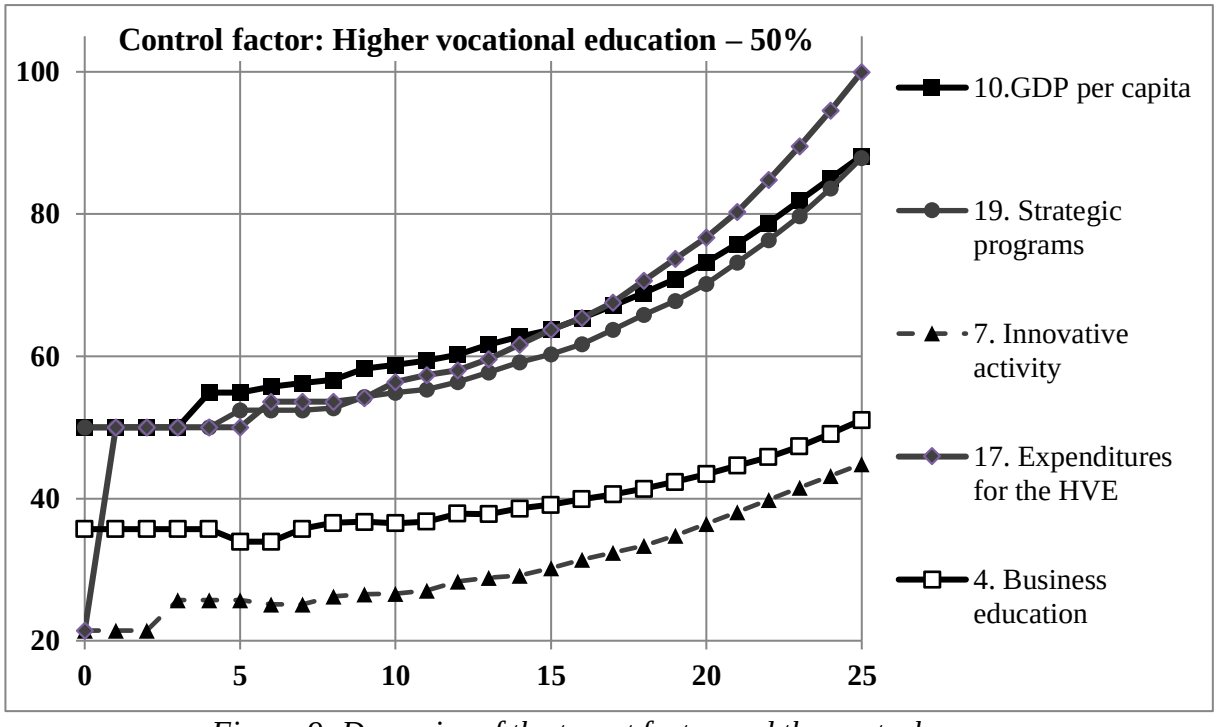

Figure 9: Dynamics of the target factor and the control group

In this case, as is seen, the change takes place slower and the target value is achieved at approximately Step 30. The change process in this case is rather monotonous. At the same time, expenditures for the higher vocational education in this system influence only on the personnel education, which results in the growth of labor productivity, and, subsequently, GDP per capita.

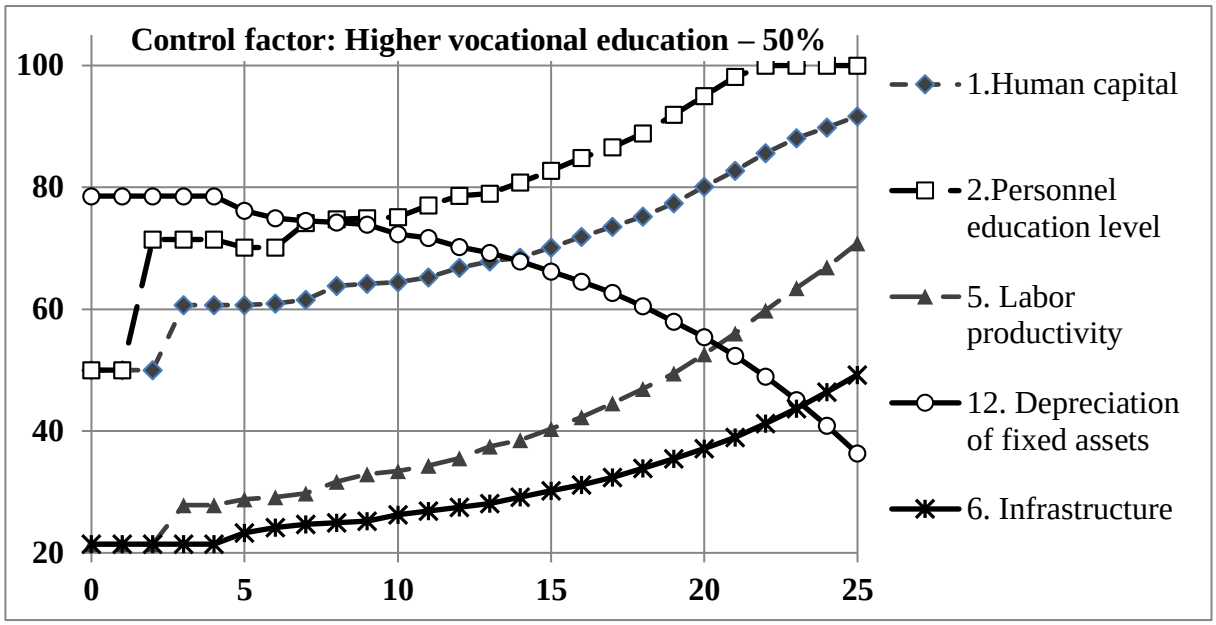

Figure 10: Dynamics of the concepts associated with labor productivity

Figures 11 and 12 show the dynamics of the system under the effect of the 'Strategic Programs' control concept.

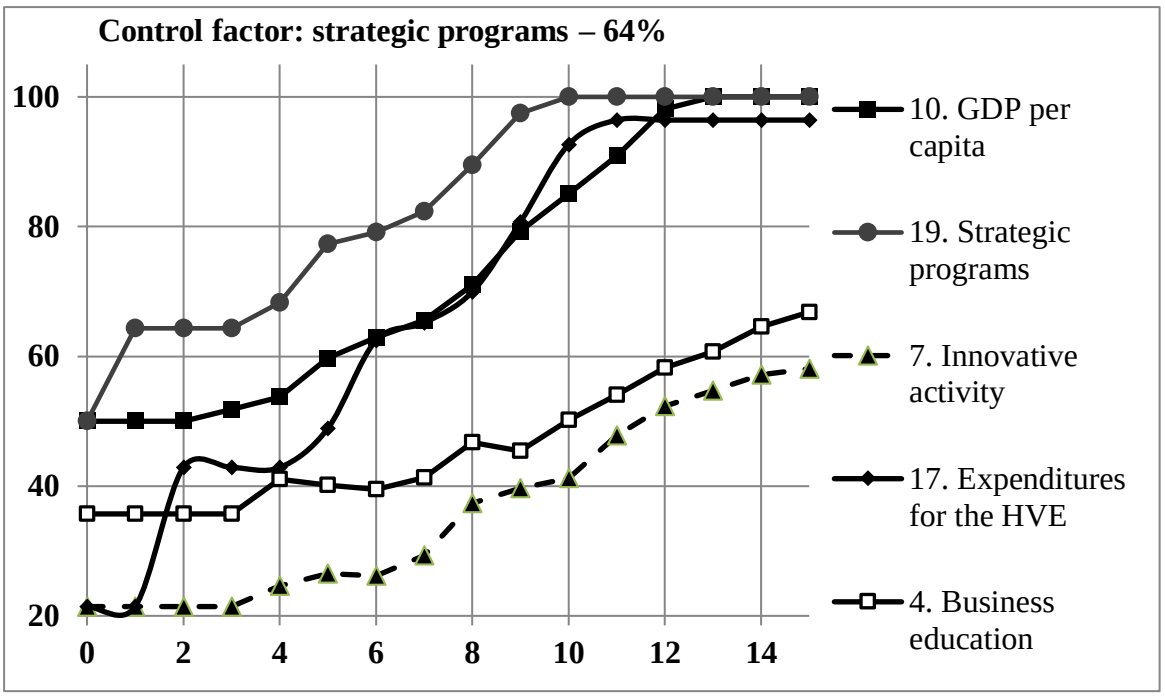

Figure 11: Dynamics of the target factor and the control group

In this case, the target value is achieved at about Step 13, that is at the same rate as under the effect of the 'Innovative Activity' control concept, and much faster than under the effect of the control concepts of the education group. It is characteristic that the control action of the 'Strategic Programs' concept in this case reaches 64% only (with the initial value of 50%), while it is very high under a combined effect (92%). The influence of the intensity of the 'Innovative Activity' control concept is provided in Figure 13. It is evident that a 14% increase in intensity results in a quicker achievement (by 1 or 2 steps) of the target concept, i.e. faster by 10–15% in terms of time.

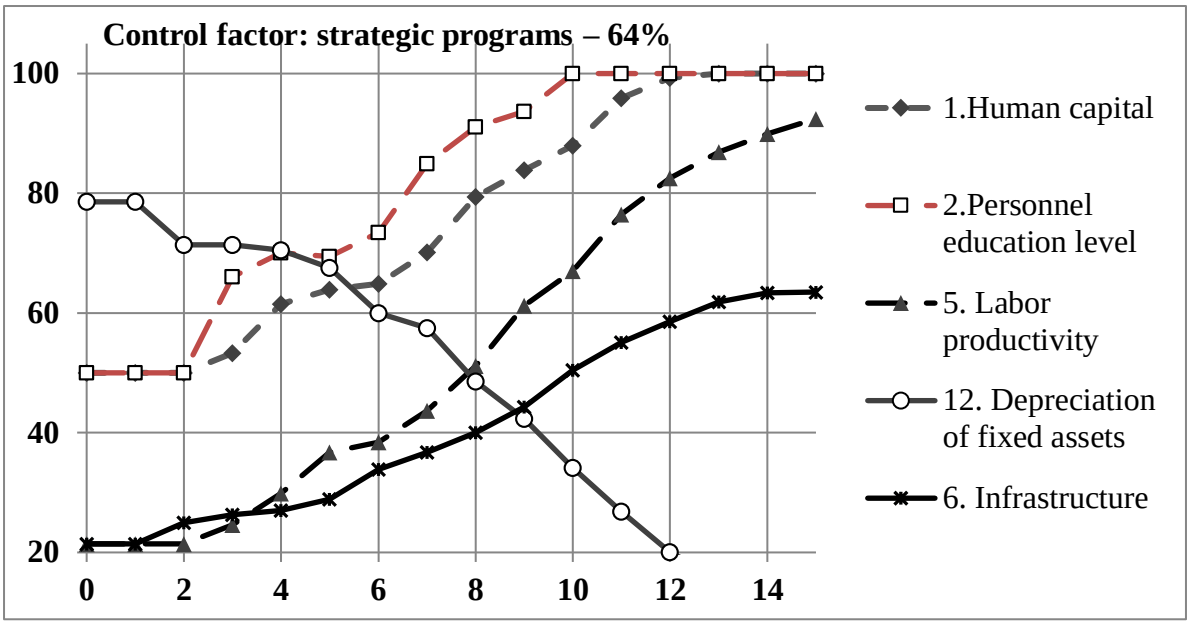

Figure 12: Dynamics of the concepts associated with labor productivity

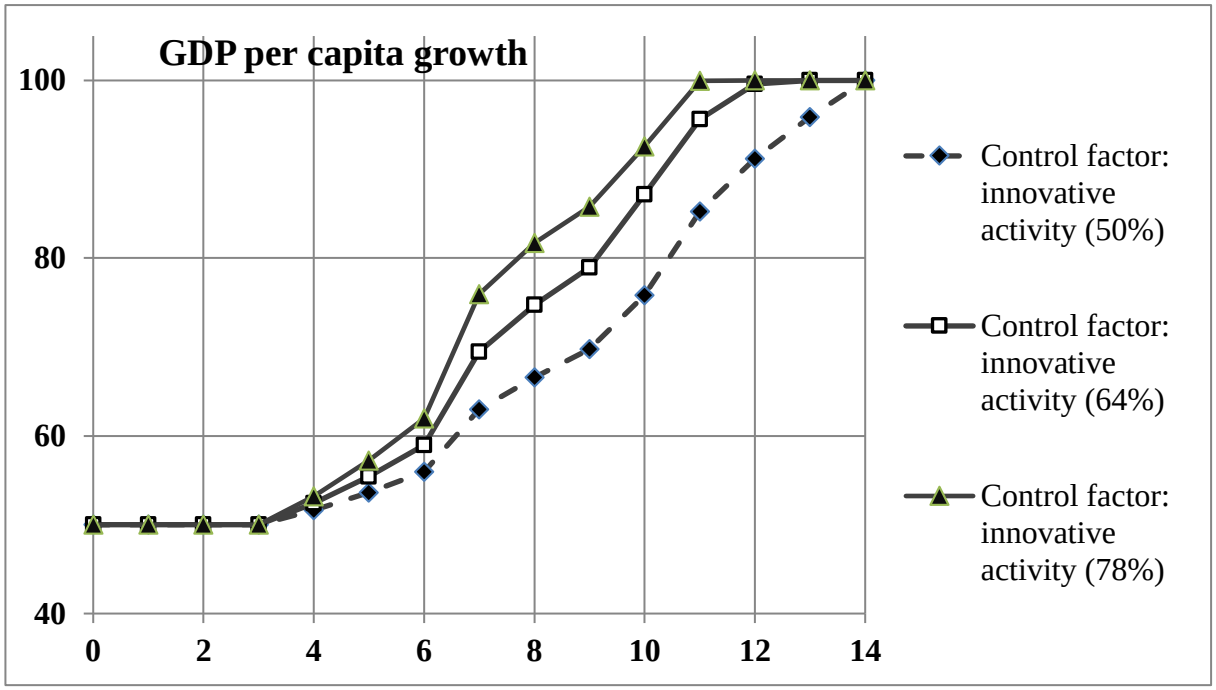

Figure 13: The effect of intensity of the control factor

A comparison of the effect of certain control factors and the combined effect (Alt. 167) is shown in Figure 14. It is evident that the combined control action allows achieving the target factor three steps faster; however, it requires a significantly more intensive control action on the system. In general, the results of the dynamic analysis of the socioeconomic system show that the innovative activity and strategic programs, in their function as the control factors, significantly faster influence the achievement of target level of 100% by the 'GDP per capita' target parameter, compared to expenditures for the higher vocational education system or business education. The target level is achieved the most quickly with a combined effect of the four control factors, but it requires a powerful control action: strategic programs 78%, innovative activity 64%, expenditures for the higher vocational education 36%, and business education 64%.

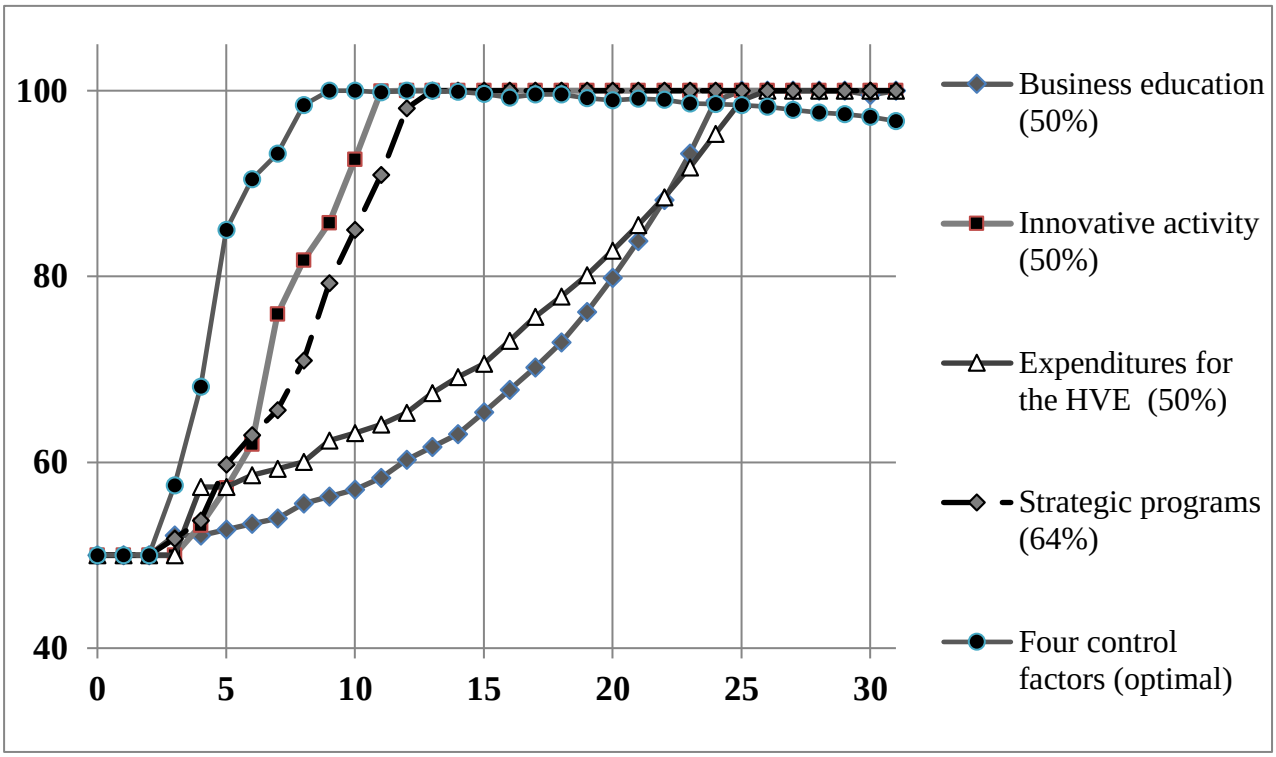

Figure 14: The effect of various control actions on GDP per capita

4. DISCUSSION

The main goal of this study was to investigate the systematic capacity of increasing GDP per capita, though a focus on this parameter does not ensure achieving an efficient development of the socioeconomic system on the national or regional scale currently. It is due to the fact that the most important task for Russia is to increase the efficiency of human capital utilization and labor productivity. However, wider aspects of socioeconomic development should be considered in the future, primarily with a focus on the factors of environment and sustainable use of natural resources. It is suggested to consider the approach focused on inclusive development (Spence M., 2011, 336 p.). However, the system becomes much more sophisticated in this case; therefore, we will have to disregard some concepts that we have considered in this study, as according to the systematic approach, it is impossible to increase both the integrity of the system consideration and its level of detail. To consider the effect of the control factors without taking into account the control actions, it is recommended to use programs that are difficult to implement. Therefore, it is expedient to assess the implementation cost of such projects at the initial stage of investigation.

5. SUMMARY

Using the IGLA decision support system, we determined the dynamic characteristics of the existing established relationships that have a positive effect on the target concept: human capital, natural resources, labor productivity. Among the control factors under consideration, the ones that have the strongest influence on the system are 'Innovative Development' and 'Strategic Programs'. An investigation of the effect of certain control factors on the system enabled us to study the dynamics of a sophisticated, poorly controllable macroeconomic system and reveal the interconnection of the best combination of actors ensuring the control action achievement. With some allowances (at the level of the established objective trend in the economy), we have confirmed that the strategic development program, the key concepts of which are: 'Improvement of Strategic Programs' and 'Intensification of Innovative Activity', is the most efficient one.

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