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Distribution of financial resources by areas of investments in the human capital of the region

KEYWORDS

human capital of the region;
 investments in human capital;
 financial resources;
 socially responsible investments;
 optimization of investments structure;
 multiperiod economic and
 mathematical model
 development targets

ABSTRACT

Introduction. The study has been conducted within the framework of the urgent scientific and practical task of accumulation and development of human capital of Russian regions. Under the conditions of risks and limited resources, the regional management faces the task of optimal distribution of financial resources invested in the development of human capital and improvement of the quality of life. The study aims to build and test the dynamic optimization model of financial resources distribution by areas of investment in human capital through the example of the Primorye Territory (Russian Federation).

Materials and methods. The multi-period economic and mathematical model describes the influence of the volumes and structure of public and private investments on the regional human capital in the form of recurrent dependencies. The target function of the model is an integrated index of achieving the objectives for the development of human capital in the region. The model is a mathematical programming problem, the optimization variables are the shares of investment resources distributed by investment areas and years.

Results. In a practical sense, the proposed model is a management tool for searching the optimal structure of investments in human capital by areas of investment and periods. Based on the annual results of modeling and numerical calculations through the example of the Primorye Territory (Russian Federation), the structure of the investments that allow advancing in the achievement of target values of strategic indicators in the field of human capital development is offered.

Conclusion. In the long term, the achievement of target indicators will be facilitated by a more even structure of investments in the following areas: along with education and health care, it is advisable to increase investments in other areas, first of all, in the issues of national importance, national security, public order, and social policy.



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INTRODUCTION

Human capital is a productive factor in the socio-economic development of countries and regions. Numerous studies within the framework of the human capital theory substantiate the leading role of investments in education, health, and quality of life in the promotion and development of intellectual and innovative potential. The very notion of human capital is interpreted by the classics of this theory as a set of investments in the education and professional skills of a person, increasing his/her ability to work [1; 2]. In particular, Becker compares human capital with physical capital and shows that investments in human capital (IHC) are equivalent to investments in physical capital and can bring no less or even more profit in the future [3].

The questions connected with processes of optimization of financial resources structure by areas of IHC have huge practical value for the Russian national and regional management, which aspires to increase the labor and innovative potential of territories according to the current priorities of development of the country*. In this process, regional authorities rely on programs of strategic importance, which outline the targets of socio-economic growth. In particular, the "Strategy of Socio-Economic Development of the Far East and the Baikal Region for the Period up to 2025" is referred to (approved by the Russian Federation Government Decree No. 2094-r dated December 28, 2009), as well as the new program document of national importance – "Strategy of Spatial Development of the Russian Federation until 2025" (approved by the Russian Federation Government decree of February 13, 2019, No. 207-r). Given the existence of a clear scenario of territorial development of Russia and its regions for the next five years, improving the local structure of investment spending will make state support measures more targeted and effective, and target benchmarks more achievable.

The final effect of IHC for regions is expressed in the increase in competitiveness of the territorial economy in the national and international arenas, growth of the gross regional product, and reduction of inter-regional socio-economic differentiation by steadily improving the quality of life of the population. The obvious scarcity of financial resources permanently increases the relevance of the problem of their optimal distribution by the areas of investment funds.

At present, the most priority areas for IHC in Russia are education and health care, as these very spheres determine the basic level of the population's viability. The importance of these spheres both on the part of the state and private investments is also explained by obtaining in them a rather high rate of profit. However, the changes over time in the volume of investments and their economic effect in the regional context do not correspond to the required indicators of innovation and human capital development, which indicates the low efficiency of the ongoing investments. Traditionally, housing and communal services, environmental protection, culture and sports, urban and rural infrastructure, social support, and other areas

* Strategy for Innovative Development of the Russian Federation for the Period until 2020. Approved by the Russian Federation Government Decree No. 2227-r of December 08, 2011 "On Approval of the Strategy for Innovative Development of the Russian Federation for the Period until 2020".

of financing remain underinvested and weak in terms of efficiency. Those are called "socially responsible investments" in Western literature [4].

At the same time, the improvement of the distribution of regional financial resources allocated for socially responsible investment will contribute to the formation of synergies between the financed spheres of economic management to obtain the highest benefit in the form of improved quality of life, development of social and economic environment and, consequently, the preservation of human capital in the territories. In this case, the use of optimization models as one of the problems of mathematical programming allows finding the best shares of the distribution of the financial resources by the areas. The purpose of this study is to build and test a dynamic optimization model of the distribution of financial resources by the areas of IHC by the example of the Primorye Territory. The results of this study are aimed at identifying ways to maximize the development of human capital in the regions and thereby contribute to solving several important scientific and practical problems of Russian society related to the population, quality of life, and innovation potential of the territories.

DEGREE OF THE SCIENTIFIC PROBLEM DEVELOPMENT

Much credit for the formation of views on the significance and role of human capital investments belongs to classic authors of human capital theory – Schulz, Becker, Blaug, Mintzer, Thurow, and others. Their work was continued by a galaxy of modern scientists, who provided conclusions and recommendations on the problems of increasing the efficiency of socially responsible investments based on their studies. It is possible to distinguish several research areas on the given theme in the scientific literature.

1. *Assessment of the role of human capital and IHC in the overall socio-economic development of countries and regions.* The subject of research here is the place of human capital in the modern socio-productive process, the relationship between human capital and the key parameters of economic growth, as well as the specifics of transformation of human capital into specific parameters of improving the quality of life, improving the business environment and accelerating economic growth on this basis. Thus, the Russian academician Aganbegyan substantiates the role of human capital and the knowledge economy as the main source of economic growth. He considers the low degree of integration of investments in fixed and human capital as the main reason for a series of depressions and stagnations in the Russian economy in the 2010s [5]. At the same time, recessive features are especially pronounced at the regional level [6]. The study [7] reveals that in the 1960–2011 period, IHC and the changes in productive specialization were the decisive factors of economic growth for developed countries. Analysis of data on OPEC countries in the late twentieth and early twenty-first centuries shows that the development of human capital has become a decisive factor in long-term economic growth, while significantly affecting poverty reduction in these countries [8]. Analysis of data on the United States for the 1949–2014 period reflects the

positive impact of investments made by the country's defense sector in human capital on human capital accumulation and the economic growth of the country as a whole [9].

2. *Optimization of the structure of investments in the regional human capital from the reduction of territorial socio-economic differentiation perspective.* Despite differences in initial conditions and rich country specificity, studies from several countries show the essential influence of human capital investments on smoothing of social inequality, reduction of inter-regional economic differentiation [10]. Having studied the results of research on Chinese provinces for different periods of the 20th and 21st centuries, the conclusion that the weaker the territory is developed, the stronger the impact of human capital on the socio-economic development of the region [11; 12] seems to be significant for practice.

3. *Determination of the key (most effective) areas of IHC.* Most studies traditionally assign the main role to educational and professional components and justify the growth of the share of these spheres in national investment expenditures. In particular, the studies [13; 14] link the socio-economic development of the Russian Federation subjects (and their differentiation) with the generalizing indicators of education. The article [15] analyzes the regional experience of IHC through the changes of investments in education and healthcare. The work [16] considers the impact of human capital on regional economic growth through investments in education and R&D. The article [17] considers the impact through health and professional competencies. However, some authors reasonably believe that investments only in education and health are not enough, and propose to expand the areas of investments in such areas as culture [18], well-being (infrastructure provision), R&D [19], recreation, entertainment, and sports organizations activities [20], as well as in the environment [21; 22]. In the work [23], a new comprehensive measure of IHC was developed as an alternative to the traditional system of evaluation based on education.

At the same time, it should be recognized that there is still a lack of experience in research of the influence of the whole complex of different areas of IHC with their synergy effect being considered in the scientific literature. The authors, of course, adhere to the ideas about the significant positive role of IHC in the development of regions, but today they consider it more relevant to reorient research from the channel of positive analysis to a normative one, namely – to improve the structure of IHC for the maximum achievement of the life quality parameters (target benchmarks) set by the abovementioned Development Strategies by regions. To do this, the authors have previously developed a conceptual model, which presents the general logic of the dynamic process of development of regional human capital by investing financial resources from various sources in different areas in it. According to this logic, each area of investment leads to the development (growth) of the region's human capital to a greater or lesser extent by changing the components describing it [24]. At the same time, some areas of investment influence human capital directly, and some – indirectly, through the improvement of the quality of life. The existence of links between groups of parameters describing human capital, socio-economic development of territories, demographic dynamics, and quality of life was reflected by the results of econometric modeling in [25].

MODELING THE OPTIMAL STRUCTURE OF INVESTMENTS IN REGIONAL HUMAN CAPITAL AND QUALITY OF LIFE

Within the framework of the set goal of the research, the problem of choosing the optimal structure of distribution of IHC and quality of life by areas of investment and years with a planning horizon T to achieve the highest possible level of human capital in the region is considered. At each moment of time t , where $t = 0, 1, \dots, T$, financial resources are invested in the development of regional human capital.

Regional human capital as an integral system consists of certain components. In [26], six basic groups of components are distinguished, namely: levels of professionalism, education, scientific and innovative development, health and culture, and 24 indicators for assessing regional human capital are proposed. A vector function is assigned to each region:

$$Z_n^t = (z_{1n}^t, z_{2n}^t, \dots, z_{Mn}^t), \quad n = 1, \dots, N, \quad (1)$$

where z_{mn}^t is the level of the m -th characteristic of the human capital of the n -th region at the t time; M is the number of characteristics describing regional human capital; N is the number of regions.

IHC at the regional level is understood as public and private investments directed both to the development of human capital and to the improvement of the quality of life of the region's population. All public (variables x_1, \dots, x_{12}) and private (variables x_{13}, x_{14}, x_{15}) investments influencing the development of human capital, directly and indirectly, are considered as investments in the region's human capital in the following areas:

- national issues (x_1);
- national defense (x_2); and
- national security and law enforcement (x_3);
- national economy (x_4);
- housing and public utilities (x_5);
- environmental protection (x_6);
- education, state (x_7);
- culture, cinematography (x_8);
- health care, state (x_9);
- social policy (x_{10});
- physical culture and sports, state (x_{11});
- mass media (x_{12});
- education, private (x_{13});
- health care, private (x_{14});
- physical culture and sports, private (x_{15}).

Econometric dependencies were constructed to functionally describe the impact of investment on the level of human capital:

$$z_{mn}^{(t+1)} = f_m(z_{mn}^t, x_{1n}^t, \dots, x_{ln}^t, x_{1n}^{(t-1)}, \dots, x_{ln}^{(t-1)}, x_{1n}^{(t-2)}, \dots, x_{ln}^{(t-2)}), t = 0, 1, \dots, T, \quad (2)$$

where x_{in}^t is the amount of investment at the time t in the i -th area of investment; z_{mn}^t is the value of the m -th human capital indicator of the n -th region at the time t .

Strategies and programs of socio-economic development of the region within the framework of strategic goals and objectives set the target values of the resulting human capital indicators on the planning horizon under consideration. These target values are denoted by \bar{z}_{mn} .

The degree of achievement of the m -th goal for the n -th region at the time t :

$$K_{mn}^t = (z_{mn}^t) / (\bar{z}_{mn}), t = 0, 1, \dots, T. \quad (3)$$

The integrated index of the achievement of human capital development goals of the region:

$$IHC_n^t = \sum_{(m=1)}^M w_m(t) * K_{mn}^t, \sum_{(m=1)}^M w_m(t) = 1, \quad (4)$$

where $w_m(t)$ is the weight number characterizing the importance of the m -th characteristic of human capital at the time t .

The following vector function will be understood as the structure of the investments:

$$d_n^t = (d_{1n}^t, \dots, d_{ln}^t), d_{in}^t = (x_{in}^t) / (R_n^t), \quad (5)$$

where R_n^t is the total amount of investment in the quality of life and human capital of the n -th region at the time t .

Several assumptions concerning the process of human capital development are made to create a model:

1) the annual volume of investment in each area has the bottom constraints $\alpha = (\alpha_1, \alpha_2, \dots, \alpha_M)$ and $\beta = (\beta_1, \beta_2, \dots, \beta_M)$ top constraints;

2) if one period in the model is equal to a year, then each indicator of human capital for the period cannot change significantly, i.e. the relative growth of the indicator is limited from above and below;

3) the degrees of achievement of the target values at the end of the planning horizon, i.e. at the moment of time T , should not differ significantly from the target values.

Thus, the formation of the optimal structure of investments in the development of regional human capital is proposed to be carried out using the following model:

$$\left\{ \begin{array}{l} IHC_n^T = \sum_{m=1}^M w_m(T) * K_{mn}^T \rightarrow \max \\ K_{mn}^t = \frac{z_{mn}^t}{\bar{z}_{mn}}, \\ z_{mn}^{t+1} = f_m(z_{mn}^t, x_{1n}^t, \dots, x_{ln}^t, x_{1n}^{t-1}, \dots, x_{ln}^{t-1}, x_{1n}^{t-2}, \dots, x_{ln}^{t-2}), \\ x_{in}^t = d_{in}^t * R_n^t, \\ \sum_{i=1}^N d_i^t \leq 1, \\ \alpha_i \leq d_{in}^t \leq \beta_i, n = 1, \dots, N \\ -\delta_m \leq \frac{z_{mn}^{t+1} - z_{mn}^t}{z_{mn}^t} \leq \gamma_m, n = 1, \dots, N \\ p_m \leq K_{mn}^T \leq q_m, n = 1, \dots, N, \end{array} \right. \quad (6)$$

where $\bar{\alpha} = (\alpha_1, \dots, \alpha_M)$, $\bar{\beta} = (\beta_1, \dots, \beta_M)$ – bottom and top restrictions on the amount of investment in each area; $\bar{\gamma} = (\gamma_1, \dots, \gamma_M)$, $\bar{\delta} = (\delta_1, \dots, \delta_M)$ – bottom and top restrictions on the relative change in each human capital indicator over one time period; $\bar{p} = (p_1, \dots, p_M)$, $\bar{q} = (q_1, \dots, q_M)$ – bottom and top restrictions on the degree of achievement of the target value of each human capital indicator.

The variables of the model, for which the optimization is carried out, are the annual shares of investments in separate investment areas d_1^t, \dots, d_{12}^t , $t = 0, 1, \dots, T$.

TESTING OF THE PROPOSED MODEL FOR THE PRIMORYE TERRITORY

The model described above can be applied in real conditions. An example of forming the optimal structure of investments in the development of human capital and improvement of the quality of life in the Primorye Territory is considered.

The indicators of human capital development and the volume of investments by area for the Primorye Territory for 2011–2017 were taken as input data. The authors conducted a clustering of the regions of the Russian Federation by human capital indicators, which resulted in five clusters named "Scientific", "Environmental", "Industrial", "Resource" and "Small" in accordance with the types of leading and lagging industries [26]. The Primorye Territory was included in the "Small" cluster, which includes regions with no obvious sectoral affiliation, with the dominance of small and medium businesses and indicators of regional human capital development at the average level. The econometric dependence of human capital indicators on investment of the form (2) constructed in [27] is used for further analysis.

The optimization of the structure of the investments with a planning horizon of three years ($T = 3$) is considered. The target values of human capital development indicators are set as follows:

$$\bar{z}_{mn} = 1.15 \cdot z_{mn}^0, \quad (7)$$

where z_{mn}^0 is the value of the m -th indicator for the Primorye Territory in 2017.

The vectors of restrictions used in the model (formula (6)) are set as follows.

1) Vectors $\alpha = (\alpha_1, \alpha_2, \dots, \alpha_M)$ and $\beta = (\beta_1, \beta_2, \dots, \beta_M)$, representing the bottom and top restrictions on the volume of investment by area are presented in Table 1.

Limits indicated in Table 1 are calculated based on the sample mean x_{mean} and sample standard deviations σ , found based on statistical data for the Primorye Territory for 2011–2017: $\alpha_i = x_{\text{mean}} - 3\sigma$, $\beta_i = x_{\text{mean}} + 3\sigma$.

2) The lower and upper limits of the relative changes in the indicators of regional human capital for one period of time are set as follows: a) for indicators of the "professionalism", "education", "scientific development", "health", "culture" groups, γ_i and δ_i are equal to 0.7; b)

for indicators of the "innovative development" group, they are equal to 1.5. The difference for the "innovation development" group is connected with a possibility of more considerable change of indicators for a year in connection with essentially less inertia of these indicators.

Table 1

Lower and upper limits of the volume of annual public investments by areas (thousand rubles/thousand people)

Investment volumes variables	Lower limit	Upper limit
x_1	950	2774
x_2	9.74	18.25
x_3	549	4063
x_4	3807	16,428
x_5	2619	10,379
x_6	21	94
x_7	1456	18,061
x_8	31	2223
x_9	3246	15,020
x_{10}	4470	16,651
x_{11}	407	2589
x_{12}	72	295

Source: compiled by the authors.

3) Proceeding from what the degrees of achievement of human capital indicators at the time $t = 0$ are equal to, the lower limit on the degree of achievement of the target value of each indicator is set to 0.75 for all groups; the upper limit for indicators of the "innovation development" group is set to 3, and for all other indicators – to 1.5. This is due to the consideration that a not very significant spread in the degrees of achievement of target values is desirable.

Below are the results of the optimization of the structure of the financial resources according to the proposed model of the development of regional human capital with the above-mentioned restrictions on the $T = 3$ planning horizon. Two scenarios are considered: a) inertial, in which at all time moments $t = 0, \dots, T - 1$, the investment structure that was at the time $t = -1$ is preserved; b) optimization, in which the optimal investment structure calculated by the model is used. The volume of investments for both scenarios each year increases by 5%.

Figure 1 shows the integrated index of achievement of the objectives for the development of human capital of the region IHC_n^t and the degree of achievement of similar integrated indices for all basic groups of human capital components under the inertial and optimization scenarios at time $T = 3$.

At the endpoint of time $T = 3$, the integral index of the degree of goal achievement IHC_n^t under optimization equals 1.01, while under the inertial scenario, only a 0.83 value can be achieved. At the time $t = 0$, the level of goal achievement is 0.77. Achievement of target values of indices is not evenly distributed in groups both under optimization and inertial scenario.

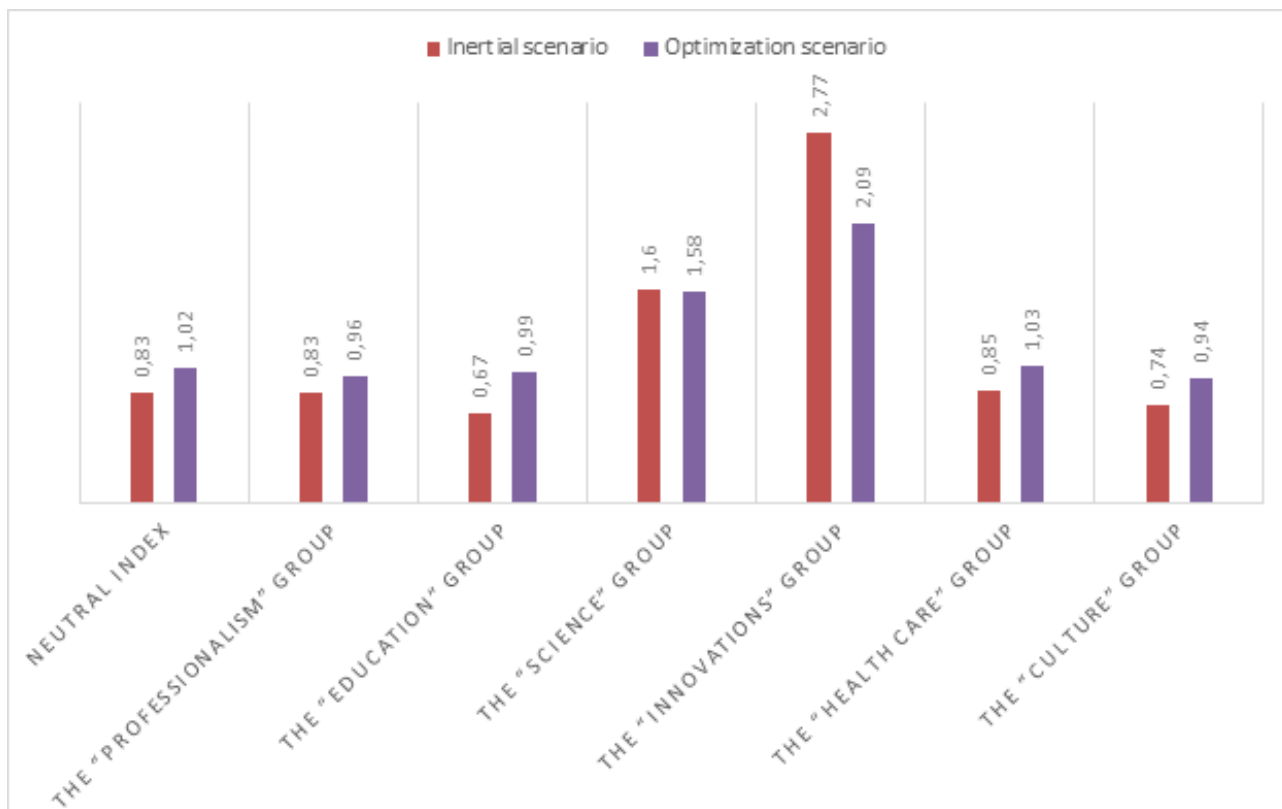


Figure 1 Integrated indices of the degree of goal achievement under the inertial and optimization scenarios at the endpoint of the planning horizon (in general and for the basic groups of indicators) *Source: compiled by the authors*

It is worth noting that during optimization, the structure of investments changes by years. Figure 2 compares the structure of investments for the optimization scenario (at time moments $t = 0$, $t = 1$, and $t = 2$) with the structure of investments under the inertial scenario.

As can be seen from Figure 2, the shares of investment areas in the total amount of investment (variables d_i , corresponding to the investment areas x_i) under the inertia scenario may or may not differ significantly from the structure of investment under the optimization scenario. At the same time, the structure of investments under the optimization scenario is not static and differs at each point of time t .

For example, the share of investment in the national economy (d_4) under the inertial scenario is equal to 0.19 and varies from 0.37 to 0.13 under the optimization scenario. Investment in education (d_7) accounts for 0.21 of total investment under the inertia scenario, and changes from 0.21 to 0.27 in the first year, and then decreases to 0.053 under the optimization scenario. The share of investments in health care (d_9) steadily increases from 0.075 to 0.118 by the third year.

Based on the model, it can be concluded that in the long term, the achievement of the target indicators will be facilitated by a more even structure of investment by area. In addition to education and health care, it is advisable to increase investment in other areas, primarily in issues of national importance (variable x_1), national security and public order (x_3), and social policy (x_{10}). The growth of the share of these areas in the total volume of investment is seen in Figure 2.

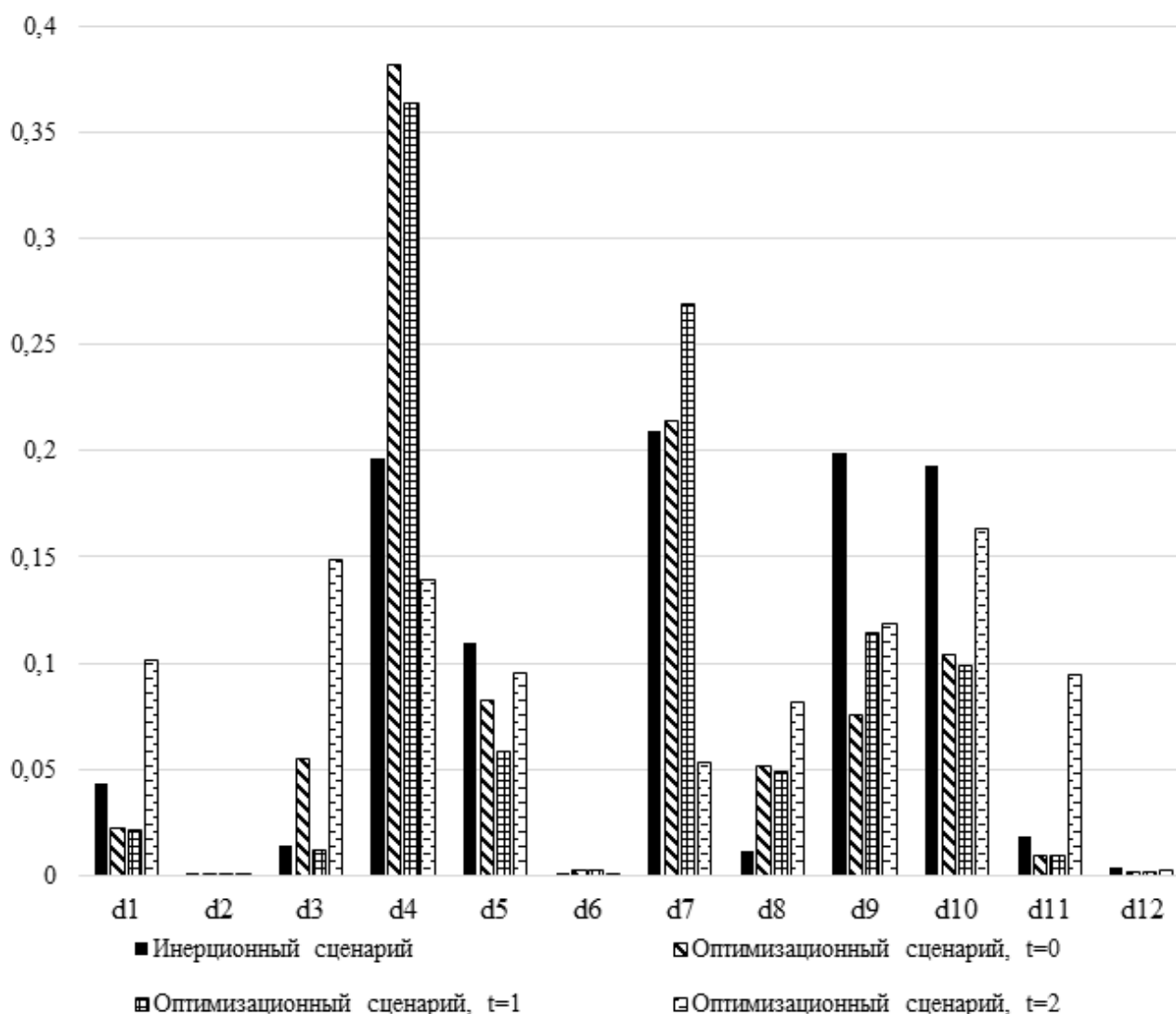


Figure 2 Investment structure change by areas for the optimization and inertia scenarios
Source: compiled by the authors

CONCLUSIONS

The conducted research allows drawing the following conclusions.

1. The need for serious progress in the development of human capital in the Russian regions objectively requires optimization of the investment distribution structure and increasing the efficiency of socially responsible investment. The formation of the optimal investment strategy in the field of human capital management will allow achieving timely strategic objectives set in the region both in the sphere of human capital preservation and in innovative development, ensuring economic growth of the regions, and improving the quality of life.

2. In the optimization model proposed by the authors, the target function is an integrated index, which characterizes the degree of achievement of the set strategic objectives for the development of human capital in the region. In a practical sense, the model is a tool to find the

optimal structure of the distribution of IHC by areas of investment and time periods.

3. In the inertial scenario, a significant share of investments in education and health care will remain in the total volume of investments. The optimization scenario shows an objective decrease in the share of spending on education with a simultaneous increase in the share of spending on health care, issues of national importance, national security and public order, and social policy. These spheres represent the key areas of further development of a civilized state. The offered mathematical model confirms the necessity of transition from representations about the expense of socially oriented investments and burdening of modern society by them to comprehension of high importance, reliability, and high social-economic return of IHC in long-term prospect.

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