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The Model of Extended Reproduction of Human Capital in Russian Regions (the Example of Karelia Republic)

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Abstract

The Karelia Republic is one of Russian regions with low rating where complex instruments for human capital development are implemented. Quantification of collective human capital level and its contribution to economic development is the method to evaluate the governance efficiency. The extended human capital reproduction evaluation model and its accounting in GDP production based on mathematical modelling methods, forecasting and econometrics is presented. Results include:

- The production function model, based on Mankiw–Romer–Weil model modification, which allows to consider together endogenous scientific and technical progress, and the human capital.

- A new model for extended human capital reproduction evaluation includes among 4 known stages of reproduction, 3 more stages. It also considers the human development index, population quality index and intellectual capital development index. The presence in the model the penalty function for inappropriate use of human capital in the economy is key feature.

Proposed method was implemented in the Republic of Karelia and its advantage is open source data: official state and departmental statistics for quantitative assessment of model parameters and subsequent calculations are enough. Expensive surveys are not required. This method is effective for use in depressed regions with low financing/ The model is universal and can be used for quantification and comparison of human capital, and its effectiveness in the production of goods and services in various regions.

Keywords: *human capital; forecasting; regional economic development; mathematic modelling; governance efficiency.*

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1. Introduction

The Republic of Karelia of the Russian Federation is one of the regions that occupy low positions in development ratings within the country. To improve these positions, it is especially important to develop integrated tools that implement core values in the field of human capital. To solve the problem, it is proposed to expand the approach to the quantitative assessment of human capital. The task is to develop models for estimating the expanded reproduction of the human capital and take it into account in the production of a country's and region's GDP based on the methods of mathematical modelling, forecasting, econometrics, and applied statistics. It also considers the approach adopted in the Russian Federation to building a regional development policy that differs from Western countries' models.

It seems necessary and expedient to develop a theoretical and methodological basis for the expanded reproduction of human capital, taking into account the role of external and internal factors of regional development and reproduction of human capital, including geographical location (cross-border region), infrastructure development, depopulation, de-intellectualization of human capital, the state of the labour market, etc. As a result, the concept of changing the paradigm of expanded reproduction in terms of innovative economy should be worked out. Based on this concept, it is planned to develop and test a mathematical model for evaluation of expanded reproduction of human capital in the Republic of Karelia for the medium and long term, considering the human development index, population quality index and intellectual capital development index.

2. Problem Statement

One of the most significant recent domestic Russian studies on the assessment of human capital is the work of R. I. Kapelyushnikov [1], in which he conducts a deep and comprehensive analysis of the problem of estimating the human capital value in Russia in 2002 and 2010, and also provides calculation results for the Russian economy in the framework of the cost approach based on the Jorgenson-Fraumeni model [2],[3].

The definition, structure and methods for evaluating human capital for the Russian Federation were also studied by other scientists (Yu.A. Korchagin [4], Ya.I. Kuzminov [5], [6], V.I. Martsinkevich [7], [8], R.M. Nureev [9] and others), but its effect on labor productivity, and the production functions connected with it, was not studied in depth.

In this regard, an interesting and relevant task is the simultaneous study of methods for evaluation of the accumulated human capital and its

role in changing labor productivity, in other words, to consider its impact on the production process through production functions.

The concept of human capital as an economic category is constantly expanding with the development of the global information community and the knowledge economy. The founders of the theory of human capital gave a narrow definition of this concept, which expanded over time, and as a result, human capital turned into a complex intensive factor in the development of a modern economy — a knowledge economy [10].

For our study, the problem of numerical evaluation of the human capital is important.

There are many methods for human capital evaluation. For example, in a generalized study of R.I.Kapelyushnikov [1] there are four approaches to solving the problem of human capital evaluation:

1) "Indicator" approach is based on various non-cost, natural characteristics of human capital, where various educational performance indicators are used.

2) The discount (or residual) method of estimating the human capital value was proposed by analysts of the World Bank report "What is the wealth of nations?" [11]. At the same time, the realism of his estimates is called into question [1].

3) The cost method, proposed by J. Kendrick, T. Schulz [12], of calculating the human capital value is based on statistical data to calculate the accumulation of investments in a person. It should be noted that the methodology for estimating human capital by costs gives a significant margin of error for developing countries and countries with transition economies [13].

4) Value approach based on the income derived from it. The methodology for valuing human capital was developed and applied by the British economist and statistician W. Farr [14]. W. Petty [15] was first to make calculations of the valuation of human capital using an income-based method. The development of this approach became a convenient operational method for estimating the value of human capital, which was proposed in the works of D. Jorgenson and B. Fraumeni [16], [17].

Even though, according to R.I. Kapelyushnikov [1], the latter method is generally accepted, the initial data for it can only be obtained during the population census, so it is not possible to trace the annual dynamics with it.

In the work of A.V.Komarova and O.V.Pavshok [18] the following methods were proposed for assessing the accumulated human capital, based on the available information on the subjects of the Russian Federation:

- By the share of university graduates in the total working population.
- On wages (wages were considered as the sum of the minimum wages and returns on human capital).
- In terms of investment in education (state expenditures, private sector, indirect investments (income not received due to studies)).

As noted in [18], the calculations results, differ markedly depending on the chosen method of human capital estimating. In [19] it was found that the investment-based approach is the most popular and has the best estimates.

The described existing approaches to the numerical evaluation of the human capital are not perfect enough. Because they are one-sided and include an unreasonably small number of influencing factors, usually one or two. In this regard, it is necessary to develop new methods and models for evaluation the expanded reproduction of the human capital, which will try to highlight this problem in a complex, given the wide variety of influencing factors.

3. Research Questions

The aim of the study is to find opportunities to expand the existing tools to improve the management of human capital development in the region in the context of limited resources.

On the basis of theoretical statements describing the change in the paradigm of expanded reproduction of human capital and taking into account new approaches in quantitative and qualitative assessments of expanded reproduction of human capital, it is proposed to create and test a mathematical model for evaluating expanded reproduction of human capital for the medium and long term, taking into account the human development index, index population quality and intellectual capital development index. Currently, there are mathematical models that describe the implementation of human capital and models that describe some aspects of the reproduction of human capital, but there is no comprehensive methodology.

Within the framework of an integrated approach, an analysis of the change in the paradigm of expanded reproduction of human capital in the region in an innovative economy has shown due to a shift in focus on the acquisition of knowledge and new competencies, as well as the rapid updating of the knowledge base required total reproduction cycle. The period of schooling is extremely important. The correct choice of educational strategy at the school stage, namely, the occupation demanded in

the future in the labor market, will contribute to the most efficient reproduction of human capital.

4. Research Methods and Models

When solving research problems, the methods of system, logical and economic analysis, methods of economic and mathematical modeling and econometrics were used. For information processing methods of comparative and statistical analysis, content analysis were used.

The modern interpretation of the concept of human capital is as follows: a person has a stock of knowledge, skills, abilities, motivations that are used to meet the diverse needs of a person and society as a whole, related to obtaining a stream of income through the effectiveness of investments in the development of the professional qualities of its carrier, as well as efficiency use in the process of consumption during the reproductive cycle [20].

Human capital, as an economic resource, requires reproduction on an expanded scale, in order to ensure the realization of the strategic goals of the state.

The mathematical model of human capital reproduction may include elements of the model that characterize each of the stages of the reproductive cycle:

- production (formation) of human capital - characterized by such parameters as fertility and the demographic structure of the population; the literacy structure of the population and data on schooling, professional educational organizations, the workplace (the acquisition of general and narrow professional competencies), in advanced training institutes, etc.;
- distribution (redistribution) - characterized by a professional structure of employment and level of competence;
- exchange - characterized by the wage structure of the population in the context of occupations;
- consumption of human capital - characterized by the level of compliance of the professional structure of employees with the structure of education received.

For forecasting of expanded reproduction, the following significant parameters should be added at the input of the model:

- physical reproduction of human capital (forecast of the demographic structure of the population);
- receiving education by the population;
- acquisition of demanded competencies and their application in the workplace to increase the level of labor productivity.

At the output, the important parameter of expanded reproduction is the professional structure of employment of the population (the correspondence of the received education and the demanded specialties, the employment in the demanded specialties).

Mathematical models in which, in one way or another, human capital participates, are divided into models of production functions, where it enters as a factor, as well as assessment models (calculations) of human capital itself.

4.1. Production function model

Modern economic theory offers many models to evaluate the productivity of labor. The key factors in these models are often considered capital $K(t)$ (fixed assets), labor $L(t)$ (number of employees or workers), and for some time, technical progress $A(t)$ (level of technological growth of the economy). The output parameter is gross domestic product $X(t)$ (GDP). At the end of the last century, several scientists proposed to introduce another factor – human capital $H(t)$.

Of greatest interest is the expansion of the Solow production function model, considering the contribution of human capital [21].

R. Lucas (1988) [22] was one of the first to include human capital in the Solow model as a key factor. The Mankiw–Romer–Weil model (1992) uses the Solow model with a clear delineation of physical $K(t)$ and human capital $H(t)$ [23]:

$$X(t) = K(t)^{\alpha} H(t)^{\beta} \left[A(t)L(t)\right]^{1-\alpha-\beta}, \ \alpha + \beta < 1,$$

where α and β – the coefficients of elasticity of funds and human capital, respectively.

This model during econometric testing showed the importance of the human capital contribution. It is in evidence that for medium- and highly developed countries, the contribution to GDP growth per capita exceeds the contribution of physical capital [24].

Despite external consistency, in formula (1) the largest number of questions causes the function type $H(t)$.

Mankiw–Romer–Weil models (1) are characterized by the assumption that scientific and technological progress $A(t)$ (level of technological growth of the economy) is an exogenous value, and does not depend on investments, the effectiveness of their development and other innovative factors.

The production function with endogenous scientific and technical progress according to Harrod, which was described in the works of S. V. Dubovsky [25]:

$$\frac{X'(t)}{X(t)} = \alpha \frac{K'(t)}{K(t)} + (1-\alpha)\left(\frac{L'(t)}{L(t)} + \frac{\sigma I(t)}{K(t)}\right),$$

where $I(t)$ – investments, σ – the efficiency of new technologies in labor productivity, α – the coefficient of elasticity on funds, $(1-\alpha)$ – the coefficient of elasticity on labor.

The rate of employment growth $l = \frac{L'(t)}{L(t)}$ has become an endogenous value; The scientific and technical progress $e = \frac{\sigma I(t)}{K(t)}$ is also endogenous, since the growth rate of people employed in it in GDP is described by internal dependent variables – investments and funds. The study of the finite-difference form of the model (2) and its application to assessing the effectiveness of new technologies at the regional level was carried out in [26].

In [27], in order to consider the impact of human capital on the development of the economy, it is proposed to introduce another component γ to the rate of economic growth in labor:

$$l^* = l + e + \gamma,$$

where $\gamma = \frac{H'(t)}{H(t)}$ is the growth rate of human capital.

Unfortunately, there are no numerical estimates of the parameters (3) for regional economies of Russia.

The Mankiw-Romer-Weil (1) and S. V. Dubovsky (2) models have a common structure, allowing endogenous consideration of human capital and scientific and technological progress. It seems reasonable to create a model that allows endogenously taking both parameters into account simultaneously based on the combination of models (1) and (2).

For this purpose, we sequentially prologue and differentiate both sides of equation (1):

$$\frac{X'(t)}{X(t)} = \alpha \frac{K'(t)}{K(t)} + \beta \frac{H'(t)}{H(t)} + (1-\alpha-\beta)\left(\frac{L'(t)}{L(t)} + \frac{A'(t)}{A(t)}\right).$$

Replace in (4) the exogenous growth rate of the technological level of the economy $\frac{A'(t)}{A(t)}$ by the endogenous of formula (2):

$$\frac{X'(t)}{X(t)} = \alpha \frac{K'(t)}{K(t)} + \beta \frac{H'(t)}{H(t)} + (1-\alpha-\beta)\left(\frac{L'(t)}{L(t)} + \frac{\sigma I(t)}{K(t)}\right).$$

Thus, model (5) makes it possible to consider human capital $H(t)$ in the production function, along with investments, funds, labor, and other significant factors.

4.2. Extended human capital reproduction evaluation model

The next step is to identify the most significant factors of influence among all indicators of the level of accumulated human capital and develop a model of human capital adapted to Russian data as a function $H(t)$. Finding the type of this functional dependence is a separate task requiring the use of high statistical technologies [28].

To ensure the possibility of numerical calculations of the function $H(t)$ at the regional level, we use the "indicator" approach, according to the classification of R.I. Kapelyushnikov [1].

Indeed, various indicators, such as, for example, the human development index, the population quality index, and the intellectual capital development index, are close in meaning to human capital.

Consider each of these indicators in more detail.

Human Development Index (HDI).

Until 2013, it was called the Human Capital Development Index. It is a standard tool for a general comparison of the standard of living of different countries and regions. The method of its calculation is well known [29]. The human development index I_{hd} for the region is calculated as the geometric average of its three components:

$$I_{hd} = \sqrt[3]{I_e \times I_p \times I_{lt}},$$

where I_p – the income index of the GRP per capita at PPP in US dollars. USA;

I_e – education index, defined as a linear combination;

I_{lt} – life expectancy index.

Intellectual Capital Development Index (ICDI).

One of the pioneering attempts to assess the intellectual capital of the region was undertaken in the work of I. I. Kuyantseva and M. I. Kuyantseva [30]. The intellectual capital development index I_{icd} is defined in it as the arithmetic average of two groups of indices.

The first includes the above considered indices I_p, I_e and I_{lt}, used to calculate the HDI.

The second group includes indices from the Knowledge Assessment Methodology proposed by the World Bank [31]:

I_{eiir} – the Economic Incentive and Institutional Regime – conditions in which the economy and society as a whole develop, the economic and legal environment, the quality of regulation, the development of business and private initiative, the ability of society and its institutions to effectively use the existing and create new knowledge.

I_{is} – the Innovation System – the level of development of a national innovation system, including companies, research centers, universities, professional associations and other organizations that perceive and adapt global knowledge for local needs, as well as create new knowledge and new technology based on it.

I_{ict} – Information and Communication Technology Index – ICT – the level of development of information and communication infrastructure, which contributes to the effective dissemination and processing of information.

In [26], it is argued that human capital in combination with structural capital forms intellectual capital. Thus, the final index of intellectual capital development I_{icd} is proposed to be calculated using the following formula:

$$I_{icd} = \frac{I_e + I_p + I_{lt} + I_{eiir} + I_{is} + I_{ict}}{6}.$$

Population Quality Index (PQI).

The interpretation of the notion of the human capital give V. A. Iontsev and A. G. Magomedov in [32], where the demographic factors of human capital development in the regions of Russia are studied. For comparison of Russian regions, indices such as the index of the development of intellectual potential and the index of the quality of the population, developed by A.A. Sagradov [33], are calculated.

The population quality index differs from the human development index (UNDP, 1990) in that it includes two more demographic indicators characterizing fertility and nuptiality [29].

The following generalized indicators are used to calculate the population quality index:

k_b – total fertility rate (generalized fertility indicator);

k_{lt} – average life expectancy at birth for both sexes (generalized health indicator);

k_m – the number of men aged 16 years and older (per 1000) who are married (generalized indicator of marriage rate);

k_w – number of employed (per 1000) with secondary and higher education (generalized education indicator);

k_p – the decimal logarithm of the average per capita real (in terms of purchasing power parity) gross regional product (generalized indicator of qualification) [34].

For each of the above i-th quality characteristic, the corresponding index Ik_i is calculated by the formula

$$Ik_i = 1 - \left| \frac{k_{i,opt} - k_{i,f}}{k_{i,opt} - k_{i,bad}} \right|,$$

where $k_{i,f}$ – the actual value of the generalized indicator of the i-th quality characteristic;

$k_{i,opt}$ – the optimal value of the generalized indicator of the i-th quality characteristic;

$k_{i,bad}$ – the worst value of the generalized indicator of the i-th quality characteristic.

The total quality index of the population is calculated as the arithmetic average of the indices of quality characteristics:

$$I_{pq} = \frac{1}{5} \sum_{i=1}^{5} Ik_i .$$

To consider in the human capital function $H(t)$ the human development index (6), the intellectual capital development index (7) and the population quality index (8), we use the additive method:

$$H(t) = \frac{I_{hd}(t) + I_{pq}(t) + I_{icd}(t)}{3}.$$

Function (9) considers many different aspects of human capital, from intellectual and educational to infrastructural and economic, which for the first time allows evaluate human capital in such a broad setting.

Penalty function for structural mismatch of supply and demand in the regional labor market

In order to take into account the professional structure of employment in the implementation of the human capital function, it is necessary to match the education received from the supply side and the occupations in demand from the demand side of the human capital.

Define the indicated vectors. Let $Pr = \{Pr_p\}$ be a list P of all the names of current and popular occupations for the region, p the serial number of the occupation in the list, $p \in 1..P$, t is the time index; t_0 - the beginning of the forecast period; t_f - the end of the forecast period. Let $t \in [t_0, t_f]$.

Then the forecast vector of the structure of demand for the occupation $str\Delta D_p(t)$ and the structure of the supply of the occupation $str\Delta S_p(t)$ are given by the expression

$$str\Delta D_p(t) = \frac{\Delta D_p(t)}{\sum_{p=1}^{P} \Delta D_p(t)},\ str\Delta S_p(t) = \frac{\Delta S_p(t)}{\sum_{p=1}^{P} \Delta S_p(t)},$$

To assess the similarity (difference) of the required $\Delta D_p(t)$ and actual occupational structure of employees $\Delta S_p(t)$, it is proposed to use a formal measure of similarity (difference).

To select a criterion for comparing structures, we use the Euclidean distance $D_E(t)$, which, considering expression (10), takes the form:

$$D_E(t) = \sqrt{\sum_{p=1}^{P} \left(str\Delta D_p(t) - str\Delta S_p(t) \right)^2}.$$

Use when comparing dependency structures (11) allows us to limit the change in the coefficient of structural compliance in the unit range $0 \le D_E(t) < 1$. This ratio (11) can be used as a penalty function.

Expanded assessment of human capital in the region, considering professional qualifications

Analyzing the form of the function (9) it should be noted that $H(t)$ represents human capital from the supply side but does not take into account the demand for it.

To this end, it is proposed to introduce into the expression (9) a common factor (11) in the form of a penalty function $\left(1 - D_E(t)\right)$ for the inappropriate use of human capital in the region. Thus, with the complete coincidence of the structures, the value of the penalty will be equal to 1, from which nothing will change.

Finally, the evaluation function of human capital will be

$$H(t) = \left(\frac{I_{hd}(t) + I_{pq}(t) + I_{icd}(t)}{3} \right) \left(1 - D_E(t)\right).$$

As a result, expressions (6-12) represent a mathematical model for the forecast of expanded reproduction of human capital in the medium and long term.

5. Findings

The developed methodology was tested and the forecast scenarios of the expanded reproduction of the human capital of the Republic of Karelia were formed considering the features of spatial development in the medium and long term.

In accordance with the methodological decisions, the evaluation of the expanded reproduction of human capital was done taking into account the human development index, population quality index and intellectual capital development index. It also considered the vocational qualification compliance of the education received from the supply side of the human capital to popular specialties from the demand side for human capital, which imposes a penalty for inappropriate use of it in the region.

As a result of preliminary calculations, estimates of the human development index, population quality index, intellectual capital development index and penalty for inappropriate use of human capital of the Republic of Karelia were obtained. The values of the specified input parameters for the human capital assessment function are presented in Table 1:

Table 1 – Input parameters of human capital evaluation function

Indicator	2019	2020	2021	2022
human development index	0,856	0,860	0,863	0,864
population quality index	1,112	1,117	1,124	1,130
intellectual capital development index	3,418	3,479	3,502	3,503
penalty for inappropriate use of human capital	0,145	0,150	0,154	0,159
Human capital evaluation	1,536	1,546	1,548	1,541

Thus, as a finally result of calculation, the forecast of the expanded reproduction of the human capital of the Republic of Karelia was obtained.

6. Discussions

The simulation results show the maximum value of the expanded human capital index in Karelia in 2021 (Table 1), after which it is expected to decline as a consequence of the increasing penalty function for its poor use.

This can be explained by the crisis processes occurring in the economy that caused a decrease in economic indicators, features of the territorial socio-economic system (communication and secondary development of the size of the economic space) are taken into account.

The use of existing methods of modeling forecast scenarios of expanded reproduction of human capital for the Republic of Karelia was carried out for the first time. The theory and methodology of the interdisciplinary geospatial paradigm has been updated in relation to the territorial socio-economic system of the Republic of Karelia.

The novelty of the proposed approaches lies in the fact that the processes of expanded reproduction of human capital are considered during the transition to an innovative economy in a border region and the deterioration of its socio-economic development indicators.

7. Conclusions

According to the study, the following results were obtained:

For the first time, a model of the production function was proposed, based on the modification of the Mankiw-Romer-Whale model, which, unlike the traditional one, makes it possible to take into account, together

with the human capital, endogenous scientific and technical progress, as well as the growth rate of the technological level of the economy.

Within this model, a new model for estimating the expanded reproduction of the human capital has been created. The model differs from the well-known in that it considers the human development index, population quality index and intellectual capital development index. A key feature of the model is the presence in it of the penalty function for inappropriate use of human capital in the economy.

Approbation of the evaluation model of expanded human capital reproduction by the example of the Republic of Karelia was carried out.

The advantages of the proposed method lie in the fact that for a quantitative assessment of model parameters and subsequent calculations, there is enough data from open sources of official state and departmental statistics. At the same time conducting costly surveys are not required.

References

[1] Kapelyushnikov RI. How much is the human capital of Russia? Moscow: National researches University "Higher School of Economics", 2012. 76 p.

[2] Jorgenson DW, Fraumeni BM. The Accumulation of Human and Nonhuman Capital, 1948–1984. The Measurement of Savings, Investment and Wealth. Chicago: The University of Chicago Press; 1989.

[3] Jorgenson DW, Fraumeni BM. The Output of the Education Sector. Output Measurement in the Services Sector. Chicago: The University of Chicago Press; 1992.

[4] Korchagin YA. Investment strategy. Rostov: Phoenix; 2006. 316 p.

[5] Kuzminov Y. "Human capital of Russia: education" [Electronic resource]. Available from: http://gosbook.ru/node/18680

[6] Human capital as a factor of socio-economic development. Short version of the report. By XVII April international scientific conference on problems of economic and social development, Moscow, April 19-22, 2016. National researches University "Higher School of Economics". Publishing House of the Higher School of Economics. 2016. 76 p.

[7] Martsinkevich VI. Education in the USA: economic importance and efficiency. Moscow: Science; 1967.

[8] Martsinkevich V, Sobolev I. Human economics. Moscow: Aspect Press; 1995.

[9] Nureev RM. Theory of Development: New Models of Economic Growth. Voprosy ekonomiki, 2000; p. 4-8.

[10] Korchagin YA. Modern Russian economy. Rostov-on-Don: Phoenix; 2008.

[11] World Bank. Where is the Wealth of Nations? Washington: World Bank; 2006.

[12] Schultz T. Investment in Human Capital. N.Y.: London, 1971.

[13] Konstantinov I. Human capital and strategy of national projects / Open electronic newspaper forum.msk.ru [Electronic resource]. Available from: http://forum-msk.org/material/economic/310895.html

[14] Farr W. Equitable Taxation of Property. Journal of Royal Statistics. 1852;16(1):1–45.

[15] Petty W. Economic and statistical work. Moscow: Sotsekgiz; 1940. p. 1–2.

[16] Jorgenson DW, Fraumeni BM. The Accumulation of Human and Nonhuman Capital, 1948–1984. The Measurement of Savings, Investment and Wealth. Chicago: The University of Chicago Press; 1989.

[17] Jorgenson DW, Fraumeni BM. The Output of the Education Sector. Output Measurement in the Services Sector. Chicago: The University of Chicago Press, 1992.

[18] Komarova AV, Pavshok OV. Evaluation of the contribution of human capital to the economic growth of the regions of Russia (based on the Mankiw-Romer-Weil model). Bulletin of the NSU. Series: Socio-economic sciences. 2007;7(3).

[19] Kiryanov DA, Sukhareva TN. Methods for assessing human capital: an analysis of objectivity and data sufficiency [Electronic resource]. Available from: http://teoria-practica.ru/-3-2011/ekonomika/kiryanov-sukhareva.pdf

[20] Kekkonen AL. The human capital of the region: the formation and development in modern conditions. Dissertation thesis. Institute of Problems of Regional Economics of the Russian Academy of Sciences. St. Petersburg; 2013.

[21] Solow R. Growth Theory and After. American Economic Review. 1988;78(3):307-317.

[22] Lucas R. On the Mecanics of Economic Development. Journal of Monetary Economics. 1988;22:3-42.

[23] Mankiw G, Romer D, Weil DN. A Contribution to the Empirics of Economic Growth. The Quarterly Journal of Economics. 1992;107(2):407-437

[24] Lapin AE. Regional labor market: monitoring, labor economics models and state policy. Ulyanovsk. UAPU; 2002. 328 p.

[25] Dubovskiy SV. Computational experiments with a macromodel of a nonstationary Russian economy. Modeling socio-political and economic dynamics. Moscow. RGSU; 2004. 224 p.

[26] Pitukhin EA, Gurtov VA. Mathematical modeling of dynamic processes in the system "economy - labor market - vocational education". Moscow: SPb. Publishing house of St. Petersburg State University; 2006. 346 p.

[27] Pitukhin EA. The impact of human capital on labor productivity in the sectors of the economy corresponding to the priority areas of development of science, technology and technology. Scientific Notes of the Russian State Social University. Moscow: Russian State Social University; 2012. p. 16-21.

[28] Orlov AI. Econometrics. Moscow: "Exam"; 2002. 442 p.

[29] United Nations Development Programme. Human Development Report. New York: Palgrave Macmillan, 1990. 141 pp.

[30] Kuyantseva II, Kuyantseva MI. Evaluation of the intellectual capital of the region. Terra Economicus. 2011;10(3):123–126.

[31] http://web.worldbank.org/

[32] Iontsev VA., Magomedova AG. Demographic aspects of the development of human capital in Russia and its regions. Economy of the region. 2015;3:89-102.

[33] Sahradov AA. Theory and methods for studying the quality of the population. Moscow. Humanitarian Foundation; 1995. 238 pp.

[34] Kolesov VP. Ekonomika znanij [Knowledge economy]. Moscow. Infra-M; 2008. 432 p.