Forecasting of Need for the Human Capital for Development of Economy

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Abstract. The model of calculation of volume of the materialized knowledge used in an economic system on the basis of the analysis of the used resources and the size of a gross product is provided. The model allowed to calculate return of business assets and intellectual factors and to estimate influence of a human capital on growth rates of economy. On the basis of statistical data forecasts of need for a human capital for achievement of desirable indicators of development of economy are calculated. For decision making about influence of knowledge of personnel on results of work of the enterprise modeling of this factor in dynamics is carried out and objective estimates for the investing in a human capital are received.

1. Introduction

Researches of the last years showed that the human capital makes a basis of a national wealth of developed countries and determines the level and indicators of development of economy [1]. There is a number of valuation methods of the size of a human capital of the country [2.3], model of its changes and communications with an intellectual capital of the country and the organization [4], but the needs for a human capital for the economic growth of the country are not studied. Therefore such researches are relevant. Article purpose - development of a new method of calculation of the size of a human capital (HC) of the country or the organization on the basis of results of its activity, calculation of a deposit of a human capital and intellectual factors in economic result and growth rates,and also calculations of needs for a human capital. At the same time the economy is considered as the system consuming three types of resources: the fixed business assets F, number of the materialized knowledge of U (Figure 1) occupied in economy N and intellectual resources in the form of.

Figure 1. Scheme of Transformation of Resources economy.

The production function of the economic system has the form of dependence:

$$Y = F(\Phi, N_3, U) \quad (1)$$

Since this is a function of three variables, we transform it by eliminating the number of employees and using specific values:

$P = \frac{Y}{N_3}$ - GDP per worker (2)

capital-labor ratio, rub / person in year:

Φt = Φ/ Nз (3)

$U_t = \frac{U}{N_3}$- human capital, rubles / person in year (4)

Φ0 = Y/ Φ (5)

- return on assets, return / 1 rub. fixed assets costs.

The simplest way to assess human capital is to build the country's production function in the form:

$P = A*\Phi t^{\alpha}*Ut^{\beta}$ (6)

where Φt is the capital-labor ratio of the worker,
Ut is the average specific value of human capital.
α, β elasticity, A – constant, p is the average gross product output by the employee.
Solving (5) regarding to Ut, we obtain:

$U_t = P^{1/\beta} * (A * \Phi_t^{\alpha})^{-1/\beta}$ (7)

When α = β = 0.5 (with parabolic dependencies) we get the expression for calculating the specific armament with knowledge:

$P^2 = \Phi_t \cdot U_t$ (8)

$U_t = \frac{P^2}{\Phi_t}$ (9)

In a more complex case, taking into account the level of the current organization of the use of resources O, a production function of the form is obtained:

$P = a * \Phi t^{\alpha} * Ut^{\beta} * O^{\chi}$ (10)

where a is a coefficient taking into account the use of working time, a = Tp / Tnorm.
If we consider the management organization high (O = 1) and a = 1, then we obtain a two-factor production:

$P = \Phi t^{\alpha} * Ut^{\beta}$ (11)

To calculate the indicator used by the employee of materialized knowledge (i.e. human capital) we prologue the expression (11):

Ln p= ln a +α* ln Φt + β*ln Ut (12)

and $Ut = e^{1/\beta(\ln p - \ln a - \alpha \ln \Phi t)}$ (13)

Calculations by formula (13) showed changes in Ut in Russia and the Rostov region. Based on the real economic data of the Russian Federation for 2018, it is possible to calculate the return on human capital as the sum of income received by the country's population for the year:

$R_{d2} = \sum_i R_{cpdi} * N_i$ (14)

where R_{cpdi} is the average annual income of the i-th population group,
Ni – the number of people in the i group, I =1, 8

Rd2 =(30,85 trillion dollars / year)

With an average work experience of ti = 30 years and about 80 million people employed in the economy, Rd = 11.55 million dollars for 30 years of work experience. UN experts estimate the value of the human capital of the Russian Federation in 2010 at 23.7 trillion dollars out of 59.29 trillion dale national wealth. According to ILO estimates, one person working in the Russian Federation generates

11 thousand dollars a year, with 87 million employees Rd2 = 957 billion dollars / year, which is lower than the Russian state statistics. Calculations show that Ut in the Rostov Region has a value of Ut of 25,000 rubles per person, which is twice lower than the Φt indicator.

We construct a methodology based on a comparative analysis of the indicators of the economy and human capital of the USA, Europe and Russia. We will proceed from the well-known indicators of the economy and human capital [3].

World GDP in 2008 amounted to 68996 billion dollars, with a population of 7 billion per capita, 9856 dollars per day was produced. In 2002, the United States had a GDP of 7.4 trillion. dollars with a population of about 280 million people, while human capital was estimated at 95 trillion. dollars, which accounted for 26% of global human capital, which was estimated at 365.4 trillion dollars. In 2008, Russia's GDP was 2.26 trillion. dollars, the national wealth of Russia was estimated at 59.9 trillion. dollars, while, according to World Bank estimates, Russia's human capital was estimated as 50% of national wealth, i.e. about 30 trillion. dollars. In 2005, Russia's GDP was equal to 0.776 trillion. dollars. If we calculate the linear model of Russia's GDP growth over this period, we get the equation:

$$GDP = - 1,67 + 0,49\ t, \quad (15)$$

for the base year, take 2000. If we assume that the trend is stationary, then by 2025 Russia should have GDP = 10.58 trillion dollars, by 2050 22.83 trillion. dollars. If we assume that human capital is 10 times higher than GDP (as is accepted in the well-known Allianz Global Wealth Report in 2010 [4]), then by 2025 Russia should have human capital at the level of today's US human capital, and by 2050, double it with stable economic growth. We systematize this data in table 1.

Table 1. Indicative data on GDP and human capital of the United States and Russia.

t	GDP USA	GDP Europe	HC USA	GDP RF	HC RF	N citizens USA	N citizens RF
2002	7.4 trillion $	8.8 trillion $	95 trillion $	0,78 trillion $	27 trillion $	225 million people	146 million people
2005	9,8	11,0	100 «	1,23 »	30 trillion	228	144
2008	14,2	14,0	106	2,25	33	230	142
2025	26	27	150	4,5	60	240	135
2050	38,5	40	200	8,6	100	260	130

The estimates for 2050 were taken from the forecast of the Verturatis agency (2011), which predicted a sharp increase in the GDP of developing countries, but gave estimates for Russia of a 6.6-fold increase in GDP, for the US GDP (2050) = 38.5 trillion dollars. From here, it is possible to calculate the specific values of GDP (per capita per year) and human capital per capita (Table 2).

Table 2. Estimated specific HC.

t	GDP production per capita per year USA	GDP production per capita per year Russia	Human capital per capita USA	Human capital per capita Russia
2002	32,8 thousand dollars	5.34 thousand dollars	422,2 thousand dollars	184,9 thousand dollars
2005	42,98 «	8,54 «	438,6 «	208,3 «
2008	62,0	15,8	460,8	225,3

Russia is still lagging behind the United States in terms of these indicators. In the USA, 59% of the population have higher education, in the Russian Federation - 29%. To increase HC, you need to

double the number of people with high-quality higher education in Russia. For GDP growth, it is necessary to increase the high-tech sector of the economy - over the past 15 years, sales of high-tech products have increased in developed countries by 65.8%, the high-tech sector's high-tech sector has grown 2.8 times. The share of high-tech industries in the manufacturing industry increased from 7.1% to 12%. Since 2000, in the USA, Germany, France and England, the knowledge-based sector has been producing 15–25% of GDP growth annually. In Russia, only 30% of GDP growth is provided by intensive factors. The annual volume of high-tech products in the world is $ 2.5 trillion, in 15 years it will be $ 4 trillion. The potential oil export of Russia is only 40 billion dollars per year, i.e. 1% of the potential of high-tech production in the world. High-tech production is directly related to the growth of HC and research. In absolute terms, the Russian Federation spends on science less than Japan by 9.3 times, Germany 4.7 times, France 2.8 times, the United States 24 times. Export of machinery and equipment of the Russian Federation 9%, USA, Germany-50%, Japan 70%. World exports of the Russian Federation equipment $ 41 billion, raw materials and metal $ 30 billion. Let's try to calculate what kind of HC the Russian Federation needs to move to the sixth technological structure.

If for the production of 14.3 trillion US dollars, 95 trillion US dollars of HC USA were used, then the ratio of GDP / $ 1. HC = 14.3 / 95 = 0.15 $ / 1 $ of generated GDP. With such a critical ratio at HC of 30 trillion dollars. Russia would have to generate $ 0.15 / $ .30 = 4.5 trillion. dollars, but generated 2.25 trillion dale at the maximum estimate of GDP, i.e. two times less. Russia has this indicator for HC, equal to: 2.25: 30 = $ 0.075 / $, i.e. the demand for HC in Russia is now about 60 trillion dollars, i.e. twice as much as is available. It is necessary to double HC to achieve the potential sufficient for high-tech exports.

Experts need to establish the affiliation of the selected qualities to the assessed employee, according to whom the average affiliation is M (Ai):

$$M(A_i) = \sum M(A_{ij}/)n, \tag{16}$$

where M (Aij) is the assessment of the membership of the quality xj in the class Ai.

In order to objectively evaluate the employee, it is necessary to build his quality profiles, which will help to identify his strengths and weaknesses. To determine the mismatch profile between the real and ideal employee profiles, it is necessary to combine the received professiogram and personogram (Figure 2).

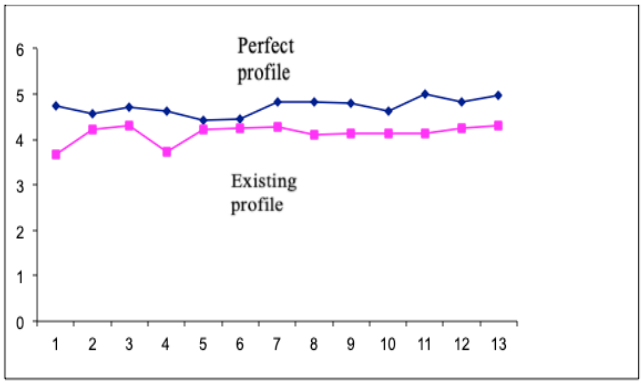

Figure 2. The ratio of required and existing employee profiles.

Using this method, the manager can evaluate how much the employee meets the requirements that he makes. In addition, the manager can also compare the ideal profile of the employee as a whole in a given industry (estimated on average) with the profile of the employees of his company so that the human capital he possesses is competitive.

Of primary interest are the graphs of the dependencies of the firm's GDP production on the capital-labor ratio and on the level of human capital, since it is necessary to find out which of the development

factors — extensive or intensive — prevails in the organization. For example, KomInzh LLC production is growing almost linearly (Figure 3).

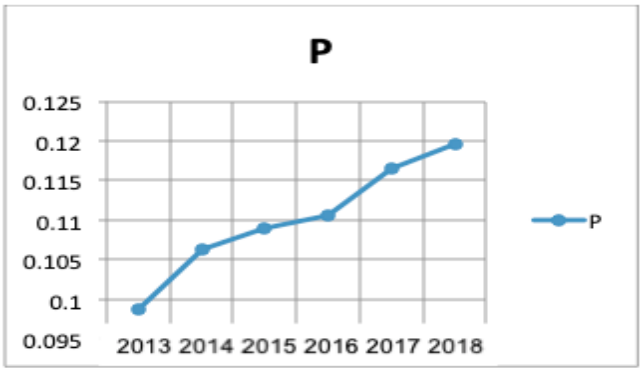

Figure 3. Growth in the production of employees in time.

The calculated graph of the dependence of GDP production on the growth of capital-labor ratio is shown in Figure 4 and is characterized by a nonlinear dependence.

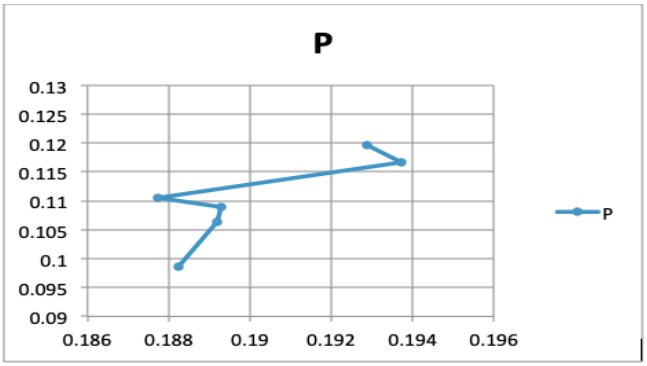

Figure 4. Dependence of output on capital ratio.

The constructed graph of the dependence of production on changes in human capital, which grows along with an increase in the number of employees, shows the high sensitivity of Ut to the level of knowledge and skills of personnel (Figure 5).

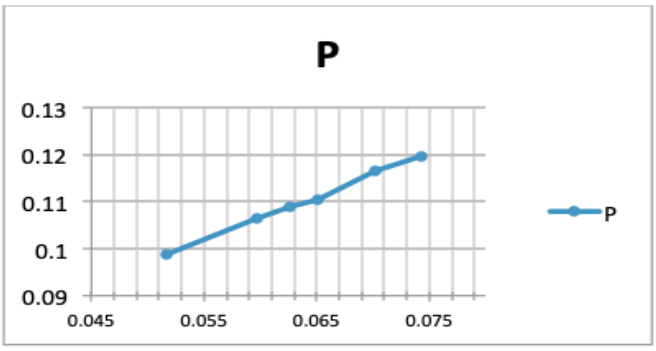

Figure 5. Dependence of production on the level of human capital.

The increase in production is primarily caused by an increase in human capital, that is, an intensive factor prevails in the development of KomInzh LLC production. Let us find the ratio of these values.

Since the gross product of the enterprise is created on the basis of the growth of fixed assets and an increase in human capital, we calculate the volume of gross product due to these factors (Figure 6).

Figure 6. Separation of GDP by factors of its formation.

If you fix the return on assets in the base year and then multiply it by the size of fixed assets, you can calculate the share of GDP due to funds with a constant level of knowledge. Then the share of GDP due to knowledge will be determined by the difference:

$$GDP(U) = GDP(T) - GDP\ (\Phi_{T-1}) \tag{17}$$

With a basic GDP_{2019} = 35 million rubles KomInzh LLC and the size of the size of fixed assets = 167 million rubles it follows that the ratio of extensive and intensive factors in GDP is about 2: 1, the extensive factor occupies about 2/3 (or 65%) of the total value of GDP, and the intensive factor accounts for 1/3 (or 35%). It should be noted that the return on human capital (Figure 7) is higher than on capital productivity, despite the fact that the cost of OPF in the total cost of GDP is almost 2 times higher (Figure 7).

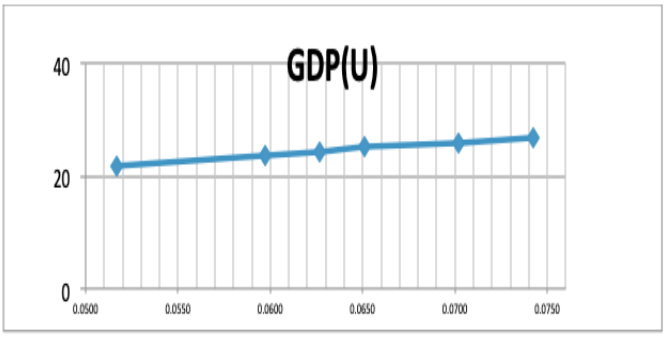

Figure 7. Dependence of GDP on the cost of human capital.

We study the dependence of changes in GDP production on changes in extensive and intensive factors. The pace calculations will be carried out according to the formulas:

$$\theta_U = \frac{\Delta U_t}{U_t} \tag{18}$$

$$\theta_P = \frac{\Delta P}{P} \tag{19}$$

$$\theta_U = 2\theta_P - \theta_\Phi \tag{20}$$

$$\theta_P = \frac{1}{2}(\theta_U + \theta_\Phi) \tag{21}$$

Calculations showed a significant dependence of economic growth on the level of materialized knowledge of the organization.

To simulate the influence of knowledge on the results of the organization, the application software package Ithink was used. To assess the quality of the LLC's work, we will use a generalized indicator based on selected private indicators: net profit, total number of customers, production volume,

increase of staff competencies. For the fourth indicator, a block of stream modeling “Knowledge Management” has been introduced. (Figure 8).

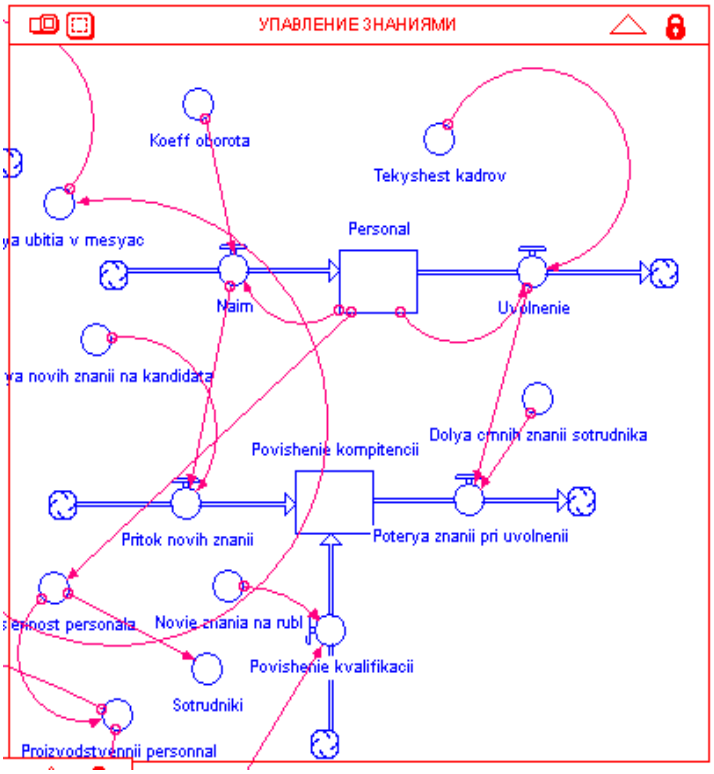

Figure 8. Stream model of the subsystem "Knowledge Management".

Analytical model description (knowledge management).

УПАВЛЕНИЕ ЗНАНИЯМИ

- Personal(t) = Personal(t - dt) + (Naim - Uvolnenie) * dt
  - INIT Personal = 200
  - INFLOWS:
    - Naim = ROUND(Personal*Koeff_oborota)
  - OUTFLOWS:
    - Uvolnenie = ROUND(Personal*Tekyshest_kadrov)
- Povishenie_kompitencii(t) = Povishenie_kompitencii(t - dt) + (Pritok_novih_znanii + Povishenie_kvalifikacii - Poterya_znanii_pri_uvolnenii) * dt
  - INIT Povishenie_kompitencii = Pritok_novih_znanii+Povishenie_kvalifikacii
  - INFLOWS:
    - Pritok_novih_znanii = Naim*Dolya_novih_znanii_na_kandidata
    - Povishenie_kvalifikacii = Obychenie_personala*Novie_znania_na_rubl
  - OUTFLOWS:
    - Poterya_znanii_pri_uvolnenii = Dolya_crnnih_znanii_sotrudnika*Uvolnenie
- Chislennost_personala = ROUND(Personal)
- Dolya_crnnih_znanii_sotrudnika = RANDOM(0.2,0.25)
- Dolya_novih_znanii_na_kandidata = RANDOM(0.15,0.2)
- Dolya_ubitia_v_mesyac = 1-Vosproivodimoe_kachestvo
- Koeff_oborota = RANDOM(0,0.033)
- Novie_znania_na_rubl = 0.00037
- Proizvodstvennii_personnal = Chislennost_personala*0.8
- Sotrudniki = Chislennost_personala*0.14
- Tekyshest_kadrov = RANDOM(0,0.033)

Increasing staff competency is carried out through continuing education programs, training and hiring specialists (Figure 9).

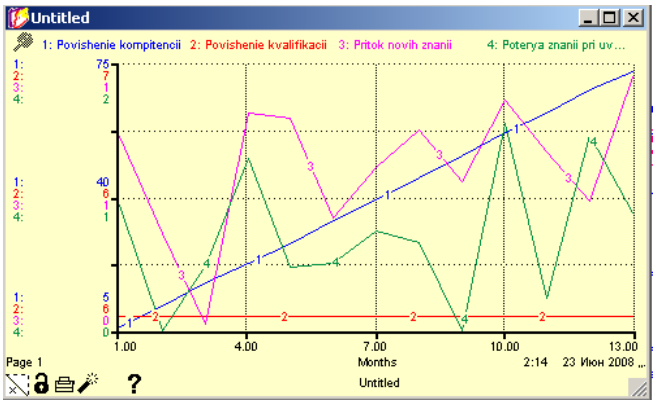

Figure 9. Modeling the dynamics of increasing competence.

Simulation results indicate successful staff development. There is a steady trend of replenishment of knowledge in the enterprise.

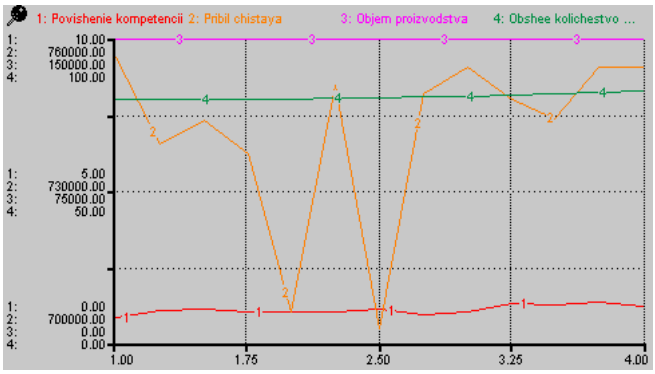

Figure 10. Results of modeling quality indicators.

Obviously increasing the results of the organization while increasing the level of knowledge of employees.

2. Discussion

The proposed hypothesis of the relationship between the level of materialized knowledge and economic results is confirmed by the analysis of statistical data and the construction of a model for calculating the size of real human capital used in the economic system. These results allow us to compare the sizes of intensive and extensive factors in the economic system and make a diagnosis of development factors, which is important when developing strategic plans.

3. Conclusion

Quantitative analysis of development factors, their assessment provides new opportunities for understanding the logic of processes in the development of a specific economic system. The constructed models are a tool for strategic analysis of development factors and the dynamics of the evolution of the economic system.

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