The model of human capital development with innovative characteristics in digital economy

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Abstract. In the conditions of digital transformation of the economy, the structure of human capital and the instruments of human capital development are changing. The development of human capital management system in the conditions of digital economy development is possible only with the high quality of human capital and the high level of knowledge. A system model is developed, which is represented by the subsystems "The Structure of Human Capital", "Instruments of Human Capital Development", "Organizational and Economic Instruments of Human Capital Management", taking into account the peculiarities of human capital management in the digital economy. To determine the ways to improve the quality of human capital structure and to assess the effectiveness of human capital development tools, an approach to assessing the efficiency level of human capital development, including indicators of qualitative and quantitative assessment, is presented. This will make it possible to take more fully into account all aspects of the management of intellectual resources in the digital economy. In order to be able to classify enterprises by the efficiency level of human capital development with innovative characteristics on the basis of open financial information, machine learning model was created and classification rules were defined.

1. Introduction
Recently, the transition of the economy in Russia to the digital economy is being discussed at all levels of government and management. In the conditions of economic transformation, special priority should be given to the management of human capital of innovative enterprises. Calls of new times are staff shortage in the field of the mobile internet, cloud technologies, in the field of computer performance and big data, in the field of crowdsourcing and sharing economy. An innovative manager, who owns digital technologies, should have: 1) data availability in real time; 2) the capacity to predict and make strategic decisions; 3) constant self-development and the ability to learn from any device anywhere; 4) skills of virtual cooperation; 5) skills of virtual team building.

In the digital economy, the human role in production is changing, resulting in the need for further automation of production and management of human capital, development of models of human capital management in the conditions of digital transformation of the economy. The factors of human capital development in the digital economy are the level of education, digital literacy and general innovative culture.

In the research on the problems of evaluation and practical application of intellectual human capital, the structures of intellectual human capital, its importance in the innovative development of an organization, the problems of developing effective management technologies and methods of assessment the effectiveness of management of intellectual human capital in the organization have been studied [1-3]. At the same time, the conducted research does not identify the factors affecting employees’ creativity, does not reflect the
correlation of employees creative activity, the ability to self-study and the results of innovative activity of the organization, does not present models for assessing the effectiveness of human capital development with innovative characteristics [4,5].

The existing methods and tools for assessing human capital do not allow full disclosing of professional, intellectual, creative abilities and employees’ abilities to self-study for determining the directions of their formation and development, which reduce the prediction accuracy and planning of human capital development in demand in the digital economy [6-8].

It is necessary to develop tools for assessing the efficiency of employees’ human capital of innovative enterprises in the digital economy.

The aim of the study is to simulate a human capital management system with innovative characteristics in the digital economy, which is solved through the following tasks:

1. To develop a system model of human capital management, taking into account the peculiarities of human capital management in the digital economy;
2. To develop indicators to assess the efficiency level of human capital with innovative characteristics;
3. To work out a machine learning model to classify organizations by the efficiency level of human capital development.

Brief results: the system model of human capital management is developed, taking into account the peculiarities of human capital management in the digital economy and including three subsystems: "The Human Capital Structure", "Human Capital Development Tools", "Organizational and Economic Tools of Human Capital Management"; the indicators, with the help of which it is possible to evaluate the effectiveness of human capital development with innovative characteristics, are defined; the model of machine learning classification of organizations by the efficiency level of human capital development with innovative characteristics is developed.

According to Gildingersh, M. G., innovative human capital management of employees is defined as management based on the development of creativity aimed at motivating and stimulating innovative behavior of the organization's staff ([16, p.130-144]. At the heart of the qualitative development of employees Yakovleva, E. V. sees the effective implementation of the cyclic process of intellectualization, consisting of successive stages of planning, formation, development, transformation and use of human potential (transformation of the accumulated intellectual potential into intellectual capital, resulting in the formation of the so-called intellectual rent) [10, p.44-47].

In the digital economy, scientists and practitioners consider intellectual and creative abilities of a staff as the main competitive advantages of an organization. To cope with the innovation economics, the theory of corporate governance must correspond to theoretical, organizational and strategic aspects of innovative resource assignment [1]. Key performance indicators of production units of innovative enterprises in the engineering industry depend on many factors and are determined on the basis of the synergetic approach [17].

Personnel management functions include not only the development of creative and intellectual abilities of organization's personnel, but also the attraction of talented employees, which gave rise to such a direction in management as talent management [19].

The composition and structure of the institutional component of innovative organizations are considered in the work of Miheenko, O.V. [13].

Modernization of traditional manufacturing industries and service industries, trade and procurement procedures of an organization, related financial and logistics operations, changes in consumption patterns against the background of through penetration of information
technology and digitalization of economic processes creates the basis for the formation of new markets and new conditions of functioning of the market [14], as well as new approaches to analytics, forecasting and management decision-making [15]. The approach to the characteristics of human capital of an innovative enterprise is changing. Human capital includes intellectual, labor, institutional and social capital [16]. Intellectual capital refers to the value represented by certain human mental abilities, the purposeful use of which provides profitability in the form of non-material benefits, namely: new knowledge, institutions [10]. Labour capital is a value represented by a profitable combination of knowledge, skills and abilities used to create wealth. Institutional capital is a system of rules and regulations governing and coordinating the system of internal and external transactions and acts as a function of intellectual capital [16].

Innovation acts as the engine of economic development, ensuring its efficiency and productivity growth. In the information society, innovation has firmly taken the place of the main generator of economic growth of any country. [17]

In addition to intellectual abilities, creativity, professional knowledge, there is a need for the ability to constant learning and self-study [19].

Self-development of a leader is a cost-effective way for an innovative enterprise, which leads to competitive advantages of such an enterprise in modern conditions [20].

Hypothesis 1: It is possible to develop a model of human capital management system with innovative characteristics in the digital economy.

Knowledge management, according to Dresvyannikov, V. A., refers to the management of the creation, production and use of knowledge [21]. The creation of knowledge is understood as intellectual activity carried out in practice. Individual knowledge, created by a person himself, is a part of human capital and is manifested as intellectual models, skills, abilities, necessary in professional activity and life. Management of such intellectual activity is possible and necessary, as it determines the effectiveness of professional and personal life. Knowledge production is aimed at creating of a knowledge system of an organization, intended for internal use, as well as for sale of intellectual products in the market. Here knowledge is a source of income. Therefore, knowledge management can be seen as a way to make profit.

Organizations should strive not only to produce new knowledge but also to make effective use of existing knowledge.

In the approach to intellectual capital management, the problem of increasing the value of organization’s assets is investigated through knowledge audit and formation of knowledge maps [22].

The approach to intellectual resources management is based on continuous improvement and search for new management methods, introduction of management technologies, the study of new forms of communication with the external and internal environment and creating conditions under which intellectual abilities of a staff would develop. The researchers agree that intellectual resources of an organization are a set of employees’ mental abilities that they use to generate ideas that allow an organization to carry out innovative activities [23].

In contrast to the intellectual resources, creative (creative) ones are employees' abilities to creativity and innovative activities. Creativity is associated with the creation of something new, and not simply with the ability to think. At the same time, creativity is a part of intellect, so creative resources can be considered as a part of the intellectual ones. Then, creative and intellectual resources are a factor of production, which must be effectively used to achieve innovative development.
Melnikov, ON is one of the creators of creative economics theory. In his opinion, "it is absolutely clear that the economic performance of all other types of resources depends to a large extent from the level and degree of development of the creative and intellectual resources used by an organization» [24, p.201]. Therefore, it is necessary to know the essence of intellectual and creative resources.

The ICT market includes a wide range of products and services, the main characteristic of which is innovative complementarity. Today, the digital economy is the main driver of innovation and economic growth [25]. Machine learning is applicable to solve problems of municipal economy, as well as in the process of making management decisions on the management of social and economic development of the territory, in particular in forecasting key indicators of social and economic development [26]

Hypothesis 2: it is possible to work out a machine learning model to classify innovative organizations by the efficiency level of human capital development.

2. Methods

2.1 Sample

The survey used data from the national rating of Russian high-tech and fast-growing companies "Tehuspeh" - 2017. The Expert Council consists of professionals who have successful experience in business development of a particular industry.

The experts assess not only the financial performance of innovative organizations, but also the technological level of products, as well as its innovation. During the research more than 100 innovative enterprises engaged in research, including in the IT sphere, were analyzed. The resulting aggregate sample included 2828 indicator values.

A model of the human capital management system of innovative enterprises in the digital economy is developed. This model is made using a systematic approach to human capital management, represented by the subsystems "Human Capital Structure", "Tools for Human Capital Development", "Organizational and Economic Instruments for Human Capital Management" and clearly reveals the differences between these communication elements and relationships that are different from those factors under the influence of which the rate of efficiency level of human capital development varies. The structural characteristics that human capital takes in the context of digitalization of the economy, consist of the level of education, professionalism, intelligence, continuous learning and self-learning, the ability to be creative and have network literacy.

Interaction of model subjects can occur for the purpose of implementing various projects in the organization in the IT field, for which new organizational structures can be created. Interaction will most often take place in a virtual mode, rather than in real.

The following principles in human capital management of innovative organizations are defined: synergy, project management, innovation management, creative management, feedback, reproductive balance, integration with the education system and the industrial sector of the economy, flexibility and adaptability of management, efficiency, profitability.

Organizational and economic instruments of human capital management in the digital economy are:
- budget financing;
- support of educational loans
- tax benefits;
- development of a road map for the implementation "Digital Economy of the Russian Federation" program;
- creation and development of infrastructure to support innovative activity of IT enterprises;
- development of digital economy institutions (e-government, network society, social networks).

The instruments of human capital development in the digital economy are:
- order formation of IT organizations for training;
- state support of universities that implement an order for the training of IT professionals;
- guarantees of the state / state companies for the employment of the best graduates of universities;
- creation of conditions for professional and career growth of the best and promising employees;
- provision of IT organizations with qualified employees through the mechanism of interaction between universities and enterprises;
- joint scientific research of universities and innovative companies.

2.2 Assessment of the efficiency level of human capital development with innovative characteristics in the digital economy

Based on the goal and principles of management, two directions for assessing the economic efficiency of human capital management will be formed: qualitative and quantitative. Qualitative assessment of the efficiency level of human capital development of an innovative organization in the digital economy is summarized in Table 1.

| Direction                                | Indicators                                                                                   |
|------------------------------------------|---------------------------------------------------------------------------------------------|
| Organization of innovation activities    | efficient use of working time                                                                |
|                                          | efficiency of information processing                                                         |
| Costs of human capital management (management expenses) | costs of training, retraining, improvement of professional skills                           |
|                                          | costs to stimulate innovation                                                                |
|                                          | health care costs                                                                            |
|                                          | costs of attracting human capital                                                            |
|                                          | costs of formation of organizational culture                                                  |
| Results of intellectual activity          | publication activity                                                                        |
|                                          | registration of computers and databases                                                      |
|                                          | thesis defense                                                                              |
| Results of innovation activities          | volume of produced innovative products                                                       |
|                                          | use of innovative information technologies                                                   |
Figure 1. A model of human capital management of an innovative enterprise in the digital economy

Factors of the internal environment
- Professionalism
- Education level
- Intellect
- Creativity
- Self-study
- Professional training
- Network literacy

Factors of the external environment
- E-government

Human capital management
- In-house mechanism
  - Goals and objectives of the
    - Control function
  - Management structure
  - Management resources
  - Management technologies
  - Management methods

Tools for human capital development
- Organizational, psychological, financial support
- Management principles
  - Budget financing
  - Support of educational loans
  - Tax benefits
  - Development of a road map for the implementation "Digital Economy of the Russian Federation" program
  - Creation and development of infrastructure to support innovative activities of IT enterprises
  - Development of institutions of the digital economy (e-government, network society, social networks)

Feedback

Innovative processes in IT organizations
- The level of efficiency of human capital development with innovative characteristics
- Increase of innovative activity in IT organizations

Development of human capital of innovative IT organizations
Figure 1. A model of human capital management of an innovative enterprise in the digital economy
Quantitative assessment of the efficiency level of human capital development of an innovative organization in the digital economy is summarized in Table 2.

Table 2. Indicators of quantitative assessment of the efficiency level of human capital development with innovative characteristics

| Group of indicators                                      | Indicator                                      |
|----------------------------------------------------------|------------------------------------------------|
| Human capital security                                   | Number of employees directly involved in innovation development |
| Cost of an innovative organization                       | Intangible assets                              |
| Profitability and effect of use of innovations in the organization | The profitability of the end product |
|                                                          | Net profit of the organization                  |

2.3 Data Analysis

The statistical data were obtained on the basis of the primary processing of the financial statement of innovative organizations, which is publicly available on the Internet portal of statistical information Multistat and in the system of professional analysis of the company Spark-Interfax, as well as data from the portal Za Chestnyi Business. Obtained total sample included 2828 indicator values.

The expert has formed the marked data. The first, second, third class of Y – the valuation level of efficiency of human capital development with innovative characteristics is defined. The first class includes human capital with the high social component (high productivity, high management costs), but low cost of intangible assets. The second class will include human capital with the high innovative component (the number of RIA, the value of intangible assets). The third class includes human capital in terms of development with an average level of development of the social component, but both high and low levels of innovation component.

Next, the model of machine learning for the classification of organizations by Y-level assessment of the effectiveness of human capital development with innovative characteristics based on data on X1-revenue, X2-intangible assets, X4-net profit, X5-end products, X6-management costs, X7-the number of employees involved in innovation, X8-registration of computers and databases.

The data set is given (table 3).

Table 3. Data set for working out the machine learning model
|   | x1    | x2    | x4    | x5    | x6    | x7    | x8    | y    |
|---|-------|-------|-------|-------|-------|-------|-------|------|
| 0 | 1629.860 | 1.197 | 132.457 | 1591.172 | 0.000 | 140.00 | 22.00 | 1.0  |
| 1 | 1704.604 | 4.105 | 58.109 | 1662.918 | 0.000 | 140.00 | 22.00 | 1.0  |
| 2 | 1633.277 | 3.860 | 62.412 | 1585.678 | 0.000 | 169.00 | 22.00 | 1.0  |
| 3 | 1810.765 | 3.565 | 16.073 | 1764.501 | 0.000 | 165.00 | 22.00 | 1.0  |
| 4 | 2955.891 | 3.249 | 8.749  | 2856.079 | 0.000 | 178.00 | 22.00 | 1.0  |
| 5 | 4332.804 | 2.916 | 3.704  | 4152.103 | 0.000 | 184.00 | 22.00 | 1.0  |
| 6 | 38.621  | 0.008 | 0.867  | 37.710  | 0.000 | 9.00   | 1.0   | 2.0  |
| 7 | 88.554  | 10.065 | 23.772 | 66.453  | 0.000 | 10.00  | 2.0   |      |
| 8 | 296.472 | 11.480 | -3.473 | 291.046 | 0.000 | 10.00  | 2.0   |      |
| 9 | 316.537 | 36.652 | 5.652  | 316.955 | 0.000 | 10.00  | 2.0   |      |
| 10| 257.524 | 49.057 | 5.141  | 172.244 | 85.180 | 11.00  | 1.0   |      |
| 11| 672.283 | 12.683 | 8.705  | 603.465 | 43.861 | 44.00  | 16.0  | 1.0  |
| 12| 542.027 | 11.092 | 2.829  | 509.499 | 0.000 | 43.00  | 16.0  | 2.0  |
| 13| 458.024 | 15.169 | 11.507 | 419.167 | 0.000 | 43.00  | 16.0  | 2.0  |
| 14| 584.670 | 10.984 | 25.299 | 506.952 | 0.000 | 44.00  | 16.0  | 2.0  |
| 15| 1478.982| 9.337  | 127.904| 1337.488| 0.000 | 44.00  | 16.0  | 2.0  |
| 16| 2576.371| 11.633 | 339.286| 2194.700| 0.000 | 45.00  | 16.0  | 2.0  |
| 17| 266.521 | 3.437  | 4.178  | 166.739 | 95.569 | 67.00  | 8.0   | 1.0  |
| 18| 497.057 | 8.886  | 12.658 | 341.931 | 104.966| 78.00  | 8.0   | 1.0  |
| 19| 519.558 | 56.074 | 62.238 | 296.429 | 126.178| 80.00  | 8.0   | 1.0  |
| 20| 460.598 | 80.547 | 34.061 | 278.274 | 95.359 | 81.00  | 8.0   | 1.0  |
| 21| 980.880 | 40.341 | 258.572| 602.194 | 0.000 | 91.00  | 8.0   | 1.0  |
| 22| 343.673 | 0.068  | 13.645 | 262.870 | 53.300 | 25.00  | 1.0   | 2.0  |
| 23| 303.078 | 0.063  | 80.726 | 206.683 | 93.473 | 38.00  | 1.0   | 2.0  |
| 24| 345.003 | 0.057  | 75.454 | 242.319 | 125.492| 28.00  | 1.0   | 2.0  |
| 25| 343.699 | 0.052  | 71.230 | 237.928 | 124.232| 26.00  | 1.0   | 2.0  |
| 26| 470.164 | 20.427 | 97.643 | 382.645 | 51.144 | 27.00  | 1.0   | 2.0  |
| 27| 778.400 | 23.236 | 169.125| 345.001 | 111.000| 27.00  | 1.0   | 2.0  |
| 28| 562.346 | 0.147  | 49.340 | 76.658  | 37.430 | 13.00  | 5.0   | 1.0  |
| 29| 1274.558| 31.163 | 434.266| 270.710 | 55.370 | 14.00  | 5.0   | 1.0  |
| ...| ...    | ...    | ...    | ...    | ...    | ...    | ...    | ...  |
| 375| 280.407 | 0.000  | 1.888  | 227252.000| 51.220 | 219.00 | 1.0   | 3.0  |
| 376| 2399.700| 0.000  | 7.255  | 2311823.000| 78.578 | 220.00 | 1.0   | 3.0  |
| 377| 1446.683| 0.000  | 5.920  | 1316781.000| 86.901 | 222.00 | 1.0   | 3.0  |
| 378| 3168.181| 4.726  | 298.627| 2298480.000| 282.275| 65.00  | 1.0   | 2.0  |
| 379| 3721.964| 4.237  | 183.610| 2866320.000| 344.975| 68.00  | 1.0   | 2.0  |
Total 404 entries

**Table 4. Determinants for working out the machine learning model**

| X1       | Revenue, mln. RUB |
|----------|-------------------|
| X2       | Intangible assets, mln. RUB. |
| X4       | Net profit, mln. RUB. |
| X5       | End products, mln. RUB. |
| X6       | Management costs, mln. RUB. |
| X7       | The number of employees engaged in innovation, pers. |
| X8       | Registration of computers and databases, PCs. |
| Y        | The valuation level of efficiency of human capital development with innovative characteristics |

Let's see if any attributes are related. This can be done by calculating the correlation coefficients for all columns.

**Table 5. Calculation of correlation coefficients**

|   | x1        | x2        | x3        | x4        | x5        | x6        | x7        | x8        | y         |
|---|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| x1| 1.000000  | 0.396006  | 0.035698  | 0.379485  | 0.611336  | 0.22502   | 0.481412  | -0.177429 |
| x2| 0.396006  | 1.000000  | 0.237907  | -0.084350 | 0.161158  | 0.101219  | 0.293144  | -0.201466 |
| x3| 0.035698  | 0.237907  | 1.000000  | -0.013908 | -0.000166 | 0.051692  | 0.175323  | -0.047102 |
| x4| 0.379485  | -0.084350 | -0.013908 | 1.000000  | 0.158027  | 0.180878  | -0.045112 | -0.018455 |
| x5| 0.611336  | 0.161158  | -0.000166 | 0.158027  | 1.000000  | 0.134607  | 0.601574  | -0.202991 |
| x6| 0.22502   | 0.101219  | 0.051692  | 0.180878  | 0.134607  | 1.000000  | 0.259347  | 0.111472  |
| x7| 0.481412  | 0.293144  | 0.175323  | -0.045112 | 0.601574  | 0.259347  | 1.000000  | -0.291861 |
| y | -0.177429 | -0.201466 | -0.047102 | -0.018455 | -0.202991 | 0.111472  | -0.291861 | 1.000000  |

It can be seen that the attributes do not correlate with each other.

The following methods to create the model will be used:
1. Least square method
2. Random Forest
3. Nearest-neighbor method

The estimation will be made using the coefficient of determination (R-square). This coefficient is determined as follows:
1.
\[ R^2 = 1 - \frac{V[y|x]}{V(y)} = 1 - \frac{\sigma_y^2}{\sigma_y^2} \quad (1) \]

\[ V(y|x) = \sigma_y^2 \] — where is the conditional variance of the dependent quantity y by factor x. The coefficient takes the value on the interval and the closer it is to 1 the stronger the dependence is.

2. The most obvious quality measure will be the proportion of correct responses (accuracy):

\[ \text{accuracy} = \frac{\sum_{i=1}^{\ell} [a(x_i) = y_i]}{\ell} \quad (2) \]

The parameters and metrics of the quality of education

Random forest

DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=5, max_features=None, max_leaf_nodes=None, min_impurity_decrease=0.0, min_impurity_split=None, min_samples_leaf=1, min_samples_split=2, min_weight_fraction_leaf=0.0, presort=False, random_state=17, splitter='best')

accuracy = 0.9457
R-square = 0.7516

Nearest-neighbor method

KNeighborsClassifier(algorithm='auto', leaf_size=30, metric='minkowski', metric_params=None, n_jobs=1, n_neighbors=10, p=2, weights='uniform')

accuracy = 0.5247
R-square = 0.4238

The parameters and metrics of the quality of education

Linear regression

LinearRegression(copy_X=True, fit_intercept=True, n_jobs=1, normalize=False)

R-square = 0.0238
accuracy = 0.3247

It can be concluded that Random Forest method has coped with the task better than others. Let's determine the weight of each factor in the final model.
In our case, it can be seen that the most impact on the valuation level of efficiency of human capital development with innovative characteristics:

- X6-Management costs, mln. RUB.
- X8-Registration of computers and databases, PCs.

3. Results and Discussion
A taught model based on random forest algorithm (Figure 2) is obtained. Let's make a set of rules for this model.

- X[0] - Revenue, mln. RUB.
- X[1] - Intangible assets, mln. RUB.
- X[2] - Net profit, mln. RUB.
- X[3] - End products, mln. RUB.
- X[4] - Management costs, mln. RUB.
- X[5] - The number of employees engaged in innovation
- X[6] - Registration of computers and databases, PCs

Rule No. 1. Organizations with the efficiency level of human capital development with innovative characteristics of level 2 include organizations with the following set of characteristics:

- X[6] - Registration of computers and databases, PCs-less than or equal to 1.5
- X[3] - End products, mln RUB - less than or equal to 592,904;
- X[1] - Intangible assets, mln. RUB - less than or equal to 4,081;
- X[2] – Net profit, mln RUB less than or equal to 121,118.

Rule No. 2. Organizations with the efficiency level of human capital development with innovative characteristics of level 1 include organizations with the following set of characteristics:

- X[6] - Registration of computers and databases, PCs-less than or equal to 1.5
- X[1] - Intangible assets, million rubles-more or equal to 4,081;
- X[4] – Management expenses, million RUB - greater or equal 3,307 and less than or equal of 98.09.

Rule No. 3. Organizations with the efficiency level of human capital development with innovative characteristics of level 2 include organizations with the following set of characteristics:

- X[6] - Registration of computers and databases, PCs-less than or equal to 1.5
- X[3] - End products, mln RUB - less than or equal to the value 592,904;
- X[1] - Intangible assets, mln RUB -more or equal to 4,081;
- X[4] - Management costs, mln RUB -less than or equal to 3,307.

Rule No. 4. Organizations with the efficiency level of human capital development with innovative characteristics of level 2 include organizations with the following set of characteristics:

- X[6] - Registration of computers and databases, PCs-less than or equal to 1.5
X[3] - End products, mln. RUB. - more or equal to 592,904;
X[1] - Intangible assets, mln. RUB. - less than or equal to 4,394;
X[5] - The number of employees engaged in innovation-less than or equal to 121.5

Rule No. 5. Organizations with the efficiency level of human capital development with innovative characteristics of level 3 include organizations with the following set of characteristics:

X[6] - Registration of computers and databases, PCs-less than or equal to 1.5
X[3] - End products, mln. RUB. - more or equal to 592,904;
X[1] - Intangible assets, mln. RUB. - less than or equal to 4,394;
X[5] - The number of employees engaged in innovation-more or equal to 121.5

Rule No. 6. Organizations with the efficiency level of human capital development with innovative characteristics of level 2 include organizations with the following set of characteristics:

X[6] - Registration of computers and databases, PCs-less than or equal to 1.5
X[3] - End products, mln. RUB. - more or equal to 592,904;
X[1] – Intangible assets, mln. RUB. – greater than or equal 4,394 per.

Rule No. 7. Organizations with the efficiency level of human capital development with innovative characteristics of level 2 include organizations with the following set of characteristics:

X[6] - Registration of computers and databases, PCs - more or equal to 1.5
X[5] - The number of employees engaged in innovation-less than or equal to 89
X[2] – Net profit, mln. RUB greater than or equal to value - 226,649.
X[4] - Management costs, mln. RUB-less than or equal to 1,716.

Rule No. 8. Organizations with the efficiency level of human capital development with innovative characteristics of level 3 include organizations with the following set of characteristics:

X[6] - Registration of computers and databases, PCs - more or equal to 17, more or equal to 1.5
X[5] - The number of employees engaged in innovation - more or equal to 89

Rule No. 9. Organizations with the efficiency level of human capital development with innovative characteristics of level 1 include organizations with the following set of characteristics:

X[6] - Registration of computers and databases, PCs - greater than or equal to 1.5, less than or equal to 12
X[4] – Management expenses, mln. RUB. - greater than or equal to 6.56.
X[1] – Intangible assets, million rubles-less than or equal to 0.001.
X[0] - Revenue, million rubles-more or equal to 466, 319

Rule No. 10. Organizations with the efficiency level of human capital development with innovative characteristics of level 2 include organizations with the following set of characteristics:

X[6] - Registration of computers and databases, PCs - more or equal to 1.5
X[4] – Management expenses, mln. RUB. - greater than or equal to 6.56.
X[1] – Intangible assets, mln. RUB-more or equal to 0.001.
X[2] – Net profit, mln. RUB greater than or equal to the value 172,542.
X[3] - End products, mln. RUB. - less than or equal to 147,035
Rule No. 11. Organizations with the efficiency level of human capital development with innovative characteristics of level 2 include organizations with the following set of characteristics:

X[6] - Registration of computers and databases, PCs - more or equal to 1.5

X[4] – Management expenses, mln. RUB. - greater than or equal to 6.56.

X[2] – Net profit, mln RUB less than or equal to the value 172,542.

X[1] – Intangible assets, mln RUB - more or equal to 0.001.

4. Conclusions

The conducted research has shown that the development of the human capital management system in the conditions of the digital economy development is possible with the high quality of human capital and high level of knowledge.

The authors have proved the formulated scientific hypotheses.

The principles of human capital management with innovative characteristics in the digital economy are formed: the principles of synergy, project management, innovative management, creative management, feedback, reproductive balance, integration with the education system and the industrial sector of the economy, flexibility and adaptability of management, efficiency, profitability.

In accordance with these principles, the model of human capital management with innovative characteristics has been developed. To determine the ways to improve the quality of human capital structure and assess the effectiveness of human capital development tools, an approach to assessing the efficiency level of human capital development, including indicators of qualitative and quantitative assessment, is presented. This will make it possible to take more fully into account all aspects of the management of intellectual resources in the digital economy. In order to be able to classify enterprises by the efficiency level of human capital development with innovative characteristics, on the basis of open financial information, the machine learning model is worked out and the classification rules are defined.

The tools for the human capital development in an innovative IT organization are singled out. They include:

- order formation of IT organizations for training;
- state support of universities that implement an order for the training of IT professionals;
- guarantees of the state / state companies for the employment of the best graduates of universities;
- creation of conditions for professional and career growth of the best and promising employees;
- provision of IT organizations with qualified employees through the mechanism of interaction between universities and enterprises;
- joint scientific research of universities and innovative companies.
Figure 2. – The taught model by random forest algorithm
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