The Impact of Network Human Capital on Economic Growth of Supply Chain in Digital Economy

Dyatlov S.A.[1]
Selishcheva T.A.[2]
Feigin G.F.[3]
Borodushko I.V.[4]
Gilmanov D.V.[5]
[1]oetdsa@yandex.ru
[2]selishcheva@list.ru
[3]fgrig@list.ru
[4]kafedra_itemeo@mail.ru
[5]finec_oet@mail.ru
[1,2,3,4,5]*St. Petersburg State Economic University*

Abstract- The article reveals the features of the neural-network technological revolution and digital economy development. They substantiate the proposition that in the modern digital economy new informational-network properties and the competences of highly skilled workers are developed and human capital is transformed into network human capital. The definition of "network human capital" concept is given and its basic properties are revealed. The available methodological approaches are summarized in the economic literature to study the influence of human capital and labor quality on productivity and economic growth of supply chain. They reveal the methodical problems of investment in education quantitative evaluation and their return is determined. They substantiate the thesis that the digital economy has various neuro-network effects from the use of network human capital in the digital neuro-network economy and it is concluded that they need to be evaluated, recorded and included in the gross national product.

Keywords- *Network human capital, digital economy, economic growth, network effects, supply chain*

1. Introduction

In the modern global information and network economy, highly qualified workers, the level of education have the leading role in labor productivity and economic growth of supply chain. Human capital (health, knowledge, intellectual and creative abilities, education, specialized skills and competencies of workers, their experience) is the main factor of competitiveness and dynamic, sustainable innovative economic growth of supply chain nowadays. The investments in fixed assets and the investments in human capital have traditionally been two interconnected sources of socio-economic growth of supply chain [1]. Under modern conditions the investments in human capital become a high-performance form of capital investment. So the famous economist J. Grayson noted: "Education creates human capital, which in combination with physical capital provides productivity and quality increase. This was always true, but it is twice true for the global modern economy" [2].

The object of research is human (intellectual) capital and its educational and qualification parameters as the most important factors of modern innovation development. The purpose of the analysis is to review the methodological approaches and the models based on economic theory methodology and information and network economics to assess human capital and to identify its impact on economic growth of supply chain and productivity. In July 2017, the federal program "Russian Federation Digital Economy", developed by the Ministry of Communications, was adopted until 2025 [3]. There is a growing demand for highly skilled personnel with developed hyper-competitive digital and network capabilities and competencies in new conditions. Under the influence of the modern neuro-network technological revolution and the Neuronet, there is a qualitative change of the global economic system organization principles, all spheres and elements of the world economy [4], as well as the transformation of human capital into networked human capital.

A wide introduction of neural network technologies leads to the development of a hypercompetitive network of human capital of an innovator in the 21st century, the resulting characteristics of whom are embodied in new products and services and in new objects of intellectual property. A highly educated innovator expert who is the bearer of information and network human capital, included in the global distributed, information-network system of social reproduction, becomes the main creative subject for the creation of advanced multifunctional, dominant innovations that ensure success in the modern hypercompetitive struggle and achieve sustainable rates of innovative economic growth of supply chain.

2. Theory

In the modern information-network economy, the processes of total informatization and network development are unfolding, an active formation of

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

the new generation global computer network takes place which is called "Neuronet". The human capital of highly skilled, mobile, creative workers, its network competencies and functions become the most important network resources and the factors of the high dynamism of the global information economy and the achievement of success in the conditions of global innovative hyper competition. In the global information economy, the human capital of experts is becoming increasingly multifunctional and universal, the role of worker creative, network competencies and abilities will increase, their active positioning in the traditional and network market of highly skilled labor, in business networks, in social networks, leadership skills, the aim on professional skill improvement, the aspiration to success achievement will also be more valuable. In the global information economy, traditional human capital is transformed into networked human capital (intellectual and network capital). The scientific literature has several definitions of "network capital" concept. [4] suggest the following interpretation of this concept: "Network capital is a set of synergistic effects acquired by a company from network interactions and resource capabilities of corporate networks, the value that a company acquires from various configurations of corporate synergy in the core and related industries" [5].

Network human capital is the information and intellectual capital of a network that, in the course of its turnover in the global network, assumes various functional forms and brings intellectual-status rent and diverse synergic-network effects distributed in time and space in addition to usual market and public benefits. Network human capital can be defined as a set of capitalized distributed network capabilities, the skills and the competencies of managers, highly skilled workers and population used for an effective interaction via the Internet with network state structures (e-government structures), with network business structures (e-business, innovation firms, offshore programming), network scientific and educational communities (network research groups, electronic libraries, network universities) and with social networks, which are used to obtain a variety of public goods, market advantages and network effects [6]. In the conditions of an active development of the information and network economy for state, corporate and private structures, the investments in the development of digital and network competences of human capital among highly qualified specialists become the priority. A modern highly qualified specialist, as a human capital carrier, must possess the skills and the competences of digital and network interaction with network state structures (e-government), with network business structures (e-business, innovation firms, providers) and social networks. The new functions of expert intellectual and network capital in the global digital economy are the following ones: creativity, versatility, poly functionality, network thinking and mobility, a distant continuous network education and self-education. Network human capital takes the form of a variety of social, market and network assets that can be capitalized and marketed, and accumulated and treated as a public good and a network benefit in the public, private segments of the global market, as well as in social networks during the process of its economic turnover and commercialization. On the one hand, network human capital is personified in an employee (an expert, an innovator), on the other, it is embodied in certain new knowledge, intellectual products and services, information products, conditionally alienated from their producer and becoming an object of purchase and sale in the form of intellectual object property. In the information-and-network economy, the value and economic return from the use of intellectual capital and intellectual-knowledge goods and network effects produced by it are multiplied.

3. Data and Methods

In modern economic literature, the main sources of economic growth of supply chain are the following ones: innovation, R&D costs, the degree of their introduction into production, the increase of employed labor; the improvement of its quality and structure; the increase of material capital; the improvement of capital and technology quality; better organization and management, a more efficient resource allocation and use. Most Western specialists in the field of education economics recognize that education has a direct or an indirect relationship to each of the above-mentioned sources of growth and therefore it certainly contributes to economic growth of supply chain, but which cannot be fully taken into account always. Therefore, the problem of education efficiency measurement and its impact on economic growth is relevant, but it has a number of methodological difficulties. For the first time, labor and human capital figured as an independent factor of economic growth in the neoclassical model of economic growth of supply chain by [8]. In this model, the output of products is the function of capital and labor factors. In the extended model by R. Solow, proposed by a group of scientists, capital is divided into physical and human one. At the same time, it is proved that the share of human capital varies in the range from 1/3 to 1/2. The qualification of the workforce and the quality of physical capital are mutually complementary. A low quality of fixed capital can be compensated by a high qualification of labor force, and a high quality of fixed capital can be largely depreciated by the low qualification of workers.

The degree of human capital influence on economic growth of supply chain is not easy to verify empirically. This opinion was expressed by [14], who noted that human capital affects economic growth not directly, but through physical capital. In his opinion, it is very difficult to study the full effect of human capital. In addition to the internal effect of human capital on the economic effectiveness of an individual, this phenomenon also reveals external effects - in particular, the production of new

knowledge - that affect economic growth of supply chain. Human capital is the key to economic progress to the extent of its influence on physical capital [7]. When you analyze the impact of human capital on labor productivity, the rates of scientific and technological progress and economic growth also highlight the following factors: the accumulation of production experience, the development of the education system, the costs of science and education, the level of personal consumption and the total investment in labor. In economic-mathematical models that take into account these factors, the production function is used most often, which relates the amount of output to the volume of resources (production factors). In most macroeconomic functions, the final social product (gross national product, national income) is taken as output, and fixed assets and labor (living labor) are taken as resources.

The economics of education have several approaches that explain the relationship between education and economic growth of supply chain. The essence of the first approach in its most general form is to measure the correlation between the indicators that reflect the overall level of education development and the indicators that characterize the national economy dynamics. The correlation method is usually used in the following cases: when conclusions are drawn about the tightness of the links between educational levels and the indicators of a country economic growth of supply chain based on international comparisons; to study the relationship between education and economic development within each country; in inter branch and intercompany comparisons, when the parameters of labor force development are associated with the indicators of the economic efficiency of industries or firms. Thus, the American scientist E. Cohn revealed a strong correlation (the correlation coefficient - 0.93) between the national income per capita and the costs of education per person, using the example of seventeen developed capitalist countries [8].

Interesting results were obtained in the process of the relationship determination between the current educational potential and the rates of economic growth of supply chain by the employees of the Netherlands Institute of Economics. On the basis of statistical data, they calculated that in 23 differently developed capitalist countries, every 1,038% of labor force increase with a higher education and 0.65% increase of the workforce with secondary education is associated with the increase of the national income by one percent [9]. The advantage of the correlation approach to the study of the links between education and economic growth of supply chain lies in its simplicity and in the usefulness of the information it provides. However, the correlation method measures the degree of functional connection between the phenomena under study. It does not reveal the causal relationship between education and economic growth. For example, a high level of national income per capita can be explained by the increase of education costs, but it can also be the other way round: to try to justify the increase of education cost by the national income increase per capita. In general, the correlation methods are limited to the detection of functional dependencies only. There are three main channels of education impact as the component of human capital on labor productivity and economic growth of supply chain : in the process of training, a future worker develops an educational complex that is a set of learned and accumulated knowledge; the retraining of already employed workers facilitates the acquisition of new knowledge necessary for highly effective work; general and special education contribute not only to the activation of a worker's creativity and entrepreneurial spirit, but also promotes the transfer of the experience that he has accumulated to the younger generation.

4. Model

Education as the most important component of human capital is seen as the main factor of economic growth and affects productivity growth directly. First of all, it makes the work of each individual worker more productive. This can be confirmed by a close correlation that exists between the level of the labor force education and its wages. Education either increases the productivity of an employee in a given workplace (he produces more per unit of time than his less trained colleague), or it makes him capable of such work, the results of which are of great value and which therefore is paid higher. The higher the educational and the qualification level of employees, the higher should be an average level of labor productivity in the economy and the higher the rate of economic growth of supply chain. The estimation of education contribution to GNP (NI) increase can be determined via the multiplication of educational fund growth by the rate of investment return in human capital. In this case, education appears as an independent factor, as a special kind of productive "capital". With this in mind, the traditional neoclassical growth model, built on the basis of the Cobb-Douglas function, looks like this:

$$Y = BK^a L^b H^c$$

Where:
Y - Production volume;
B - Function parameter;
L, K, H - the volumes of physical labor of physical and human capital;
a, b, c - the coefficients of output elasticity for these production factors.

However, in order to determine the contribution of education to economic growth of supply chain, it is not necessary to calculate the amount of accumulated human capital. Education can be seen not as a separate source of growth, but as a qualitative characteristic of the labor factor:

$$Y = AK^a (LE)^b = AK^a L^b E^b$$

Where:

Y - The volume of production;
A - Function parameter;
L, K - The volumes of labor and capital;
E - The index of labor (labor force) quality, obtained by the weighing of an educational category number by their relative wages (in the base period);
a, b - the coefficients of output elasticity by capital and labor.

If there are only two types of labor force with the number N_1 and N_2 during the first period, N^1_1 and N^1_2 during the second one, and with the wage w_1 and w_2 (during the basic period), then the labor quality index E will be determined according to the following formula:

$$E = \frac{N_1' W_1 + N_2' W_2}{N_1' + N_2'} \div \frac{N_1 W_1 + N_2 W_1}{N_1' + N_2'}$$

[8] paid much attention to the study of these issues in their works. T. Schultz extends his methodological approach to the determination of educational effectiveness at the micro level (at the level of education influence on individual incomes) and distributes it at the macro level, analyzing the degree of education impact on the growth of GNP and national income at the level of the economy as a whole. The basic idea of its research is still the premise that education as a kind of human capital is autonomous one, i.e. an economic effect source independent of living labor. According to Schultz, the growth rates of the national income are composed of the following values:

$$G_v = kfK + G_L S_L ,$$

Where:
G_v - The growth rate of the national income;
k - The coefficient of capital intensity;
fK - The maximum productivity of capital;
G_L - The rate of workforce increase;
S_L - The share of labor in the national income.

If, in its turn, the value of k is differentiated into the investments in real and human capital, the above-mentioned equation can be represented as follows:

$$G_v = \frac{I_m}{v} r_m + \frac{I_n}{v} r_n + G_L S_L ,$$

Where:
I_m - The investments in tangible capital;
I_n - The investments in human capital;
v - National income;
r_m -The standard of material capital effectiveness;
r_n - The norm of human capital effectiveness.

In this equation, the direct contribution of education to economic growth of supply chain is equal to the share of national income invested in education in a given year (I_n/v), multiplied by the social efficiency rate of investments in this kind of human capital (r_n). [9] disaggregates the total amount of education impact on economic growth to the contributions of each level of education on national income increase, i.e.

$$\frac{I_n}{v} r_n = \frac{I_p}{v} r_p + \frac{I_s}{v} r_s + \frac{I_h}{v} r_h ,$$

Where:
r_p, r_s, r_h - the norm of capital investment efficiency in primary, secondary and higher education respectively.
According to the calculations by Schulz, education in the United States provided the increase of national income by 21% from 1929 to 1957, with r_n = 11% [10].

In the framework of neoclassical models, the works by [11], in which a number of factors of economic growth related to work are of special importance: employment, hours worked, the age and sex structure of the workforce and the level of education. E. Denison considers education not as an independent factor of production, but reveals the economic importance of education through the determination of its impact on the workforce quality. The contribution of education to economic growth of supply chain is analyzed by [12], primarily in connection with the improvement of living labor quality. He believes that education increases the efficiency of labor due to the following circumstances: the workers who have a higher educational and qualification level perform their work better and more qualitatively than those who are less educated; a higher education contributes to the activation of an employee's personality, his initiative and business qualities, the mastering of new methods of work; a more educated workforce is more accurately oriented with information about the labor market, chooses the type of occupation more optimally; industrialization and automation changes the professional structure in such a way, that an increasing number of employees in it requires a higher level of general education.
Proceeding from its main premise, Denison constructed the production function of the following form:

$$v = f\left(L_p, L_s, L_h, K\right),$$

Where:
L_p, L_s, L_h - the labor force with primary, secondary and higher education, respectively.
The "residual" factor in it is predominantly integrated with the qualitative growth of the labor force. Hence, the growth rate of the national income (Gv) is determined as follows:

$$G_v = kfK + \sum_i G_i S_i ,$$

Where: i - all available levels of labor force education.

Thus, the contribution of education to the growth of the national income is equal to the following value:

$$G_pS_p + G_sS_s + G_hS_h$$

In order to get an estimate of the higher education contribution to economic growth of supply chain by [12] method, we must multiply the increase of the workforce with the university training by the difference (in a base year) between the earnings of people with higher and secondary education, i.e. on "net income" from higher education [11].

According to the methodology by T. Schultz, it is necessary to multiply the increase in the human capital of the corresponding category by the rate of its return. The first of these quantities is nothing more than the product of expert number increase who graduated from college, by the cost of training in it. The rate of return can be presented in an approximate form as a fraction, the denominator of which has the same cost of training in college, and in the numerator has the difference between the earnings of people with higher and secondary education.

There are important methodological differences between two approaches that are reduced to the following. The methodology by Denison assumes that the productivity and the level of earnings of one or another educational category of labor force are not related to the dynamics of its supply. The methodology by [13] allows the possibility of worker productivity and wage reduction with this level of training as their supply increases. Although the indicator of education contribution to economic growth of supply chain and internal rates of return differ by their intended purpose, they proceed from one general assumption that the increase in labor productivity is reflected in the increase of the relevant worker category income due to higher education levels.

The following provision is entirely logical: the economic importance of education and qualifications can be assessed on the basis of differences in workforce quality, which are adequately reflected in the differences of remuneration levels of the relevant categories of workers. The workforce of a higher quality requires not only a large cost of its preparation, but also brings a greater return in the process of its more efficient use in production, and, consequently, its owners must also be paid better. Education not only improves the quality of the labor force and increases labor productivity, but also develops "entrepreneurial" abilities in it, empowers the initiative, makes it a more skillful organizer of the labor process. The function of education is not only to transfer already existing "old" knowledge and skills to students, but also to improve their ability to perceive and use new scientific ideas, new technical tools and new production methods in practice. All the economic sectors benefit from the fact that the workers with a high level of training adapt more quickly to changing production conditions, react to innovations more quickly and introduce them into production as a whole. Innovations start to come faster from developers to end users. Reducing the path from discovery to its practical development, education, thereby increases the social productive power of labor and stimulates economic growth of supply chain. Education also increases not only the speed with which scientific discoveries spread, but also affects the speed with which scientific discoveries and new developments are performed, contributes to the increase of scientific and technological progress rates. Education develops innovative abilities in an employee, makes him more initiative and enterprising, activates his inventive activity, which contributes to the acceleration of scientific and technological progress and, thereby, contributes to higher labor productivity and economic growth of supply chain.

Both approaches use one common premise: they assume that the increase of efficiency, or labor productivity (due to the increase of education level), is reflected in income increase of the corresponding categories of labor. In other words, the economic return of labor is proportional to the growth of incomes, caused by education and qualification level increase. In the economic literature, the concept of "learning by doing" or "learning in the process of production", which was proposed in 1962 by [11] [12], became widely known. According to this concept, the main factor of production efficiency and economic growth of supply chain increase is the improvement of the workforce quality, which in its turn is conditioned by the accumulation of experience gained by an employee in the process of an active labor activity. At that, they take into account not only the experience accumulated by an employee, but also the experience accumulated by an entrepreneur, who performs the functions of production and employee organizing and managing. The indicator that characterizes the number of means of labor mastered by an employee during the entire period of his labor activity (for example, the volume of fixed assets) serves as the measure of this experience.

In a brief formalized form, the concept by [13] can be represented as follows:

$$Y(t) = f(K(t), L(t));$$
$$L(t) = A(t)\, N(t);$$
$$A(t) = [K(t)]^b$$
$$Y = f(K, AL(t));$$
$$A = K^b, \quad 0 < b < 1,$$

Where:

$Y(t)$ - output volume;
$K(t)$ - capital resources;
$N(t)$ - labor resources measured in natural units, for example, the number of employed or the number of worked man-hours;
$L(t)$ - labor resources, measured taking into account the quality (accumulated experience).
A - the indicator of an employment-enhancing STP or economic growth of supply chain due to the factor of living labor, characterizing the dynamics of labor resource quality (the efficiency of use).

b - The indicator characterizing the intensity of experience accumulation by labor force, the larger it is, and the higher it is.

There are the models in the economic literature in which the dynamics of an effective labor is determined by the investments in the labor force. [12] offered to use one of such models with reproducible resources [13]. In these models, an effective labor is identified with labor potential, which is the accumulated amount of investments in labor force after the deduction of retirement and it is measured in the same units as the fixed assets and output. Formally, a model with reproducible resources can be represented as follows:

$$Y = f(K, L),$$
$$Y = I + E + C,$$
$$I = sY,$$
$$E = eY,$$
$$s + e = g,$$
$$K = I - uK,$$
$$L = E - mL,$$

Where:

I - Gross investments in fixed assets;
E - Gross investments in labor force;
C - Consumption;
L - Labor potential;
e - The rate of investment in labor force;
s - Accumulation rate;
m - The norm of labor potential retirement;
u - The rate of fixed asset retirement;
g - The rate of total reproductive accumulation, i.e. that part of the aggregate output that is spent on economic development.

[6] proposed to consider such an asset as the "motivational potential" of a person as the most important factor of production, which, according to their estimates, is in a close correlation with productivity increase. In order to calculate this indicator, they suggest using the following formula:

$$Mn = ((Ncn + ШО + Вр)/3)\ Cc\ Cк,р$$

Where:

Mn – motivational potential;
Ncn – the number of specialties for a worker;
ШО – the scope of production cycle coverage;
Вр – the importance of work and the realization of it by a performer;
Cc – the degree of a worker's independence;
Cк,р – the degree of connection between the quality of work and the quality of its results [14].

The use of qualification, innovation and other employee qualities depends on their motivation (internal and external) directly, understood as the degree of their incentive to perform tasks at the highest quality level. Motivation is the most essential element of human capital, which directly affects the current activity of employees and determines their productivity. In modern information and networked economy, the evaluation of intellectual capital is of paramount importance. This problem has not been fully solved yet. Currently, the modern world scientific literature has no a universal method and methodology to estimate intangible assets. There are several approaches to assess intellectual capital and, accordingly, to determine the real value of intangible assets and objects of intellectual property in the modern economy. The Austrian scientist [15] developed the method to estimate intellectual capital on the basis of value added by intellectual capital. This method focuses on the value of a company structural capital, although human capital is also taken into account. The evaluation of intellectual capital takes place in four stages. At the first stage, the value added is calculated. The calculation is based on the traditional method of comparing gross income from sales and costs in the "input-output" scheme. The peculiarity is that expenses do not include the expenses related to the payment of labor as a living carrier of the intellectual resources of a company. At the same time, added value, in fact, is identical to the concept of newly created value, consisting of the equivalent of payment for labor and the value of the surplus product, which takes the form of a company profit:

$$VA = OUT - IN,$$

Where VA (value added) - the added value; OUT (output) - the total income from the sale of goods and services on the market; IN (input) - the costs after labor cost deduction.

The second stage determines the structure of value-added, based on the fact that it was created by company capital, consisting of three parts: financial capital, physical capital and intellectual capital. Two coefficients are calculated for this:

$$VACA = VA / CE,$$

Where VACA (value added capital coefficient) - the coefficient of the value added by capital; CE (capital employed) - used physical and financial capital.

This indicator characterizes the return of material and financial cost per unit excluding labor costs;

$$VAHU = VA / HC,$$

Where VAHU (value added human capital coefficient) is the ratio of the added value created by human capital, which shows how much added value was created per money unit spent on labor; HC (human capital) - the human capital defined as the sum of all expenses for the personnel. At the third stage, it becomes clear what role the structural capital plays in added value creation. If we consider that structural capital is an intellectual capital after human capital deduction, then:

$$SC = VA - HC,$$

Where SC (structural capital) is the part of the added value attributed to the structural capital.

Further, the relative share of structural capital contribution to a company added value is determined:

$$STVA = SC / VA,$$

Where STVA is the coefficient showing the contribution of structural capital to a company added value. At the final stage, we will get a general picture of a company intellectual potential use. This potential is characterized by a share of added value in the total cost of the company products:

IC = CE + HC + SC,

Where IC is the total cost of the company products; CE - the cost of material expenditure; HC - human capital; SC is the part of the added value attributable to structural capital. The higher the share of added value in the cost of the company products, the higher the estimate of intellectual resources. The ratio of value added to the total cost of a product is proposed to be interpreted as the coefficient of value added by intellectual capital. This ratio shows an effective use of financial and intellectual potential of a company:

VAIC = VA / IC.

The method by [15], which is called the method of intellectual capital value determination on the basis of information productivity or the impact on management, is of a particular interest. [16] uses the concept of information management, which denotes any intellectual actions performed in the process of company management: contracting, planning, negotiation, etc. There are traditional methods of efficiency measurement: the return on equity (ROE), the return on investment (ROI), the return on assets (ROA). Due to the fact that traditional methods become unsuitable in the conditions of the post-industrial economy, [17] proposed to use the indicator "return on management" (ROM) as the measure of efficiency. The evaluation of management effectiveness is used to determine that part of the net income that can be attributed to the art of management. In order to determine this value, the concepts of information management and income added by intellectual capital are introduced [16]. The generalization and a detailed review of the various methods of intellectual capital (IC) measurement were carried out by [17]. [18] groups all methods of intellectual capital measurement in four enlarged categories.

I. The methods of direct measurement of intellectual capital (IC) - Direct Intellectual Capital methods (DIC). This category includes all the methods based on the identification and evaluation in money of individual assets or individual components of IC. After the assessment of IC individual assets (components), an integrated assessment of the IC Company as a whole is carried out.

II. Market Capitalization Methods (MCM). In accordance with this method, the difference between the market capitalization of a company and the equity capital of its shareholders is calculated. The resulting value is regarded as the value of its intellectual capital or intangible assets.

III. Return to Assets Methods (ROA). In accordance with this method, the ratio of a company average income before taxes for a certain period for the company tangible assets is calculated - ROA of the company, which is compared with the same indicator for the industry as a whole. The resulting difference is multiplied by the company tangible assets and, thus, they receive an average additional income from intellectual capital. Further, the IC value of the company is calculated by direct capitalization or received cash flow discounting.

IV. Scorecard Methods (SC). In accordance with this method, various components of intangible assets (intellectual capital) are identified, the indicators and the indexes are generated and determined in the form of scoring. The use of SC methods does not imply a monetary evaluation of the IC. These methods are similar to the methods of the diagnostic information system, the fresher the data, the more accurate the estimates. The resulting indicators are contextual ones and should be configured specifically for each organization and each goal.

According to [18], considering the development of new technologies, mostly developed at a highly intellectual level, intellectual capital will soon become the main criterion to estimate the value of leading companies, because only this capital is able to reflect the dynamics of organizational stability, the process of value creation and modern production evaluation.

5. Results

As the part of the methodological approach generalization to determine the role and the contribution of human capital to economic growth of supply chain, basic models were examined that show that human capital, its professional and qualification parameters (education, qualifications, experience, innovation, motivation of employees) are the most important factor of productivity increase and a sustainable economic growth provision. They should note the prospects for further research in this subject area. In the global digital economy, the development of network human capital (intellectual-network capital), creative, digital and network properties and competencies of highly skilled workers takes place. The technologies of network education and online education are developing dynamically. Cross-platforming, machine learning and virtual reality are the main directions of digital education development [19]. There is a qualitative transformation of all spheres and elements of the world and national economies, all states, public and private institutions, a digital state and a digital government are being formed [20]. The current stage of development is characterized by a dynamic development of technology integration and convergence processes, the methods of regulation and accounting concerning companies, institutions, information spaces and databases. Additional network connections that arise in the process of integration and convergence can be defined as the synergy of information space convergence, characterized by the emergence and the

obtaining of additional synergetic effects [21]. The methodologies for the study of network forms of a business organization were described in a collective monograph, published and edited by [22].

The structural elements of the network human capital (knowledge, creative abilities, innovation, competitive behavior, market enterprising, professional mobility, qualification flexibility, the advanced decision-making methods, information lability, labor culture, socialization) receive monetary and non-monetary valuation, accumulate, capitalize, enter into market, public and network turnover, bring additional money income, intellectual-information rent, social-status benefits, various network effects, become the objects of intellectual property, lead to the improvement of people living standard quality and ensure a sustainable innovative economic growth of supply chain and social stability in society [23].

[24] Prescott substantiated the proposition that the inclusion of a company "in the network of innovative interaction forms drivers of a company value, as it gives significant advantages to it in the process of its value increase, measured by three variables: the volume of information, the diversity of information and the richness of information [24]. In this regard, the research and the development of theoretical and methodological approaches to the analysis of network human capital essence, the characterization of its information-network parameters and its influence on economic growth of supply chain and productivity in the conditions of the digital neuro-network economy is of great importance and perspective. Also, the development of methods and methodological approaches to the classification, estimation and accounting of various network benefits and effects from the use of network human capital (intangible assets, intellectual-network ownership) is of particular relevance and significance [26].

6. Summary

The emerging new neural network effects derived from the use of network human capital must be identified, verified and adequately quantified and qualitatively evaluated. These network effects should be included in the global value chain of innovative good and service creation, and be taken into account when they calculate the expanded gross national product (GNP) and gross world product. This implies the expansion of the traditional system of national accounting by including new integratively distributed poly functional neuro-network effects. In view of this, it becomes necessary to adjust (increase) the GNP estimate by the value of new neural network effects from the use of network human capital) [25]. In the current digital transformation of all spheres of society, the main priority for the majority of the advanced and developing countries of the world should be a massive increase of public and private investment in networked human capital (in digital learning, network education) of highly qualified specialists, which becomes a decisive factor of productivity increase and economic growth of supply chain in a digital neural network hyper-competitive economy [27].

7. Acknowledgements

The article has been developed under the grant of the Saint-Petersburg State University of Economics.

References

[1] Aganbegyan, A.G. *"Investments in fixed assets and investments in human capital are two interconnected sources of socio-economic growth. Problems of forecasting"*, Vol 163, No. 4, pp. 17-20, 2018.

[2] Grayson, D., and O'Dell, K. "American management on the threshold of the XXIst century", M.: Economics, pp. 251, 1991.

[3] The program Digital Economy of Russian Federation was approved by the Order of RF Government, The site of Russian Federation Government in the Internet. URL: http: government.ru/docs/28653/, No. 1632, p. 28, 2017.

[4] Dyatlov Sergey, A., Bulavko Olga, A., Balanovskay Anna, V., Nikitina Natalia V. and Chudaeva Alexandra A. *"Principles of the Organization of the Global Economic System"*. International journal of environmental & science education, Vol 11, No. 10, pp. 3783-3790, 2016.

[5] Baiburina, E.R., and Zhukovets, O.S. *"The concept of network capital analysis as the driver of company value"*. Corporate finance: electronic journal. Vol. 12, No. 4. pp. 130-144. 2009.

[6] Dyatlov, S.A. *"Network intellectual capital in digital economy"*. Economic growth and the priorities of legal policy: monograph. Penza, pp. 17-23, 2017.

[7] Schultz, T. *"Investment in Human Capital: The Role of Education and of Research"*, 1971.

[8] Cohn, E. The Economics of Education.- Canbridge, pp. 83-84, 1979.

[9] Perlman, R. Economics of Education. Kent, p. 61, 1973.

[10] Schultz, T. *"Investment in Human Capital Economic Growth – an American Problem.- Englewood Cliffs"*. The Journal of Political Economy. P. 454, 1964.

[11] Denison, E. *"The study of differences in the rates of economic growth"*. M., 1971.

[12] Arrow, K.J. *"The Economic implication of learning by doing"*. Journal 1962, Vol. 29, No. 80, 1962.

[13] Ryvkin, A.A. *"The stability of growth trajectories in the models with reproducible resources"*. Mathematical methods for economic problem solution.- Moscow: Nauka, 1974.

[14] Hackman, J.R., and Oldrin, O.R. "Motivation through the Design of Work: Test of a Theory". Yale Univ, 1974.

[15] Klimov, S.M. Intellectual resources of an organization. M.: The Case, pp. 83-85, 2000.

[16] Strassmann, P. "The ways of knowledge measurement. Computerworld Russia. No. 15, 1998.
[17] Sveiby, K.-E. *"Measuring Intangibles and Intellectual Capital. An Emerging First Standard"*. Internet version. 1998. A
[18] Edvison, L. *"Intellectual Capital. Determination of a company true value. A new post-industrial wave in the West: Anthol"*. Moscow: Logos, p. 412, 2000.
[19] Azad N., Ghandvar P., Rahimi Z., "Online Search Behaviour of Customers in Shoe Market", Astra Salvensis, Supplement No. 2, p. 793, 2017.
[20] Mohammadzadeh, S., Zadkarim, S., Ammari 20. H., Re-Engineering of Drinking Water Facilities of Villages of City of Saqqez for Water Loss Reduction Management, Supplement No. 2, 2017, p. 859.
[21] Dyatlov, S.A., and Lobanov, O.S. *"NBIC Convergence as a Stage of Transition of Saint-Petersburg's E-Government Information Space to the Sixth Techno-Economic Paradigm"*. Communications in Computer and Information Science, pp. 347-361, 2017. doi: 10.1007/978-3-319-69784-0_30.
[22] *Methodology for the study of network forms of business organization*. Ed. BY M. Yu. Sheresheva. - Moscow: The Publishing House of the Higher School of Economics, p. 446, 2014.
[23] Dyatlov, S.A. Neuro-network hypercompetitive economy. - St. Petersburg. Publishing house SPbGEU. P. 133, 2017.
[24] Koka, B., Prescott, J. *"Strategic Alliances as Social Capital: A Multidimensional View"*. Strategic Management Journal, Vol 23, No. 9, PP. 795–816, 2017.
[25] Dyatlov, S.A. *"Neuro-network effects in the global information economy"*. Economics. Scientific research and development. Vol 4, No. 4, pp. 4-10, 2017.
[26] Gunasekaran, A., Lai, K., and Cheng, TC.E. Responsive supply chain: a competitive strategy in a networked economy. *Omega*, Vol 36, No.4, pp. 549-564, 2008.
[27] Lambert, D.M., Cooper, M.C., and Pagh, J.D. Supply chain management: implementation issues and research opportunities. *The international journal of logistics management*. Vol 9, No 2, pp. 1-20, 1998.