DECOMPOSITION OF INFORMATION PROVISION OF THE SYSTEM OF PUBLIC MANAGEMENT OF INVESTMENT RISKS IN THE DEVELOPMENT OF HUMAN CAPITAL

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Abstract: The article emphasizes that investing into human capital is crucial for any nation hoping to achieve long-term economic growth, it contributes to the development of a trained labor force that can promote innovation and technological advancement, increase productivity, and adjust to shifting economic situations. It is shown that the study of issues related to the accumulation of high-quality human capital is of particular relevance. There is an urgent need to study various aspects of investing in human capital at all stages of its reproduction in order to develop scientifically based recommendations for preserving already accumulated human capital and determining the possibilities for the effective distribution of investments in the development of human capital. Based on two crucial components of human resource development – education and healthcare – provisions of state management of investment risks in this capital development are outlined and decomposition model is suggested.

Keywords: public management; human capital development; risk management; education; healthcare; information provision.

1 Introduction

To a large extent, the level of well-being is determined by the national wealth of the country, which can be defined as the totality of assets created and accumulated during the existence of the state. The higher the level of development of a country, the greater the contribution of human capital to well-being (see Table 1).

Table 1: National wealth of world countries [11]

Country	*Structure of national wealth, %*		
	Natural resources	*Human capital*	*Physical capital*
Germany	8	67	25
Brazil	24	56	20
China	35	47	17
France	1	75	24
Great Britain	1	90	9
Japan	1	73	26
USA	7	78	16
Saudi Arabia	65	27	8
World in whole	13	55	32

The data confirms that human capital is the main factor of well-being (55%), followed by produced capital (32%) and natural capital (13%). The only exception is Europe. In Eastern and Northern Europe in particular, physical capital has been the main source of growth in recent years. There are several possible explanations for this: some European countries have already achieved a high level of education of the population (one of the indicators of the 'stock' of human capital), thereby reducing the possibility of its growth. In addition, a high level of migration can lead to a decrease in the level of human capital development (except in cases of "brain drain" and "brain circulation") [1].

On a global scale, the contribution of human capital to the growth of well-being shows a clear positive trend over the past 20 years, which once again confirms its importance as the main factor in modern socio-economic development [10].

The possibilities for self-reproduction of human capital as a system are limited; its formation and functioning requires an influx of resources from systems external to humans [5]. Human capital is largely formed as a result of investments in it at the micro and macro levels [16-20]. The benefits of government participation in investments in human capital (taking the form of financing national education and healthcare systems) can be an increase in incomes of the population and smoothing out inequalities in their distribution, the emergence of positive external effects of education, stabilization of the social structure of society, etc.

The high educational level of citizens creates the prerequisites for building a society capable of optimal self-organization, i.e., controlling power structures and rejecting models and stereotypes of behavior that are negative for the development of society (in Japan, with its 'cult' of education, there are 47 prisoners per 100 thousand people; for comparison, in the USA – 693 people) [12]. Investing in human capital also provides many other societal and economic benefits.

In successful states, investing in human capital development is inseparable from investing in sustainable growth. High-quality human capital is a foundation for sustainable growth, and at the same time, effective development of human capital is not possible without sustainable growth, thus these two components are mutually complementary. A symbiotic paradigm of investing in human capital and sustainable growth is schematically depicted in Figure 1 below.

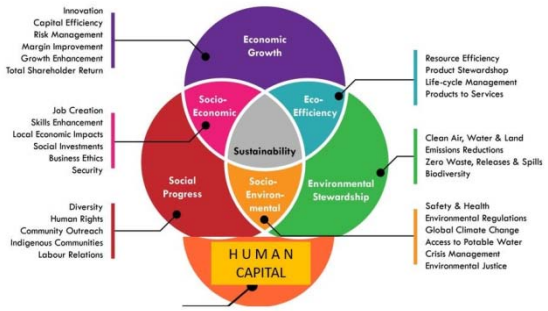

Figure 1. Symbiotic paradigm of investing in human capital and sustainable growth [31]

Modern global trends in the formation of an innovative economy and knowledge economy place qualitatively new demands on human capital as the main productive factor in the creation of the latest highly efficient technologies that contribute to the active development of the social sphere, science, education, healthcare, etc. The transition from an industrial to an information society is characterized by the transformation of information into a system-forming factor that has a real impact on the environment. As the social role of science and education increases, the "knowledge economy" has increasingly come to be understood as a certain type of economic development, in which the knowledge sector plays a system-forming role, and knowledge production becomes the main source of innovative economic growth in the context of globalized economic growth [2]. The sustainable development of the national economy directly depends on the formation, dissemination and effective use of knowledge, which, in turn, is impossible without the active development of human capital and increasing its adaptive capabilities to changing socio-economic conditions.

Achieving sustainable development involves the formation of sustainability capital, which is made up of the sum of capitals. Sustainability experts consider different types of capital. Summarizing their research, one can distinguish five types of capital that ensure sustainable development: financial, natural, industrial, social, and human [10]. Financial capital ensures production, although it is not itself productive. Natural capital includes natural resources and the world's ecosystem. Productive capital ensures the production of goods and services. Social, the most difficult type of capital to measure, includes elements of trust and mutual understanding, common values and socially significant knowledge [8]. Human capital, in the modern sense, is what is usually called human potential or human resources. It can also be defined as the totality of human resources inherent in an individual, including individual abilities, knowledge, qualifications, time, and energy. The theory of human capital proceeds, first of all, from the receipt by individuals of private economic benefits from its use. More educated people are more economically active and can earn higher earnings [13; 36; 37].

On the other hand, as studies devoted to the analysis of the impact of education on economic growth show, human capital in general and education in particular have a serious impact on the growth of economic well-being in society. OECD studies show that an increase in human capital by 10% leads to an increase in return on capital by 4-7% [27].

Thus, human capital in modern economic systems is a necessary independent resource and is important for ensuring national competitiveness. The designing of a doctrine for the development of human capital as the main factor in the progress of society is a requirement of today. The center of the main efforts of the state should be the person. The more opportunities – educational, intellectual, informational, etc. – each member of society will have, the higher the intellectual resource of the entire nation and state, the more dynamic the rate of economic growth, the greater the opportunities of society.

It is advisable to agree with the statement that further development of the theory of human capital should occur within the framework of political economy. The main reason for turning to the methodology of political economy is that the formation of a post-industrial society is determined by the expansion of creative activity, which in turn is determined by the qualities of the worker. Namely his human capital, his ability to carry out creative activities and the need to carry out such activities become the main condition for the growth of innovative production as the basis of the knowledge economy. Only by determining the economic essence of human capital, studying in detail the process of its reproduction, and establishing the laws of movement of human capital, can one respond to the challenges of innovative production and thus solve the problems of its development.

In turn, the economic essence of human capital as a resource of continuous innovation and national competitive advantages opens up opportunities for considering issues of investing in the development of this capital at the national level, with a corresponding analysis of investment risks. Of great importance here is the information support of such management, the decomposition of this support in order to better understand the characteristics of the functioning of each element and system connections.

2 Materials and Methods

The methodological basis of the study was the integrated use of methods of scientific abstraction, logical, comparative, structural and functional analysis. Also, the methodological basis is the dialectical method and the systemic, normative, situational, and comprehensive scientific approaches that develop it. The general philosophical basis of the study is the constructivist paradigm.

3 Results and Discussion

The process of human capital formation begins in early childhood and continues throughout life in the process of socialization and professionalization of the individual. In the formation of human capital in childhood, the leading role belongs to the family, the person's immediate environment, and the institution of education. At school, the foundations of cultural and moral capital are formed, the individual abilities of children are identified and strengthened. The process of socialization continues at the stage of receiving secondary specialized and higher education. The theoretical knowledge, practical skills and competencies acquired during training influence the formation of qualifications, labor capital, and professional abilities.

It is important to pay special attention to the process of professionalization of the individual as a condition for the development of human capital. Most often, professionalization is defined as a holistic, continuous process of developing the personality of a specialist and professional, which begins from the moment of choosing a profession, lasts throughout a person's professional life, and ends when a person stops his professional activity [14]. The results of professionalization can be considered the formation of a professional, the development of new professionally important qualities, the transition of a person to the next level of professionalism, etc. [21-24] Enterprises and organizations, commercial and non-commercial sector play a significant role in the process of professionalization.

Investing in human capital is a high-risk activity due to its duration and uncertainty. The last circumstance is related to the quality of accumulated capital. The risks of investing in human capital can be divided into two types: structural and non-structural. The former are the result of general structural changes in the economy, which are largely related to incomplete information in the labor market; they are inevitable by definition. The existence of non-structural risks is the result of the presence/absence of any employee qualities (age, origin, availability of resources, etc.). Workers represent a collection of simple and complex productive and unproductive forces. Some productive properties are important for certain types of activity and useless for others (for example, knowledge of rare languages has evidently different importance for a philologist and an engineer). Non-structural risks can be eliminated, but the question is whether such elimination is desirable in each specific case. The depressive effect of risks leads to underinvestment in human capital, and intervention to reduce them is socially desirable [33].

The advent of the digital era is characterized by the introduction of 'high technologies' into human life and society. This process is accompanied by relevant problems and risks. The main challenge and risk factor for the development of human capital in digital reality is the speed of transformation of anthropo-socio-technological reality, when the illusion arises of replacing a person with a machine.

In this environment, the innovation process integrates technological, organizational, and social innovations that force human capital to quickly adapt and develop. According to Chan Kuok Lama (cited in Paunescu et al.), the researcher of human capital, one of the conditions for recognizing the economy of a society as innovative "is a well-established system of advanced training of personnel in the field of innovation and innovative activity" [26]. Rapid development of human capital reduces the risks of investing in human capital.

The formation of "human capital" as an economic category occurred gradually, was subject to meaningful revision and periodic expansion of the boundaries for analysis. While at the initial stage human capital was considered exclusively as a social factor of development and included only knowledge and the ability to work, now it is a rather complex, multidimensional economic category that expresses the totality of creative abilities, personal qualities, and motivations of individuals. This aggregate is accumulated through investment, it is used in the national economy for a certain time in order to generate income and, as a result, contributes to the growth of national wealth. Currently, investments in knowledge (education, research and development) are growing faster than investments in fixed capital. Knowledge becomes a determining factor in the development of the innovative potential of the economy, contributing to the development of high-tech industries based on intellectual work. Investments in human capital are considered as investments with a high degree of return for the national economy, ensuring an increase in its competitiveness.

However, investments in training specialists at University 3.0, not to mention University 2.0, are extremely risky, due not only to the rapid obsolescence of knowledge, but also to changes in the composition of soft skills required by the market today, not only from university graduates, but even from college graduates, specialists with specialized secondary education and representatives of working professions.

A joint study by Michigan State University and Central Michigan University found a significant impact of government investments in safety net programs and education on high school completion rates. The study analyzed seven years of data for U.S. public schools, including spending on safety net programs and education, as well as various school and district

characteristics. The findings suggest that increased spending in both areas has a positive impact on graduation rates, especially for historically underserved groups of students. The study highlights the direct correlation between additional funding and improved graduation outcomes. In particular, according to Ignacio Acevedo-Polakovic, co-author of the study, a one percent increase in the number of graduates is directly associated with additional social protection costs of $437 per child or $720 allocated to education.

Scientists recommend expanding the areas of diversification of funding sources and introducing a binary financing system. The authors see it as urgent to develop and implement progressive methods of financing educational activities, including the introduction of a single unified model of financing universities at the national level, which will have the following components: (1) financial support for the education of one student; (2) scholarship provision for one student on a grant (competitive) basis; (3) development of infrastructure (training and production equipment, library collection); (4) financial support for research activities of teachers and students. The change in the higher education funding model is aimed at introducing a three-component model, which includes: basic funding (up to 80% of total income), performance-based funding up to 15%), and other revenues (up to 5%).

However, today one of the pressing problems of the modern educational process is the constant increase in the volume of information and at the same time the rapid obsolescence of knowledge. As the researchers note, “in the modern world, the “life cycle” of knowledge and skills is very short. In the scientific literature of the USA, for example, there is a special unit for measuring the obsolescence of a specialist’s knowledge – the so-called “competence half-life” [6]. This term means the length of time after graduation when, as a result of the obsolescence of acquired knowledge as new information appears, the competence of a specialist decreases by 50%.

Thus, continuous acquisition of new knowledge becomes an important need for specialists. According to American economists, 5% of theoretical and 20% of practical knowledge possessed by engineers, doctors, biologists, and representatives of other groups of specialists is updated annually. American researchers have shown that the knowledge of an engineer graduate of 1940 became obsolete in 12 years, knowledge of a graduate of 1960 - in 8-10 years, and for graduate of the 70s this term was 4-5 years. For a 21st century graduate, knowledge becomes obsolete within 2-3 years [28]. Recent studies have found that after graduation, an average of 20% of knowledge is lost every year. Their rapid obsolescence is noted in various fields. For example, in metallurgy, knowledge becomes outdated every 3.9 years; in mechanical engineering - 5.2 years; in the chemical industry - 4.8 years; in advertising - 5 years; in business - 2 years [28]. At the same time, in the most knowledge-intensive industries, the obsolescence of knowledge occurs even faster; for example, in the field of IT it is no more than one year, and in the future it will be even less. The update speed of many software applications is already faster than the speed of mastering them. Modern technologies of communication and data exchange force to look for new approaches to education.

Olena Shelest-Szumilas, [29, p. 220] notes that in “a few years, many of occupations and jobs will not be requiring skills that are in demand today”. According to OECD projections, in the next 15 to 20 years, automation may cause 14% of current occupations to vanish, while another 32% of jobs are projected to undergo significant change. Globalization, automation, and digitization will also cause the creation of new professions and industries at the same time [29].

Moreover, at the present stage of development of society, simply knowing is no longer enough; it is necessary to be able to apply the acquired knowledge to solve specific problems in the conditions of not just the educational process, but when performing a specific task, taking into account new conditions in which it is necessary to achieve success in performing a specific practically important tasks. Consequently, when training specialists in universities, it is necessary to form and develop the ability to apply acquired knowledge in practice and, moreover, in non-traditional conditions.

Abel and Deitz [1] write that colleges and universities may help a region's economy by improving its citizens’ skills and knowledge, known as human capital. One method these institutions develop human capital is by producing graduates who will join the region’s educated workforce. Furthermore, the information and technology developed via research activities at local institutions may attract new firms to a region while also assisting current enterprises to expand and innovate. These “spillover effects” might drive up the region’s need for highly trained personnel.

However, if the dominating paradigm of education is University 1.0, training of students will not keep up with the need for human capital, and thus any investments whether it is investments in the infrastructure, teachers’ motivation, encouraging of high-performing students will be poorly effective. This is another significant risk.

Even University 2.0 does not correspond to the change of knowledge, professional and soft skills expected to be available in graduate. Moreover, even in case of investment in transformation of University 2.0 environment to University 3.0, no evident results will be achieved if not to reform high school too. A student, graduate from the school teaching by methods from 20th century, unlikely will be able to study at University 3.0. Thus, there is critical necessity for the state to be provided with complete, detailed, and continuous information about the situation and trends in education both in national scale and abroad, to make right and farsighted investment decisions for development of human capital. This will allow mitigate investment risks.

As for investments in healthcare (which, as noted above, is also an area of investing in the development of human capital), the risks are associated with underestimating trends in the digitalization of healthcare on the one hand and changes in the “profile” of the nation’s health on the other hand.

It is common knowledge that there is a direct connection between a country’s economy and the health of its population. The world experience of economic development shows that an effective economy is formed by a healthy nation. The health of the nation is a productive resource, the main wealth of any social system. The quality of health determines the competitiveness of the workforce and the development of the economy as a whole [10]. The main negative effect of low health is the depletion of the labor potential of the country’s economy.

According to the WHO Global Health Assessments published in December 2020, 7 of the 10 leading causes of death in the world are non-communicable diseases. In 2000, only four noncommunicable diseases appeared on the list of leading causes of death. The new data covers the period from 2000 to 2019 [34]. The document describes trends over the past twenty years in terms of mortality and morbidity due to various diseases and injuries. These data clearly demonstrate the need for increased global attention to the prevention and treatment of cardiovascular diseases, cancer, diabetes and chronic respiratory diseases, as well as injury prevention in all regions of the world, in accordance with the goals of the UN Sustainable Development Agenda.

According to recent data, obesity rates have nearly tripled since 1975, and obesity now causes 4 million deaths worldwide each year. Heart diseases has remained the leading cause of death worldwide for 20 years. However, they have never claimed as many lives as they do today. Since 2000, the number of deaths from cardiovascular disease has increased by more than 2 million and reached almost 9 million in 2019. Heart diseases today account for 16% of all deaths worldwide. More than half of the two million excess deaths from cardiovascular disease were recorded in the WHO Western Pacific Region [34]. In

2019, Alzheimer's disease and other forms of dementia were among the top ten leading causes of death worldwide, ranking third in the Region of the Americas and Europe. Women bear a disproportionately high burden of mortality from this cause: worldwide, 65% of people who die as a result of Alzheimer's disease and other forms of dementia are women. Between 2000 and 2019, deaths from diabetes worldwide increased by 70%, with 80% of this increase occurring among men. In the Eastern Mediterranean countries, mortality from diabetes has almost doubled and, in percentage terms, the increase in mortality from this disease is the highest in this region [34].

Despite increasing life expectancy, the rise in chronic and non-communicable diseases has become a global threat. Chronic and non-communicable diseases are becoming a serious problem in all countries, regardless of their income level. All this is a very serious threat to the development of human capital.

Digital transformation in medicine and healthcare should also be mentioned. Medical organizations are already transferring all information into digital format, business processes are being automated, and centralized systems are being created in all regions. The use of information technologies is aimed, among other things, at improving the quality of medical care provided through the latest diagnostic and treatment methods, systems for interpreting the results of medical research. All this should lead to a reduction in the number of medical errors, a decrease in the time spent waiting for medical care, and an increase in the effectiveness of treatment.

At the same time, a certain conservatism of the medical industry does not always allow the rapid implementation of advanced tools and technologies. Legislative barriers are often overcome with great difficulty, since the use of various types of innovations requires changes to a huge array of documents. The development of scientific thought on the issues of digital transformation of the healthcare sector indicates the growing relevance of problems associated with increasing the digital skills and awareness of medical workers and the population, which will ensure the creation of an effective healthcare system and the formation of an attractive and favorable environment for life and health. All this is also part of the development of human capital and requires thoughtful government investments.

Digital transformation in healthcare provides the government with enormous opportunities to invest in human capital, but at the same time creates risks. For competent investment, a systemic and forward-looking vision is required, it is necessary to deeply and comprehensively understand existing and prospective trends and correctly identify the appropriate areas, vectors, and types of influence - regulatory, supportive, and encouraging.

Digital transformation in healthcare is a high-impact strategy that focuses on customer centricity and a cultural shift toward technology-enabled healthcare. The introduction of modern information technologies into various processes in the medical industry is called the digitalization of medicine. Implementing digital transformation in organizations allows to effectively manage data and improve decision-making. The main benefits of digital transformation have been easy access to information, better organization and tracking of data, and increased accountability across all departments. As such, digital transformation is quickly becoming critical for businesses seeking to gain a competitive advantage in today's world, and healthcare is not exclusion. One of the most significant trends in digital transformation is the use of artificial intelligence. Using artificial intelligence, organizations can process huge amounts of data easily and quickly; artificial intelligence can be used to automate processes, gain insight into customer behavior, reduce human errors and improve overall productivity. The explosive growth of digital medicine is facilitated by new solutions in the field of artificial intelligence, sensors, robotics, wireless communications, information processing and analysis, augmented and virtual reality. Healthcare providers today must prioritize patient-centered care and leverage real-time data to achieve better clinical outcomes. APIs enable the shift towards value-based healthcare, driving several digital transformation initiatives in healthcare [7].

In addition, since the first WHO eHealth resolution in 2005, which initiated the development and adoption of the WHO Global Digital Health Strategy, more than 120 WHO Member States have developed a national digital health policy or strategy. Given recent experience with the COVID-19 pandemic and the dramatic increase in the use of digital health technologies, many countries indicate the need to support the transition from pilot digital health initiatives focused on specific products to the creation of national digital health infrastructure with appropriate governance, policies, and skilled health workers needed to select, maintain, and adapt digital health interventions.

The formation of the digital contour of the healthcare sector should be based on a clear understanding of the competency profile, its inclusion in the innovative healthcare system and the preservation of human capital. The use of a competency-based approach to the digital transformation of the healthcare sector helps to increase the adaptability of the existing healthcare organization system to the conditions of the new technological order, provides the opportunity to introduce end-to-end technologies in management decision-making processes to improve the accessibility and quality of medical care. In addition, staffing the healthcare system has a significant impact on accelerating the digitalization of the industry. Accordingly, public investment in health care should include investment in supporting the development of new technologies on the one hand and in staffing – on the other, both of which represent investment in human capital development.

Thus, education and healthcare, as well as sustainable social development, are elements, subsystems of managing the development of human capital, and information support for public management of investments in the development of human capital should be based on decomposition, in order to continuously obtain the most complete and reliable data for each of these elements. Accordingly, the effectiveness of information support should be determined by the presence of a synergy effect in the functioning of these subsystems, otherwise there will be patchwork that will make impossible not only the advanced innovative development of the state, but even stable catch-up development.

Furthermore, creative human capital is a collection of particular values that produce new values in the form of innovative, original ideas and fresh information [25]. Therefore, in order to build and develop this creativity, significant investments must be made for its all-encompassing and progressive growth, in addition to an awareness of the expanding role and significance of human capital in today's economy. It is no coincidence that the experts at the Davos Forum highlighted that one of the top three trends in the job market going forward would be creativity [32].

As it is known, New Public Management (NPM) applies approaches, methods, and practices from private (business) sector. Accordingly, it concerns, in particular, investments in the development of human capital, risks of this investment, and appropriate information provision for management and decision-making. Thus, it is rational to address to best practices also in the information provision and its decomposition.

Businesses today are increasingly using GRC, a structured way to align IT with business goals while managing risk and complying with all industry and government regulations. It includes tools and processes to integrate organizational governance and risk management with technological innovation and implementation. Companies use GRC to reliably achieve corporate goals, eliminate uncertainty, and comply with regulatory requirements. GRC stands for governance, risk (governance) and compliance. Most businesses are familiar with these terms but have practiced them separately in the past. GRC integrates governance, risk management, and compliance into a single, coordinated model. By implementing GRC programs, businesses can make better, risk-aware decisions. In accordance with the NPM paradigm, the same principle can be successfully applied in public administration.

In particular, the information model of the hierarchical structure of a complex quality criterion reflects the qualitative side of the information resource, fulfilling the functional role of defining essential criteria and their connections. A multi-criteria task becomes a single-criteria, scalar task if there is a sign of hierarchy and provided that the measurability of single criteria of the lower level of the hierarchy is ensured. Subsequently, the applied aggregation (convolution) of indicators of complex criteria of different levels of the hierarchical structure, starting from the lowest, allows obtaining an integral indicator [9].

The tasks of analyzing the quality of objects in any field of scientific research are based on the analysis of the interrelated properties of its quality. Quality is often the central link of multi-criteria tasks in a variety of areas in deciding the need to improve quality and understanding the prospects for the development of objects of the quality being studied, as well as in a comparative analysis of qualities, economic costs, and other tasks, including when assessing the quality of investment in the development of human resources, that is, minimizing the impact of risk factors.

To carry out the scalarization stage (representing a multi-criteria problem as a single-criteria one), it is necessary to supplement the created model with information that will provide the ability to evaluate criteria of different levels quantitatively. This additional information about each complex criterion in its group at each level of the hierarchy is [9]:

1. The status of a complex criterion is a qualitative parameter determined by the nature and degree of importance of its influence in a group of criteria of the same level with a semantic meaning - dominant (D) or compensated (K):

- the dominant criterion is characterized by greater weight and main influence when the criteria are unequal among themselves and in the group; any of its low assessments, up to a zero value, cannot be compensated by other no matter how high quantitative assessments of the compensated criteria; its zero value is fatal and resets the overall result of the resource quality to zero - this is an important condition in the relationship of criteria that affects the choice of the formula for calculating the integral quality indicator;
- the compensated criterion has a mutually compensating nature of influence in its homogeneous group of criteria; it is additional to the dominant criterion when coexisting in one group and in this case determines the mixed type of connection of criteria in it; the formula of the so-called scalar convolution consists of combining two formulas for calculating the integrated indicator.

2. Weight - a quantitative, weighting coefficient of the significance of the influence of a criterion in a group on the overall result of criteria of the same level.
3. Evaluation according to the scale of quantitative evaluation of the criterion adopted for this model, i.e., determination of its indicator (the most common point estimates are on an ordinal scale with gradations of 3, 5, 7, 10).

At this stage of setting a single-criteria task, expert opinions (collective or individual) are used to determine the status, weight, and assessment of single criteria of the information model.

The method of combining (integrating) indicators of criteria of different levels, which determines the scalar convolution formula, generally depends on 1) the type of task (problem), 2) the nature of the contribution of each criterion to the complex criterion of the highest zero level, 3) the type of relationship between criteria at different levels of the hierarchy. The most common formulas are additive (adding indicators of complex criteria of different levels) and multiplicative (multiplying indicators). The use of the additive formula is legitimate in the absence of dominant criteria in the hierarchical structure of the complex criteria of the model. There are tasks in which "the loss of quality according to one criterion is not always compensated by an increase in another", i.e., the status of the dominant criterion is not taken into account and, as a consequence, the result of determining quality will be erroneous. To solve these tasks, multiplicative convolution is used, since additive convolution is not sensitive to small values of the criteria.

In general, a formula that includes both additive and multiplicative forms of convolution of a group indicator at different levels of the hierarchical structure of the quality information model has the following form [9]:

$$P_{u-1} = \underbrace{\sum_{i=1}^{n} v_{iu} K_{iu}}_{\text{Additive form of convolution}} \times \underbrace{\prod_{j=1}^{m} D_{ju}^{v_{ju}}}_{\text{Multiplicative form of convolution}}, u = h, h-1, \dots 0$$

where

h – total number of hierarchical model levels
u – current hierarchy level
v_{iu} – weight of indicator (i) of the compensated criterion included in the number (n) of one group with the dominant criteria at level (u)
K_{iu} – indicator of the compensated criterion (modified or assessed) with the corresponding weight v_{iu}
D_{iu} – indicator of the dominant criterion (modified or assessed) with the corresponding weight v_{ju}
V_{ju} – weight of indicator (j) of the dominant criterion, included in quantity (m) in one group with compensated criteria at level (u)
n+m – size of one mixed group of compensated and dominant indicators.

Using this general convolution formula or separately for any of its components, the integrative contribution of each criterion is assessed according to its indicator in the corresponding complex criterion of a higher level, and so on until the complex criterion of the highest, zero level of the hierarchy. As a result of such convolutions, we obtain the indicator of the integral complex quality criterion as a synthesis of the indicators of the quality criterion of the hierarchical structure into a single comprehensive assessment of the quality of information support.

Meanwhile, conceptually, for example, partial information decomposition for three variables can look like the Figure 2 shows:

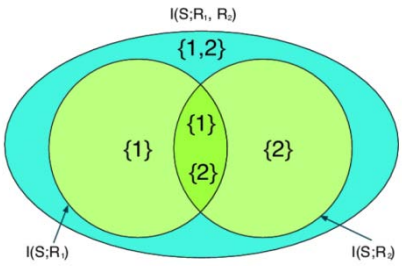

Figure 2. Partial information decomposition for three variables [4]

This and similar methods represent an important direction of effective decomposition of information provision in the system of state management of human capital development, including managing risks, which enables application of really systemic, integrative approach with the continuous use of 'real-time' data and timely reacting in case of any parameter change.

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Primary Paper Section: A

Secondary Paper Section: AE