Practical Implications of Human Capital Asset Allocation for the Business and Economy

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Abstract: In the current context of transformation processes of economic systems caused by digitalization, automation and changes in the labour market, human capital quality management is becoming of key importance. The exhaustion of traditional growth factors emphasizes the need for innovative strategies to optimize human potential, increase the competence and adaptability of employees, which is the basis of the competitiveness of economies and enterprises. The purpose of the study is to substantiate strategic approaches to human capital quality management in the context of transformational changes in economic systems, taking into account the impact of digitalization, automation of business processes and the evolution of the global labour market. 20 medium-sized EU machine-building enterprises were studied according to 2023 data, selected according to the criteria for the quality of human capital formation. Primary reporting data, J. Mintzer's model, descriptive statistics and correlation analysis were used to assess the impact of qualifications and adaptability on productivity with further verification of the level of significance using the t-test. The relationship between investments in human capital and enterprise performance is studied, and the importance of digital skills for increasing labour productivity is also investigated. The impact of automation on the transformation of professional requirements and employment is analysed. A methodological approach to assessing human capital performance in the context of current digital changes in the economy is proposed. The results open up opportunities for developing adaptive human capital management strategies in the digital economy. Further work may focus on new quality indicators, assessment of cognitive and digital competencies and their integration into management systems to increase competitiveness.

Keywords: human capital, strategic management, digital economy, investment efficiency, innovative development, employee competencies.

Introduction

Global transformation processes taking place in the modern economy necessitate a review of traditional development models and the search for new strategic approaches to managing key resources, among which human capital plays a decisive role. The exhaustion of traditional factors of economic growth, such as natural resources and mass production, creates an objective need to develop innovative mechanisms aimed at optimizing the use of human potential, increasing the level of employee competence and ensuring their ability to adapt to changing conditions of the socio-economic environment [1].

In modern conditions, the competitiveness of national economies and individual enterprises largely depends on the effectiveness of the formation, development and use of human capital, which, in turn, requires the use of new approaches to its assessment, motivation and management. World experience confirms that a high level of human

capital is an important prerequisite for ensuring long-term economic growth, stimulating innovative activity and forming modern models of sustainable development. At the same time, the relevance of research on the issues of human capital quality management is increasing in the context of digital transformation, globalization of labor markets, demographic changes and increasing requirements for the level of professional competence [2].

The formation of human capital in a knowledge economy is characterized by an emphasis on continuous learning, innovation, adaptability, collaboration, diversity, and entrepreneurship, and the elements of this direction are identified as fundamental for the formation of a quality workforce that can not only compete in the global market, but also direct the economy towards sustainable development and prosperity [3]. It is also worth mentioning the model of human capital management in the VUCA era, which confirms the idea of the need to rethink human capital management, where the selection of the workforce comes to the fore and the conditions for a new social contract and equal cooperation of stakeholders are formed. The paradigm shift is observed in recruiting, work organization configuration, modifications in the world of work caused by excessive automation, management of generational differences, management of a multicultural workforce, and employee motivation [4].

The leading factor in the most effective strategic management of human capital is taking into account its qualitative characteristics, which are determined by the level of education, professional knowledge, practical experience, innovative activity, personal abilities and social competencies. The difference between the concepts of "personnel" and "human capital" is that the first concept focuses on the workforce itself, while the second emphasizes the quality and economic efficiency of human resources, which is manifested in the level of their productivity, ability to learn and flexibility in the face of change [5].

In the conditions of the modern economy, the assessment of human capital is of particular importance not only as a tool for optimizing personnel management costs, but also as a basis for forming feedback in the enterprise management system, which allows for a reasoned assessment of the professional competencies of employees, determining the need for their further training, formulating directions for improving their qualitative characteristics, and ensuring that the staffing structure meets the modern challenges of the external environment.

Literature Review

The category of human resources is traditionally used to analyze human resources in the business environment, but its application is not limited to the micro level and can also be relevant for level economic systems, where it is considered as a component of general economic resources. Thus, in the studies of Abubakar et al. [6], Chen [7], a review of existing interpretations of the concept of human resources was carried out, which allows us to identify common features between this concept and the category of human capital. It emphasizes that human resources are formed in the process of training and directly affect the quality of human capital, therefore, there is a close connection between these concepts, and in some aspects they can be considered identical. At the same time Bielialov et al. [8], Iwamoto and Suzuki [9] focus their attention on the inverse impact of the effective use of human resources on the quality of human capital, which confirms the need for a strategic approach to managing these resources in the context of transformational changes for individual economic systems. Jalan and Pednekar [10], analysing the relationship between the concepts of human capital and human resources, do not draw unambiguous conclusions about the direction of this relationship, but emphasize their interdependence, which is an important aspect in the formation of human capital quality management strategies.

Some scientists [11, 12], studying the problem of human capital management, do not distinguish between the concepts of "human capital" and "human potential", using them as interchangeable terms. This is explained by the fact that in the format of the resource approach, the category of "human resources" is more universal and allows it to be used for the analysis of economic systems of different levels – states, industries or enterprises. Special attention should be paid to the problems of assessing human capital, in particular the lack of a single methodology for its quantitative measurement, which is noted in their studies by Giamos and Stroehle [13], Otoo and Rather [14]. Such a problem becomes especially relevant in the context of the digital transformation of economic systems, when there is a need to develop new indicators and methodological approaches to assessing the quality of human capital.

From the perspective of Murdiono et al. [15] and Zayed et al. [16], when assessing human capital, it includes not only personal and social components, but also material and intangible foundations. The material foundations include demographic characteristics of the population, the level of health of society, human resources infrastructure and social security, while the intangible component includes educational level, human resources qualifications, social capital and social relations, which form the basis for the development of human capital.

In turn Makedon et al. [17], Yu and Lan [18] indicate that human capital is characterized by a number of inherent characteristics, in particular, the natural abilities and professional skills of employees, which determine their ability to engage in active economic activity. At the same time, human capital implements a mechanism for attracting human resources to the economic system, which emphasizes the relationship between the concepts of human capital, labor potential and personnel management.

Special attention is paid to approaches to strategic human capital management at the level of individual economic systems. In particular, Ben Brahim and Hadoussa [19], Devassia et al. [20] propose to implement human capital management through effective human resource management, taking into account the specifics of a particular region, in particular its competitive advantages, socio-economic features and the need to form a single socio-cultural space. In turn, Abiddin and Talha [21] focus on creating favourable conditions for the development of human capital as a key resource of the regional economy, which involves investments in education, development of professional qualifications of personnel, improvement of working conditions and an increase in the level of social protection.

Aldulaimi et al. [22] specifically highlights the fact that investment in education and training is crucial for developing the skilled workforce needed for a knowledge economy and developing human capital. They show that such investments can effectively and reliably promote innovation, increase productivity, and also ensure economic growth.

Thus, scientific approaches to the analysis of human capital and human resource potential demonstrate their close interrelationship, with a significant part of researchers considering human resource potential as a practical embodiment of human capital in active transformation processes for economic systems.

The purpose of the article is to form a methodological approach to the implementation of human capital quality management strategies in the context of transformational changes in economic systems, taking into account digitalization trends.

Research methodology

The object of analysis was selected 20 medium-sized engineering enterprises of the European Union, representing key manufacturing countries (Germany, Sweden, France, Denmark, Italy, etc.). All enterprises were selected based on their compliance with the criteria for medium-sized businesses according to the EU classification (number of employees up to 250 people, annual turnover up to 50 million euros) and their role in the engineering sector, which is undergoing active transformation through digitalization and globalization. To assess the participation of human capital in the activities of enterprises, primary data obtained by analyzing company reporting were used. The data was collected based on the results of 2023, taking into account current economic conditions, such as the transition to Industry 4.0 as a transformation process.

The distribution of observations between enterprises is made proportionally to their activity in the formation and use of human capital. As shown in Appendix A, the specific weight of observations varies from 3.6% (Atlas Copco, Sweden) to 6.4% (Bosch Rexroth, Germany), which reflects the difference in the scale of personnel involvement and strategic approach to management. The total sum of the specific weights is 100%, which ensures the representativeness of the sample.

To conduct a study of the effectiveness of human capital formation in machine-building enterprises, the equation of J. Mintzer was chosen:

$$W = \beta_0 + \beta_1 \times s + \beta_2 \times x + \beta_3 \times 2 + u \quad (1)$$

where:

W – wage level (in monetary terms),

$\beta 0, \beta 1, \beta 2, \beta 3$ – coefficients of the regression equation,

s – number of years spent on education,

x – production experience, reflecting the turnover of human capital in the labor market,

u – the influence of factors not included in the model.

Descriptive statistics were used to process the data, which allowed us to determine the share of human capital in the activities of each enterprise. Additionally, correlation analysis was introduced to assess the density of the relationship between the level of employee qualifications, their adaptability to change and the productivity of enterprises in the context of economic transformation [23]. The statistical significance of the results was checked using a t-test with a confidence level of 95%.

Results

Competency assessment of human capital formation

The use of modern analytical models and platform solutions for human capital analysis contributes to increasing the efficiency of managerial decision-making, allowing to operate with previously inaccessible data and improve methodological approaches to strategic human capital management. Today, it is generally accepted in the scientific community that capital can exist not only in tangible but also in intangible form, and it is human capital that plays a key role in modern economic systems [24].

The further transition to an innovation economy will actualize the need for a highly skilled workforce capable of creative and intellectual activity, while the digital economy will create a demand for workers with advanced competencies in information technology, data management and artificial intelligence. Accordingly, strategic human capital management should be adaptive, innovative and aimed at developing creative thinking, digital competencies and implementing the concept of lifelong learning, which will allow employees to maximize their potential in the changing conditions of the global economy [25, 26].

In modern economic systems, the competency-based assessment of human capital is of key importance, which not only determines the level of knowledge, skills and professional abilities of employees, but also allows optimizing personnel management processes by increasing the share of specialists belonging to the “knowledge” category and playing a critically important role in the organizational systems of the digital economy [27]. Thus, in the industrial economy, the concept of labour resources was used, where the main criterion for evaluating personnel was labour productivity, determined by the performance of specific production functions. In post-industrial society, there was a shift in emphasis on personnel management, which involved the assessment of professional skills and abilities taking into account the impact of technological changes [28].

With the transition to the information economy, a new concept of human resource management emerged, which expanded traditional approaches to employee assessment, including the analysis of personal characteristics, the level of social adaptation, motivation to work and the quality of labour relations, which determine the effectiveness of performing professional duties. The next stage of development of economic systems, associated with the fifth industrial revolution and the spread of the innovation economy, put the process of intellectualization of labor in the spotlight, which necessitated the assessment of the level of involvement of the intellectual potential of employees, their ability to generate new knowledge and participation in scientific and research activities [29].

The fourth industrial revolution, which initiated the formation of the digital economy, has put forward new requirements for the development of human capital, focusing on the digitalization of business processes, automation of management decisions and integration of artificial intelligence into all spheres of economic activity. If in the industrial economy the key factor of the production process was the mechanization of labour (“manufacturing”), and in the innovation economy – the intellectualization of labour activity, then in the digital economy the so-called concept of “brainfacturing” becomes the determining factor of development, which involves the production of knowledge and the creation of intellectual products as the basis of economic growth [30, 31].

The rapid development of automation and artificial intelligence is causing significant changes in the structure of employment, as technological solutions allow to significantly reduce the need for human resources in those areas of economic activity where work is based on the routine execution of algorithms or involves the functions of mediation between systems. At the same time, there is a need to create new jobs that are directly related to constant technological changes, and therefore require workers to have radically new competencies that are not possessed by the workforce released through automation. For example, the skills of solving non-standard tasks, the ability to process and analyse large data sets, the use of analytical tools and understanding the principles of digital platforms are gaining special value. As a result, the main challenge for companies is the growing gap between the real needs of the business and the level of training of existing employees, which requires strategic changes in approaches to managing the quality of human capital [32].

Managing the digital development of human capital in the transformation of economic systems

Managing the digital development of human capital in the context of the transformation of economic systems requires a review of traditional approaches to the formation and implementation of HR management strategies, which is due to the growing dynamics of technological change, increasing uncertainty and increased competition for highly qualified personnel. In this context, there is a transition from the classic SPOD management strategy, which is characterized by stability, predictability, simplicity and certainty (S – Sustainable, P – Predictable, O – Ordinary, D – Definite), to a more flexible and adaptive VUCA strategy (Figure 1).

The VUCA concept (V – Volatility, U – Uncertainty, C – Complexity, A – Ambiguity) reflects the realities of the modern digital economy, where rapid changes in the technological, economic and social environment create new challenges for human capital management.

Chowdhury [33] examines the implications of human resource management (HRM) in a VUCA environment, focusing on leadership styles, training, motivation and recruitment, and highlights the component of implementing a digital HR architecture that contributes to increasing organizational agility and effectiveness. Examples of companies such as IBM, Google and Salesforce demonstrate the successful application of digital HR practices to achieve competitive advantages. On the other hand, Shet [34] develops a competency framework for employees ready for a VUCA environment, highlighting ten key competencies. The highlighted competencies are divided into cognitive (flexible thinking, adaptability and personal ambidexterity), intercultural (cross-cultural intelligence and collaboration), analytical (creativity and complex problem solving) and personal effectiveness (resilience, continuous learning and adaptive thinking). The most holistic concept of human capital quality management in the digital economy is based on the author's approach to studying the theoretical and practical aspects of human resources management, the key feature of which is the transition from the traditional SPOD management strategy (based on stability, predictability, simplicity and certainty) to the VUCA strategy, which takes into account the volatility, uncertainty, complexity and ambiguity of modern economic processes.

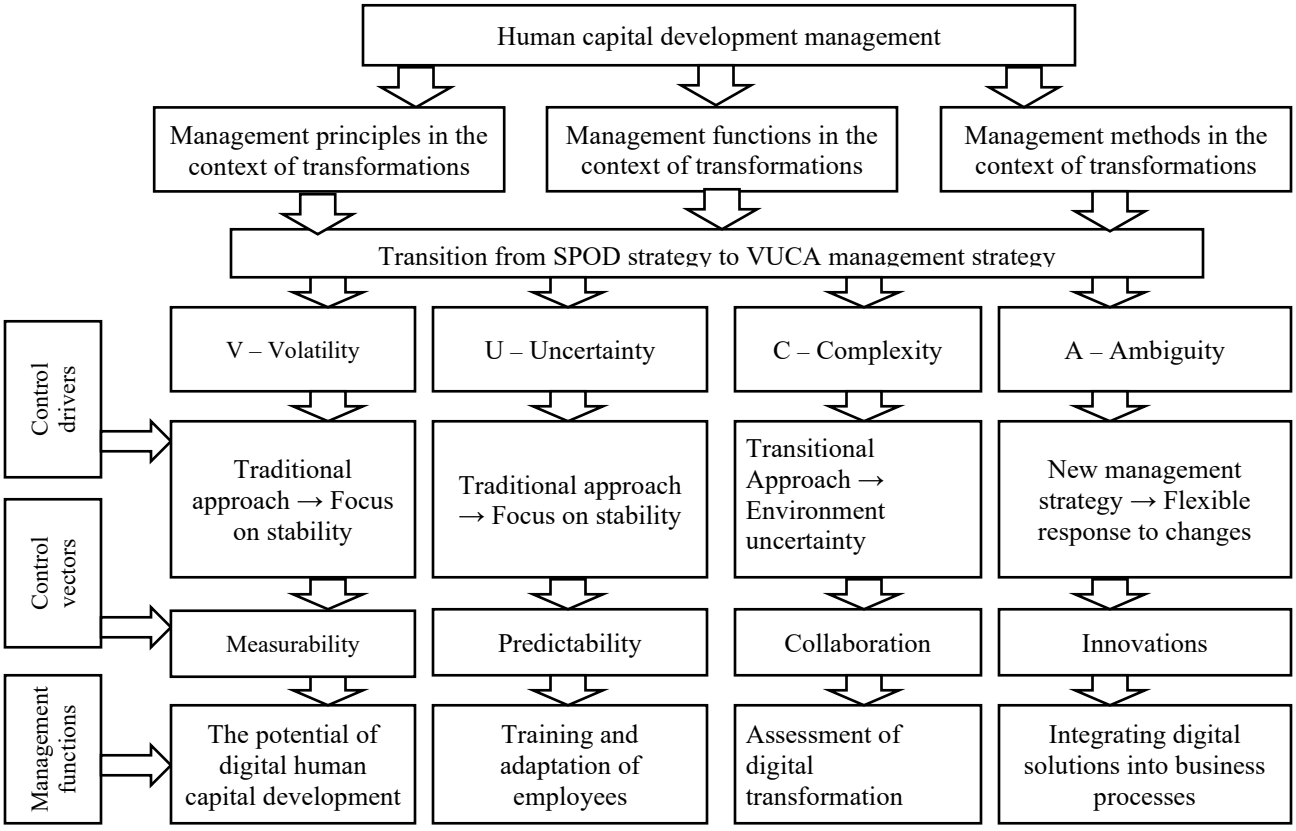

Figure 1. Modelling of strategic management of human capital quality in the context of digital transformation of economic systems
Source: compiled by the author

Within the framework of this approach, there is a review of the structural and substantive characteristics of human capital management, which includes changing the organization of workplaces and production processes, introducing new mechanisms for making management decisions based on artificial intelligence, which, in turn, creates opportunities for improving the human capital management system on fundamentally new methodological principles.

It should be noted that cognitive skills within the framework of modern strategic approaches to human capital management are somewhat different from classical models of their interpretation, which usually include such basic components as sensation, perception, thinking, memory, attention and imagination. In addition, a high level of development of cognitive skills provides the ability to quickly switch between different types of tasks, find effective management solutions and increase the overall productivity of employees.

As digital transformation contributes to increased interdependence between different sectors of the economy, the ability to build effective communications, collaborate, negotiate, work under uncertainty, and ensure productive interaction within the team becomes one of the most important factors in the success of an employee and the organization as a whole. Digital skills also play a crucial role in modern human capital management, which are necessary not only to expand the possibilities of using modern technologies, but also for productive work in areas where artificial intelligence and automated systems complement human labor, increasing its efficiency [35]. In the context of digital transformation, companies are increasingly focusing on the development of digital competencies of employees, which allows them to optimize business processes, increase the efficiency of management decisions, and strengthen competitive advantages in the market.

Based on the above competencies, the main directions of development of human capital quality management strategies can be identified:

1) Automation of production, the introduction of artificial intelligence, and the transformation of organizational structures are changing traditional requirements for employees, which necessitates the training of personnel with appropriate skills for effective functioning in the digital economy;

2) The list of required competencies is constantly updated, and new ones are added to traditional technical skills, including programming, emotional intelligence, adaptability, and strategic thinking [36];

3) Manual labor and traditional management approaches are gradually losing their relevance, and the ability to work with financial resources and tangible assets is increasingly being replaced by data analysis and digital analytics skills;

4) The classic division of skills into “hard skills” and “soft skills” is becoming insufficient, because for the successful integration of employees into the digital economy, it is necessary to take into account cognitive skills that allow them to work effectively in conditions of rapid change and digital transformation [37];

5) A separate category of skills is distinguished – “digital skills”, which are mandatory for maximum realization of the potential of the latest technologies and effective interaction with automated systems;

6) The ability to continuously learn acquires the status of a metacompetence, without which even the highest level of professional training loses its relevance over time, which confirms the need to form a lifelong learning system [38];

7) Investments in education and professional development of employees are considered key factors in maintaining the competitive advantages of companies, which requires understanding current scientific data on learning processes, determining their effectiveness, and applying this knowledge in practice;

8) Communication skills become crucial in the process of interpersonal interaction, as modern business involves active teamwork, cooperation, the ability to effectively present one's own ideas and negotiate;

9) Competencies that machines cannot replicate are becoming key to human capital. These include empathy, emotional intelligence, creativity, innovative thinking, and the ability to control robotic processes and make unconventional decisions [39].

Modeling the processes of formation and assessment of the quality of human capital for the economic system

The popularity of J. Mintzer's model (formula 1) among human capital researchers is explained by its flexibility and adaptability for analyzing various aspects of labor resource development, in particular when assessing the qualification level of employees. Advanced modifications of this model include only qualitative determinants of human capital:

$$Y = \alpha + Mk + c \times E + n \times Tc + p \times S_s + q \times R_s + v \times H + w \quad (2)$$

where:

α is the constant of qualitative determinants,

Mk – employee's competency level,

c – coefficient of qualification level (*c=8*),

E – level of education,

n – number of levels of vocational education (*n=3*),

Tc – target competencies of the employee,

p – number of target competencies (*p=2*),

Ss – social status of the employee (*q=2*),

Rs – employee health level, reflecting the number of working days missed due to illness (*v=3*),

w – factors not included in the model.

Regression analysis of primary sample data reflecting the relationship between the level of employee income and qualitative indicators of his human capital is presented in Appendix A. In the process of studying modern requirements for the quality of human capital in the digital economy, scientists identify three main groups of supra-professional skills that are critical for the adaptation of employees to the dynamic VUCA environment, characterized by a high level of volatility, uncertainty, complexity and multiplicity. These skills include cognitive, socio-behavioral and digital competencies, each of which plays a key role in the formation of competitive labor potential in the context of the transformation of economic systems [40].

The study of the quality of human capital in the activities of medium-sized machine-building enterprises of the European Union in the context of the transformation of economic systems is based on a quantitative approach using statistical analysis methods. The selection of indicators was based on scientifically sound criteria that take into account the specifics of technological dynamics and human capital in this sector. The selected variables integrate key aspects such as innovative activity, adaptation to digital transformation processes and qualification characteristics, which have become determinants of development for machine-building enterprises. Indicators related to automation, digitalization and outdated technological base characterize the trajectory of technological development of the industry, but at the same time, factors of creativity, intellectual competencies and motivational factors emphasize the importance of human capital in innovation processes. Table 1 presents the results of a regression analysis conducted using the selected econometric model, which assesses the strength of the influence of a number of selected factors on the development and efficiency of human capital use in the context of the digital transformation of the economy.

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Table 1. Results of regression analysis of human capital formation for a sample of 20 medium-sized EU machine-building enterprises

Model	Non-standard coefficients		*β*	*t*	Significance
	α	Standard error			
Constant	10.875	0.412		26.398	0.000
Implementation of personnel development strategies	1.312	0.465	0.029	2.822	0.005
Level of creativity and innovation	0.894	0.438	0.021	2.041	0.041
Adaptability to economic transformations	0.765	0.429	0.018	1.783	0.075
Application of automated systems	-0.718	0.451	-0.014	-1.592	0.111
Participation in workplace digitalization projects	1.147	0.442	0.025	2.595	0.009
Using outdated technologies	-0.987	0.431	-0.019	-2.290	0.022
Development of intellectual competencies	0.876	0.427	0.016	2.051	0.040
Low qualification of employees	-0.905	0.446	-0.013	-2.028	0.043
Secondary education	0.287	0.185	0.015	1,551	0.121
Specialized higher education	0.198	0.117	0.011	1,692	0.091
Language skills for global interaction	0.245	0.129	0.023	1.899	0.058
Big data analysis skills	0.403	0.203	0.030	1.985	0.047
Digital competence	0.322	0.189	0.027	1.704	0.089
Stability of professional experience	0.167	0.123	0.013	1.358	0.175
Motivation for professional growth	0.294	0.136	0.020	2.162	0.031
Work breaks due to burnout	-0.385	0.108	-0.035	-3.565	0.000

Model	Non-standard coefficients		*β*	*t*	Significance
	α	Standard error			
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Implementation of personnel development strategies	1.312	0.465	0.029	2.822	0.005
Level of creativity and innovation	0.894	0.438	0.021	2.041	0.041
R^2	0.011				
Adjusted R^2	0.006				
F-statistic	69.745				
Durbin-Watson statistics	1.802				
Number of observations	1000				

Source: calculated by the author

The results of the regression analysis, presented in Table 1, are of important practical importance, as they allow for a comprehensive analysis and correct interpretation of factors that directly affect the efficiency of human capital use in the context of digital transformation of economic systems. In particular, it was found that the key positive determinants are the implementation of personnel development strategies (α = 1.312, p = 0.005), participation in digitalization projects (α = 1.147, p = 0.009), development of intellectual competencies (α = 0.876, p = 0.040) and motivation for professional growth (α = 0.294, p = 0.031). The identified factors form a statistically significant positive impact on the quality of human capital. In contrast, the use of outdated technologies (α = -0.987, p = 0.022), low employee qualifications (α = -0.905, p = 0.043), and work interruptions due to burnout (α = -0.385, p = 0.000) negatively affect efficiency.

Understanding these factors makes it possible not only to identify the main factors that shape the quality of human capital, but also to reasonably choose the optimal tools for managing it, aimed at its development as a strategic resource for economic growth. For example, the significant negative impact of burnout (t = -3.565) emphasizes the need to implement programs to support the psychological health of employees, while the positive effect of participation in digital projects (t = 2.595) indicates the importance of investments in technological modernization. The results obtained can become the basis for developing long-term strategies for the formation, accumulation and effective use of human capital, taking into account the requirements of the digital economy, which poses new challenges to the professional qualifications, cognitive and digital skills of employees. Despite the low level of explained variation (R^2 = 0.011), the high *F*-statistic (69.745) confirms the overall adequacy of the model. The conducted research should open new prospects for further analytical work aimed at identifying new strategic approaches to the fundamental management of human capital quality during systemic transformations.

Discussion

The results of the study emphasize the importance of a strategic approach to managing the quality of human capital in the context of the digital transformation of economic systems. All the conclusions obtained are consistent with the results of studies by a number of authors who studied the relationship between human capital and human resource potential. In particular, Abubakar et al. [6] and Chen [7] prove that human resource potential is formed through training and professional development, which directly affects the quality of human capital. Scientific results confirm this point

of view, demonstrating that investments in education and training are key factors for the effective use of human resources.

The research of Iwamoto and Suzuki [9] emphasizes the direct impact of effective use of human resources on the quality of human capital, which is consistent with our conclusions on the need for strategic management of these resources in the context of economic change. At the same time, Jalan and Pednekar [10] do not draw unambiguous conclusions about the direction of this relationship, but emphasize their interdependence, which is reflected in our analytical models.

Regarding the conceptual framework, Capozza and Divella [11] and Harney and Gubbins [12] do not distinguish between the concepts of "human capital" and "human potential", which is consistent with our approach to integrated human resource analysis. At the same time, Giamos and Stroehle [13] and Otoo and Rather [14] emphasize the lack of a single methodology for quantitatively measuring human capital, which is one of the key challenges in our study.

An important innovation of our study is the integration of modern approaches to assessing human capital, taking into account the digitalization and automation of production processes. Murdiono et al. [15] and Zayed et al. [16] distinguish between tangible and intangible components of human capital, and our work confirms the importance of considering both aspects for effective personnel management. We paid special attention to strategic approaches to human capital management, which is especially important at the level of individual economic systems. In particular, Ben Brahim and Hadoussa [19] and Devassia et al. [20] emphasize the need for a regional approach to human resource management. The proposed econometric model confirms that taking into account the specifics of economic systems creates the conditions for achieving more effective results in the formation of competitive labor potential in the event of transformation.

Thus, the results obtained are consistent with modern scientific approaches and complement them, offering a new methodology for measuring and assessing human capital, adapted to the conditions of the digital transformation of the economy.

Conclusion

Research has shown that the concept of human capital has undergone significant changes: from its perception as an analogue of fixed capital to a modern understanding that encompasses a wide range of intangible assets, such as knowledge, skills, competencies and intellectual potential of employees. A multi-level system of indicators for assessing the quality of human capital and individual aggregated and material indicators were analyzed, which made it possible to clearly establish the fact of the formation of a comprehensive picture of the level of development of labor resources, but requires further improvement to translate the qualitative characteristics of human capital into quantitative and cost estimates.

It is substantiated that in modern conditions it is necessary to transition from the traditional SPOD management strategy, which is based on stability, predictability, simplicity and certainty, to the VUCA strategy, which takes into account the volatility, uncertainty, complexity and ambiguity of the economic environment. The presented strategic transformation of management approaches allows to increase the efficiency of human capital use, in particular through the creation of adaptive mechanisms of professional development and the integration of technological solutions into the processes of managing human capital formation.

An econometric model for assessing human capital has been developed, which takes into account its qualitative determinants, such as the level of employee competencies, educational level, target competencies, social status and health level. Using this model allows us to assess the effectiveness of investments in human capital and predict its impact on the development of economic systems. A comprehensive approach to managing the quality of human capital is proposed, which is based on the development of an innovative culture, creating favorable conditions for continuous learning, increasing the flexibility of the labor market and forming digital competencies of personnel.

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Appendix A

Distribution of observations on the participation of human capital in the activities of medium-sized EU engineering enterprises in the context of economic transformation

No.	Enterprise	Number of observations	Specific weight of observations from the total number, %
1	SKF (Sweden)	50	5.0
2	Festo (Germany)	45	4.5
3	GKN Automotive (United Kingdom)	55	5.5
4	Sidel (Italy)	48	4.8
5	KSB Group (Germany)	52	5.2
6	Metso (Finland)	40	4.0
7	Bühler Group (Switzerland)	60	6.0
8	Voith (Germany)	38	3.8
9	Sandvik (Sweden)	54	5.4
10	Manitou Group (France)	42	4.2
11	Sauer-Danfoss (Denmark)	46	4.6
12	Poclain Hydraulics (France)	50	5.0
13	Alfa Laval (Sweden)	58	5.8
14	Trumpf (Germany)	44	4.4
15	Atlas Copco (Sweden)	36	3.6
16	Liebherr (Switzerland)	62	6.2
17	DMG Mori (Germany)	48	4.8
18	Tetra Pak (Sweden)	56	5.6
19	Bosch Rexroth (Germany)	64	6.4
20	Grundfos (Denmark)	52	5.2
	Total:	1000	100.0

Source: [41, 42]