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DEVELOPMENT OF DIGITAL HUMAN CAPITAL AS A KEY FACTOR IN SHAPING UKRAINE'S COMPETITIVE ADVANTAGES IN THE EUROPEAN SPACE

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РОЗВИТОК ЦИФРОВОГО ЛЮДСЬКОГО КАПІТАЛУ ЯК КЛЮЧОВОГО ЧИННИКА ФОРМУВАННЯ КОНКУРЕНТНИХ ПЕРЕВАГ УКРАЇНИ У ЄВРОПЕЙСЬКОМУ ПРОСТОРІ

The article examines the theoretical and methodological foundations of digital human capital development as a key factor in shaping Ukraine's competitive advantages in the context of European integration, artificial

intelligence advancement, and digital transformation. The essence of digital human capital is clarified as an integrated system of digital competencies, innovative potential, professional skills, and adaptive capabilities of the population that ensure the effective functioning of the knowledge economy. The study systematizes the key factors influencing labor productivity, national competitiveness, and the efficiency of human capital utilization under conditions of digital transformation and artificial intelligence development.

An integrated scientific and methodological approach to assessing the impact of digital human capital on labor productivity and Ukraine's competitiveness is proposed, based on a comprehensive consideration of educational, technological, and institutional factors. Unlike existing approaches, the proposed framework takes into account the synergistic effects of artificial intelligence development and digital transformation on the formation of the state's competitive advantages within the European economic space.

A conceptual model describing the relationship between digital human capital, artificial intelligence development, digital transformation, labor productivity, and national competitiveness is developed. The findings demonstrate that the synergy between digital competencies, innovative potential, and the institutional environment creates the preconditions for sustainable economic growth and Ukraine's integration into the European economic area.

The practical significance of the research findings for public authorities, higher education institutions, and the business sector in shaping digital human capital development policies, modernizing educational programs, and designing digital transformation strategies is substantiated. The study confirms that the effective development of digital human capital contributes to more informed managerial decision-making, higher labor productivity, and the strengthening of Ukraine's competitive position in international markets.

У статті досліджено теоретико-методичні засади розвитку цифрового людського капіталу як ключового чинника формування конкурентних переваг України в умовах європейської інтеграції, розвитку штучного інтелекту та цифрової трансформації. Уточнено сутність

цифрового людського капіталу як інтегрованої системи цифрових компетентностей, інноваційного потенціалу, професійних навичок та адаптивних здібностей населення, що забезпечують ефективне функціонування економіки знань. Систематизовано основні чинники впливу цифрової трансформації та розвитку штучного інтелекту на продуктивність праці, конкурентоспроможність країни та ефективність використання людського капіталу.

Обґрунтовано інтегрований науково-методичний підхід до оцінки впливу цифрового людського капіталу на продуктивність праці та конкурентоспроможність України, який базується на комплексному врахуванні освітніх, технологічних та інституційних факторів. Запропонований підхід, на відміну від існуючих, враховує синергетичний вплив розвитку штучного інтелекту та цифрової трансформації на формування конкурентних переваг держави в європейському економічному просторі.

Розроблено концептуальну модель взаємозв'язку між цифровим людським капіталом, розвитком штучного інтелекту, цифровою трансформацією, продуктивністю праці та конкурентоспроможністю країни. Встановлено, що синергія цифрових компетентностей, інноваційного потенціалу та інституційного середовища формує передумови для стійкого економічного зростання та інтеграції України до європейського економічного простору.

Обґрунтовано практичне значення результатів дослідження для органів державного управління, закладів вищої освіти та бізнес-середовища при формуванні політики розвитку цифрового людського капіталу, модернізації освітніх програм та розробці стратегій цифрової трансформації економіки. Доведено, що ефективний розвиток цифрового людського капіталу сприяє підвищенню обґрунтованості управлінських рішень, продуктивності праці та зміцненню конкурентних позицій України на міжнародних ринках.

Keywords: *digital human capital; digital transformation; digital divide; labor productivity; European integration; country competitiveness.*

Ключові слова: *цифровий людський капітал; цифрова трансформація; цифровий розрив; продуктивність праці; європейська інтеграція конкурентоспроможність країни.*

Problem statement in general terms and its connection with important scientific and practical tasks.

In the context of digital transformation, artificial intelligence development, and Ukraine's European integration, digital human capital has become a key factor of national competitiveness. Its level of digital competencies, innovative potential, and ability to use modern technologies determines a country's capacity for sustainable economic growth and integration into the European economic space.

Current trends in the development of artificial intelligence and business process automation significantly change the requirements for the structure of human capital, leading to the need for new professional competencies, the development of digital skills, and increased adaptability of the workforce to technological changes. At the same time, existing approaches to human capital assessment largely fail to account for the comprehensive impact of digital transformation and artificial intelligence development on labour productivity and national competitiveness, as well as the insufficient consideration of the interrelationship between educational, technological, and institutional factors.

This issue is particularly relevant for Ukraine in the context of European integration and post-war economic recovery, as structural labour market imbalances, the outflow of highly qualified specialists, the mismatch between digital skills and modern economic requirements, and unequal access to digital infrastructure hinder the formation of the country's competitive advantages. This creates a need for an integrated scientific and methodological approach to assessing the role of digital human capital in ensuring labour productivity and

national competitiveness, taking into account the influence of artificial intelligence, digital transformation, and the institutional environment.

Addressing this problem is of crucial importance both for the development of theoretical foundations of human capital management in the digital economy and for shaping effective public policies in the field of digitalisation, education system modernization, innovation development, and strengthening Ukraine's competitive position within the European economic space.

Analysis of recent research and publications.

The development of digital human capital (HC) in the context of digital economic transformation and the expansion of artificial intelligence technologies is one of the key directions of contemporary economic research. The theoretical foundations of human capital theory were established in the works of prominent scholars such as T. Schultz and Gary Becker [1], who substantiated the decisive role of education, professional skills, and knowledge in ensuring economic growth and labour productivity.

Further development of the HC concept is reflected in the works of Robert Lucas Jr. [2], Olha Hryshnova [3], Paul Romer, and Edward Denison [4], who emphasized the interconnection between innovation, technological development, and the quality of human capital as key drivers of long-term economic growth. The impact of digital human capital (DHC) on firms' innovation quality is examined in recent studies [5], which demonstrate that DHC significantly enhances innovation performance by increasing knowledge complexity, optimizing resource allocation, and improving organizational cognition.

The issues of digital transformation (DT) of the economy and its impact on labour markets, productivity, and competitiveness are extensively studied in the works of Klaus Schwab and other scholars [6,7,8,9], who highlight the effects of automation, digitalization, and artificial intelligence on employment structure transformation and the formation of new digital competencies.

The development of digital transformation and digital competencies is also addressed in the works of Ukrainian scholars [10,11,12], who investigate issues of

economic digitalization, labour market transformation, digital skills development, and the impact of digital technologies on economic growth. Certain aspects of digital human capital development and Ukraine's integration into the European digital space are reflected in studies on the digital economy, innovation activity, and knowledge management.

However, despite a considerable body of research, insufficient attention has been paid to the comprehensive assessment of the impact of digital human capital on labour productivity and national competitiveness, particularly considering the synergistic effects of artificial intelligence development, digital transformation, and institutional factors. This highlights the need for further development of scientific and methodological approaches to evaluating the role of DHC in shaping Ukraine's competitive advantages in the context of European integration.

Formulation of the article's objectives (research aim).

The aim of the article is to develop the theoretical and methodological foundations and to substantiate an integrated scientific and methodological approach to assessing the impact of digital human capital on labour productivity and the formation of Ukraine's competitive advantages in the context of European integration, based on the consideration of artificial intelligence development, digital transformation, as well as educational, technological, and institutional factors.

To achieve the stated aim, the following objectives have been defined: to analyse the essence and structural components of DHC in the context of artificial intelligence development and digital transformation; to systematize the key factors influencing digital human capital on labour productivity and national competitiveness; to examine the impact of digital transformation and artificial intelligence technologies on the formation of digital competencies and labour market transformation; to develop an integrated scientific and methodological approach to assessing the interrelationship between digital human capital, labour productivity, and Ukraine's competitive advantages; to identify the main threats and structural imbalances in the development of digital human capital in the

context of European integration; and to substantiate a conceptual model of the impact of digital human capital on ensuring national competitiveness, as well as to define directions for its practical application in public policy, the education system, and the business environment.

Main body of the research.

In the contemporary conditions of the formation of a digital economy and the transition to the Industry 5.0 paradigm, the study of the interrelationship between artificial intelligence, digital transformation, and human capital as key drivers of economic development is of particular importance. The interaction between labour productivity, digital transformation, digital human capital, and the context of artificial intelligence development forms a systemic foundation of modern national economic competitiveness.

In contemporary economic theory, human capital is defined as a set of knowledge, skills, competencies, health status, and professional experience of an individual that determine their ability to create economic value. Classical approaches introduced by Gary Becker and Theodore Schultz define human capital as an investment resource that ensures productivity growth and economic development through the accumulation of knowledge and skills [1].

According to the World Bank methodology, human capital is viewed as an integrated system of health, education, and skills that determines the future productivity of the workforce. The quality of these components determines an economy's ability to generate long-term added value and maintain global competitiveness [13].

In the context of DT, the content of this category is undergoing a significant expansion. While traditionally human capital included education, professional skills, and health status, in the digital economy the key importance is increasingly attributed to digital competencies, the ability to work with data, the use of digital platforms, and artificial intelligence technologies. According to the Organisation for Economic Co-operation and Development (OECD) definition, digital skills are

a fundamental prerequisite for participation in the modern labour market and a factor in improving economic efficiency in the context of digitalisation [14].

Human capital is a key determinant of a country's economic innovativeness. The availability of highly qualified professionals with advanced digital and analytical skills supports knowledge creation, innovation development, and the implementation of technological solutions. International studies confirm that countries with higher levels of human capital demonstrate stronger innovation performance and greater efficiency in knowledge commercialization. Thus, human capital forms the foundation of national innovation systems and contributes to technological advancement.

Human capital also significantly affects a country's investment attractiveness. Investors consider not only macroeconomic indicators but also workforce quality, educational attainment, digital competencies, and innovation capacity. The World Bank further emphasizes that countries with stronger human capital achieve higher long-term economic growth, as investments in education, healthcare, and skills development enhance labour efficiency and innovation capacity, whereas countries with weaker human capital experience slower income growth and limited development potential [13].

Human capital is also a core driver of high-tech sector development, including IT, biotechnology, financial technologies, and other innovation-intensive industries. The availability of specialists with STEM (Science, Technology, Engineering, and Mathematics) and AI-related competencies supports sectoral growth, integration into global value chains, and the expansion of export potential. In this regard, human capital functions not only as a resource but also as a strategic economic asset.

On the basis of these transformations, a new scientific category is emerging—digital human capital, which can be defined as an integrated system of knowledge, digital skills, innovative competencies, and the ability to apply artificial intelligence technologies in economic activities. Unlike traditional human capital, digital human capital reflects not only the level of education and

qualification but also the degree of an individual's digital maturity and their ability to interact with digital ecosystems.

The transition from traditional human capital to digital human capital represents a natural stage in the evolution of the knowledge economy and is driven by digital transformation and the development of artificial intelligence. In this context, digital technologies act not only as a tool for improving labour productivity but also as a factor transforming the very nature of human capital, reshaping employment structures, competency requirements, and value creation mechanisms.

Thus, the contemporary theoretical paradigm is shifting from the classical understanding of human capital toward the concept of digital human capital, which is becoming a key resource for ensuring economic competitiveness in the context of digital transformation, artificial intelligence development, and globalization.

In the context of contemporary transformations, it is also important to consider the concept of Industry 5.0, which emphasizes human-centricity, sustainable development, and synergy between humans and technologies. Unlike previous stages of industrial development, which were dominated by automation, Industry 5.0 предполагає the integration of human intelligence, creativity, and social values into technological processes [15].

Thus, human capital generates competitive advantages through enhanced innovativeness, investment attractiveness, and the development of high-tech sectors, while its interaction with digital transformation, artificial intelligence, and the principles of Industry 5.0 produces a multiplicative effect on labour productivity growth and strengthens a country's position in the global economy.

The methodological framework of the study is based on an integrated approach to analysing the interrelationship between artificial intelligence development, digital transformation, digital human capital, labour productivity, and national competitiveness. The conceptual model is grounded in the principles of the digital economy, human capital theory, and innovation-driven development,

and also incorporates contemporary approaches to assessing digital competencies and technological maturity (Fig. 1).

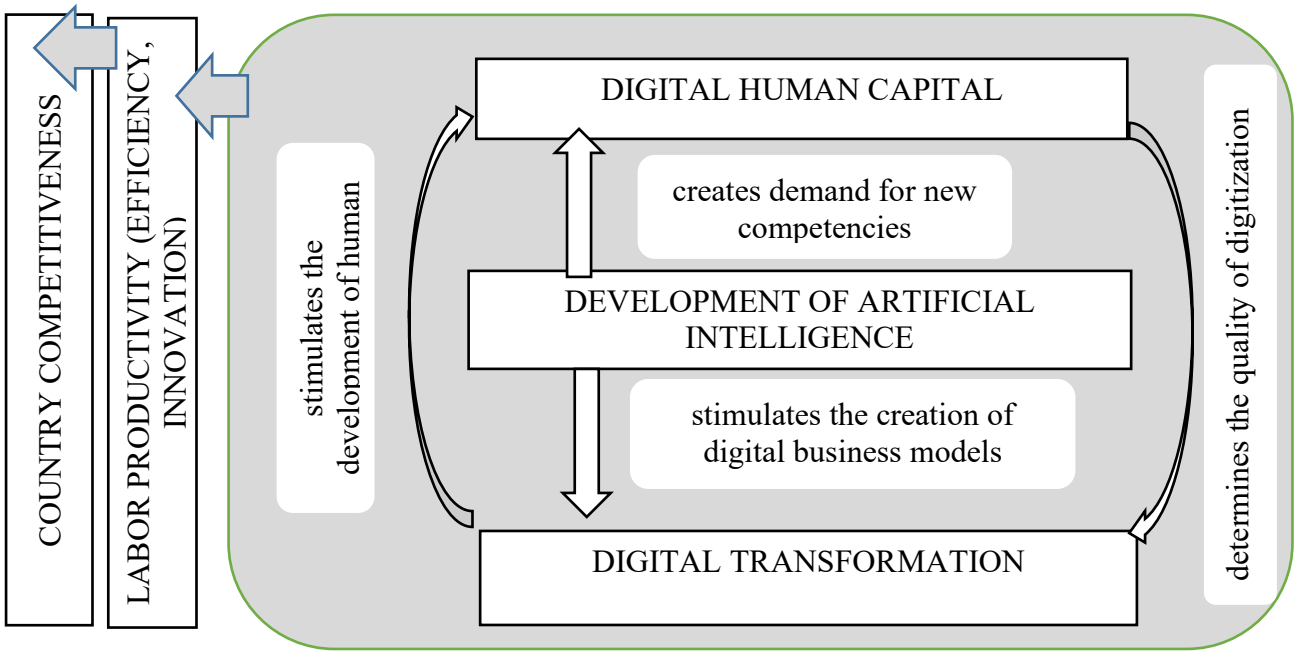

Figure 1. Conceptual framework of the interrelationship between digital transformation, digital human capital, and artificial intelligence

Source: developed by the author

For the empirical validation of the proposed conceptual model, research hypotheses have been formulated.

The proposed hypotheses H1–H5 reflect the cause-and-effect relationships between artificial intelligence development, digital transformation, digital human capital, labour productivity, and national competitiveness, which makes it possible to empirically test synergistic and mediating effects within an integrated econometric model, through which the preconditions for labour productivity growth and enhanced national competitiveness are formed (Tab. 1). A key feature of the proposed model is its cyclical, ecosystem-based nature. Increased competitiveness generates additional resources for investment in artificial intelligence, digital infrastructure, and human capital, which further strengthens digital transformation processes. The system thus operates as a closed-loop

structure with positive feedback, where each component influences and reinforces the others.

Table 1. Hypotheses formulation and their interpretation

	Hypothesis	Impact	Interpretation
H1.	The impact of the AI context on digital transformation	The level of artificial intelligence development has a positive impact on the level of digital transformation in the economy	countries with developed AI infrastructure, investments in AI and digitalization policies have a higher level of digital technology implementation
H2.	The impact of digital human capital on digital transformation	The level of digital human capital has a positive impact on the level of digital transformation	the presence of digital competencies in the population and employees is a necessary condition for the effective implementation of digital technologies
H3.	The synergistic effect of DT and DHC on labor productivity	The interaction of digital transformation and digital human capital has a positive and statistically significant impact on labor productivity)	the effect of digitalization is significantly enhanced if the population has a high level of digital skills.
H4.	The impact of labor productivity on the country's competitiveness	Labor productivity has a positive impact on the level of country's competitiveness	the increase in resource efficiency increases the country's position in global rankings
H5.	Indirect (mediation) effect of digitalization through productivity	Digital transformation and digital human capital impact on competitiveness through labor productivity	digital transformation and digital human capital shape labor productivity, which acts as a key channel of their impact on the country's competitiveness

Developed by the author

Empirical validation of the model is based on contemporary statistical data on digital skills, human capital, and labour productivity, supporting the relevance of the identified relationships. A cross-country analysis reveals significant disparities in digital development (Fig/.2).

In particular, the highest levels have been recorded in the Netherlands (83%) and Finland (82%), whereas in Romania the figure is only 28%. Such

differentiation confirms the existence of structural imbalances in the development of digital human capital across Europe [16].

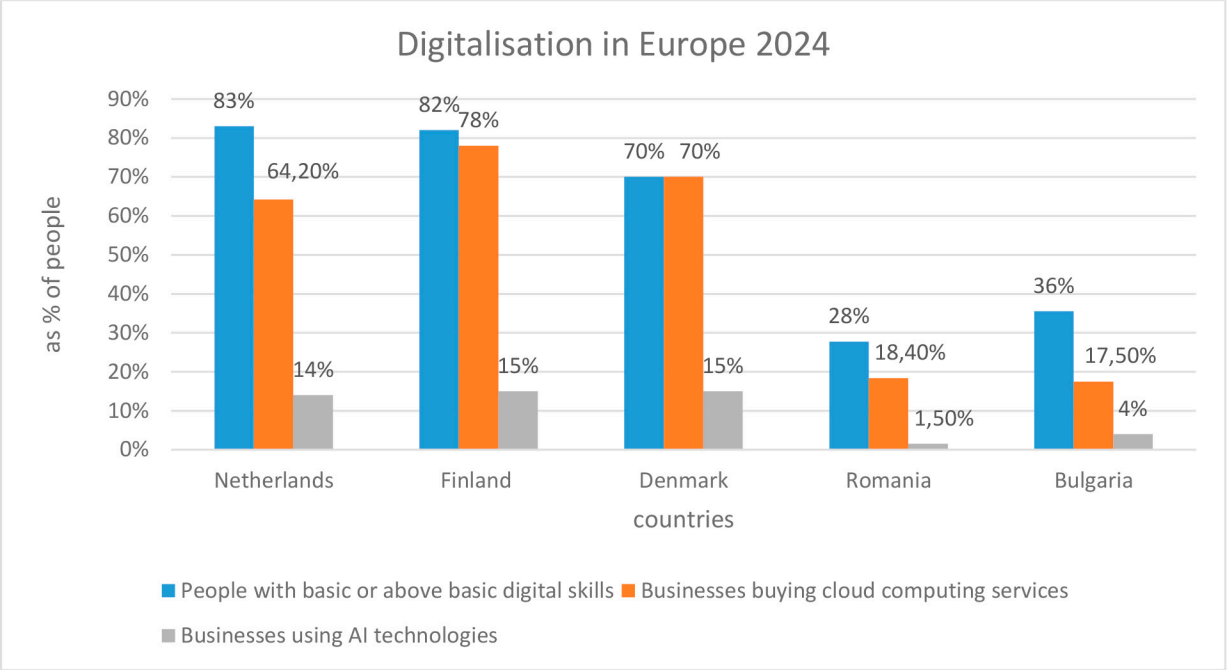

Figure 2. Digitalisation in Europe 2024
Source: based on [13, 16].

In 2025, 60% of EU citizens aged 16-74 had at least basic digital skills - an increase compared to 54% in 2021 and the corresponding level in 2023. Four countries exceeded the EU target of 80%: the Netherlands (84%), Ireland (83%), Denmark, and Finland (both 81%). A particularly important aspect is the relationship between education level and digital skills. According to Eurostat data, among individuals with a high level of education, the share of those possessing basic digital skills reaches 80%, whereas among individuals with a low level of education it is only 34%. This empirically confirms the hypothesis regarding the key role of digital human capital in digital transformation processes [17].

In addition, it should be noted that the share of ICT employment in the EU accounts for approximately 5% of total employment (over 10 million people), and this indicator has demonstrated steady growth over the past decade. This reflects structural changes in the labour market and the increasing role of digital competencies as a determinant of economic productivity [18].

From an international comparative perspective, OECD studies confirm that around 25% of the adult population in OECD countries does not possess even basic digital skills, which significantly limits their participation in the digital economy. At the same time, the combination of digital and cognitive skills substantially increases labour productivity and adaptability to technological change [19].

Nevertheless, despite active digitalisation, European countries continue to experience a slowdown in labour productivity growth. According to Eurostat, in the first quarter of 2025 labour productivity per person in the euro area increased by only 0.8% year-on-year, while productivity per hour worked grew by 1.1%, indicating a persistent trend of weak productivity recovery following recent crises [20].

At the same time, projections by the European Central Bank indicate that labour productivity growth in 2025–2027 will remain below the long-term pre-pandemic trend due to structural factors, including population ageing, slow adoption of artificial intelligence technologies, energy shocks, and the ongoing structural shift towards the service sector. This highlights the need to enhance the efficiency of both digital technologies and human capital utilisation.

The presented statistics confirm a significant digital skills gap across countries and social groups, while education level remains directly correlated with digital competencies. Empirical evidence demonstrates that digital human capital is a critical determinant of the effectiveness of digital transformation and labour productivity growth. Therefore, the interaction between digital transformation, digital human capital, and artificial intelligence creates a multiplicative effect that shapes long-term national competitiveness and economic growth.

A comparative analysis of human capital development in Ukraine and European Union countries reveals significant structural gaps manifested in education, digital competencies, labour productivity, and composite competitiveness indicators.

According to the Human Capital Index Plus (HCI+) assessment, at the beginning of 2026 Ukraine recorded a score of 220 out of a maximum of 325

points. This value is lower than the average for the Europe and Central Asia region (240 points), but higher than the average for upper-middle-income countries (204 points). The index reflects the level of human capital accumulation through investments in health care, education, and employment (Fig. 3).

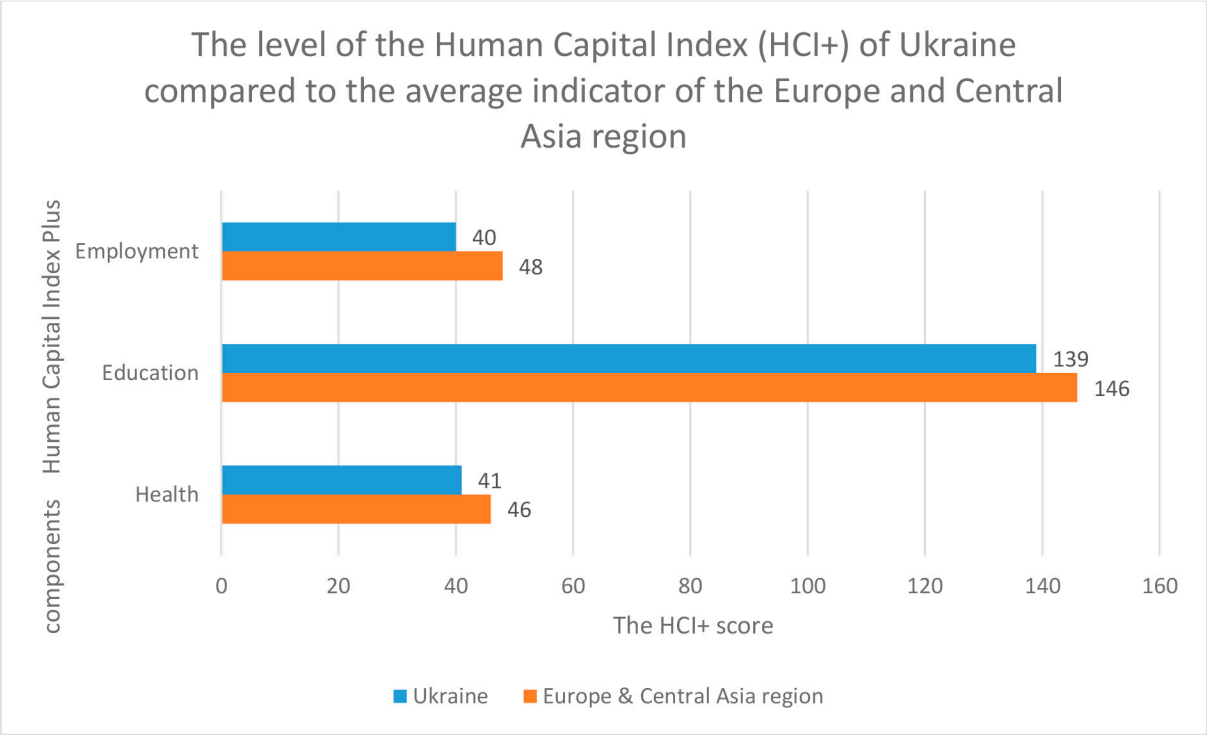

Figure 3. The level of the Human Capital Index (HCI+) of Ukraine compared to the average indicator of the Europe and Central Asia region
Source: based on [21].

The data presented in the diagram indicate that Ukraine's HCI+ level is below the regional average of Europe and Central Asia across all major components—education, healthcare, and employment. The most pronounced gap is observed in the employment dimension, highlighting the need to strengthen public policy aimed at human capital development, improving labour productivity, and integrating digital competencies into the labour market.

Analytical estimates suggest that a 10-point increase in the HCI+ index is associated with approximately a 10% rise in future income levels, confirming the strategic role of human capital in shaping labour productivity and economic competitiveness. At the same time, reducing existing structural gaps in education,

healthcare, and employment compared to countries with higher HCI+ scores and similar GDP per capita levels could potentially ensure a 19% increase in future income levels in Ukraine.

Ukraine's HCI+ indicator is lower than the average level of the Europe and Central Asia region (240 points), but it exceeds the average for upper-middle-income countries (204 points) [21].

According to the Global Talent Competitiveness Index, Ukraine ranks 61st in the world with an overall score of 46.31. Particularly low performance is observed in skills development (Grow – 33.71) and digital competencies (digital skills – 80th position) [22]. Ukraine's position in the Index indicates a medium level of human capital development, with relatively strong technological and business competencies, but with significant limitations in lifelong learning and the institutional environment. This confirms the structural nature of the problem of digital human capital development, which is critical for enhancing national competitiveness in the context of digital transformation and integration into the European economic space. In EU countries, particularly in Northern and Western Europe, a more balanced model is observed, where education is closely aligned with labour market needs and the requirements of the digital economy.

Another important aspect is the level of digital skills and digitalisation. Within the EU, a key assessment instrument is the Digital Economy and Society Index, which reflects the level of development of digital human capital, internet usage, integration of digital technologies, and digital public services [23]. The analysis shows that EU countries demonstrate gradual convergence in digital development, although the pace of convergence remains uneven. At the same time, Ukraine, not being an EU member state, lags significantly behind in digital competency indicators, which creates a "digital gap" and limits its integration into the European digital space.

The third critical parameter is labour productivity, which directly determines the level of an economy's competitiveness. According to international rankings, Ukraine is characterized by low labour productivity, as reflected in its weak

position in relevant indicators (for example, 82nd place in labour productivity within the Global Talent Competitiveness Index structure) [24]. At the same time, EU countries—particularly leading economies such as Germany, the Netherlands, and the Scandinavian states—demonstrate significantly higher productivity levels, driven by a combination of highly skilled human capital, innovation, and digitalisation. Empirical evidence also confirms a direct relationship between the level of digitalisation and labour productivity, which forms the basis of competitive advantages [25].

Composite indicators of global competitiveness, particularly the Global Competitiveness Index, further illustrate these disparities. Ukraine records significantly lower values (approximately 56.99 points), corresponding to positions in the lower half of the global ranking [26]. In contrast, most EU countries demonstrate substantially higher scores due to the development of institutions, innovation ecosystems, digital infrastructure, and human capital. The methodology of the index explicitly highlights the role of skills, innovation, and adaptability as key determinants of competitiveness in the context of the Fourth Industrial Revolution.

The current state of human capital development in Ukraine is characterized by a range of systemic constraints that significantly hinder the formation of sustainable competitive advantages within the European economic space. Key challenges include labour migration outflows, the consequences of military conflict, skills mismatches relative to labour market needs, insufficient digitalisation of education, and unequal access to quality educational services.

One of the most critical issues is the outflow of intellectual capital, which has intensified significantly since the outbreak of full-scale war. According to estimates, millions of Ukrainians, including a substantial share of highly qualified professionals, have relocated to European countries, resulting in a loss of national intellectual potential [27]. The OECD also emphasizes that the war has significantly exacerbated the “brain drain” problem, creating risks of long-term weakening of the country’s scientific and innovation capacity [28].

An equally important factor is military conflict, which has a multidimensional negative impact on HC. War leads to the destruction of educational infrastructure, disruption of the learning process, and loss of skills among both students and workers. Studies indicate that declines in education quality and skills loss may result in an approximate 7% reduction in long-term labour productivity [29]. In addition, mobilisation and forced migration reduce labour supply, creating labour shortages and increasing pressure on the economy.

An additional factor is inequality in access to quality education, which has been exacerbated by the war and regional disparities. Forced population displacement, varying levels of infrastructure development, and unequal access to digital resources lead to an uneven formation of HC. In the long term, this generates structural imbalances in the labour market and constrains the overall productivity level of the economy.

In the IT sector, which serves as a key driver of Ukraine's digital economy, a significant economic contribution is observed: in 2025, the industry accounted for approximately 3.2% of Ukraine's GDP, while the market size reached around USD 7.85 billion [30]. Moreover, the sector generates about 41.6% of the country's service exports and provides employment for more than 305,000 IT professionals, and, including adjacent industries, over 800,000 jobs [31]. This highlights the significant role of digital human capital in shaping export potential and economic resilience. At the same time, migration and HC loss remain critical challenges. According to international studies, as a result of the war and demographic trends, Ukraine may face a labour shortage of up to 3–4.5 million workers by 2030, creating long-term risks for economic growth and innovation development (labour market expert estimates).

Thus, statistical data confirm that Ukraine possesses considerable human capital potential, particularly in the high-tech sector; however, its realization is hindered by migration losses, structural skills mismatch, and the consequences of war. The combined impact of these challenges manifests in declining labour productivity and reduced national competitiveness. The loss of HC, declining

education quality, and skills mismatch lead to lower efficiency in resource utilization, slower innovation processes, and reduced value added in production. Consequently, this limits Ukraine's ability to compete in the European market, attract investment, and integrate into high-tech economic sectors.

In the context of strengthening the interconnection between artificial intelligence development, digital transformation, and economic productivity, the formation of an effective human capital development policy requires an integrated approach that takes into account the synergy of technological, educational, and institutional factors. Such an approach enables digital human capital to be viewed as a key link connecting the implementation of artificial intelligence with improvements in labour productivity and national competitiveness.

Despite existing challenges, Ukraine is implementing a range of state initiatives aimed at supporting the integrated development of the digital economy, human capital, and innovation.

First, an important instrument is state digitalisation policy and the development of digital public services, in particular through the "Diia" ecosystem and the digital transformation of public administration [32].

Second, programmes supporting the digital transformation of business, particularly small and medium-sized enterprises (SMEs), are being implemented. The OECD highlights the preparation of the SME Development Strategy (2024–2027), which provides for the stimulation of digitalisation, access to finance, and the development of institutional support mechanisms [33].

Third, considerable attention is being paid to the development of the innovation and AI ecosystem, including the creation of digital clusters (for example, a defence technology cluster) and support for artificial intelligence development [34].

Fourth, programmes supporting HC and the reintegration of displaced persons are being implemented, aimed at skills development, employment, and social integration.

Fifth, international financial and technical assistance plays a key role, enabling the compensation of limited domestic resources and ensuring the implementation of reforms in digitalisation, education, and innovation.

Within the framework of an integrated model of the interrelationship between "artificial intelligence – digital transformation – human capital – productivity – competitiveness," the effectiveness of these measures will determine Ukraine's ability to achieve sustainable economic growth and integration into the European economic space.

The directions for enhancing Ukraine's competitiveness based on the development of digital human capital are presented in Figure 4.

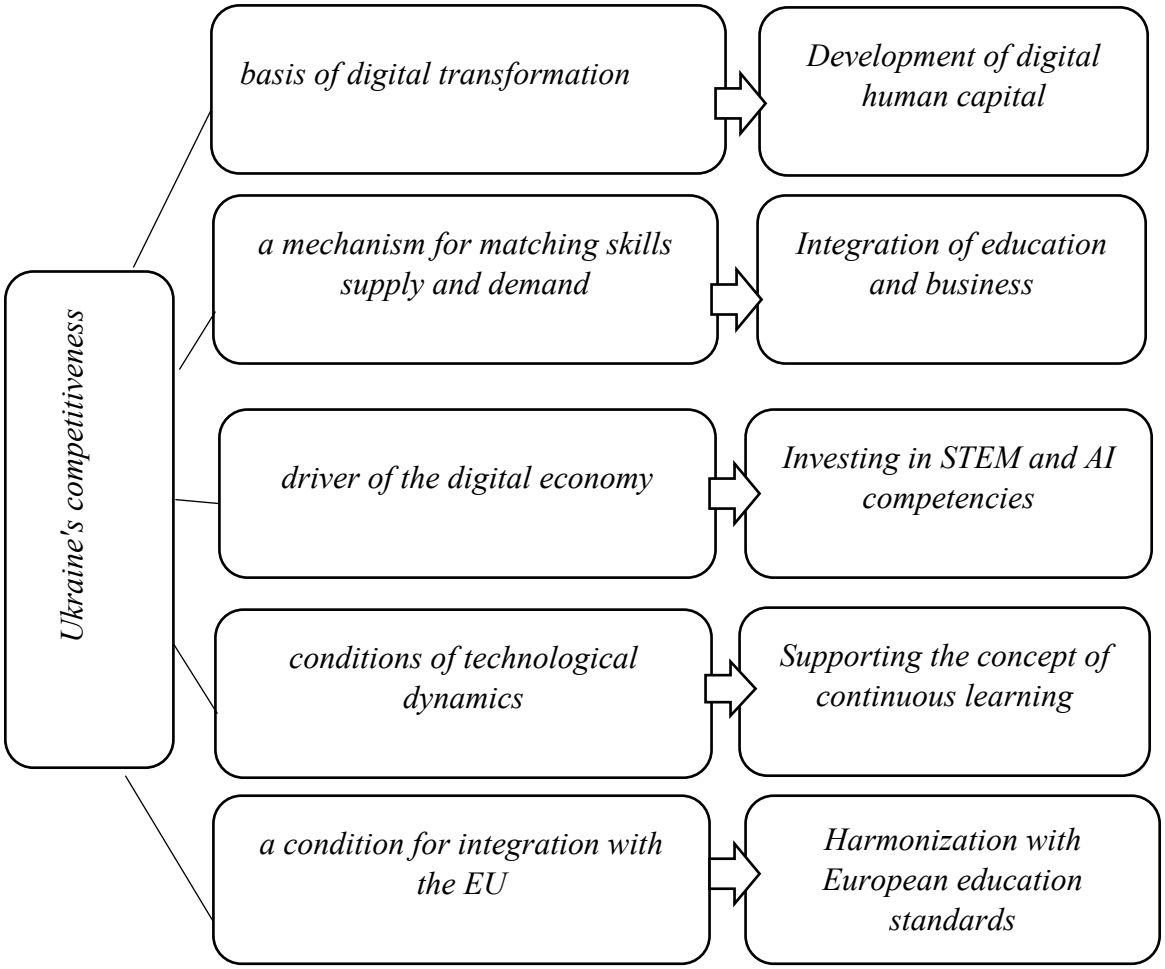

Figure 4. Directions for Enhancing Ukraine's Competitiveness Based on the Development of Digital Human Capital

Source: developed by the author

The formation of digital human capital involves the development of digital and cognitive competencies necessary for the effective use of artificial intelligence technologies. According to the OECD, digital skills are a critical factor in adapting to labour market changes and contribute to improved economic efficiency by reducing skills mismatches and accelerating technological diffusion. At the same time, the growing demand for AI-related competencies confirms the need for systematic skills development that directly influences innovation activity and economic productivity. The development of digital human capital requires digital and cognitive skills essential for effective AI use, while OECD highlights their role in reducing skills mismatches and improving productivity, making investment in digital competencies a prerequisite for digital transformation.

Aligning education with business needs is essential to address rapid AI-driven skill changes, as traditional models lag behind, therefore dual education and university–industry cooperation are crucial for labour productivity growth.

Investment in STEM and AI competencies is necessary for an innovation-driven economy, as digital transformation increases demand for technical specialists and AI enhances productivity through automation and cognitive support.

Lifelong learning is essential due to rapid technological change, as it improves adaptability, reduces unemployment, and maintains productivity, making reskilling and upskilling key priorities.

Harmonization of Ukraine's policies with EU standards is required for integration into the European economic space, as inclusive access to digital skills and infrastructure strengthens human capital quality and competitiveness.

Conclusions and prospects for further research in this field. The study substantiates the theoretical and methodological foundations of digital human capital development as a key factor in forming Ukraine's competitive advantages in the context of European integration, artificial intelligence development, and digital transformation of the economy. The concept of digital human capital has been refined as an integrated system of digital competencies,

professional skills, innovative potential, and adaptive capabilities of the population that ensure the effective functioning of a knowledge-based economy. The main factors influencing digital transformation and artificial intelligence development on labour productivity, national competitiveness, and the efficiency of human capital utilization have been systematized.

A conceptual model of the interrelationship between digital human capital, artificial intelligence development, digital transformation, labour productivity, and national competitiveness has been developed. It has been demonstrated that the relationship between artificial intelligence development, digital transformation, and human capital is multiplicative in nature: artificial intelligence increases the demand for professional and digital competencies; digital human capital ensures the effective implementation of innovative technologies; digital transformation contributes to productivity growth; and productivity growth generates long-term competitive advantages for the state within the European economic space.

The practical significance of the research results lies in their applicability by public authorities, higher education institutions, and the business sector in shaping policies for digital human capital development, modernizing educational programmes, and designing digital transformation strategies. The implementation of a comprehensive digital human capital development policy will contribute to sustainable economic growth, increased labour productivity, and the strengthening of Ukraine’s competitiveness in international markets.

Prospects for further research include the development of methodologies for the quantitative assessment of the impact of digital human capital and artificial intelligence on macroeconomic indicators, empirical validation of the proposed model using international statistical data, and deeper investigation of the impact of STEM technologies and artificial intelligence tools on labour market transformation and the development of the knowledge economy.

Література

1.Becker G. *Human capital: A theoretical and empirical analysis, with special reference to education*. New York: Columbia University Press, 1964. 187 p.

2.Lucas R. E. Jr. Human Capital and Growth. *American Economic Review*. 2015. Т. 105, № 5. С. 85–88. DOI: https://doi.org/10.1257/aer.p20151065 .

3.Грішнова О. А. «Людський капітал» в системі економічних категорій. *Вісник КНУ. Економіка*. 2001. Вип. 49. С. 55–61.

4.Romer P. M. Human capital and growth: Theory and evidence. *Carnegie-Rochester Conference Series on Public Policy*. 1990. Т. 32, № 1. С. 251–286. URL: RePEc.

5.Huang H., Song J. Digital human capital and firms' innovation quality: evidence from China. *Applied Economics Letters*. 2026. С. 1–7. DOI: https://doi.org/10.1080/13504851.2026.2653819.

6.Schwab K. The Fourth Industrial Revolution: What it means and how to respond. *World Economic Forum*. 2016. URL: World Economic Forum (дата звернення: 14.05.2026).

7.Aleca O. E., Mihai F. The Role of Digital Infrastructure and Skills in Enhancing Labor Productivity: Insights from Industry 4.0 in the European Union. *Systems*. 2025. Т. 13. Article 113. DOI: https://doi.org/10.3390/systems13020113

8. He X., Chen W. Digital transformation and environmental, social, and governance performance from a human capital perspective. *Sustainability*. 2024. Т. 16. Article 4737. DOI: https://doi.org/10.3390/su16114737 (дата звернення: 14.05.2026).

9.Flores E., Xu X., Lu Y. Human Capital 4.0: A workforce competence typology for Industry 4.0. *Journal of Manufacturing Technology Management*. 2020. Т. 31. С. 687–703. DOI: https://doi.org/10.1108/JMTM-08-2019-0309

10. Мельничук В. Е., Бояринова К. О. Цифровізація розвитку людського капіталу. *Економічний вісник НТУУ «Київський політехнічний*

інститут». 2023. № 25. С. 94–99. DOI: https://doi.org/10.20535/2307-5651.25.2023.278414 (дата звернення: 14.05.2026).

11. Кирильчук О. В., Красота О. В. Структурні трансформації людського капіталу в умовах розвитку цифрових платформ. *European Scientific Journal of Economic and Financial Innovation*. 2026. № 1(19). DOI: https://doi.org/10.32750/2026-0146 (дата звернення: 14.05.2026).

12. Дуга С. Теоретико-методичні підходи до оцінки якості людського капіталу: сучасний аспект. *Економіка та суспільство*. 2024. № 68. DOI: https://doi.org/10.32782/2524-0072/2024-68-9 (дата звернення: 14.05.2026).

13. World Bank**.** Human Capital Index Plus (HCI+) URL: https://datacatalog.worldbank.org/search/dataset/0067030/human-capital-index-plus

14. OECD. *Digital skills and labour market transformation*. Paris: OECD Publishing, 2023. URL: https://www.oecd.org

15. Горобинська М., Крівцова Т. Вплив Індустрії 5.0 на стійкість підприємств у цифровому середовищі. *Фінансово-кредитні системи: перспективи розвитку* : зб. наук. праць V. N. Karazin Kharkiv National University. Харків, 2025. Вип. 2(17). С. 167–180. DOI: 10.26565/2786-4995-2025-2-14. (дата звернення: 14.05.2026).

16. European Commission. Digitalisation in Europe – 2024 edition. *Eurostat*. 2024. URL: https://ec.europa.eu/eurostat/web/interactive-publications/digitalisation-2024

17. European Commission. Skills for the digital age**.** *Eurostat*. 2025. URL: https://ec.europa.eu/eurostat/statistics-explained/SEPDF/cache/124994.pdf

18. European Commission. Digitalisation in Europe-2025. *Eurostat*. 2025. Edition. URL:https://ec.europa.eu/eurostat/web/interactive-publications/digitalisation-2025

19. Організація економічного співробітництва та розвитку (OECD). Skills for the digital age. *OECD Digital Economy Outlook 2024, Volume 2* URL:https://www.oecd.org/en/publications/2024/11/oecd-digital-economy-

outlook-2024-volume-2_9b2801fc/full-report/skills-for-the-digital-age_da6162fb.html

20. European Commission. GDP and employment both up by 0.1% in the euro area. *Eurostat*. 2025. URL: https://ec.europa.eu/eurostat/web/products-euro-indicators/w/2-06062025-ap (дата звернення: 14.05.2026).

21. World Bank. Human Capital Project. *Ukraine*. 2026. Washington, DC: *World BankGroup.*URL: https://thedocs.worldbank.org/en/doc/2026/original/Ukraine.pdf (дата звернення: 14.05.2026).

22. INSEAD; Portulans Institute. Global Talent Competitiveness Index 2025: Country profile – Ukraine URL: https://www.globaltalentcompetitivenessindex.org/country/ukraine.

23. European Commission. Digital Economy and Society Index (DESI) 2020 URL:https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2020

24. Global Talent Competitiveness Index. *Ukraine* / Global Talent Competitiveness Index. URL:https://www.globaltalentcompetitivenessindex.org/country/ukraine.

25. Polozova T., Kolupaieva I., Sheiko I. Digital Gap in EU Countries and its Impact on Labour Productivity and Global Competitiveness. *Hradec Economic Days*, 2021.Vol. 11, issue 1. P. 659-670. URL: https://openarchive.nure.ua/entities/publication/b834cdc2-bcfd-41ee-aa9a-1afbb1d782fb.

26. Trading Economics. *Ukraine Competitiveness Index* URL:https://tradingeconomics.com/ukraine/competitiveness-index

27. Лібанова Е., Романюк С. *Conceptualization of governance in social relations* / Demography and Social Economy. 2023. Vol. 53, No. 3. С. 33–35. URL:https://ojs.dse.org.ua/index.php/dse/article/view/152.

28. Організація економічного співробітництва та розвитку (OECD). *The future of science in Ukraine: Actions now will affect post-war recovery* /

OECD Policy Responses on the Impacts of the War in Ukraine. 2022. URL:https://www.oecd.org/en/publications/the-future-of-science-in-ukraine_afbd05df-en.html

29. Égert B., de la Maisonneuve C. *The Impact of the War on Human Capital and Productivity in Ukraine*/ CESifo Working Paper No. 10513, ifo Institute. 2023. URL:https://www.ifo.de/en/cesifo/publications/2023/working-paper/impact-war-human-capital-and-productivity-ukraine.

30. DEV.UA. *Ukrainian IT sector provided 3.2% of GDP and paid over UAH 50 billion in taxes in 2025* URL:https://dev.ua/en/news/ukrainskyi-it-sektor-zabezpechyv-32-vvp-i-splatyv-ponad-50-mlrd-hrn-podatkiv-u-2025-rotsi-1775558025

31. Interfax-Ukraine. *[Economic news article]* / Interfax-Ukraine. 2026. URL:https://en.interfax.com.ua/news/economic/1157472.html

32. Організація економічного співробітництва та розвитку (OECD). *Digitalisation for recovery in Ukraine* [Електронний ресурс] / OECD Policy Responses on the Impacts of the War in Ukraine. 2022. URL:https://www.oecd.org/en/publications/digitalisation-for-recovery-in-ukraine_c5477864-en.html

33. Організація економічного співробітництва та розвитку (OECD). *Enhancing resilience by boosting digital business transformation in Ukraine* / OECD Publishing. 2024. URL:https://www.oecd.org/en/publications/enhancing-resilience-by-boosting-digital-business-transformation-in-ukraine_4b13b0bb-en.

34. Організація економічного співробітництва та розвитку (OECD). *OECD Economic Surveys: Ukraine 2025*/ OECD Publishing. 2025. URL:https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/05/oecd-economic-surveys-ukraine-2025_0bb82ef9/940cee85-en.pdf

References

1. Becker, G. (1964), *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, Columbia University Press, New York.

2. Lucas, R. E. Jr. (2015), "Human Capital and Growth", *American Economic Review*, vol. 105, No. 5, pp. 85–88. https://doi.org/10.1257/aer.p20151065

3. Grishnova, O. A. (2001), "Human capital in the system of economic categories", *Bulletin of Taras Shevchenko National University of Kyiv. Economics*, vol.49, pp. 55–61.

4. Romer, P. M. (1990), "Human capital and growth: Theory and evidence", *Carnegie-Rochester Conference Series on Public Policy*, vol. 32, No. 1, pp. 251–286.

5. Huang, H. and Song, J. (2026), "Digital Human Capital and Firms' Innovation Quality: Evidence from China", *Applied Economics Letters*, pp. 1–7. https://doi.org/10.1080/13504851.2026.2653819

6. Schwab, K. (2016), "The Fourth Industrial Revolution: What it means and how to respond", World Economic Forum, available at: https://www.weforum.org (accessed: 14.05.2026).

7. Aleca, O. E. and Mihai, F. (2025), "The Role of Digital Infrastructure and Skills in Enhancing Labour Productivity: Insights from Industry 4.0 in the European Union", *Systems*, vol. 13. Art. 113. https://doi.org/10.3390/systems13020113

8. He, X. and Chen, W. (2024), "Digital transformation and environmental, social, and governance performance from a human capital perspective", *Sustainability*, vol. 16. Art. 4737. https://doi.org/10.3390/su16114737

9. Flores, E., Xu, X. and Lu,Y. Human (2020), "Capital 4.0: A Workforce Competence Typology for Industry 4.0", *Journal of Manufacturing*

Technology Management, vol. 31, pp. 687–703. https://doi.org/10.1108/JMTM-08-2019-0309

10. Melnichuk, V. E. and Boiarinova, K. O. (2023), "Digitalization of human capital development", *Economic Bulletin of NTUU "Kyiv Polytechnic Institute"*, vol. 25, pp. 94–99. https://doi.org/10.20535/2307-5651.25.2023.278414

11. Kyrylchuk, O. V. and Krasota, O. V. (2026), "Structural transformations of human capital in the context of digital platforms development", *European Scientific Journal of Economic and Financial Innovation*, vol. 1(19). https://doi.org/10.32750/2026-0146

12. Duga, S. (2024), "Theoretical and methodological approaches to assessing human capital quality", *Economy and Society*, vol. 68. https://doi.org/10.32782/2524-0072/2024-68-9

13. World Bank. (2026), "Human Capital Index Plus (HCI+)", available at: https://datacatalog.worldbank.org/search/dataset/0067030/human-capital-index-plus (accessed: 14.05.2026).

14. OECD (2023), "Digital Skills and Labour Market Transformation", available at: https://www.oecd.org (accessed: 14.05.2026).

15. Gorobynska, M. and Krivtsova, T. (2025), "Impact of Industry 5.0 on enterprise resilience in the digital environment", *Financial and Credit Systems: Development Prospects*. Kharkiv: V. N. Karazin Kharkiv National University, vol. 2(17), pp. 167–180. https://doi.org/10.26565/2786-4995-2025-2-14

16. European Commission. Eurostat (2024), "Digitalisation in Europe – 2024 edition", available at: https://ec.europa.eu/eurostat/web/interactive-publications/digitalisation-2024 (accessed: 14.05.2026).

17. European Commission. Eurostat (2025), "Skills for the Digital Age", available at: https://ec.europa.eu/eurostat/statistics-explained (accessed: 14.05.2026).

18. European Commission. Eurostat (2025), "Digitalisation in Europe – 2025 edition", available at: https://ec.europa.eu/eurostat/web/interactive-publications/digitalisation-2025 (accessed: 14.05.2026).

19. OECD (2024), “Skills for the Digital Age”, OECD Digital Economy Outlook, available at: https://www.oecd.org (accessed: 14.05.2026).

20. European Commission. Eurostat (2025), “GDP and Employment Both Up by 0.1% in the Euro Area”, available at: https://ec.europa.eu/eurostat (accessed: 14.05.2026).

21. World Bank (2026), “Human Capital Project: Ukraine”, available at: https://thedocs.worldbank.org/en/doc/2026/original/Ukraine.pdf (accessed: 14.05.2026).

22. INSEAD (2026), “Portulans Institute. Global Talent Competitiveness Index 2025: Ukraine profile”, available at: https://www.globaltalentcompetitivenessindex.org/country/ukraine (accessed: 14.05.2026).

23. European Commission. (2020), “Digital Economy and Society Index (DESI)”, available at: https://digital-strategy.ec.europa.eu (accessed: 14.05.2026).

24. Global Talent Competitiveness Index. (2026), “Ukraine profile”, available at: https://www.globaltalentcompetitivenessindex.org/country/ukraine (accessed: 14.05.2026).

25. Polozova, T., Kolupaieva, I. and Sheiko, I. (2021), “Digital gap in EU countries and its impact on labour productivity and global competitiveness”, *Hradec Economic Days*, vol. 11, No. 1, pp. 659–670.

26. Trading Economics. (2026), “Ukraine Competitiveness Index”, available at: https://tradingeconomics.com/ukraine/competitiveness-index (accessed: 14.05.2026).

27. Libanova, E. and Romaniuk, S. (2023), “Conceptualization of governance in social relations”, *Demography and Social Economy*, vol. 53, No. 3, pp. 33–35.

28. OECD (2022), “The Future of Science in Ukraine”, available at: https://www.oecd.org (accessed: 14.05.2026).

29. Égert, B. and de la Maisonneuve, C. (2023), “The impact of the war on human capital and productivity in Ukraine”, CESifo Working Paper No. 10513, available at: https://www.ifo.de (accessed: 14.05.2026).

30. DEV.UA. Ukrainian IT sector provided 3.2% of GDP in 2025 (2026), “”, available at: https://dev.ua (accessed: 14.05.2026).

31. Interfax-Ukraine (2026), “Economic news article”, available at: https://en.interfax.com.ua (accessed: 14.05.2026).

32. OECD (2022), “Digitalisation for recovery in Ukraine”, available at: https://www.oecd.org (accessed: 14.05.2026).

33. OECD (2024), “Enhancing resilience by boosting digital business transformation in Ukraine”, available at: https://www.oecd.org (accessed: 14.05.2026).

34. OECD (2025), “OECD Economic Surveys: Ukraine 2025”, available at: https://www.oecd.org (accessed: 14.05.2026).

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