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Index-Based Analysis of Ukraine's Ranking Position in Human Capital Development

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Abstract: The article is devoted to an index-based analysis of Ukraine's ranking position in human capital development, with special attention to the interconnections between human capital, innovation activities, the knowledge economy, and the formation of national economic competitiveness. The analysis relies on international indexes whose dynamics reflect both Ukraine's development in this

area and the country's relative position in global rankings. According to the Global Competitiveness Index (GCI) for 2014–2019, Ukraine demonstrated progress in education and social protection, yet unresolved challenges remain in institutional capacity, stability, and public health. The lack of post-2019 data complicates the evaluation of reform outcomes. The Human Development Index (HDI) for 2015–2023 highlights strengths in education and healthcare, underpinned by macroeconomic stability and high literacy rates, though vulnerabilities persist. The Index of Economic Freedom (IEF) for 2015–2022 suggests that reforms contributed to stabilizing human capital development, but deficiencies in the rule of law, market openness, and financial freedom continue. Missing data for 2023 further obstruct analysis in the context of the ongoing war. Earlier, between 2008 and 2012, Ukraine ranked low in the Knowledge Index (KI) and Knowledge Economy Index (KEI), primarily due to weak institutions and insufficient innovation policy. The World Bank's subsequent discontinuation of these indexes limited opportunities for comparison and hindered strategic planning. The Global Talent Competitiveness Index (GTCI) confirms Ukraine's potential but stresses weak talent retention and limited support for skilled professionals. Similarly, the Global Innovation Index (GII) points to the urgent need to rebuild innovation potential through institutional strengthening, curriculum modernization, and infrastructure renewal. Overall, the findings underscore the need to же modernize education, foster STEM and digital skills, expand mentoring, and support both youth and older workers. These efforts are critical for innovation recovery and can inform strategic policies in education, innovation, and employment.

Keywords: economic freedom; global competitiveness; human capital; human development; knowledge economy

Introduction

In the current context of global competition, the development of human capital is a key factor for economic growth, social well-being, and a country's innovation potential. The quality, mobility, education level, and health of the population increasingly determine a nation's ability to adapt to changes in the global market and ensure the competitiveness of its economy. At the same time, for developing countries, particularly Ukraine, the issue of effective formation, preservation, and utilization of human capital is extremely relevant, considering demographic challenges, migration, the mismatch between education and labor market needs, and the lack of investment in human resources.

In this context, international indexes, in particular the Global Talent Competitiveness Index (GTCI) and the Human Capital Index (HCI) serve as important tools for assessing a country's success. These indexes allow for comparison of the effectiveness of human capital management in a global dimension. Analyzing Ukraine's ranking position helps to identify the dynamics of its development, the strengths and weaknesses of the national model of human capital formation, and to outline strategic directions for its improvement.

However, academic studies that systematically analyze Ukraine's position in global human capital indexes remain limited, while available statistics often fail to account for the causal relationships between specific index components and concrete economic or political processes in the country. This highlights the need for a more in-depth index-based analysis that takes into consideration both internal and external factors influencing Ukraine's position in the global ranking landscape. For the first time, a comprehensive, expanded analysis of international indices and sub-indices was conducted to identify trends and create recommendations for improving Ukraine's rating positions.

Literature review

As of today, many scholars are interested in studying the ranking of country in human capital development, which underlies the influence of its indicators.

Duha [1] analysed modern tools for the formation and utilization of human capital in Ukraine, emphasizing their practical application in the domestic economy. This approach not only enables the identification of strengths and weaknesses in the human capital formation system but also allows for the tracking of changes in its qualitative and quantitative characteristics over time, including those influenced by external factors. At the same time, the relationship between the use of these tools and international rankings was not sufficiently explored, and the reasons behind the country's ranking dynamics were not analysed.

Kozyr [2] researched the formation of an indicator system for assessing Ukraine's potential for future recovery, where human capital is mentioned as one component of the overall potential, because the ranking of human capital development serves as a tool for comprehensive monitoring of a country's progress in education, innovation capacity, digital transformation, and labor market structure. Analyzing trends in composite indicators, particularly indexes, facilitates timely responses to challenges and the development of effective mechanisms for the modernization of human capital management. Nevertheless, the study lacks a dedicated focus on the index-based evaluation of human capital and does not provide an in-depth analysis of international indexes.

In the study by Krasota and Radkevych [3], the interconnection between human capital development and sustainable economy was revealed, emphasizing the importance of social investment. However, the analysis of Ukraine's specific ranking positions is insufficient.

Krylov [4] analysed ranking assessments of innovation activity in Ukraine, indirectly addressing human capital as an impact on innovation. Yet, human capital as an independent category was not the main object of the research, and its ranking assessment was not included in the analysis.

Kuprina [5] explored the economic transformation of the national economy through the lens of global competitiveness, including human capital as one of the important components. However, insufficient attention was paid to the index-based assessment of human capital in Ukraine.

Mishchuk and Husaruk [6] studied the impact of human capital on the innovative development and competitiveness of enterprises. Nevertheless, the researchers mainly focused on the microeconomic level, without analysis of Ukraine's national ranking positions in global indexes.

Morozova [7] addressed the relevance of human capital utilization in enterprises, considering international experience. The trends in human capital development should be understood not merely as changes in the level of education, qualifications, and labor productivity, but as transformations in access to educational, healthcare, and information services under the influence of institutional, economic, and motivational factors. Studying these changes through the lens of international indexes allows for a deeper assessment of both the driving and constraining factors in realizing the potential of human capital and, accordingly, substantiates directions for improving state investment and information policies. However, the national ranking position of Ukraine in the field of human capital development was not examined.

Pererva and Kuchynskyi [8] focused on the effective formation of human capital to enhance the market potential of enterprises, emphasizing the importance of strategic personnel management. Alongside this, their study lacks analysis of the macro-level development of human capital in the context of international indexes.

Plaksiuk et al. [9] considered human capital as a factor of improving company efficiency and competitiveness, with examples of corporate governance. However, the study does not address the national context and lacks an analysis of Ukraine's human capital performance in global rankings.

Volosnikova et al. [10] studied the directions of increasing Ukraine's competitiveness under globalization, taking into account the role of human capital as one of the key factors. However, the study did not conduct an index-based analysis of Ukraine's positions in international human capital rankings, which limits the assessment of dynamic changes in a comparative context.

Zinchenko and Samoilenko [11] examined the global dimension of human capital development, outlining its role in the knowledge economy and specifics of its assessment. However, the study did not reflect the dynamic changes in Ukraine's rankings or the impact of internal factors on its global position.

Thus, Ukraine's ranking position in international human capital development indexes requires further research, with a systematic consideration of internal and external impacts on its dynamics, as well as the identification of structural imbalances for the development of effective strategic decisions in this field.

The aim of the article is to conduct a comprehensive index-based analysis of Ukraine's ranking position in the field of human capital development based on international indexes, in order to identify main impacts and, consequently, determine strategic directions for enhancing the effectiveness of human capital formation and utilization under conditions of global competition.

Methods

As part of the scientific research on the ranking assessment of human capital development in Ukraine in index positions of the country, various research methods were applied in the article. These include:

1) systematic approach – the study of the essence of index-based analysis of human capital development as a method of using international indexes to examine and measure changes in sub-indexes and/or indicators across space and time as impacts on Ukraine's ranking position;

2) grouping – used for grouping specific sub-indexes and/or indicators while analyzing the impacts on Ukraine's ranking position in human capital development according to international indexes;

3) statistical analysis – reviewing trends in the human capital development in Ukraine according to international indexes, their impact on the competitiveness and ranking position of the country among other countries in the world from 2013 to 2023 year. Trend analysis was performed and demonstrated in graphs;

4) comparative analysis – applied in comparing Ukraine's ranking position in human capital development across different periods based on index values;

5) abstraction – determination of key characteristics of the rating assessment of human capital development, taking into account impacts on the country's position in the global knowledge economy;

6) analysis and synthesis – identifying key problems in human capital development and specification of changing conditions in Ukraine based on the ranking position according to international indexes;

7) structural-logical generalization – used for identifying strategic directions to enhance the effectiveness of human capital formation and utilization in Ukraine under global competition, taking into account the influencing factors shaping strategic priorities in this area.

Results and discussion

In the context of modern global transformations and the emergence of the knowledge economy, human capital is a key factor in the competitiveness of the national economy and the development of society. Demographic challenges, migration processes, and the reform of education and healthcare systems have a significant impact on the human capital development in the country, particularly on its ranking positions in international indexes. To monitor and analyze the dynamics of human capital development in Ukraine, it is essential to utilize international rankings aimed at assessing both the overall state of human resources and the effectiveness of public policy in the economic and social spheres. Over the past decades, Ukraine, as a country undergoing constant socio-economic and political transformations, has demonstrated fluctuating results in human capital development, which necessitates a systematic index-based analysis. So, during 2014–2018, Ukraine experienced unstable trends in the dynamics of human capital

development according to the ***Global Competitiveness Index (GCI)***, which were associated with economic reforms and structural changes (Table 1).

Table 1: Analysis of Ukraine's Human Capital Development in GCI Ranking for 2014–2018 Based on the Previous Methodology

No	Index and Its Components	2014–2015		2015–2016		2016–2017		2017–2018	
		1–7	Rank	1–7	Rank	1–7	Rank	1–7	Rank
	Global Competitiveness Index (GCI)	4.1	76	4.0	79	4.0	85	4.1	81
1	Basic requirements	4.4	87	4.1	101	4.0	102	4.2	96
1.1	Institutions	3.0	130	3.1	130	3.1	129	3.2	118
1.2	Infrastructure	4.2	68	4.1	69	3.9	75	3.9	78
1.3	Macroeconomic environment	4.1	105	3.1	134	3.2	128	3.1	121
1.4	Health and primary education	6.1	43	6.1	45	6.0	54	6.0	53
2	Efficiency enhancers	4.1	67	4.1	65	4.0	74	4.1	70
2.1	Higher education and training	4.9	40	5.0	34	5.1	33	5.1	35
2.2	Goods market efficiency	4.0	112	4.0	106	4.0	108	4.0	101
2.3	Labor market efficiency	4.1	80	4.3	56	4.2	73	4.0	86
2.4	Financial market development	3.5	107	3.2	121	3.0	130	3.1	120
2.5	Technological readiness	3.5	85	3.5	86	3.6	85	3.8	81
2.6	Market size	4.6	38	4.5	45	4.4	47	4.5	47
3	Innovation and sophistication factors	3.4	92	3.6	72	3.5	73	3.5	77
3.1	Business sophistication	3.7	99	3.7	91	3.6	98	3.7	90
3.2	Innovation	3.2	81	3.4	54	3.4	52	3.4	61

Source: developed by the author [12]

From the end of 2014 to the beginning of 2018, Ukraine's GCI score remained relatively stable within the efficiency range of 4.0 to 4.1. However, the country's position in the ranking fluctuated between 76th and 85th place. This indicates that even with stable internal indicators, other countries demonstrated more dynamic progress in improving their rankings. Low reform effectiveness, corruption, and institutional instability negatively affected Ukraine's competitiveness.

The subindex of ***Basic Requirements*** showed a downward trend from 2014 to 2016, decreasing from 4.4 to 4.0, with only a slight improvement by the end of 2017 (to 4.2). In 2016 Ukraine's rank reached its lowest point (102nd place), indicating significant problems in fundamental institutional and infrastructural characteristics.

The *Institutions* had the most negative impact, as the weakest component, with scores ranging from 3.0 to 3.2 and one of the worst global positions – 130th place during 2014–2016. This suggests a lack of trust in the judiciary, ineffective public administration, widespread corruption, and weak rule of law. A slight improvement by the end of 2017 (up to 118th place) may be attributed to the launch of anti-corruption initiatives and judicial reforms. However, such changes remained limited, as the country's ranking in the subindex of Basic Requirements rose to 96th place.

Meanwhile, *Infrastructure* appeared to be a relatively stable indicator. Its score slightly declined from 4.1 to 3.9 during the analyzed period, reflecting a fairly stable subindex position, despite a noticeable drop in rank from 68th to 78th place. This indicates a relatively acceptable state of transportation, energy, telecommunications. However, outdated roads, the lack of strategic planning, and poor connectivity in rural areas constrain Ukraine's position at the macroeconomic level.

Macroeconomic Environment, as a key indicator, demonstrated a significant decline in score from 4.1 to 3.1 and a drop in ranking from 105th to 134th place between 2014 and 2017. This was largely due to military conflict in Eastern Ukraine, the devaluation of the hryvnia, high inflation, external debt, and an unstable exchange rate. The lack of economic predictability and dependence on international loans (from the IMF, EU, etc.) significantly undermined investor confidence in Ukraine.

At the same time, *Health and Primary Education* emerged as one of the strongest indicators, with only a slight decrease in score from 6.1 to 6.0 and a decline in rank from 43rd to 54th place over the entire period analyzed. This may reflect a high level of access to basic education and healthcare services. However, issues such as low quality of education and outdated medical technologies remain unresolved, as this indicator tends to reflect quantitative rather than qualitative characteristics, which ultimately affects its rank and the overall subindex.

As another subindex, ***Efficiency Enhancers*** reflect a stable score ranging from 4.0 to 4.1, with Ukraine's ranking position fluctuating between 65th and 74th place during the analyzed period. In this context, Ukraine demonstrates high potential, but fails to realize it due to a weak institutional foundation.

Higher Education and Training appear as a consistently strong indicator, with scores ranging from 5.0 to 5.1 and structural fluctuations in the ranking improving from 40th to 35th position. This situation may indicate a well-developed system of higher education institutions and a large number of specialists with university degrees. However, problems persist in the lack of alignment between education and the labor market, the outflow of qualified personnel abroad, and low motivation for R&D.

Consequently, the *Goods Market Efficiency* shows weak performance at the level of 4.0, despite an improvement in the ranking from 112th to 101st place. This could suggest low competition in the country, monopolization of economic sectors, and difficulties in doing business due to non-transparent regulations.

As a result, the *Labor Market Efficiency* showed relative volatility as a rise in ranking from 80th to 56th place in 2014–2015, followed by a decline to 86th place by the end of 2017, with a stable fluctuation in the score between 4.1 and 4.0. This may point to inflexibility in labor legislation, migration of professionals, and weak incentives for workforce productivity.

The *Financial Market Development* steadily worsened, with the score dropping from 3.5 to 3.1 and the ranking fluctuating between 107th and 120th place, likely due to a banking system crisis, loss of trust in authorities, and the shadow economy.

At the same time, *Technological Readiness* remained a relatively stable indicator, showing a slight improvement in score from 3.5 to 3.8, and an increase in ranking from 85th to 81st place. Between 2014 and 2017, digital technologies were gradually introduced in the country, with growing significance of the IT sector as particularly after the Government's adoption of the Concept for the Development of E-Governance in Ukraine.

However, the widespread application of innovations remains limited, as indicated by the situation with *Market Size*, whose score fluctuated between 4.6 and 4.5, while the ranking significantly declined from 38th to 47th place. While this indicator is based on population size and internal potential, it remains problematic due to low purchasing power and underdeveloped domestic value chains.

As the final subindex, the ***Innovation and Sophistication Factors*** showed moderate score fluctuations from 3.4 to 3.5 over the analyzed period and occupied relatively low positions, with a moderate upward trend from 92nd to 77th place, contributing to long-term competitiveness.

One of the indicators, *Business Sophistication*, reflected unstable trends in the ranking, rising from 99th to 91st place in 2014–2015, declining to 98th in 2016, and then increasing again to 90th by the end of 2017. At the same time, the indicator remained almost unchanged at the level of 3.7 throughout the period, as Ukrainian companies rarely integrate into global supply chains, demonstrate weak strategic management, and show low productivity in implementing innovations.

However, *Innovation* as another indicator showed a relatively positive trend, with an increase in the score from 3.2 to 3.4 and stable fluctuations in the ranking towards improvement – from 81st to 61st place. Still, the score remained rather low, considering no significant changes occurred from 2015 to 2017. Despite the growth of the startup culture, particularly in IT, driven by the activation of agricultural and industrial projects, state support for innovation remains almost nonexistent. In this regard, institutional support for innovation is greatly needed not only from government and local authorities but also from civil society organizations, which could be financed by potential entrepreneurs and a segment of the solvent population. This, in turn, would increase labor productivity and support startup development.

According to the new ***Global Competitiveness Index (GCI)*** calculations from 2018 to 2019, the analysis of an index reflects the complex and contradictory state of Ukraine's economy, characterized by both positive trends and serious structural problems (Table 2).

Table 2: Analysis of Ukraine's Human Capital Development in the GCI Ranking for 2018–2019 Based on the New Methodology

Category	**Components**	**2018**		**2019**	
		%	**Rank**	**%**	**Rank**
Global Competitiveness Index (GCI)		57.0	83	57.0	85
Enabling environment	Institutions	46.3	110	47.9	104
	Infrastructure	70.1	57	70.3	57
	ICT adoption	51.0	77	51.9	78
	Macroeconomic stability	55.9	131	57.9	133
Human Capital	Health	72.0	94	65.6	101
	Skills	68.9	76	69.9	44
Markets	Product market	55.3	73	56.5	57
	Labor market	59.5	66	61.4	59
	Financial system	48.7	117	42.3	136
	Market size	62.7	47	63.0	47
Innovation ecosystem	Business dynamism	55.3	86	57.2	85
	Innovation capability	39.0	58	40.1	60

Source: developed by the author [13]

During the analyzed period, the GCI remained unchanged at 57.0%, yet Ukraine dropped in the ranking from 83rd to 85th place. This may correspond to a slower rate of improvement in Ukraine's ranking compared to other countries, where key constraining factors were reflected in specific categories.

For instance, regarding the ***Enabling Environment***, the growth in the *Institutions* indicator from 46.3% to 47.9% (moving from 110th to 104th place) points to minor progress in public governance, anti-corruption measures, or the judicial system. However, the level remains critically low due to the prolonged judicial reform, slow progress in combating corruption, and ongoing political instability. Despite a slight increase in the *Infrastructure* from 70.1% to 70.3%, Ukraine retained the 57th position in the ranking. This position may reflect relative competitiveness in the development of transport, energy, and communication infrastructure. At the same time, the wear and tear of the transport network, especially in the regions, and uneven development require increased investment through public-private partnerships (PPPs), particularly in the IT sector. Indeed, *ICT Adoption* showed a minor increase (from 51.0%

to 51.9%) alongside a deterioration in ranking from 77th to 78th place. This indicates a slowdown in digitalization compared to competitors, due to an underdeveloped IT infrastructure in rural areas and the outflow of IT professionals abroad. Meanwhile, macroeconomic stability showed a slight rise from 55.9% to 57.9%, but a drop in ranking from 131st to 133rd place, reflecting the worst result, likely caused by the overall public debt stemming from high inflation and the devaluation of the national currency.

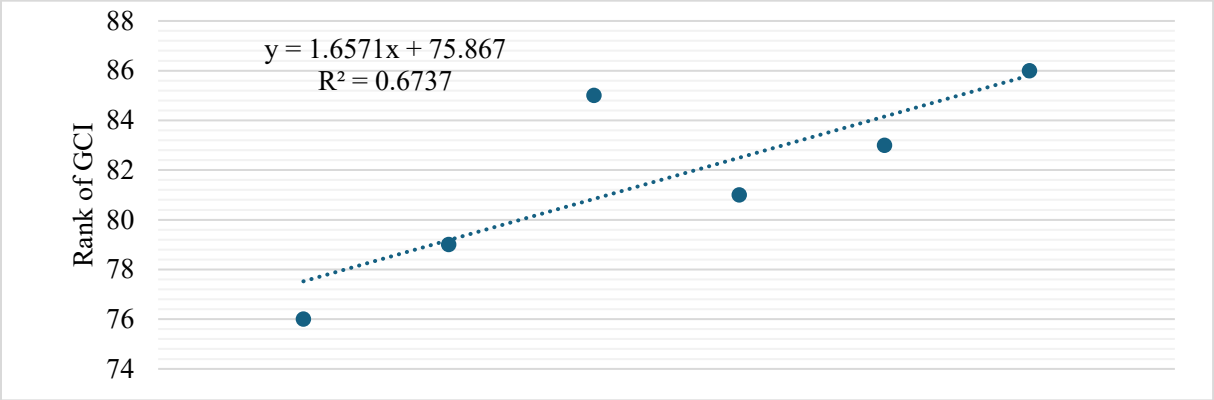
Under the category of ***Human Capital***, the *Health* showed a decline from 72% to 65.6%, with a drop in the ranking from 94th to 101st place, which is a serious warning sign. By the end of 2019, access to medical services had significantly worsened due to the low level of healthcare system funding, leading to increased mortality, especially among working-age men. In contrast, the improvement in the *Skills* indicator from 68.9% to 69.9%, which moved up in the ranking from 76th to 44th place, represents the most positive development. This situation reflects an improvement in the quality of secondary and higher education, as well as the development of competencies in demand on the labor market. However, the spread of distance learning and the increase in training of qualified personnel through academic mobility programs may not always have a positive impact on the ranking in the long term, due to the worsening situation in the healthcare sector. This highlights the need to support dual education, particularly in IT and STEM fields related to this sector.

Under the category of ***Markets***, the *Product market* increased from 55.3% to 56.5%, rising in the ranking from 73rd to 57th place. This may indicate signs of deregulation and improved ease of doing business, considering the simplification of registration procedures and partial liberalization of foreign trade. Consequently, the *Labor Market* showed improvement from 59.5% to 61.4%, moving up in the ranking from 66th to 59th place, indicating relative labor market flexibility. At the same time, massive labor migration limits the availability of the workforce within the country, which has brought the *Financial System* to a critical level, with the indicator dropping from 48.7% to 42.3% and the ranking falling from 117th to 136th place. A high level of distrust in banks and limited business lending may have negatively affected the *Market Size*, which showed stable growth (from 62.7% to 63.0%) but remained at 47th place in the ranking. This reflects the attractiveness of the domestic market for investors due to its geographical location and ongoing trade with the EU. However, the growth of this indicator requires investment in the domestic market, which would contribute to the development of an innovation ecosystem within the country.

As a separate category, the ***Innovation Ecosystem*** reflects a slight growth in two indicators. In particular, *Business Dynamism* showed an increase from 55.3% to 57.2%, rising in the ranking from 86th to 85th position. This may suggest a facilitation in the formation of a business environment and the country's readiness for change in the context of the expansion of innovative business support programs, as *Innovation Capability* displayed a slight increase from 39.0% to 40.1%. However, the decline in ranking from 58th to 60th position for this indicator demonstrates lagging behind countries that actively invest in R&D, where limited funding for scientific research and the outflow of talent abroad played a significant role.

As we can see, Ukraine demonstrates certain positive shifts in education and the market environment. However, issues related to institutional weakness, macroeconomic instability, the decline of the financial system, and the deterioration of public health remain unresolved. As a result, the competitiveness trend based on trend analysis demonstrated negative dynamics with a further decrease in positions in the rating with a probability of $R^2 = 0.6737$ (Fig. 1). Moreover the absence of data on Ukraine in the GCI ranking after 2019 complicates the comprehensive assessment of human capital development dynamics and limits the possibilities for effective strategic management. The inability to conduct international comparisons of the country's competitiveness makes it impossible to objectively evaluate the effectiveness of reforms in education, healthcare, the labor market, and the innovation environment as key components shaping human capital. The lack of comparative GCI indicators negatively affects decision-making in the formation and implementation of the state's investment and information policies in the field of human capital development, as it reduces access to representative data on the effectiveness of implemented targeted programs, the international investment climate, and the dynamics of transformations in economic and social spheres. At the same time, the GCI remains one of the key tools for systemic assessment of national economic development, taking into account a wide range of factors – from the institutional environment to the population's level of technological skills.

Figure 1: GCI rating trend analysis of Ukraine from 2014 till 2019



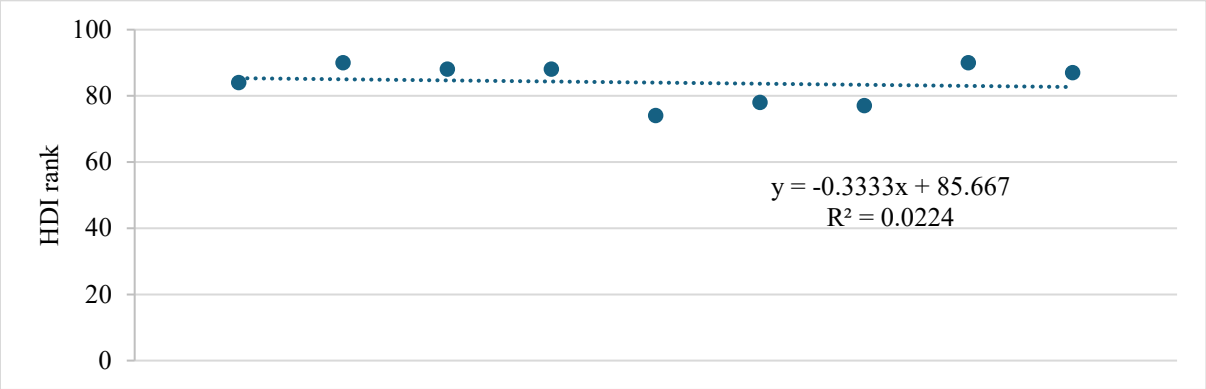
Source: made by authors based on [12, 13]

Identifying the specific factors influencing Ukraine's competitiveness can be facilitated by an analysis of the ***Human Development Index (HDI)***, which, over the period from 2015 to 2023, demonstrates trends in Ukraine's ranking position within the overall macroeconomic environment and allows for an analysis of the dynamics of the country's economic and social development (Table 3).

Table 3: Analysis of Ukraine's Human Capital Development in the HDI Ranking for 2015–2023

No	Index and Its Components	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Human Development Index (HDI), score / rank	0.778	0.780	0.785	0.784	0.789	0.783	0.772	0.772	0.779
		84	90	88	88	74	78	77	90	87
1	Life Expectancy Index	0.811	0.822	0.831	0.825	0.829	0.820	0.794	0.811	0.822
1.1	Life expectancy at birth (years)	72.7	73.4	74	73.6	73.9	73.3	71.6	72.7	73.4
2	Education Index	0.757	0.751	0.754	0.748	0.750	0.748	0.739	0.739	0.739
2.1	Mean Years of Schooling Index	0.747	0.747	0.747	0.740	0.740	0.740	0.740	0.740	0.740
2.1-1	Mean years of schooling (years)	11.2	11.2	11.2	11.1	11.1	11.1	11.1	11.1	11.1
2.2	Expected Years of Schooling Index	0.767	0.756	0.761	0.756	0.761	0.756	0.739	0.739	0.739
2.2-1	Expected years of schooling (years)	13.8	13.6	13.7	13.6	13.7	13.6	13.3	13.3	13.3
3	Income Index	0.770	0.770	0.775	0.780	0.786	0.783	0.780	0.767	0.775
3.1	Gross national income per capita, PPP$	16379	16348	16886	17479	18193	17821	17517	16044	16933

Figure 2: HDI ranking trend analysis of Ukraine from 2015 till 2023.



Source: made by authors based on [14].

So, during 2015–2019, the value of the HDI fluctuated from 0.778 to its peak of 0.789, then declined to 0.772 in 2020–2022, and slightly increased to 0.779 by the end of 2023. The country's position in the global ranking also changed: from 84th place (2015) to 74th place (2019), followed by a drop to 90th place in 2022 and a slight rise to 87th place in 2023. Given this, it is worth examining the simple indexes included in the HDI, which would help specify the factors influencing the situation.

The value of the ***Life Expectancy Index (LEI)*** during 2015–2019 fluctuated from 0.811 to 0.829 and by the end of 2021 had decreased to 0.794, before slightly recovering to 0.822 by the end of the analyzed period. The main influencing factor here was *Life Expectancy at Birth*, which in 2017 reached its peak of 74 years, then fell noticeably to 71.6 years in 2021, and gradually increased to 73.4 years in 2023. It can be assumed that by the end of 2019, the healthcare system had significantly improved. However, the COVID-19 pandemic from 2020 and the full-scale war since 2022 caused a decline in the availability of medical services. This created a serious psychological burden on the population due to worsening living conditions in combat zones, increased mortality among working-age men, and the mass migration of medical personnel abroad.

At the same time, the ***Education Index (EI)*** decreased from 0.757 in 2015 to 0.739 in 2020 and remained unchanged through the end of 2023. In this situation, both the *Mean Years of Schooling (MYS)* and the *Expected Years of Schooling (EYS)* remained consistently low during the crisis period (11.1 years and 13.3 years, respectively) impacting on the certain indexes. In addition to the closure of educational institutions in frontline areas, damaged infrastructure and outdated teaching methods significantly contributed to a decrease in the number of students in Ukraine and the migration of young people abroad. All this caused inequality in access to quality education, the loss of potential among teaching and academic staff, and slowed the integration of digital technologies in rural areas, despite stability in basic education and a high literacy rate among the population.

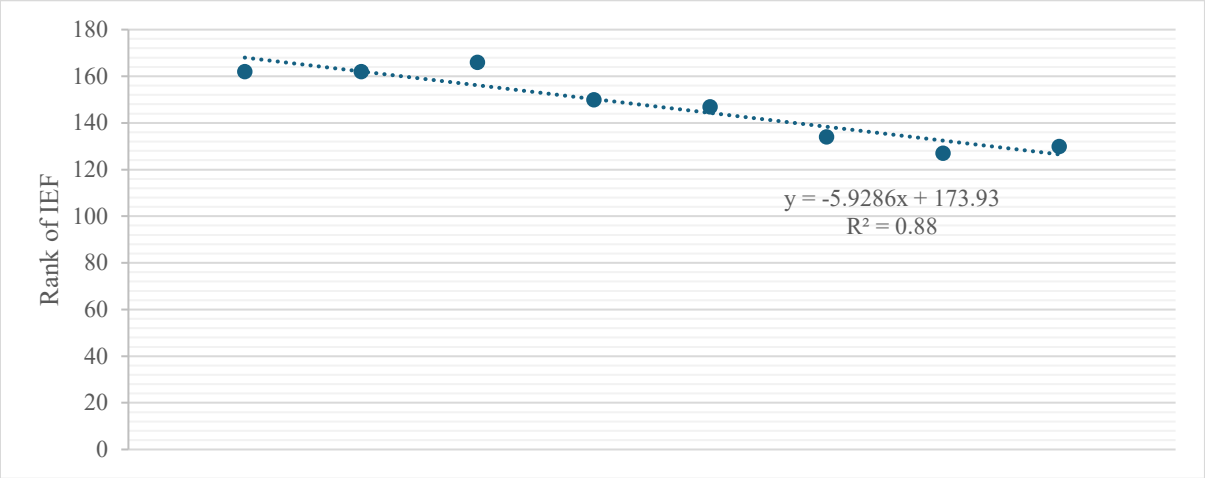
Accordingly, the ***Income Index (II)*** increased from 0.770 to 0.786 during 2015–2019, followed by a decline to 0.767 in 2022 and partial recovery in 2023 (to 0.775). As the main impact, *GNI per capita at PPP* rose from $16,379 to $18,193 by the end of 2019, but dropped to $16,044 in 2022, with a slight increase in 2023 (to $16,933). It is worth noting that IT services exports grew significantly up to 2019; however, the crisis caused by the COVID-19 pandemic and later the war led to the suspension of innovative product manufacturing. This situation was driven by the shadow economy, heavy dependence on foreign aid, and the decline in the real purchasing power of the population.

Trend analysis of the dynamics of the HDI rating did not reveal any regularity in trends, which requires the search for more informative indices (Figure 2). Moreover, education and healthcare remain critical areas requiring urgent reform. Particularly concerning is the persistently low EI, which hinders the long-term development of human capital, while maintaining macroeconomic stability and a high level of basic literacy create potential for recovery. Therefore, a detailed review of Ukraine's macroeconomic stability is proposed through an analysis of the ***Index of Economic Freedom (IEF)*** and its components for 2015–2022 (Table 4)..

Table 4: Analysis of Ukraine's Human Capital Development in the IEF Ranking for 2015–2022

Category	Components	2015	2016	2017	2018	2019	2020	2021	2022
Index of Economic Freedom (IEF), score / rank		46.9	46.8	48.1	51.9	52.3	54.9	56.2	54.1
		162	162	166	150	147	134	127	130
Rule of law	Property rights	20.0	25.0	41.4	41.0	43.9	47.5	48.5	39.7
	Judicial effectiveness	-	-	22.6	29.5	31.5	42.2	41.1	31.4
	Government integrity	25.0	26.0	29.2	29.0	29.6	37.9	37.9	33.8
Government size	Tax burden	78.7	78.6	78.6	80.2	81.8	81.1	88.7	89.1
	Government spending	28.0	30.6	38.2	45.0	46.9	47.2	48.2	44.5
	Fiscal health	-	-	67.9	75.9	82.6	83.9	87.7	73.6
Regulatory efficiency	Business freedom	59.3	56.8	62.1	62.7	66.1	61.3	63.5	61.1
	Labor freedom	48.2	47.9	48.8	52.8	46.7	48.3	48.7	60.7
	Monetary freedom	78.6	66.9	47.4	60.1	58.6	63.0	65.8	71.2
Market openness	Trade freedom	85.8	85.8	85.9	81.1	75.0	81.2	79.2	78.6
	Investment freedom	15.0	20.0	25.0	35.0	35.0	35.0	35.0	35.0
	Financial freedom	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Figure 3: IEF ranking trend analysis of Ukraine from 2015 till 2022



Source: developed by the author [15]

Trend analysis revealed negative dynamics of Ukraine's economic freedom rating for the period from 2015 to 2022, with the probability of further decrease $R^2 = 0{,}88$. So, during 2015–2021, the value of the IEF increased from 46.9% (162nd place) to its peak of 56.2% (127th place), where partial reforms in taxation, fiscal policy, business deregulation, and the strengthening of fiscal control played a significant role. By the end of 2022, the IEF had decreased to 54.1% (130th place), as martial law and political instability became restraining factors in the dynamics of index. Therefore, as of today, unresolved issues remain, including insufficient progress in the rule of law and market openness, as well as only minor improvements in investment and financial freedom. Consolidation of the achieved results should focus on deepening structural reforms and strengthening the legal system.

Relying on the category of the ***Rule of Law***, between 2015 and 2021, the *Property Rights* increased from 20.0% to 48.5% due to judicial system reforms and the introduction of electronic property registries. However, in 2022, the war and cases of corporate raiding negatively affected the indicator, reducing it to 39.7%. Consequently, a high level of corruption and political influence over the courts deprived foreign investors of guarantees for property rights protection, particularly in agriculture and for SMEs investing in innovations. As a result, *Judicial Effectiveness* rose between

2017 and 2021 from 22.6% to 41.1%, taking into account the institutionalization of the National Anti-Corruption Bureau of Ukraine and the Specialized Anti-Corruption Prosecutor's Office. Nevertheless, inconsistent implementation of judicial reform and martial law, which restricted court proceedings, had a negative impact on the indicator, lowering it to 31.4% by the end of 2022. Under such conditions, *Government Integrity* gradually increased from 25.0% to 37.9% during 2015–2021 due to the introduction of the Prozorro system and the launch of the Unified Public Services Portal "Diia". However, in 2022, the indicator experienced a notable decrease (to 33.8%) because of restricted access to many electronic systems, particularly of a financial nature, during martial law, due to instances of cyberattacks from hostile actors.

The category of ***Government Size*** reflects a gradual increase in the *Tax Burden* over the analyzed period, from 78.7% to 89.1%, indicating a reduction in fiscal pressure due to tax system reform, simplified administration, and the introduction of incentives for SMEs. However, such conditions do not provide sufficient fiscal space for investment. Between 2015 and 2021, *Government Spending* rose from 28.0% to 48.2%, primarily due to increased subsidies and social expenditures. By the end of 2022, however, the indicator had decreased to 44.5%, with an emphasis on defense spending. Consequently, *Fiscal Health* showed an increase between 2017 and 2021 from 67.9% to 87.7%, but in 2022, the indicator declined to 73.6% due to external debt, budget revenue shortages, and the need for loans during wartime.

The ***Regulatory Efficiency***, as a category, reflects moderate fluctuations in indicators. In particular, between 2015 and 2019, *Business Freedom* showed an upward fluctuation from 59.3% to 66.1%, largely driven by the simplification of business registration through online platforms under startup support programs. However, in 2020, the indicator sharply declined to 61.3%, rose again in 2021 to 63.5%, and by the end of 2022 fell to 61.1% due to licensing issues in certain sectors related to regulatory instability. Alongside this, the *Labor Freedom* showed notable growth from 48.2% in 2015 to 52.8% in 2018, a drop to 46.7% in 2019, and a sharp increase to 60.7% by the end of the analyzed period. In this context, factors such as flexible labor legislation, opportunities for remote work, and the legalization of freelancing may have played a role. Under these conditions, *Monetary Freedom* reflected noticeable fluctuations, with a drop from 78.6% in 2015 to 47.4% in 2017, a sharp rise to 60.1% in 2018, and a significant increase to 71.2% by the end of 2022, where price liberalization under the influence of external markets and inflation played a substantial role.

Finally, the category of ***Market Openness*** reflects a rather unfavorable picture regarding the trend of changes in the indicators. In particular, *Trade Freedom* shows a decline from 85.8% to 75.0% over 2015–2019, mostly due to a decrease in exports, a slight increase in 2020 to 81.2% owing to the partial recovery of export-import operations, and a gradual decline by the end of 2022 caused by trade barrier issues and damaged logistics as a result of hostilities within the country. At the same time, *Investment Freedom* recorded only one increase during 2015–2018 (from 15.0% to 35.0%), followed by stagnation throughout the analyzed period due to the absence of investment security guarantees and the risks associated with the war. As for *Financial Freedom*, this indicator remained stagnant throughout the entire period at the level of 30.0%, which could be attributed to the incomplete implementation of banking system reforms, the "crowding-out effect" of government expenditures, and low competition among non-bank financial institutions and small enterprises.

In 2023, there are no available data for Ukraine in the IEF ranking. This may be due to the impact of the war on the economic situation, which has complicated the collection and objective assessment of data, as well as significant structural changes in the economy, including the redistribution of state resources and changes in the legislative framework. The latter could have led to a temporary inability to assess the level of economic freedom using the traditional methodology. All this complicates the evaluation of the dynamics of economic reforms and reduces the quality of rating-based governance in human capital development. After all, economic freedom is an important factor in human capital development, providing opportunities for self-realization, entrepreneurship, and innovative activity. Without up-to-date data, the government and international investors face difficulties in making informed decisions regarding the country's economic development, which makes any analysis of the situation only approximate.

As for the available IEF data, Ukraine has made significant progress in fiscal discipline, tax policy, and labor regulation. However, it lags behind in terms of investment attractiveness, financial freedom, protection of property rights, and transparency of the legal system. So, reforms should be not only quantitative but also structural and profound, taking into account martial law and post-war recovery, which particularly requires considerable attention to the knowledge economy.

Between 2008 and 2012, there was a slight decline in the ***Knowledge Index (KI)*** and the ***Knowledge Economy Index (KEI)***, which are used to assess the development of the national knowledge economy. The state of human capital development in Ukraine during this period points to a number of structural, institutional, and technological problems that existed already at the beginning of the institutional reform process. Therefore, it is important to analyze each

indicator, specifying the impacts on the knowledge economy development within the framework of the government's and society's understanding of these issues (Table 5, Figure 4).

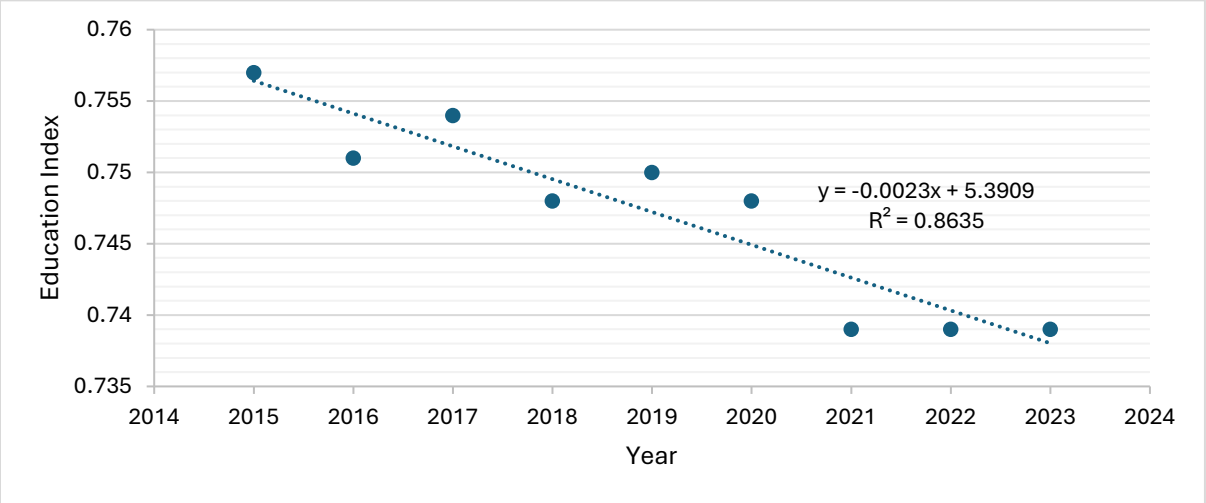
Over the period from 2008 to 2012, the KI declined from 6.38 to 6.33. The decrease in the overall level of workforce training through education and the use of ICT may have been the result of the deterioration of state policy in the field of education and the slow development of digital infrastructure.

Table 5: Analysis of Ukraine's Human Capital Development in the KI and KEI Ranking for 2008 and 2012

No	Index and Its Components	2008		2012	
		1–10	Rank	1–10	Rank
1	Knowledge Index (KI)	6.38	-	6.33	-
2	Knowledge Economy Index (KEI)	5.80	52	5.73	56
2.1	Economic incentive regime	4.06	70	3.95	93
2.2	Education	7.91	22	8.26	21
2.3	Innovation	5.77	48	5.76	59
2.4	ICT	5.45	58	4.96	77

Source: developed by the author [16, 17]

Figure 4: Trend analysis of Education index of Ukraine from 2015 till 2023



Source: made by authors based on [14]

This situation could have been driven by insufficient funding for education and science, as well as limited access to quality ICT education. It was caused by a lack of incentives for innovation, particularly in the digitalization of education, despite the relatively high potential of the population.

At the same time, the KEI fell from 5.80 (52nd place) in 2008 to 5.73 (56th place) in 2012 as an integrated index that takes into account four subindexes. The decline in ranking indicates a deterioration in Ukraine's competitive position in the global knowledge economy due to political instability, slow economic reforms, and the absence of a long-term knowledge development strategy. This led to institutional weakness and a non-transparent economic policy under

conditions of low investment in innovation, while the educational level of the population at that time remained relatively high. Analyzing each subindex separately, it should be noted that almost all of them experienced a decline in Ukraine's ranking between 2008 and 2012.

The most significant drop among all KEI subindexes was observed in the *Economic Incentive Regime*, which fell from 4.06 (70th place) to 3.95 (93rd place) over the analyzed period. This situation may reflect a worsening of economic instability due to non-fulfillment of contractual obligations, an increase in corruption among high-ranking officials, and, as a result, the expansion of the shadow economy under conditions of ineffective regulation of investment activity, rooted in the absence of legal certainty for investors.

At the same time, *Education* is the only subindex that demonstrated positive trends as an increase from 7.91 (22nd place) to 8.26 (21st place). The dynamics of the decline in the education index also confirms this negative trend with the probability $R^2 = 0.8635$ of further decline, although the level of education has the highest Ukrainian ratings in international rankings of GCI. In this context, Ukraine has consistently occupied high positions due to the wide coverage of education, the large number of higher education institutions, and the high literacy rate of society, taking into account the stable demand for education and its accessibility for various social groups. However, despite the strong educational culture and high-quality technical training of personnel, Ukraine at that time still faced issues of insufficient practical orientation and outdated curricula, which reflected a lack of alignment with the needs of the labor market.

The *Innovation* declined from 5.77 (48th place) to 5.76 (59th place). Although its absolute value remained almost unchanged, the position in the ranking significantly worsened. A major factor behind this drop was the lack of funding for R&D in the absence of a national innovation strategy aimed at fostering cooperation between the state, science, and business in the process of commercializing ideas.

Finally, the *ICT* noticeably decreased from 5.45 (58th place) to 4.96 (77th place), indicating Ukraine's technological lag in the IT sector due to the low level of digital technology implementation in public administration, limited access to broadband Internet in the regions, and the high cost of digital infrastructure for the population. All of these contributed to the problem of uneven digital infrastructure development, taking into account the limited use of ICT in the fields of education and healthcare.

As the dynamics of the KI and KEI over the 2008–2012 period show, that Ukraine was noticeably lagging behind its competitors in the global context, amid systemic deterioration in institutional, innovation, and ICT areas. At that time, insufficient attention was paid to innovation, which points to a low level of efficiency in state policy in the sphere of the knowledge economy and to institutional weakness that hindered scientific and technological progress.

At the same time, the World Bank's discontinuation of the official calculation of the KEI and KI after 2012 has made the analysis of these indexes impossible, resulting in Ukraine's absence from the respective rankings. Consequently, conducting a comprehensive analysis of the level of knowledge economy development in Ukraine becomes quite challenging. This complicates international comparisons and reduces the effectiveness of decisions related to developing the innovation potential of research activities carried out by highly skilled personnel, where talent competitiveness plays a key role. In this case, it is advisable to analyze further trends in the accumulation, modernization, and retention of human capital in Ukraine in the context of effective integration into the global knowledge and technology environment by examining the analysis of the ***Global Talent Competitiveness Index (GTCI)*** over the period 2015–2023 (Table 6).

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Table 6: Analysis of Ukraine's Human Capital Development in the Global Talent Competitiveness Index (GTCI) Ranking for 2015–2023, %

No	Index and Its Components, score / rank	2015–2016	2017	2018	2019	2020	2021	2022	2023
	Global Talent Competitiveness Index (GTCI)	41.4	42.3	41.5	39.4	41.5	47.4	40.6	44.8
		66	69	61	63	66	61	66	64
1	Enable	45.2	40.9	38.7	39.8	40.7	44.9	36.3	40.4
		91	103	99	96	94	85	86	75
2	Attract	39.8	41.0	33.8	34.5	43.6	47.7	52.7	53.4
		97	94	98	105	93	80	59	57
3	Grow	37.8	42.6	38.5	36.0	37.7	38.8	30.1	35.9
		72	64	66	68	68	57	75	68
4	Retain	50.9	54.7	52.4	46.2	45.1	54.0	56.9	65.1
		56	54	58	66	73	59	52	50
5	Vocational & technical skills	47.0	43.6	49.3	45.8	46.8	49.6	41.1	42.7
		40	66	44	45	56	69	82	77
6	Global knowledge skills	27.9	31.3	36.3	34.3	34.8	49.6	26.3	31.2
		61	53	42	37	46	39	51	50

Source: developed by the author [18]

Throughout the analyzed period, the GTCI showed moderate fluctuations. The largest decline occurred in 2019 (from 41.4% to 39.4%), while the biggest increase was in 2021 (up to 47.4%). However, changes in the index barely reflected on Ukraine's ranking position: in 2015–2016, the country held 66th place; in 2017, it dropped to 69th; in 2018, it rose to 61st; by 2020, it fell back to 66th; and in 2021, it sharply climbed to 61st position. Subsequently, during 2022, the index decreased to 40.6% (66th place), and in 2023, it rose to 44.8% (64th place). Despite some improvements through crisis management, other leading countries progressed faster and more effectively, preventing Ukraine from strengthening its ranking positions despite the gradual growth of the index itself, while extraordinary events significantly affected both the index and its rank.

When it comes to *Enable*, this indicator showed unstable trends both in value and ranking position. In 2015–2016, its value was 45.2% (91st place), which sharply dropped to 40.9% (103rd place) in 2017, and by the end of 2018 it further declined to 38.7%, despite a partial rise in ranking to 99th position. This decline may have been caused by political instability, slow reform progress, weak protection of property rights, and limited access to quality public services. Subsequently, by the end of 2021, the indicator rose to 44.9% (85th place), driven by economic digitalization, intensified anti-corruption efforts, business deregulation, and increased institutional capacity amid European integration aspirations. In 2022, it again fell to 36.3% (86th place), negatively impacted by military threats, weakening of the legal system, and overall worsening business conditions. By the end of 2023, there was some recovery with the indicator rising to 40.4% (75th place), likely due to the adaptation of public administration to wartime conditions, enhanced international support, and increased civic society activity.

At the same time, the *Attract* showed uneven fluctuations. In 2015–2016, its value was 39.8% (97th place), rising to 41.0% (94th place) in 2017, reflecting gradual integration into international markets with positive signals for specialist migration. However, in 2018, the indicator significantly dropped to 33.8% (98th place), which can be explained by increased internal instability, brain drain, and an unfavorable investment climate. In 2019, the indicator slightly increased to 34.5%, but the ranking fell to 105th place, indicating Ukraine's slower improvement compared to other countries. From 2020 through the end of the analyzed period, the indicator steadily rose from 43.6% (93rd place) to 53.4% (57th place). This growth could be attributed to the implementation of various digital platforms supporting the expansion of remote employment to increase international technical assistance, which stimulates business relocation and, consequently, fosters institutional support for cooperation with the Ukrainian diaspora and foreign representatives.

The *Grow* also reflected uneven trends. From 2015 to 2016, the indicator was 37.8% (72nd place), rising in 2017to 42.6% (64th place), indicating gradual recovery of the education system, strengthening of professional growth, and adaptation of educational programs to labor market needs. By the end of 2019, the indicator gradually declined to 36.0%, ranking 68th. This drop can be explained by unstable funding for education reforms, caused by a lack of systematic support for workforce development at enterprises, resulting in unequal access to quality education. Subsequently, the indicator steadily increased to 38.8% in 2021, reaching 57th place. This rise can be linked to the transition to online learning, which activated educational initiatives that expanded coverage and access to learning resources. In 2022, the indicator sharply dropped to 30.1% (75th place) due to widespread destruction of educational infrastructure caused by the war, which forced the temporary suspension of the educational process in many regions. However, mobilization of volunteer educational platforms, support from international organizations, and the expansion of distance learning enabled the education system to adapt to wartime conditions, leading to a recovery of the indicator to 35.9% and an improvement to 68th place by 2023.

The *Retain* demonstrates an overall positive trend amid uneven changes in ranking positions. From 2015 to 2016, the indicator was 50.9% (56th place), rising to 54.7% (54th place) in 2017. Despite an increase to 52.4% in 2018, the ranking dropped to 58th place, reflecting stronger competition from other countries. In 2019, there was a significant decline both in value (to 46.2%) and ranking (to 66th place), which may indicate economic instability and brain drain caused by weak social support for specialists. In 2020, the indicator further declined to 45.1% (73rd place), partly explained by the COVID-19 pandemic, which worsened employment conditions and deepened social vulnerability. In 2021, the situation somewhat improved, with the indicator rising to 54.0% (59th place), likely due to government anti-crisis measures introducing flexible work formats and expanding support for workers and digital services. In 2022, the indicator increased again to 56.9% (52nd place), driven by the growing role of volunteer initiatives in remote employment and increased patriotic motivation to stay in the country despite the war. In 2023, the indicator reached its highest level at 65.1%, rising to 50th place. Stabilization may have been supported by increased internal resilience of the talent retention system due to the launch of public-private initiatives, including expanded psychological support programs and employment provision for especially vulnerable groups (wounded military personnel, victims of hostilities, internally displaced persons).

The *Vocational & Technical Skills* demonstrated uneven fluctuations. In 2015–2016, the indicator stood at 47.0% (40th place), which may reflect Ukraine's relatively strong position in the development of applied skills. In 2017, the indicator declined to 43.6%, with a sharp drop in ranking to 66th place, associated with reduced funding for vocational and technical education institutions due to migration of technical specialists and weak modernization of educational programs. In 2018, the indicator rose to 49.3% (44th place), likely driven by reforms in vocational education including the introduction of dual training systems. In 2019, the indicator fell to 45.8% (45th place), which may indicate insufficient investment in practical workforce training and youth outflow. In 2020, there was a slight increase to 46.8%, but the ranking dropped to 56th place, reflecting faster progress by other countries in developing professional skills. Accordingly, in 2021 the indicator increased to 49.6%, but again fell in ranking to 69th place. Despite internal improvement, it was insufficient against the general progress of competitors. In 2022, the value sharply declined to 41.1%, and the ranking dropped to 82nd place, directly reflecting the war situation and associated destruction of educational infrastructure, workforce mobilization, and reduction in educational opportunities. A slight increase to 42.7% and improvement to 77th place by the end of 2023 may indicate increased investment support for upskilling programs in vocational and technical education institutions by civil society and international organizations, helping the education system adapt to new realities.

The *Global Knowledge Skills* showed an overall upward trend with some declines alternating with recoveries. In 2015–2016, the indicator was only 27.9% (61st place), reflecting Ukraine's weak integration into global innovation and knowledge creation chains, as well as limited application of knowledge-intensive technologies. In 2017, the indicator rose to 31.3% (53rd place), which may reflect increased participation of Ukrainian researchers in international programs based on cooperation with European partners and IT sector development. In 2018, the indicator sharply increased to 36.3% (42nd place), explained by a growing number of startups and increased exports of high value-added services. In 2019, the indicator slightly declined to 34.3%, but the ranking improved to 37th place, indicating more stable positioning of Ukraine on the international stage. In 2020, the indicator slightly increased to 34.8%, but the ranking fell to 46th place, reflecting intensified competition among countries in the innovation environment, especially amid the COVID-19 pandemic that stimulated investment in technologies. In 2021, the indicator sharply rose to 49.6% (39th place), primarily due to digital transformation, activation of online education, technological business flexibility, and implementation of international projects involving Ukrainian citizens. However, in 2022, the value collapsed to 26.3% (51st place), caused by the loss of part of the scientific and educational infrastructure, migration of intellectual

personnel, and decreased participation in international scientific exchange due to martial law. In 2023, the situation somewhat stabilized: the indicator rose to 31.2% (50th place), possibly indicating adaptation by some educational institutions and research organizations to new conditions in the context of maintaining international cooperation and enhancing digitalization during the war.

As we can see, Ukraine has a stable potential in human capital management but is unable to fully realize it due to military, political, and economic upheavals. The key issues relate to the absence of a systemic policy for talent retention and, consequently, a low level of attraction and support for highly qualified personnel. Therefore, despite a strong IT foundation, the flexibility of civil society, a high level of basic education, and the creative potential of the youth, it is necessary to focus on implementing programs to attract and bring back Ukrainian specialists from abroad, creating a stable talent support system by investing in educational infrastructure, and thereby fostering a favorable innovation environment through business deregulation.

The implementation of these reforms is possible given the country's innovative potential, which can be assessed by analyzing the human capital development in Ukraine according to the ***Global Innovation Index (GII)*** for the period 2015–2024 (Table 7).

Table 7: Analysis of Ukraine's Human Capital Development in the Global Innovation Index (GII) Ranking for 2015–2024, %

No	Index and Its Components, score / rank	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
	Global Innovation Index (GII)	36.5	35.7	37.6	38.5	37.4	36.3	35.6	31.0	32.8	29.5
		64	56	50	43	47	45	49	57	55	60
1	Input Sub-Index (ISI)	39.1	38.9	41.0	40.5	40.7	40.2	39.6	35.7	33.3	31.6
		47	76	77	75	82	71	76	75	78	78
1.1	Institutions	52.2	48.7	47.9	49.1	53.9	55.6	56.2	47.4	38.4	30.8
		98	101	101	107	96	93	91	97	100	107
1.2	Human capital & research	40.4	40.8	39.6	37.9	35.6	40.5	38.2	36.6	35.6	34.3
		36	40	41	43	51	39	44	49	47	54
1.3	Infrastructure	26.3	32.3	39.3	38.1	36.0	33.1	32.3	38.7	36.9	35.5
		112	99	90	89	97	94	94	82	77	82
1.4	Market sophistication	43.9	42.1	43.2	42.7	43.3	42.1	42.3	23.4	23.2	25.7
		89	75	81	89	90	99	88	102	104	85
1.5	Business environment	32.4	30.6	35.3	34.5	34.8	29.5	28.9	32.3	32.4	31.8
		78	73	51	46	47	54	53	48	48	45
2	Output Sub-Index (OSI)	33.9	32.5	34.2	36.6	34.1	32.5	31.6	26.4	32.3	27.4
		47	40	40	35	36	37	37	48	42	54
2.1	Knowledge & Technology Outputs (KTO)	36.4	34.1	32.8	36.7	34.6	35.1	32.3	32.9	30.0	31.1
		34	33	32	27	28	25	33	36	45	34
2.2	Knowledge Creation (KC)	31.3	31.0	35.6	36.5	33.5	29.9	30.9	19.8	34.6	23.7
		75	58	49	45	42	44	48	63	37	68

Source: developed by the author [19]

Thus, during 2015–2024, the GII demonstrated uneven fluctuations with a gradual deterioration of the overall result (from 36.5% to 29.5%). The highest value was reached in 2018 (38.5%), which coincided with the best ranking position when Ukraine occupied 43rd place. The subsequent decline, particularly after 2020, is linked to the aggravation of the security situation due to the COVID-19 pandemic, and since 2022 – to the full-scale war, which led to a talent outflow, a decrease in investment in science and innovation, and a slowdown in reforms. After the drop in 2022 to

31.0% (57th place), a slight increase was observed in 2023 to 32.8% (55th place). However, in 2024 the GII fell to 29.5%, causing a drop to the 60th position in the ranking.

The ***Input Sub-Index (ISI)*** throughout the analyzed period showed uneven trends reflected in changes in its indicators. In 2015, the ISI stood at 39.1% and ranked 47th, based on relatively high values of key indicators that contributed to a comparatively strong position. In 2016, despite a slight decrease in the overall score to 38.9%, the ranking fell to 76th place, which was due to the downward trend in indicators such as the *Institutions* – from 52.2% (98th place) to 48.7% (101st place), with a gradual decline in ranking until 2018 (107th place), and *Human Capital & Research*, which slightly increased from 40.4% to 40.8% but saw a noticeable ranking drop from 36th to 40th place, continuing to decline until 2019 (51st place). This situation may indicate a deterioration in the regulatory environment and the country's scientific and educational capacity. Thus, in 2017, despite the score increasing to 41.0%, the ISI ranking remained almost unchanged (77th place), as the growth in certain indicators, in particular, *Infrastructure* – from 26.3% (112th place) to 39.3% (90th place) and *Business Environment* – from 32.4% (78th place) to 35.3% (51st place), was insufficient to significantly improve Ukraine's position amid the overall progress of other countries.

In 2018, a slight decrease in the ISI to 40.5% (75th place) was caused by declines in indicators such as the Institutions, which scored 49.1% while ranking 107th, and *Human Capital & Research*, which fell to 37.9% (43rd place). This situation signals insufficient development of higher education and scientific personnel. In 2019, despite a stable overall value (40.7%), the ISI ranking dropped to 82nd place due to decreases in indicators like *Human Capital & Research* – to 35.6% (51st place) and *Infrastructure* – to 36.0% (97th place). This points to deepening problems related to security and the effectiveness of infrastructure project management, reflecting growing barriers to competition in education and science. In 2020, the ISI value decreased to 40.2%, yet the ranking rose to 71st place. This was due to improvements in indicators such as the *Institutions* – to 55.6% (93rd place) and *Human Capital & Research* – to 40.5% (39th place). These gains acted as compensatory factors against a backdrop of global market slowdown, reflected by a drop in the *Market Sophistication* to 42.1% (99th place), and worsening business environment conditions, as shown by the *Business Sophistication* falling to 29.5% (54th place).

However, starting from 2021 and continuing until the end of the analyzed period, the decline in the favorability of the institutions – accompanied by a gradual fall of the indicator of *Institutions* to 30.8% (107th place) after a slight increase – the deficit of human resources, and limited access to science, evidenced by the indicator of *Human Capital & Research* dropping to 34.3% (54th place), led to a gradual decline in the ISI to 29.5% (60th place). At the same time, the indicators of *Infrastructure*, *Market Sophistication*, and *Business Sophistication* showed unstable fluctuations. This situation indicates a profound regression in trust toward state institutions, which gradually restricted access to knowledge and technology, causing losses in infrastructure capacity and a reduction in private initiative due to war, legal uncertainties, and investment instability. All of this was reflected in the results of ***Output Sub-Index (OSI)***, which correspond to the achievement of planned indicators in the ISI.

The OSI over demonstrated uneven trends both in value and in ranking, which can be explained by fluctuations in its component indicators – *Knowledge & Technology Outputs (KTO)* and *Knowledge Creation (KC)*. Between 2015 and 2018, the OSI value fluctuated upward from 33.9% to 36.6%, accompanied by a gradual rise in ranking to 35th place. This trend reflects a notable increase in KTO rankings (from 34th to 27th place) amid moderate value fluctuations from 36.4% to 32.8% up to 2017, followed by a sharp increase in 2018 to 36.7%. A similar upward trend in ranking was observed for KC, which rose from 75th to 45th place. While in 2015–2016 the indicator fluctuated between 31.3% and 31.0%, by the end of 2018 its value had grown to 36.5%.

At the same time, starting from 2019 and continuing until 2022, the OSI experienced a gradual decline to 26.4%, which was also reflected in its component indicators. The KTO fluctuated between 34.6% and 35.1% during 2019–2020, with an improvement in ranking from 28th to 25th place, but by the end of 2022 the ranking dropped to 36th place, continuing to fall sharply in 2023 to 45th place. In 2024, the situation improved, and the ranking rose to 34th place. However, despite noticeable ranking fluctuations, the result remains at a low level, given the moderate downward trend in value from 34.6% to 31.1%. As for KC, despite a slight decline in value in 2019 to 33.5%, the ranking somewhat improved to 42nd place. However, by the end of 2022, the indicator had undergone a gradual decline in ranking to 63rd place, while its value during 2020–2021 showed moderate growth from 29.9% to 30.9%, only to experience a sharp drop in 2022 to 19.8%. This situation indicates a deep crisis in the field of science, reflected in reduced innovation funding. This, in turn, gradually limited access to technology, thereby lowering the competitiveness of national cultural and digital products against the backdrop of the war, which triggered an outflow of highly skilled personnel.

During 2023, the OSI rose to 32.3% (ranking 42nd), but by the end of 2024 it decreased to 27.4%, dropping to 54th place in the ranking. The dynamics of the OSI were primarily influenced by KC, which increased to 34.6% (37th place) in 2023 but sharply declined to 23.7% (68th place) in 2024. This situation was driven by a reduction in the number of published creative works, largely due to a decline in online creativity, which significantly decreased the export of design services. At the same time, KTO had almost no impact on the OSI, as this indicator slightly decreased to 30.0% (45th place) during 2023, then showed a barely noticeable rise to 31.1% by the end of 2024, while its ranking position improved notably to 34th place. This outcome may be attributed to stable volumes of patent applications, scientific publications, and high-tech exports of innovative products amid declining scientific activity in other countries.

As seen from the GII trends, the recovery and growth of Ukraine's innovation potential require comprehensive strengthening of institutional capacity to support the renewal of educational programs. The implementation of these programs will reflect the gradual reconstruction of critical and civil infrastructure in the post-war period, thereby improving market conditions with the support of the knowledge economy. At the same time, the quality of human capital remains a crucial prerequisite for the development of the innovation ecosystem. Human capital is the carrier of knowledge, skills, and creative ideas, which form the foundation for the effective functioning of the national innovation system, underscoring the need to analyze the dynamics of the Human Capital Index (HCI) for Ukraine (Table 8).

Table 8: Analysis of Ukraine's Human Capital Development in the Human Capital Index (HCI) Ranking for 2015–2017, %

No	Index and Its Components, score / rank	2015	2016	2017				
					Subindexes			
	Human Capital Index (HCI)	76.2	78.4	71.3	71.5	81.7	72.6	59.3
		31	26	24	38	5	31	38
1	0–14 age group	90.5	90.7	86.6	Development	-	-	-
		27	28					
2	15–24 age group	77.5	78.0	72.4		Capacity	Deployment	-
		17	15					
3	25–54 age group	66.8	71.8	70.5				Know-How
		41	32					
4	55–64 age group	79.2	79.1	66.0	-			
		19	21					
5	65+ age group	72.4	72.2	73.1	-			-
		9	10					

Source: developed by the author [20]

So, during 2015–2017 Ukraine's HCI showed generally unstable trends. While in 2015 the HCI was 76.2%, ranking 31st, in 2016 the result increased to 78.4%, but by the end of 2017 it had decreased to 71.3%. The noticeable competitiveness of especially leading countries did not become a clear stimulus for Ukraine's human capital development. This is indicated by the gradual rise in the country's ranking to 24th place despite the decline in the index value itself. The main factor behind these shifts was structural changes in the age composition of the population, represented by five age groups. Each group had a different impact on the overall HCI assessment, which in 2017 included four subindexes.

For example, the indicator of the *0–14 age group* showed stable fluctuations during 2015–2016 within the range of 90.5% (ranked 27th) to 90.7% (28th), but by the end of 2017 it dropped to 86.6%. This group is key in terms of the potential for future educational integration. The slight decline in 2017 could have resulted from reduced education coverage or demographic changes (lower birth rates, migration), which also influenced the HCI decrease.

Meanwhile, the indicator of the *15–24 age group* demonstrated stable growth during 2015–2016 – from 77.5% (ranked 17th) to 78.0% (15th), but experienced a significant decline in 2017 to 72.4%. This situation may correspond to a partial outflow of youth abroad, combined with insufficient adaptation of the education system to labor market needs. This is further confirmed by the overall HCI deterioration in 2017, as this indicator is critical in the context of professional training and mobility.

Speaking about the *25–54 age group* as the most economically active segment of the population, this indicator rose from 66.8% (ranked 41st) in 2015 to 71.8% (32nd place) in 2016, but then declined to 70.5% in 2017. This drop may have been caused by uneven employment, which contributed to professional degradation and relocation of specialists.

The indicator of the *55–64 age group*, despite high values, gradually decreased during 2015–2016 from 79.2% (ranked 19th) to 79.1% (21st place), and in 2017 fell to 66.0%. This situation may have been influenced by changes in pension policy and rising unemployment among pre-retirement age individuals due to reduced expected productivity in this age group. Considering that this indicator remains significant for professional activity, the negative trend substantially impacted the overall HCI.

Finally, the indicator of the *65+ age group* demonstrated relative stability throughout the analyzed period: in 2015–2016, a slight decline from 72.4% (ranked 9th) to 72.2% (10th place), followed by an increase to 73.1% in 2017. Despite its low direct impact on economic productivity, the high values of this indicator reflect relatively good living conditions, increased attention to healthcare, and social support for the elderly during this period.

Accordingly, based on the subindexes used to calculate the HCI in 2017, the *Capacity* holds the highest value (81.7%), ranking Ukraine 5th, while the *Know-How* has the lowest value (59.3%), ranking 38th, similar to the *Development*, which scored 71.5%. All of this is causally linked to the *Deployment*, which had a value of 72.6% (31st place). Under these conditions, *Development* reflected a negative impact on the HCI due to weak career guidance, which affected the *Deployment* and, especially, *Know-How*. Without properly organized career guidance activities, initial aspirations for acquiring knowledge, reflected by the high education, subindex influenced mainly by the indicators of the first two age groups and continuous learning among older adults. All of these was reflected by the high indicator value for the *65+ age group* – often disorient individuals in choosing their field of study within the education process, leading to continuous changes in professional interests. On the one hand, the constant search for new knowledge motivates individuals to take responsibility for acquiring skills and applying this knowledge in their professional duties. On the other hand, it slows down the country's scientific and technological development because changes in individuals' areas of interest do not always align with shifts in demand among various population segments for innovations. Innovations often fail to reach the improved level initially expected by the population. This issue frequently becomes a barrier to the development of human capital in the long term. It hinders the introduction of innovative technologies to the market technologies on which the quality of services in all other critically important sectors largely depends, including IT, agriculture, industry (especially military), energy, and healthcare.

Given the above, it is advisable to analyze the HCI according to the new calculations since 2018 on a scale from 0 to 1, which will allow for a more detailed identification of impacts on human capital development in Ukraine (Table 9).

Table 9: Analysis of Ukraine's Human Capital Development in the Human Capital Index (HCI) Ranking for 2010–2020 (Scale 0–1)

No	Index and Its Components	2010	2017	2018	2020
	Human Capital Index (HCI)	0.63	0.65	0.64	0.63
1	Survival to age 5	0.99	0.99	0.99	0.99
2	Education	0.25	0.25	0.24	0.24
2.1	Mean years of schooling	10.27	10.20	10.12	9.87
2.2	Expected years of schooling	13.10	13.01	12.91	12.91
	Harmonized test scores	490.09	490.00	490.09	478.17
3	Health	-	-	-	-
3.1	Survival rate to age 60	0.77	0.81	0.81	0.81
3.2	Low stunting rate in children	-	-	-	-

Source: developed by the author [21]

So, the new HCI calculations based on three subindexes over the period 2010–2020 reflected overall stability in the index trends, with a slight downward trend: while from 2010 to 2017 there was a modest increase (from 0.63 to 0.65), by the end of 2020 the HCI had gradually declined to 0.63. These fluctuations can be explained by the uneven development of the three key subindexes, such, which, in turn, were influenced by demographic, social, economic, and institutional factors.

The *Survival to Age 5* remained consistently high throughout the analyzed period (at 0.99) indicating the effectiveness of the primary healthcare system and maternal and child health protection. In this context, Ukraine achieved a positive level in terms of basic child survival, which helped to maintain the overall HCI at an adequate level.

At the same time, the *Education* showed stagnant or slightly negative trends: from 0.25 in 2010–2017 to 0.24 in 2018–2020. Meanwhile, the *Mean Years of Schooling* decreased over 2010–2020 from 10.27 to 9.87 years, while the *Expected Years of Schooling* declined from 13.10 to 12.91 years. These trends indicate a gradual reduction in engagement with the education system, driven both by demographic changes (a decrease in the number of school-age youth) and by reduced accessibility and/or motivation for formal education. The deterioration of *Harmonized Test Scores* (from 490.09 to 478.17 points) further indicates a decline in the quality of knowledge acquired by students in the school system, which negatively affects the HCI.

Finally, the *Health* is presented only partially; however, data on the *Survival Rate to Age 60* show an increase from 0.77 to 0.81 between 2010 and 2017, with the figure remaining unchanged by the end of the analyzed period. This indicates an improvement in the overall condition of the adult population, driven by reduced premature mortality and more effective implementation of preventive measures. At the same time, the lack of data on the *Low Stunting Rate in Children* makes it impossible to fully assess the health status of the future generation, which remains a weak point in the human capital monitoring system.

So, despite consistently high child survival rates and improvements in adult survival, the negative trends of the subindex of *Education*, reflected in the shortening of the duration of schooling and the decline in its quality, have significantly constrained the growth of the HCI. Since the sectors of education and health form the foundation of innovative development, further improvement of the HCI is possible only with systematic investment in the quality and duration of the educational process, taking into account comprehensive monitoring of the health status of the younger

generation. At the same time, the lack of HCI data on Ukraine's ranking position complicates the assessment of the country's long-term human capital potential and the effectiveness of governance in the fields of education and healthcare. Such limitations may negatively affect international confidence in the country's economic forecasts, as they reduce the accuracy of strategic public policy planning.

As mentioned above, in Ukraine, the key issues hindering the development of human capital include insufficient investment in the education sector, limited opportunities for vocational training, retraining and specialization, a shortage of qualified personnel in priority sectors, and the imperfection of national systems for assessment, monitoring, and quality management of human capital. Under conditions of global competition and ongoing transformations, these problems significantly affect Ukraine's ranking in international indexes related to human capital development. In this context, the development of index-based and ranking analysis systems becomes particularly important as a tool for identifying trends, assessing dynamics, and shaping effective policies at the levels of the state, regions, enterprises, and educational institutions. At the same time, Ukraine experiences a deficit of comprehensive analytical tools capable of systematically tracking the dynamics of human capital development. This complicates the adoption of strategic decisions regarding investment incentives in human resources and the determination of priority development directions [6].

Moreover, the lack of integrated systems for analyzing changes in the structure, qualification level, and mobility of personnel leads to a fragmented understanding of issues related to education, employment, and personnel management. This reduces the adaptability of the economy to labor market challenges and global technological changes [5]. Additional complications arise from a range of external and internal factors, including economic instability, the absence of unified national systems for data collection and processing, and the impact of global crises – such as the COVID-19 pandemic and the full-scale war. These factors reduce the accuracy of assessments and the relevance of certain indicators, which in turn necessitates the implementation of new adaptive approaches to human capital assessment including current risks and trends [4]. Under such conditions, index analysis of Ukraine's human capital development can provide a more objective understanding of the country's actual socio-economic situation and serves as a basis for developing well-founded recommendations for improving investment and information policies in the field of human capital management [3].

The demographic crisis caused by the prolonged martial law in Ukraine has increased the risks to the preservation and reproduction of human capital. Forced population displacement, the loss of labor resources due to hostilities, as well as the destruction of educational and medical infrastructure significantly complicate the dynamics of capital recovery reflecting in international indexes [10]. In the context of worsening demographic conditions, there is an urgent need to develop a comprehensive and adaptive demographic policy focused on supporting the reproduction of human capital. This includes stimulating birth rates, improving social standards, developing childcare infrastructure, and creating conditions for the harmonization of professional realization with family responsibilities. Particular importance in this process is given to monitoring the age structure of the population as one of the key parameters in the index analysis of human capital [9].

A significant role in the development of human capital in Ukraine is played by the transformation of household structures and changes in traditional family models. The increasing number of single-parent families and individuals living alone affects the processes of children's socialization and the formation of their educational trajectories. This necessitates the adaptation of the education system and social support mechanisms to the new demographic realities, which are reflected in the structure of indicators used in the index-based analysis of human capital [11].

Urbanization processes also have a significant impact on the quality of human capital, as evidenced by regional disparities in access to educational, cultural, and social resources. The concentration of human resources in large cities leads to unequal development opportunities for the population residing in rural areas. This situation requires the territorial factor to be taken into account in the development of national strategies for human capital development and the design of targeted programs to support rural areas, which, in turn, influence the country's ranking in global indexes [8].

Conclusion

Based on a comprehensive analysis of the GCI, IEF and Education index, a negative trend with a high probability of further decline was identified. The trends based on the HDI did not have significant regularities, which does not allow using this index for strategic planning of human capital development. A detailed analysis of international indices and sub-indices allowed us to identify the main problem factors and provide recommendations for improving Ukraine's ranking based on international indices: 1. It is necessary to modernize all levels of the education system in accordance

with international standards, which will help update the content of curricula and the methods for assessing teaching, academic, and research staff, with the aim of improving the quality of training qualified personnel and strengthening their competitiveness in the labor market. At the same time, the implementation of the education system reform, launched back in 2017, faces numerous challenges, including resistance to change from part of the teaching community and limited financial resources. Despite the fact that Ukraine's education system has significant potential for forming high-quality human capital, there are serious problems in the field of education that require systematic solutions.

2. It is necessary to expand programs supporting birth rates, parenthood, and families with children in frontline and affected regions, as well as the development of modern primary and secondary education with an emphasis on digital skills. All this requires creating conditions for the return of Ukrainian citizens from abroad, which is fundamentally based on stimulating the long-term residence of families in Ukraine through financial and social support for young households. An important area here may be an integrated policy to support birth rates through cash payments, the provision of affordable housing, the modernization of kindergarten programs, medical care for mothers, and incentives for employers to adopt flexible work arrangements for parents. In addition, the possibility of directing investment resources toward the modernization of abandoned schools will make it possible to introduce mobile school hubs and digital educational platforms by investing in blended distance learning, ensuring access to basic education even in communities with a low number of children. Accordingly, improving the quality management system of individualized education requires adapting displaced children to new learning conditions through the launch of programs for the return and reintegration of children from abroad, as well as motivational programs for teachers in zones of educational crisis.

3. It is advisable for the future development of education to change the principles of education based on quality, accessibility, inclusiveness, and alignment with the needs of the modern economy, which will create a solid foundation for the accumulation of human capital. In this context, it is important to carry out reforms in the education system with a focus on the needs of the economy. These reforms involve the introduction of programs for the return of students after studying abroad (grants, employment guarantees) through targeted educational loans to be repaid by working in Ukraine, as well as the internationalization of Ukrainian higher education. The implementation of this action plan requires rethinking the educational paradigm from a quantitative to a qualitative approach by introducing programs for graduates' adaptation to internship conditions, soft skills, and startup management, with a priority focus on funding educational programs in shortage occupations under state procurement. Under these conditions, the consolidation of higher education institutions and the merging of resources will make it possible to improve the quality of education by establishing a network of hub universities in the regions, developing dual education, cooperating with business companies, and supporting university startups and technological business incubators.

4. It is important to implement targeted youth support programs, including grants for participation in international technology platforms with opportunities for remote work, which can significantly enhance the social status of young professionals. Considering the resource potential for targeted investment in international educational programs and mentorship, it is advisable to modernize the system of vocational and technical education by introducing programs to bring young people back through online employment, scholarships, internships, and support for youth entrepreneurship.

5. It is necessary to encourage the employment of people over the age of 50, thereby contributing to the increase of labor productivity through digital transformation, retraining, and support for STEM education. Under such conditions, it is advisable to engage retirees in mentoring and light work aimed at improving pension literacy and enhancing the mental health of older individuals. However, given the extensive experience of the older generation, it is important to introduce "second profession" programs to support career changes, taking into account regular preventive medical check-ups and targeted support for women over 40 in the labor market. All this requires the implementation of proactive longevity programs, mentoring (especially in education, healthcare, and social protection), and digital skills training with their application in hybrid roles (for example, as consultants). At the same time, the depth of worldview and loyalty to values among the elderly enables, in the long term, the creation of platforms for civic engagement, accompanied by programs to protect the physical and mental health of older people and initiatives for intergenerational transfer of values and experience. This also necessitates healthcare system reforms focused on access to quality medical services, social support for the population, and the introduction of anti-crisis medical programs for large families, pensioners, veterans, victims, and internally displaced persons. In this regard, modeling an effective mechanism for human capital development in Ukraine is extremely relevant – both in the scientific and analytical context of rankings and for the practical implementation of the obtained results into strategic plans for the modernization of educational policy and the effective management of labor potential.

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