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HUMAN CAPITAL AND ECONOMIC GROWTH IN EU COUNTRIES*

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Abstract. One of the fundamental objectives of any country is to improve its economic performance and ensure stable economic development and sustainable economic growth. Recently, human capital has become one of the most important factors in the growth of national performance, and its importance is growing in the context of the development of the digital economy. To promote economic growth, it is essential to invest in raising the level of human capital, particularly in education, health, science and research. However, it is not only the amount of these investments that is important, but also their efficient use and the government's ability to ensure favourable conditions for their long-term return. This paper aims to identify the evolution of human capital in EU countries by comparing two alternative methods, analysing its level in relation to economic growth and then identifying the dynamics of the patterns of change in these variables across member states. The research was carried out for 2013-2022 and 2023, respectively, based on statistical data from Eurostat and the United Nations Development Programme. The level of human capital was expressed using a multi-criteria method (the standardised variable method) and the Human Development Index. The position of the countries based on the value of the integral indicator calculated by the standard variable method, the HDI and the economic performance measured by the GDP indicator were compared through percentiles. A single-factor analysis of variance was used to assess the dynamics of the development of the indicators under study. The results of our research show that northern and western European countries performed better in both human capital and economic performance assessments than southern and eastern and central Europe, respectively. This is due to the different levels of investment in education, health, culture, research and development, and the different values of the outcome indicators. Sufficient investment in human capital is, therefore, essential for economic prosperity and sustainable economic growth.

Keywords: economic performance; HDI; human capital; human capital indicators; investment

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1. Introduction

Human capital is an important factor for economic growth and one of the sources of competitiveness and competitive advantage for individuals, businesses and society (Jašková, 2022). Yehorova and Drozd (2024)

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interpret human capital as a set of all knowledge, skills, abilities and experiences acquired during a person's lifetime that can be used to create additional economic value. Human capital represents the imaginary engine of an emerging economy that helps sustain the growth and development of developing and emerging countries and developed countries that want to maintain their growth momentum (Pisár, Honzová, 2024). According to Égert et al. (2022), human capital can be considered a complex phenomenon reflecting the knowledge, skills and personal characteristics that make people productive, acquired during formal and informal education. In the context of the development of the digital economy, the importance of human capital is growing, especially in terms of education and skills (Roszko-Wójtowicz et al., 2024; Mugunzva & Manchidi, 2024). As Nezhnikova (2020) states, investments in people and human capital development are key factors of modern economic growth, as they create conditions for sustainable economic growth and continuous adaptation of the socio-economic structure to new areas of scientific and technological progress.

This paper aims to identify and compare the level of human capital and economic growth in EU Member States. The multi-criteria method and the HDI indicator were used to assess the level of human capital, while the GDP per capita indicator was used to assess the economic level of the countries. Subsequently, the aim was to assess the level of human capital in relation to economic growth and to identify the dynamics of the patterns of change in these variables across EU Member States.

The novelty of the paper lies in the use of a multi-criteria method (standardised variable method) and, at the same time, the HDI indicator for a multi-faceted assessment of the level of human capital. The paper is structured as follows: in the literature review, we focus on assessing the current state of research in the field of human capital and its indicators, as well as economic growth and its interrelationship. In the next section, the research methodology is explained. Specific research results, findings, and a discussion and conclusion follow.

2. Theoretical background

The issue of human capital is receiving increasing attention, especially in the context of digitisation and automation, which are changing the requirements for jobs. Due to the rapid pace of technological development, individuals are forced to constantly adapt to the changing demands of the labour market. Human capital thus becomes a flexible element that needs to be continuously developed. According to Båk et al. (2022), human capital as an element of intellectual capital allows, at an appropriate level, easier adaptation of society to new economic challenges and opportunities. Chernenko (2023) states that human capital is very sensitive to technological changes, macroeconomic shocks and institutional changes that directly or indirectly affect the demand and supply of skilled labour, educational strategies of the population and the structural content of competencies and skills employed in the labour market. In line with the OECD (2007), human capital is defined as the totality of human capabilities formed under the influence of upbringing and education and shaped by an individual's state of health. Widarni and Bawono (2021) classify human capital as the economic value of a worker's experience and skills, including assets such as education, training, intelligence, skills, health, etc.

Whereas physical capital played a much greater role in the past, in the 21st century, human capital is increasingly important. According to a study by Zhang (2023), although physical capital is still an essential element of economic development, its role in supporting economic growth is now less evident than that of innovative human capital. Human capital accumulation is now considered one of the key drivers of economic growth. Sobiech Pellegrini et al. (2024) predict that in most countries, the value of human capital will increase as the skills of younger age groups are significantly higher than those of older groups.

Theoretically and methodologically, there are several approaches to human capital valuation. In line with Abraham & Mallatt (2022), these can be divided into three main approaches: the indicator approach (using indicators such as school enrolment, average years of schooling or adult literacy), the cost approach (based on investment in areas that affect human capital) and the income approach (based on earnings). However, Safonov et al. (2023) report that the investment-based approach is most used in human capital assessment because it provides the most accurate quantifiable estimates of the value of human capital.

Globally, investment in human capital development is key to sustaining the competitiveness of individuals, businesses and entire economies. Yet different countries approach this differently. According to Plaksiuk et al. (2023), human capital in the Slovak Republic is characterised by polarity; it develops asymmetrically, the dynamics of its development is closely related to the dynamics of GDP development, and its potential is not used efficiently, and therefore human capital in the Slovak Republic is not able to fully ensure a sustainable rate of economic growth of the country. However, as Hippe (2020) points out, there are large regional inequalities in human capital in European countries, which are determined on the one hand by historical development, on the other hand by the geographical location, economic level of countries, or the orientation of government policy. Even though differences in human capital levels across European countries are significant, Dańska-Borsiak (2023) finds that different regions are gradually converging in human capital levels. Still, the pace of the convergence process remains diversified. The interconnectedness of human capital levels with economic levels is also highlighted by Bedianashvili et al. (2024), who find that investment in particular areas affecting human capital levels - such as education, health care and environmental protection - leads to a healthier and better-educated population and hence higher levels of human capital, while it is also true that countries that invest more in human capital tend to have higher GDP per capita. At the same time, countries with rising GDP per capita are more likely to increase their spending on human capital. Similar conclusions are reached by Daňová & Širá (2023), who find that the human capital attributes that significantly affect economic performance and growth vary across economies and depend on the nature of these countries. According to Suparman & Muzakir (2023), higher human capital is associated with higher growth rates and leads to lower unemployment rates; thus, increasing human capital can positively affect overall economic progress. This effect is most visible in less developed countries. Wegari et al. (2023) find that if the share of health spending, education spending, and secondary school enrolment rates increase in Ethiopia, this leads to an increase in economic performance. Research by Widarni and Bawono (2021) showed that increased human capital through the education mechanism affects economic growth in Indonesia.

Yu et al. (2023), examining the relationship between human capital and economic performance in China, find that increasing education spending positively affects economic growth. It is important to use these investments efficiently and, if there is a limited supply of educational opportunities, to solve this problem. Educated individuals within the workforce drive economic growth. In contrast, a workforce with low education can slow innovation adoption, reduce the economy's adaptability to new challenges, and prolong periods of economic stagnation (Carillo, 2024). Even though most studies attribute a significant role to education in raising the level of human capital or in promoting economic growth (Mineeva, 2021; Doré & Teixeira, 2023; Tahsin, 2019), sceptical views also emerge. According to Wolf (2020), the larger, the higher education sector becomes, the less funding per student is likely to be available, which will have a significant impact on quality, and higher education will cease to be a pathway to success, nor will its positive contribution to economic growth be evident.

However, in addition to education, other aspects play an important role in developing human capital, particularly the population's health. Gumbau Albert (2021) considers population health to be one of the main components of human capital, and in his research, he assessed the impact of population health on economic growth. Zheng and Lu (2020) researched the relationship between human capital investment in health and economic growth in China, and their findings show that investment in health can increase economic growth. They argue that investments in health affect labour supply by reducing mortality and increasing life expectancy; they also affect individual labour productivity. Kuchmaeva et al. (2024) health determinants such as the availability of health services or healthy life expectancy explain inter-regional differences in human capital levels, while the availability of educational services has virtually no effect on inter-regional differentials in human capital levels. Also, Şentürk et al. (2023) state that health plays a key role in determining the quality of human capital; there is an interaction between these categories, with health and human capital level variables being important indicators for achieving sustainable development. Although health expenditure shows a causal relationship with GDP development, according to Raghupathi and Raghupathi (2020), its impact on health care in different care areas has different effects on the economy - GDP per capita is most affected by hospital expenditure, followed by personal health care expenditure. Gulcemal (2020) focused on the health status of human capital and its association with extending life expectancy at birth. He found that longer life has a clear positive impact on the economy, as it allows the labour force to stay in employment longer, reducing the financial burden of pension and health care costs for the elderly.

Although both areas (education and health) influence human capital development, their impact may differ. For example, in the recent past, it has been severely disrupted by the COVID-19 pandemic. Alizadeh et al. (2023) report that the pandemic was the largest crisis since the Second World War, significantly affecting economies worldwide, with seven major domains negatively affected: health, social vulnerability, education, social capital, social relations, social mobility and social welfare. Other studies have also reported the negative impact of the pandemic on health and education. According to Omotayo and Ogunniyi (2024), the disruptions caused by the rapid spread of the pandemic substantially impacted health and education outcomes. Chaabouni and Mbarek (2023) find that while education and health positively affected economic growth before the COVID-19-induced crisis, this positive effect ceased after the outbreak.

Another area that is closely linked to human capital is innovation performance. On the one hand, innovation is largely the result of human creativity, ingenuity and problem-solving skills; on the other hand, innovation creates new jobs and requires new skills, thereby increasing the demand for skilled labour. Human capital influences innovation through its structural condition and, to some extent, through its quantitative condition. Li et al. (2024) find that if human capital does not reach a certain threshold in quantity, it cannot fully manifest its effectiveness, and even its lower level may hinder innovation. Atsu and Adams (2023) also point out the interconnection between the two areas, viewing the promotion of innovation as an important element for the advancement of economies, whereby the innovation capabilities of countries depend on several factors such as the quality of institutions, human capital, the financial system, among others. According to Rakhimzhanova et al. (2024), effective investment in innovation-intensive areas, such as developing and adopting new technologies or developing digital education programs, contributes to increasing competitiveness and promotes sustainable economic development. Brodny and Tutak (2024) conducted a multi-criteria human capital assessment in the EU27. They found that human capital is strongly linked to innovation and various aspects of sustainable development, including economic growth, quality of life and reduction of social inequalities, with countries with more advanced human capital, in particular, tending to have higher levels of innovation, GDP and wages.

Weckroth and Kemppainen (2016) look at human capital from a different perspective - they argue that various linkages characterise the relationship between economic and cultural development; human values do not develop in a vacuum but are the result of historical trajectories of cultural, institutional and economic development, and for this reason, human capital issues find close links with cultural development. The importance of the aspect of culture in human capital development is also highlighted by Bucci and Segre (2011), who argue that investment in culture, like other factors, is an important element of economic growth because culture generates significant economic income and is also a field that produces new ideas, which contributes to the development of human capital in society. Therefore, human capital development cannot be seen in isolation, based on education and health alone, but is also closely linked to other aspects. Cultural values shape individuals' attitudes towards education or work, influencing a society's ability to adapt to new conditions and foster innovation. Culture is important to a country's innovation output (Lee et al., 2022). Thus, innovation results from sufficient skilled, adequately educated workers and a broader cultural and institutional context that either supports or hinders its development.

In this article, we will analyse human capital development in EU countries by comparing two different assessment methods (the standardised variable method and the HDI). At the same time, we will examine its level in relation to economic growth and analyse the dynamics of changes in these variables across EU Member States. As the literature review suggests, although some studies in the field of human capital and economic performance assess entire regions (Hippe, 2020; Dańska-Borsiak, 2023), most of the existing research focuses either on a limited set of countries or on a single country (Wegari et al., 2023; Widarni & Bawono, 2021; Zheng & Lu, 2020; Bozhechkova et al., 2024, and others). In addition, the bulk of studies assess human capital only based on partial aspects or through traditional indicators such as HDI (Şentürk et al., 2023; Gulcernal, 2020; Yu et al., 2023; Tahsin, 2019, and others.) This methodological and empirical gap provides considerable scope for research that would comprehensively cover the issue.

3. Research objective and methodology

The aim of the paper was to identify the evolution of human capital in EU countries by comparing two alternative methods, analysing its level in relation to economic growth, and then identifying the dynamics of the patterns of change in these variables across member states. The analysis was carried out for the years 2013-2022 and 2014-2023 for human capital, respectively, given the availability of key indicators, using statistical data from Eurostat and the United Nations Development Programme.

To express the level of human capital, we used the standardised variable method as well as the Human Development Index (HDI). We decided to apply the standardised variable method because of the need for a comprehensive assessment of data expressed in different units. We have used this method to express human capital in the past, but at that time, we compared only seven EU countries (Žárská & Smetanová, 2024), and one of our goals for the future was to extend the research to a larger sample of countries. The following relationships were the basis for calculating the normalised scores:

if x_j is the maximising variable: $z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j}$

if x_j is minimising variable: $z_{ij} = \frac{\bar{x}_j - x_{ij}}{s_j}$

where $\bar{x}_j$ is the arithmetic mean, s_j is the standard deviation.

We then calculated the integral index (normalised score) I_i as the arithmetic mean of the calculated normalised values. The normalised variables have a mean value equal to zero, and their standard deviation is equal to 1.

The values of selected sub-indicators were included in the analysis and are shown in Table 1.

Table 1. Indicators for assessing the level of human capital in the standardised variable method

No.	Indicator	Character
1.	share of population with less than primary, primary and lower secondary education	minimising
2.	share of population with tertiary education	maximising
3.	life expectancy at birth	maximising
4.	government expenditure on health	maximising
5.	government expenditure on education	maximising
6.	government expenditure on culture	maximising
7.	gross domestic expenditure on research and development	maximising

Source: own processing

We compared the position of countries based on the value of the integral indicator calculated by the standardised variable method, both HDI and economic performance as measured by GDP, using percentiles, which allow us to quantify what percentage of values in the set are less than or equal to a given value. Specifically, we used the 33rd and 66th percentiles, which allowed us to divide countries into 3 groups:

- countries with low values (values below the 33rd percentile),
- countries with medium values (values between the 33rd and 66th percentile),
- countries with high values (values above the 66th percentile).

Through a single-factor analysis of variance, we investigated whether there were statistically significant changes in the level of human capital and GDP in the EU countries over 2013-2022, respectively. The null and alternative hypotheses were set and tested for each of the examined indicators. The results of this analysis were intended to provide information on whether the evolution of the variables under study in the EU countries is relatively stable or whether there are more significant fluctuations in the level of human capital and GDP.

4. Results

As a first step in the analysis of human capital development, we calculated the average value of the integral indicator (normalised score) over the entire observation period. We displayed the results in a bar chart (Figure 1), which allowed us to visually compare the level of human capital between EU countries or to capture what level of human capital each country exhibits compared to the average.

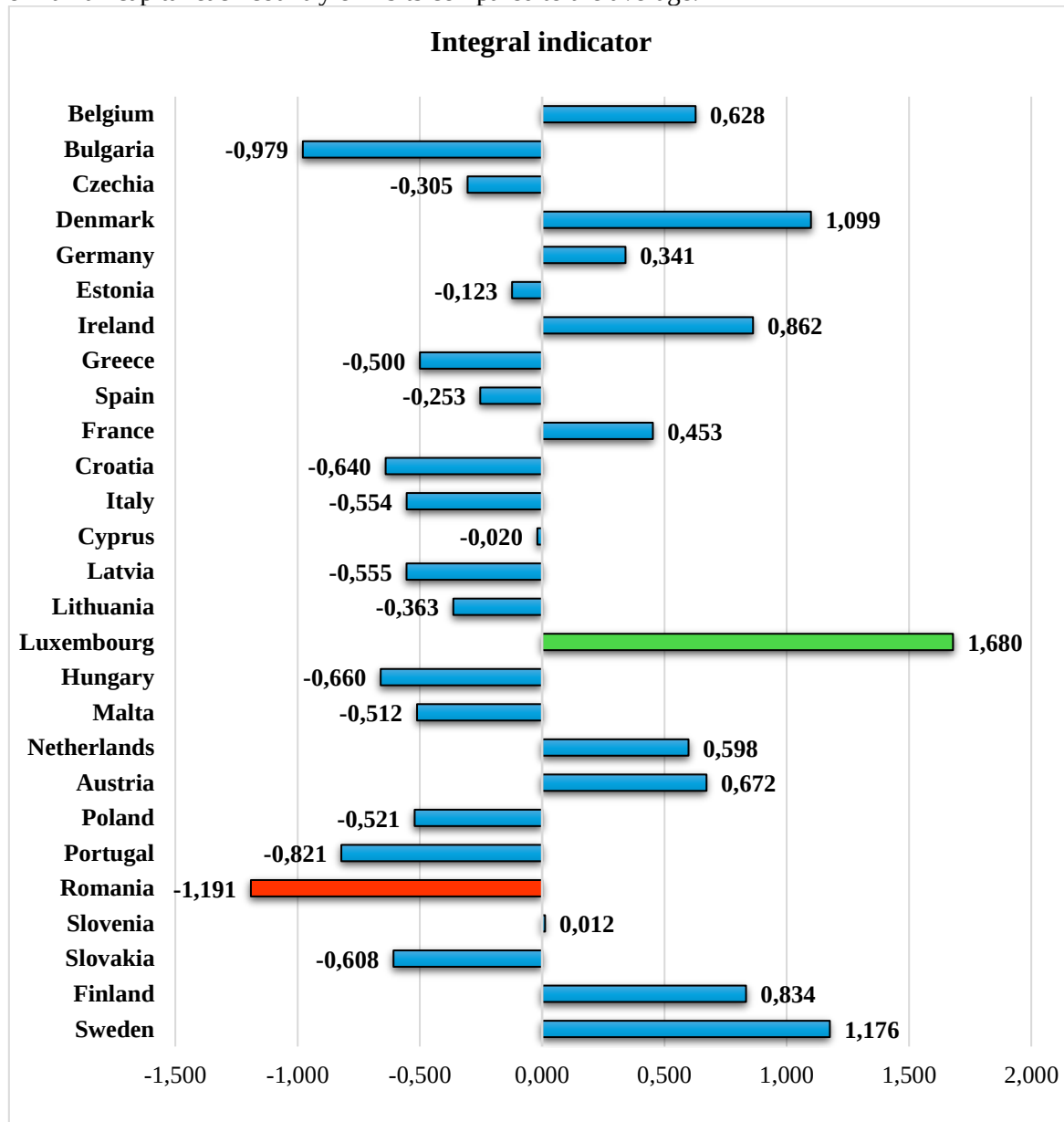


Figure 1. Human capital - average value of the standardised score for 2013-2022

Source: Eurostat, own calculating

The values shown in the graph are a dimensionless number resulting from a comparison of seven areas affecting the level of human capital in all 27 EU countries. The values shown are positive or negative depending on how each country scores compared to the average. As the scores are expressed as deviations from the EU average, this makes it possible to clearly identify countries with above- or below-average human capital development. Out of the 27 EU countries, 11 showed positive values, and the remaining 16 showed negative values. The highest value of the integral indicator (1.680) and, thus, the highest level of human capital was recorded in Luxembourg, significantly outperforming the remaining countries. Significantly above-average scores of over 1 were also reported by Sweden (1.176) and Denmark (1.099), which, although lagging Luxembourg in the

ranking, still significantly outperformed the remaining 24 EU countries. It can be concluded that these countries have the best conditions for the development of human capital within the EU countries, investing heavily in its development, which is also reflected in their position within the result indicators. The relatively high share of the population with less than secondary education in countries with high human capital scores, especially Luxembourg and Denmark, is somewhat surprising. This phenomenon would require further analysis to identify its causes and consequences. This is an indicator where Sweden scores only slightly above average, and Luxembourg and Denmark are even below average. Countries with a positive overall value for the integral indicator also included Ireland (0.862), Finland (0.834), Austria (0.672), Belgium (0.628), the Netherlands (0.598), France (0.453) and Germany (0.341). Slovenia (0.012) also showed a very low but still positive value.

These countries are characterised by relatively high levels of education, longer life expectancy, and relatively significant investments in education, health, culture and research. The other countries surveyed lag the average in terms of conditions for human capital development. However, we consider it necessary to point out that a negative score is not indicative of the absolute level of human capital but of its relative level compared to the EU average. Thus, countries with lower scores do not necessarily underperform in all areas of human capital development but, on the contrary, may perform relatively well in some areas.

For example, Italy and Malta have the longest life expectancy at birth among all EU countries, while Lithuania, Cyprus and Estonia have a high share of tertiary-educated population. Lithuania, Poland and Slovakia have the lowest proportions with less than primary, primary and lower secondary education. Looking at the value of the integral indicator, Cyprus (-0.020) and Estonia (-0.123) are slightly below average, with the potential to improve in the relatively short term. Several other countries show more significant deficits in human capital levels, such as Spain (-0.253), Czech Republic (-0.305), Lithuania (-0.363), Greece (-0.500), Malta (-0.512), Poland (-0.521), Italy (-0.544), Latvia (-0.555), Slovakia (-0.608), Croatia (-0.640) and Hungary (-0.660). Although these countries show satisfactory results in some sub-areas, they should pay more attention to human capital development in all its aspects. Portugal (-0.821), Bulgaria (-0.979) and Romania (-1.191) show the lowest negative scores, with Romania being the only one to score below -1, indicating a significant lag for the rest of the EU in human capital development. These countries will face the biggest challenges in the future if they want to gradually catch up with the rest.

We divided the values of the integral indicator in the EU countries into 3 groups through the 33rd and 66th percentiles and applied the same procedure to the HDI, which allowed us to compare the results obtained using the standardised variable method with the HDI values.

The aim was to find out whether different methodological approaches to human capital assessment yield the same or similar results or whether there are more significant differences when the level of human capital is expressed in different ways. This comparison (Table 2) makes it possible to assess the extent to which the results are influenced by the choice of methodology and indicators used to measure human capital. It also provides a more detailed insight into whether the standardised variable method is an appropriate complementary indicator to traditional ways of expressing human capital, such as the HDI.

Table 2. Distribution of EU countries by level of human capital

Percentile	HDI		Integral indicator of human capital	
	HDI value	Countries	Integral indicator values	Countries
0.33	HDI < 0.875	Bulgaria, Croatia, Lithuania, Latvia, Hungary, Poland, Portugal, Romania, Slovakia	$I_i < -0.516$	Bulgaria, Croatia, Latvia, Hungary, Poland, Portugal, Slovakia, Romania, Italy
0.66	$0.875 \leq \text{HDI} \leq 0.901$	Cyprus, Czechia, Estonia, France, Greece, Malta, Slovenia, Spain, Italy	$-0.516 \leq I_i \leq 0.359$	Cyprus, Czechia, Estonia, Greece, Lithuania, Malta, Germany, Slovenia, Spain
1	HDI > 0.901	Belgium, Denmark, Finland, Netherlands, Ireland, Luxembourg, Germany, Austria, Sweden	$I_i > 0.359$	Belgium, Denmark, Finland, France, Netherlands, Ireland, Luxembourg, Austria, Sweden

Source: own calculating

The table below compares the countries of the European Union based on two different methods of assessing the level of human capital. This makes it possible to analyse their degree of consistency and to identify possible differences depending on the indicators used. According to the UNDP (2024), the HDI is influenced by life expectancy at birth, years of schooling for adults aged 25 and over, expected years of education for children, and the gross national income per capita. In contrast to the HDI, the integral indicator reflects government spending on several key areas affecting human capital development. However, like the HDI, it includes outcome indicators on health and education. Countries with low HDI human capital scores include Bulgaria, Croatia, Hungary, Latvia, Lithuania, Poland, Portugal, Romania and Slovakia. According to the standardised variable method, this is the same group of countries, except for Lithuania, with Italy in this category instead. This discrepancy may indicate that although Italy achieves a relatively higher HDI due to its higher economic level or longer life expectancy, its lower level of public investment in areas important for human capital development has resulted in a relatively lower ranking in the normalised score. In the context of historical development, it can be noted that the group with low scores mainly includes post-communist countries. The countries with medium HDI human capital scores include Slovenia, the Czech Republic, Estonia, Greece, Spain, France, Italy, Cyprus and Malta. We find the Czech Republic, Greece, Germany, Estonia, Spain, Cyprus, Lithuania, Malta and Slovenia using the normalised score. There is, therefore, some inconsistency between the chosen assessment methods. The fact that Germany has a high HDI but is only in the middle group in the integral indicator may indicate lower spending in areas important for human capital development compared to Northern European countries and lower values for the outcome indicators. The countries with high levels of human capital in the HDI include Denmark, Germany, Ireland, Luxembourg, the Netherlands, Austria, Belgium, Finland and Sweden. The countries in the standardised score group are Austria, Belgium, Denmark, Ireland, France, Luxembourg, the Netherlands, Finland and Sweden. Thus, according to the HDI, Germany belongs to the group of countries with a high level of human capital. Still, according to the normalised score, it belongs only to the group of countries with a medium value. In contrast, Belgium and France, which are medium according to the HDI, are high according to the normalised score, indicating higher investment in human capital, as the normalised score was largely based on a cost approach.

The two methods of human capital assessment produce consistent results, and there is considerable overlap but no complete overlap. Countries with high HDI may have relatively lower spending on human capital, resulting in a lower value of the integral indicator there, as 4 of the 7 sub-indicators on which the calculation of the normalised score was based were based on the level of spending. Conversely, countries with lower HDI may record higher human capital expenditure. In addition, high government spending on education and a relatively high share of the population with tertiary education do not necessarily imply a high level of human capital, especially if the country also has a high share of the population with low educational attainment, which may

negatively affect the final score. Based on the findings, it can be concluded that the choice of methodology and indicators may influence the assessment of human capital levels. Still, given the relatively consistent results, the standardised variable method may be a suitable complementary method to traditional methods such as the HDI.

In the next step, we also divided countries into 3 groups based on the level of GDP per capita in 2014-2023 (Table 3). We compared the results with the previous division of countries by human capital level to identify correlations between these variables. The intention was to see whether higher levels of human capital in EU countries are associated with higher economic performance in those countries or whether there are exceptions that would suggest that the impact of human capital on economic growth is not clearly evident and that economic growth is more dependent on other factors.

Table 3. Distribution of EU countries by level of GDP per capita

Percentile	GDP	
	GDP value	Countries
0.33	GDP <18 957	Bulgaria, Greece, Croatia, Latvia, Lithuania, Hungary, Poland, Romania, Slovakia
0.66	$18957 \leq \text{GDP} \leq 36567$	Czechia, Estonia, Spain, France, Italy, Cyprus, Malta, Portugal, Slovenia
1	GDP > 36 567	Belgium, Denmark, Germany, Ireland, Luxembourg, Netherlands, Austria, Finland, Sweden

Source: own calculating

The low-GDP countries are Bulgaria, Croatia, Greece, Hungary, Latvia, Lithuania, Poland, Romania and Slovakia. Most of these countries fall into low HDI and standardised human capital score categories. The exception is Greece, which is in the middle category for both HDI and standardised scores but is one of the countries with low GDP per capita. The group of countries with medium GDP is made up of the Czech Republic, Estonia, Spain, France, Italy, Cyprus, Malta, Portugal, Slovenia and Spain. Most of these countries fall into both the medium HDI category and the medium standardised human capital score category. The exceptions are France, Portugal and Italy. France has a high normalised score, i.e. a high level of human capital. Despite being one of the economically stronger countries, Portugal shows low human capital scores in both cases. This is also the case in Italy, but only in the standardised human capital score, which, in addition to lower spending in some areas, is also because the share of the population with tertiary education is the lowest in the EU. Conversely, the share of the population with less than primary, primary and lower secondary education in Italy is among the highest in the EU. Belgium, Denmark, Germany, Ireland, Luxembourg, Luxembourg, the Netherlands, Austria, Finland and Sweden are among the most economically productive countries. Most of them also have high HDI and standardised scores, confirming the assumption that countries with developed human capital also have higher economic performance. Germany has a high GDP and HDI but a lower standardised score, probably because, although spending in each area is relatively high, it lags behind Luxembourg, Sweden or other countries.

A significant correlation exists, but not a perfect match, between GDP and HDI or the integral indicator. Countries with higher HDI and standardised scores generally tend to perform better economically, as a higher level of human capital is one of the prerequisites for ensuring economic growth. The results of both methods of human capital assessment yielded similar results. This suggests that regardless of whether the level of human capital is assessed based on outcome indicators or expenditure indicators, the resulting country classifications are broadly comparable.

The comparison showed that the Northern European countries performed best in terms of human capital and economic performance. Western European countries also performed similarly and, in some cases, maybe in the middle category when assessed by either method. Interestingly, Luxembourg and Ireland showed much higher GDP values per capita than other countries, but their HDI was similar to that of other Western European countries. Southern and Eastern European countries lag the North and West in terms of both human capital levels and economic performance, but some are gradually beginning to catch up. Therefore, it is clear from the

above that human capital development is an important prerequisite for economic growth but is also influenced by other factors not examined here, such as historical development, economic policy, institutional environment, etc.

Since we have been able to show that the economic level of countries shows a large degree of correspondence with the level of human capital in them, we have captured the dependence between the 2 sub-indicators of human capital and the economic performance of countries in the following graph (Figure 2). Among the sub-indicators, the share of the population with tertiary education was selected for comparison, as education is considered the most important factor in human capital development. The second indicator is per capita expenditure on research and development, as this area is characterised by a high proportion of the workforce with a university degree and plays an important role in the knowledge economy. This analysis is intended to show the extent to which the educational structure of the population and investment in research and innovation affect the economic performance of individual countries.

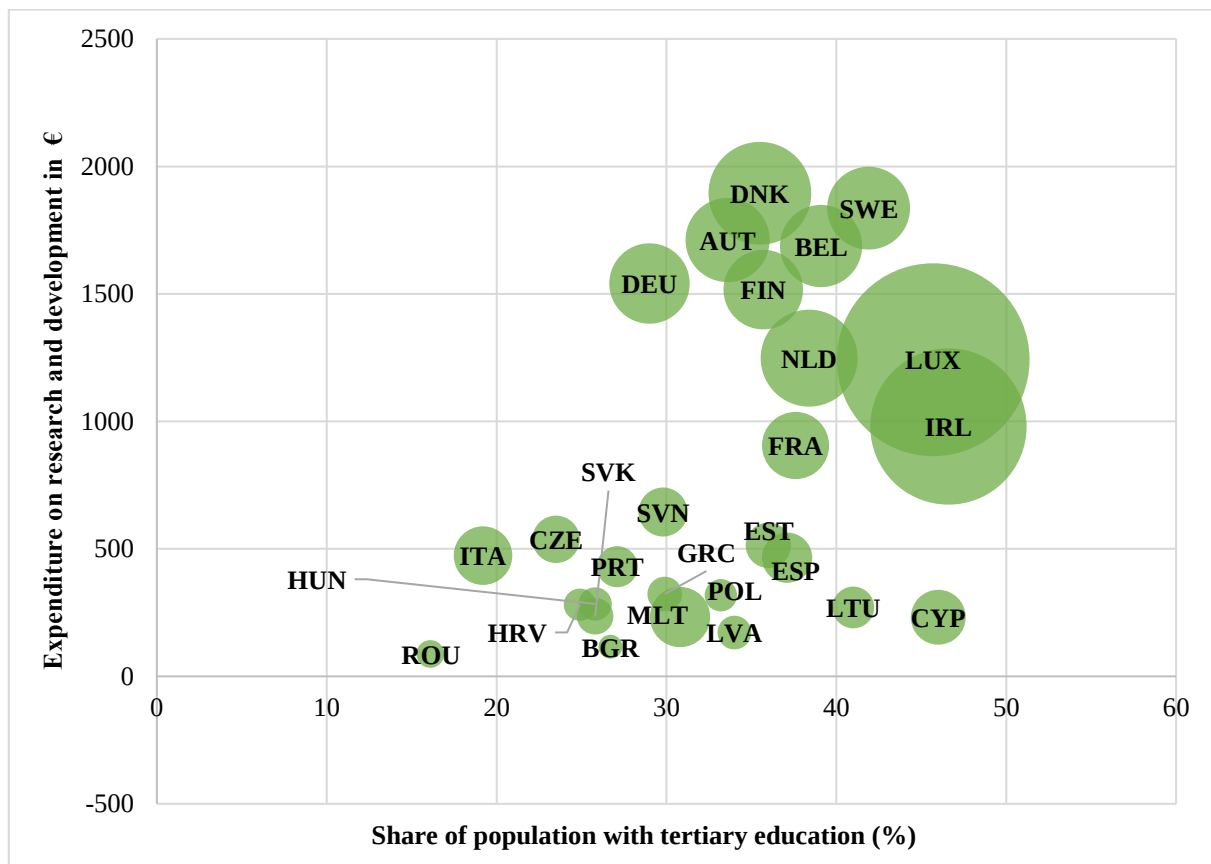


Figure 2. The relationship between the share of the population with higher education, research and development spending, and the economic performance of countries

Source: own processing

The y-axis shows how much each EU country invests in R&D per capita, the x-axis shows the share of the population with tertiary education in those countries. The bubble size represents the GDP per capita, reflecting the economic level of the countries. Countries such as Luxembourg and Ireland are characterised by high GDP per capita but are outperformed in R&D investment by countries with lower, though still relatively high, GDP per capita, such as Denmark, Sweden, Austria, Finland, Belgium, etc. These are countries which, in addition to high investment in research and relatively high GDP, also have a high share of the population with tertiary education. On the other hand, countries such as Bulgaria and Romania are at the bottom of the chart with low R&D expenditure, lower tertiary education shares and low GDP per capita. This may indicate that these countries have problems in economic development and promoting areas important for human capital development. We consider it worth noting that in addition to these countries, which show lower values for all

three indicators, we also find at the bottom of the graph countries such as Cyprus and Lithuania, which tend to have lower GDP, underinvest in research, but have a high share of the population with tertiary education. This may suggest that although education is often considered the most important prerequisite for human capital development, it may not be sufficient to ensure economic growth and development if it is not accompanied by adequate investment in R&D and other relevant areas.

As we have observed differences in the examined indicators between countries, we decided to identify the dynamics of their development in more detail. For this purpose, we used the single-factor analysis of variance (ANOVA) method to test whether there are statistically significant changes in their levels for HDI, normalised human capital score and GDP. First, we assessed the dynamics of the evolution of the normalised score. We tested the following hypotheses:

H0: There is no statistically significant change in the level of human capital as measured by the standardised score in EU countries between 2013 and 2022.

H1: There is a statistically significant change in the level of human capital as measured by the standardised score in s EU countries between 2013 and 2022.

Table 4 captures the results of the single-factor ANOVA through which we examined the changes in the level of human capital as expressed by the normalised score in the EU countries over 2014-2023.

Table 4. ANOVA - standardised human capital score

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.192338	9	0.021371	0.037322	0.999994	1.915995
Within Groups	148.8766	260	0.572602			
Total	149.069	269				

Source: own processing

The between-group variability (0.1923) is very small compared to the overall variability (149.069), but the within-group variability (148.877) is almost identical to the overall variability. This signals that most of the variability in the data examined comes from differences between countries within years, rather than from differences between years themselves. The results of the univariate analysis of variance, where the F-statistic took on a very low value (0.0373), which is less than the critical level of significance (1.916), suggest that the differences between the mean human capital values across the years under study are not large enough to be statistically significant. The p-value is very high (0.999) relative to the significance level set ($\alpha = 0.05$), indicating that there is insufficient evidence to reject the null hypothesis. We, therefore, accept the null hypothesis and conclude that there is no statistically significant change in the level of human capital in EU countries between 2014 and 2023. Individual EU countries have maintained a stable level of human capital throughout the period under study. As we did not observe a statistically significant difference between the years, we can assume that the factors affecting human capital within the EU did not undergo substantial changes during this period.

We have also identified the dynamics of HDI development. We tested the following hypotheses:

H0: There is no statistically significant change in the level of human capital as expressed by the HDI in EU countries between 2013 and 2022.

H1: There is a statistically significant change in the level of human capital as measured by the HDI in EU countries between 2013 and 2022.

Table 5 shows the results of a single-factor ANOVA to examine the changes in the level of human capital as measured by the HDI in EU countries over the period 2013-2022.

Table 5. ANOVA - HDI

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.012966	9	0.001441	1.002435	0.438424	1.915995
Within Groups	0.373659	260	0.001437			
Total	0.386625	269				

Source: own processing

The results show that the variability between groups (EU countries) is very small (0.013), suggesting that the differences in mean HDI values between EU countries are not statistically significant. This is confirmed by the F-value (1.002), which is lower than the critical value of F crit (1.916). However, the within-group (within-country) variability is much larger (0.374), indicating that there are within-country differences in HDI between the surveyed years. This may be due to various external factors, such as the COVID-19 pandemic or changes in policies aimed at human capital development. The p-value (0.438) is higher than the established significance level ($\alpha = 0.05$), indicating that there is insufficient evidence to reject the null hypothesis that the mean HDI values between EU countries do not differ significantly across years. Thus, even if there are differences in HDI values between EU countries, these differences are statistically considered to be random and do not show a consistent and statistically significant trend over time. The evolution of the level of human capital as measured by the HDI is, therefore, relatively stable and homogeneous across EU countries.

Having identified the dynamics of human capital development, we also identified the dynamics of GDP development. We tested the following hypotheses:

H0: There is no statistically significant change in the level of GDP in EU countries in 2014-2023.

H1: There is a statistically significant change in the level of GDP in EU countries between 2014-2023.

Table 6 shows the results of the single-factor ANOVA through which we examined the changes in the level of GDP in EU countries over the period 2014-2023.

Table 6. ANOVA - HDP

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	4642681913	9	515853545.8	1.134637	0.338461	1.915995
Within Groups	118 207 000 000	260	454641879.5			
Total	1 228 511 000 00	269				

Source: own processing

The variation between EU countries (4.64 billion) is lower than the variation within countries (118.2 billion) over the years studied. The F-value (1.135) is lower than the critical value of F crit (1.916), implying that there are no statistically significant differences between EU countries in GDP over the period under study. The p-value (0.336) exceeds the established significance level ($\alpha = 0.05$), indicating insufficient statistical evidence to reject the null hypothesis. As with HDI, although there are differences in HDI values between EU countries, these are statistically considered random. Thus, economic growth in EU countries is subject to some changes over time, but these changes are not large enough to create significant differences between countries in the long run.

5. Discussion

In line with Kwon (2009), 3 approaches are used to measure human capital: revenue-based, cost-based, and outcome-based. The HDI, which we have used as one of the possible approaches, is primarily based on outcomes or indicators. The second method we used to express the level of human capital was the standardised variable method, one of the multi-criteria methods. This method integrates three outcomes and four cost indicators. The choice of the indicators included in it was based on the findings of Safonov et al. (2023), who suggest that the investment-based approach is the most commonly used in quantifying human capital, as it provides the most accurate quantifiable estimates of its value. Although multi-criteria methods allow for a more comprehensive view of human capital assessment, several authors (Ivanova & Masárová, 2018; Laifa & Benhassine, 2023)

point out their subjectivity, as the final results may be influenced by the choice of indicators included in the assessment. Similarly, Balcerzak (2016) points out that the greatest weakness of using multi-criteria analysis is the great sensitivity of the final results to differences in the selection of potential variables. Still, despite this shortcoming, a multi-criteria analysis can show the structure and long-run path of the development of the phenomena under evaluation well. In order to minimise subjectivity, we compared the ranking of EU countries on the basis of the level of human capital as expressed by the HDI and the standardised variable method. Despite several outliers, we found a significant association between the HDI and the normalised score. While the choice of methodology and indicators may impact the assessment of human capital levels, given the relatively consistent results, the normalised score may be a suitable complementary method to the traditional ways of expressing human capital levels.

Countries in Northern and Western Europe performed better on human capital and economic performance measures than those in Southern, Eastern, and Central Europe, respectively. This is consistent with Hippe (2020), who states that there are large regional inequalities in human capital across European countries. According to Ederer et al. (2020), the level of investment in technological development and knowledge creation is too low in Central and Eastern European countries, which is reflected in low government spending on education, health, culture, as well as low spending on R&D in these countries compared to the rest of Europe. According to Minhaj & Ahmed (2023) investment and human capital development are key to achieving a favourable economic growth rate. This was confirmed as countries that fell into the higher human capital category generally also reported higher GDP. Conversely, countries that fell into the low human capital category generally reported lower GDP. Even though EU countries develop human capital to different degrees and are at different stages of economic development, Vaitkevicius et al. (2015) suggest that they may share the same pattern of human capital development. However, an examination of this issue would require a deeper analysis.

When assessing the level of human capital in individual countries, it is important to consider the specificities and differences in each area. The overall assessment may not always reflect the absolute structure of the individual factors that influence it, as some areas may be developing more dynamically, while others may be lagging behind. Thus, countries with relatively lower levels of human capital may not lag in all areas. They may even perform better than countries with the highest levels of human capital in some areas. Conversely, some countries with high human capital scores may lag more significantly in certain areas. Examples include Italy and Malta, which have the longest life expectancy at birth among all EU countries, while Lithuania, Cyprus and Estonia are among the countries with a high share of tertiary-educated residents. Conversely, some economically advanced countries such as Sweden, Denmark and Luxembourg have a relatively high share of the population with less than primary, primary and lower secondary education. However, this is often considered to be an obstacle to economic development. According to Carillo (2024), a poorly educated workforce can slow down the process of innovation adoption, which weakens the potential contribution of individuals with high levels of human capital and thus reduces the overall economic effect.

The contribution of this paper is that we have compared two different methodological approaches to measuring human capital, which provides a more comprehensive view of the issue. In addition to the traditional indicator, which is the HDI, we have used the normalised variable method to express the level of human capital, which is rarely used for this purpose but, with regard to its construction, can be a suitable complementary tool. While several studies have examined the correlation of variables through causal analysis, we used a comparative analysis based on the division of countries into three performance groups based on percentiles.

6. Conclusions

The paper aimed to identify the evolution of human capital in EU countries by comparing two alternative methods, analysing its level in relation to economic growth, and then identifying the dynamics of the patterns of change in these variables across member states. The stated objective was met. The two different methods of expressing the level of human capital (integral indicator, Human Development Index) showed consistent results. Minor variations may have been due to countries with high HDI scores having relatively lower human capital expenditure, resulting in a lower normalised score for the integral indicator. Conversely, countries with a lower HDI may have recorded higher human capital development expenditures. Thus, the methodology used to assess

human capital, including the choice of indicators through which it is assessed, may, influence the results obtained. However, given the high degree of agreement in the classification of countries into different groups, an integral indicator based on the standardised variable method may represent a suitable complementary method to the traditional ways of expressing the level of human capital. The analysis further revealed that there is a significant relationship, but not a perfect correspondence, between economic performance as measured by GDP and the level of human capital as measured by the HDI, or integral indicator. Countries with higher HDI and higher integral indicators tend to be more economically productive, as higher levels of human capital are one of the basic prerequisites for ensuring economic growth. However, regional disparities have been observed across EU countries. Most countries in Northern and Western Europe performed better on human capital and economic performance measures than in Southern and, Eastern and Central Europe, respectively. The results of the single-factor analysis of variance showed that the level of both human capital and economic performance in the EU countries is relatively stable. Although there were changes in the HDI, normalised score or GDP values in the years under study, these changes were not large enough to be considered statistically significant. Relatively stable levels of both human capital and economic performance may be a good indicator that the most developed countries are doing well and are not experiencing a decline in these indicators. However, this may challenge the lagging countries as they should aim to converge towards the most developed countries.

In addition to the shortcoming we have previously pointed out - that the use of multi-criteria methods is associated with a significant risk of subjectivity (Balcerzak, 2016; Ivanová & Masárová, 2018; Laifa & Benhassine, 2023), we also cite other limitations that may have constrained our research. While the analysis shows a relationship between human capital levels and economic performance, it is not possible to say conclusively whether higher levels of human capital lead to higher GDP, whether richer countries have more resources to invest in human capital, or whether the effect of both variables is synchronous in the long run (Boztosun et al., 2016). The ANOVA results showed that the level of HDI, normalised score and GDP did not show statistically significant differences between years, which may indicate stability. However, this may also be due to the statistical method used, which may not be sensitive enough to capture minor differences. Another limitation of the research carried out is the selection of the research sample, which includes only the countries of the European Union. Thus, the values of the standardised human capital scores are only meaningful for comparisons between these countries and do not allow for an assessment of their position in the global context.

Given these limitations, as well as the nature of the overall research, future research could aim to improve the methodology of human capital assessment through the standardised variable method to minimise subjectivity and increase the accuracy of the results. Given the increasing importance of technological progress and digitalisation, an indicator from this area should be added to the sub-indicators used. It could also be useful to compare the results of EU countries with those of developed countries in other regions, e.g. North America. As the research has only focused on assessing the current position of countries, further research could identify the extent to which countries with lower levels of economic development and human capital can follow the progress of developed countries.

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