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# HUMAN CAPITAL AS AN ELEMENT OF SUSTAINABLE DEVELOPMENT IN THE NUTS 2 REGIONS OF CENTRAL AND EASTERN EUROPE

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ABSTRACT: The objectives of this study are: to construct composite measures of human capital and of the three SD pillars: economic, social and environmental; to analyse their regional differentiation; to estimate the impact of human capital on the level of each of the SD pillars. The analysis covers NUTS 2 regions of the CEE countries in the year 2022. A measure of human capital was constructed adopting the Local HDI approach. The indicators of the SD pillars were constructed as geometric means of diagnostic variables. A SUR model was used to estimate the impact of human capital on the level of each pillar. The estimation results indicated a strong effect of human capital on the economic and social pillars and a much weaker effect on the environmental pillar. A significant impact of EU membership on the social and environmental pillars was also found.

KEYWORDS: human capital, sustainable development, NUTS 2 region, Central and Eastern Europe

## Introduction

The notion of sustainable development (SD) is based on three key pillars: social, economic and environmental. A prerequisite for achieving the UN Sustainable Development Goals (SDGs) is to achieve a balance between these three pillars. Purvis et al. (2019) reviewed and discussed the sustainability literature, finding that the three-pillar conception had emerged from various critiques of the economic status quo from both social and ecological perspectives, as well as from the quest to reconcile economic growth as a solution to social and ecological issues.

Human capital (HC) affects each pillar of SD. According to the OECD, HC is defined as follows: 'The knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being' (OECD, 2001). Following Mincer (1984), economists agree that HC is a key factor in economic development. It is also important for social development to reduce poverty, increase job availability, and improve quality of life. The role of HC in environmental sustainability is also highlighted in the economic literature (e.g. Liu & Fraumeni, 2020; Kim & Go, 2020; Ben-Salha & Zmami, 2024). According to Liu and Fraumeni (2020): 'Within the context of SD, human capital measures can be used to gauge how well a country is managing its total national wealth, with the purpose of assessing its long-term sustainability'. Thus, HC is essential for achieving the SDGs, many of which are directly or indirectly related to HC development. These goals include: no poverty (SDG 1), zero hunger (SDG 2), good health and well-being (SDG 3), quality education (SDG 4), decent work and economic growth (SDG 8) and reduced inequalities (SDG 10).

The integration of the SDGs – and SD more broadly – builds on experience with National Sustainable Development Strategies (NSDS), which were included in Agenda 21 (§ 8.7) in 1992. The NSDS set overarching national strategies for action. However, according to Paul Krugman, 'one of the best ways to understand how the international economy works is to start by looking at what happens inside nations' (Krugman, 1991). As such, the regional dimension is crucial for understanding socio-economic phenomena such as development or HC. According to Widuto (2022), achieving approximately 65% of the targets depends on input from local and regional authorities. SD analyses performed at the national level ignore internal variation, which is extremely important from the perspective of local residents. Regional sustainability encompasses solutions to improve human well-being without degrading the environment or affecting the well-being of others (Jovovic et al., 2017). However, issues of sustainable regional development are rarely addressed in both reports from public institutions and in academic publications, especially in empirical studies.

The analysis presented here concerns the regions of Central and Eastern Europe (CEE). When joining the EU (in 2004, 2007 and 2013), CEE countries experienced many socio-economic problems that caused delays in the implementation of the SD strategy since the priority has been to catch up with the development backlog. Currently, although most CEE countries have made a significant civilizational leap, they have not yet reached the level of development characteristic of the most developed European countries. Disparities remain between CEE countries, which are even more pronounced at the NUTS 2 level. A real implementation of the SD concept would facilitate a transition in the region towards a better quality of life, a cleaner environment, a higher level of social activity and a lower level of poverty.

The objectives of this study are as follows: to construct composite measures of HC and the three pillars of SD (i.e. economic, social and environmental); to analyse the regional differentiation of HC and each of the SD pillars; to estimate the impact of HC on the level of each of the SD pillars. The analysis was conducted for 61 NUTS 2 regions of the CEE countries (Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia) in the year 2022.

The novelty of the research approach used is threefold. First, a multi-equation model was used to explain the three SD pillars jointly in relation to the level of HC. To the best of the author's knowledge, this represents the first attempt to analyse SD pillars in the NUTS 2 regions of CEE countries. Second, a composite measure of HC was constructed. This was necessary for the present study because commonly known measures such as the UN Human Development Index (HDI) or the World Bank's Human Capital Index are only available at the national level. Third, a self-developed composite measure was used to assess development in terms of each pillar.

The remaining parts of this paper are outlined as follows. Section 2 constitutes a literature review. Section 3 presents statistical data, the methods of constructing composite measures of HC and SD

DOI: 10.34659/eis.2025.93.2.1099

pillars, and the idea behind estimation in the seemingly unrelated regression (SUR) model. Estimation results of the impact of HC on the level of each of the SD pillars are described in section 4. These results are preceded by a statistical analysis of the key variables. The results are then discussed, and the final section presents the conclusions.

## Overview of the literature

The literature on SD is abundant. In recent years, numerous publications have been published on sustainable growth, sustainable societies, and environmental sustainability. Issues related to assessing the socio-economic development of countries and regions, as well as the relationship between environmental sustainability and socio-economic growth, are addressed (e.g. Addai et al., 2023; Dasrizal et al., 2023; Nuralina et al., 2023; Terra dos Santos et al., 2023; Sueyoshi et al., 2022; Ma et al., 2025; Long et al., 2023).

Mensah (2019) presented a review of the literature on the evolution of the concepts, their meanings, the dimensions of SD, as well as the relationships between the dimensions, the principles and their implications for global, national and individual actions in pursuit of the SDGs. The author draws attention to the issue of inter- and intra-generational equity, around which the idea of SD is focused. In a series of four books published in the years 2023 and 2024 (Filho, 2023-2024), the problems of SDG implementation in different parts of the world were addressed in a manner that considers the specificities of each region: Africa and the Middle East, Asia and the Pacific, Europe, and the Americas and Caribbean.

The literature also abounds with publications on the level and diversity of HC (e.g. Bye & Faehn, 2022; Campbell & Üngör, 2020; Demirgüç-Kunt & Torre, 2022; Fraumeni, 2021; Herbst & Rok, 2013; Kościńska & Herbst, 2019). The impact of HC on sustainability is increasingly being raised. The vast majority of these publications refer to situations at the national level and the differences between countries. Notably, fewer studies analyse situations at the regional or local levels.

A literature review on education investment, information technology, skills and productive labour in the context of HC development and economic growth was presented by Sairmaly (2023). Furthermore, Yu and Jing (2024) analysed the effects and linkages between economic growth, SD, HC and natural resources in China, considering the role of the financial sector and trade and the sensitivity of natural resources to economic development. They highlighted the role of growing financial institutions in developing countries, whose activities lead to a reduction in energy consumption over time, thereby reducing the negative impacts of economic growth on SD. The problem of the market availability of HC for the green economy in Poland was addressed by Kozera-Kowalska (2024), who pointed to a possible shortage of the competencies required to 'green' the economy, which is particularly acute in the context of the demographic crisis and labour shortages.

A statistically significant impact of HC on national environmental performance (measured by a composite index) was also found by Kim and Go (2020) for a sample of 72 countries. This impact was made by improving biodiversity, habitats and sustainable agriculture. Farcnik and Istenic (2020) investigated the relationship between HC (measured by the Human Capital Index) and two measures of sustainability for a panel of EU countries: electricity use and $CO_2$ emissions. The direct and moderating effect of HC on carbon emissions in nine leading carbon emitter nations was explored by Payab et al. (2023), who concluded that HC moderates the nexus between $CO_2$ emissions and industrial value-added products, as well as per capita income, and ultimately helps to fortify environmental quality. In contrast to the aforementioned studies (and others, e.g. Guloglu et al., 2023; Dai et al., 2024) indicating a significant role of HC in improving environmental quality, Ben-Salha and Zmami (2024) showed that in MENA countries, increased HC worsens environmental quality by reducing the load capacity factor.

Using data from 132 countries, Ali et al. (2018) showed that the positive role of HC in GDP per capita growth is dependent on social capacity and high-quality legal institutions. The impact of HC on growth relates to its strength: the stronger it is, the easier it is to do business. Suborna (2021) analysed the state of HC and growth patterns in the context of SD in 22 emerging economies. She identified the challenges and actions needed for these countries to make HC work for sustainable growth

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and development. A study of the Western Balkan Countries was performed by Devassia et al. (2024), with a particular focus on the role of HC in driving economic development.

Jovovic et al. (2017) pointed out that the economic development of a region should remain at a level that does not exceed its environmental capacity, and emphasised the institutional aspects of sustainable regional development. They considered the institutional component as the most important for achieving a compromise between economic and environmental imperatives in the region. Raszkowski and Bartniczak (2019) analysed the situation of the CEE countries concerning the implementation of the SD concept. They also identified challenges and opportunities related to the implementation of this concept while considering the specificities of the CEE group, which was still characterised by a lower level of socio-economic development and less developed infrastructure when compared to Western European countries. Stec et al. (2024) evaluated changes in the level of SD in Polish voivodeships in 2012 and 2021, taking into account 30 indicators covering three pillars: social, economic and environmental. Foroudi et al. (2024) focused on local residents' perceptions of sustainability goals, created a scale to measure these perceptions and then used it to validate the key sustainability goals relevant to residents of Italian regions.

## Research methods and data

The study used data for 61 NUTS 2 European regions of the 11 CEE countries in the year 2022 – the most recent period for which data were available. Data were obtained from the Eurostat (2024) website.

According to Fraumeni (2021), there are two types of HC measures: monetary and indicator-based. One of the index-based measures is the United Nations' HDI. In this study, an indicator-based measure was constructed, adopting the local HDI approach.

The composite measure of HC *MHC* was calculated as the geometric mean of diagnostic variables for the three dimensions: education, science and technology and health:

$$MHC_i = \sqrt[3]{EI_i \cdot STI_i \cdot HI_i}, \tag{1}$$

where:
$EI_i$ – education level indicator,
$ST_i$ – science and technology indicator,
$HI_i$ – health status indicator in the *i*-th region.
Each of these partial indicators was determined as the geometric mean of the diagnostic variables, according to the formula:

$$WI = \sqrt[k]{Z_1 \cdot \ldots \cdot Z_k}, \tag{2}$$

where:
$Z_j$ denotes the j-th diagnostic variable, normalised with the modified min-max scaling according to formula (3) for stimulants and formula (4) for destimulants:

$$Z_j = 1 + 99 \cdot \frac{X_j - minX_j}{maxX_j - minX_j} \tag{3}$$

$$Z_j = 1 + 99 \cdot \frac{maxX_j - X_j}{maxX_j - minX_j} \tag{4}$$

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The following diagnostic variables were used to construct the measure (the letters S and D indicate stimulants and destimulants, respectively):

- Education:
  - number of students in relation to population aged 20–24 (S),
  - young people neither in employment nor in education or training as a percentage of the population aged 15–24 (D),
  - individuals with less than primary, primary and lower secondary education (levels 0–2) as a percentage of the population aged 25–64 (D),
  - individuals with tertiary education (levels 5–8) as a percentage of the population aged 25–64 (S);
- Science and technology:
  - individuals employed in science and technology as a percentage of the population in the labour force (S),
  - participation rate in education and training (last 4 weeks) as a percentage of the population aged 25–64 (S);
- Health:
  - life expectancy, population aged less than 1 year (S),
  - crude death rate due to neoplasms (D),
  - crude death rate due to diseases of the circulatory system (D).

The indicators of the three pillars of SD were constructed in the same manner as the indicators $EI_i$, $STI_i$ and $HI_i$, i.e. as the geometric means of the diagnostic variables, unitised according to formulas (3) or (4). The variables for calculating indicators of the economic (*I_econ*), social (*I_soc*) and environmental (*I_env*) pillars of SD were chosen based on the publications by the United Nations (UN, 2023), the Polish Central Statistical Office (GUS, 2011) and UNESCO (United Nations, 2006):

- Indicator of the economic pillar *I_econ*:
  - Gross Domestic Product, in euros per inhabitant (S),
  - unemployment rate (D),
  - net disposable income in PPS per inhabitant (S);
- Indicator of the social pillar *I_soc*:
  - persons at risk of poverty or social exclusion as a percentage of the population (D),
  - economic activity rate of persons 55–64, percentage (S),
  - economic activity rate of persons 65 and over, percentage (S),
  - police-recorded offences (all kinds) per hundred thousand inhabitants (D);
- Indicator of the environmental pillar *I_env*:
  - final energy consumption in transport (all types of fuel) in relation to GDP, in ktoe[1] per million euros,
  - emissions of GHG per km$^2$ in kt of $CO_2$ equivalent per km$^2$,
  - share of renewable energy in gross final energy consumption, percentage (country-level data).

The values of the *MHC* measure and the indicators *I_econ*, *I_soc* and *I_env* range from 1 to 100. Higher values indicate a higher level of a measure or indicator.

A model explaining the three pillars of SD of the regions was estimated with the use of the SUR estimator developed by Zellner (1962). This method is a generalisation of OLS for multi-equation systems. Zellner's approach is dedicated to a set of equations that share a common error structure with non-zero covariance; however, all the regressors are independent variables. This allows the dependent variables to have different sets of explanatory variables. The SUR method estimates the parameters of all equations simultaneously so that the parameters of each single equation also take the information provided by the other equations into account. This results in greater efficiency of the parameter estimates because additional information is used to describe the system. These efficiency gains increase with increasing correlation among the error terms of the different equations (Judge et al., 1991), as well as with larger sample sizes and higher multicollinearity between the regressors (Yahya et al., 2008).

[1] The kilotonne of oil equivalent (ktoe) is a unit of energy defined as the amount of energy released by burning 1 kilotonne of crude oil.

DOI: 10.34659/eis.2025.93.2.1099

## Results

The present study used data for 61 NUTS 2 European regions of the CEE countries in the year 2022 – the most recent period for which data were available.

The descriptive statistics of *MHC* measure and indicators of the SD pillars are presented in Table 1.

Table 1. Correlation matrix and basic statistics of the indicators

| Indicator | Correlation coefficients | | | | Basic statistics | | |
|---|---|---|---|---|---|---|---|
| | I_econ | I_soc | *I_env* | *MHC* | Min | Max | Mean |
| *I_econ* | 1.00 | | | | 4.69 | 91.59 | 34.98 |
| *I_soc* | 0.59 | 1.00 | | | 3.80 | 97.26 | 57.37 |
| *I_env* | -0.23 | -0.13 | 1.00 | | 7.53 | 96.13 | 74.24 |
| *MHC* | 0.85 | 0.70 | -0.17 | 1.00 | 15.48 | 84.14 | 43.59 |

Critical values of the Pearson coefficient: $r^*_{(\alpha=0.05)} = 0.25$, $r^*_{(\alpha=0.1)} = 0.21$.

Comparison of the correlation coefficients provided in Table 1 with the critical values given below allows us to conclude that *I_econ*, *I_soc* and *MHC* are interdependent. Notably, *I_env* does not show a significant correlation with the other two SD pillars or with the level of HC at the $\alpha = 0.05$ level, while the correlation with *I_econ* is significantly negative at $\alpha = 0.1$.

Figure 1 presents a classification of regions into quartile groups, with upward or downward outliers, based on the values of the three SD pillars' indicators and the level of HC. Comparison of the maps allows for a deeper understanding of the conclusions drawn from Table 1. In the area of economic development and HC, the predominant NUTS 2 regions – being the upper outliers – are those comprising the capital cities of Poland, Czechia, Slovakia, Hungary (only for economic development) and Slovenia (only for HC). These are regions encompassing only the capital city and its immediate surroundings, with such a small area that the importance of the city determines the situation of the region. On the other hand, four regions in the south of Romania are characterised by an extremely unfavourable situation in terms of social development and are classified as lower outliers.

Upon comparing the division of regions into quartile groups, it is evident that the vast majority of regions in the Balkan countries are characterised by low or very low values of the *MHC*, *I_econ* and *I_soc* measures, with high values of the *I_env* measure. In contrast, the capital regions of Poland, Czechia, Slovakia and Hungary score extremely high in the *MHC*, *I_econ* and *I_soc* measures and low in the *I_env* measure. Moreover, the Baltic countries achieve high levels of *I_env* and *I_soc* indicators with moderate levels of *I_econ* and *MHC*. Regions located in Poland, Slovakia, Czechia and Hungary are very heterogeneous in terms of *MHC* and *I_econ*, with moderate *I_soc* values (they mostly belong to the 2nd or 3rd quartile group). Furthermore, they generally have low or very low levels of *I_env*.

The final stage of the study involved estimating a model explaining each of the pillars of SD in the regions relative to the level of HC. Table 2 presents the estimation results of the SUR model. Since the explanatory variable of the main interest serves as the measure *MHC*, other control variables are listed as follows:

*cap* – gross fixed capital formation in billion euros,

*emp* – employment per thousand persons,

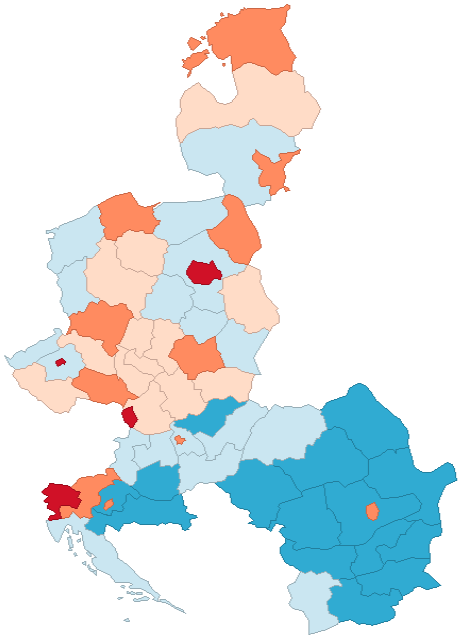
*enpi* – environmental protection investments of the total national economy as a percentage of GDP

*GDP* – gross domestic product in million euros,

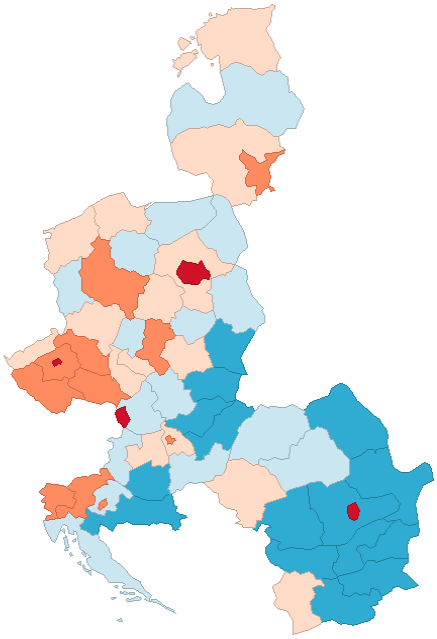
*ue_2007* – dummy variable, 1 for countries that joined the EU in the year 2007 (Bulgaria and Romania),

*ue_2013* – dummy variable, 1 for a country that joined the EU in the year 2013 (Croatia).

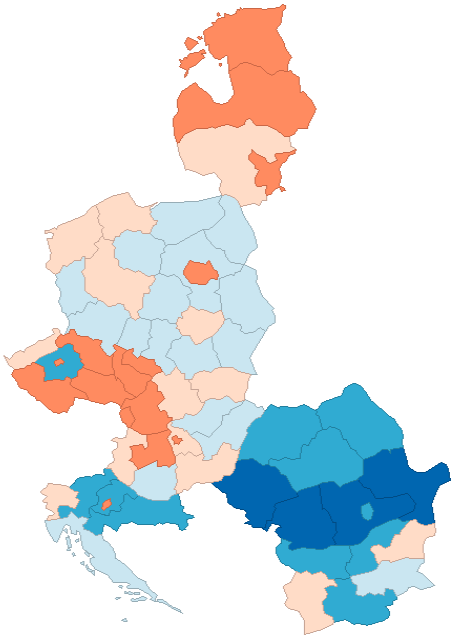
DOI: 10.34659/eis.2025.93.2.1099



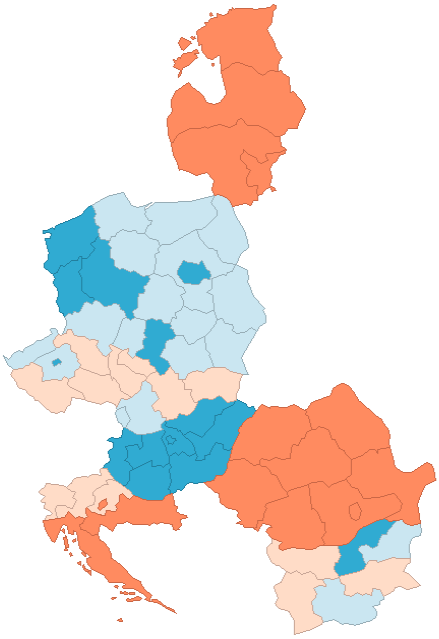
Human capital measure *MHC*



Indicator of the economic pillar *I_econ*



Indicator of the social pillar *I_soc*



Indicator of the environmental pillar *I_env*

The quartile groups and outliers are marked with colours:

denote lower outlier, 1st group, – 2nd group, – 3rd group, – 4th group and – upper outlier

Figure 1. Spatial differentiation of HC and the pillars of SD

DOI: 10.34659/eis.2025.93.2.1099

Table 2. Estimation results of the model of the impact of HC on SD pillars

| Dependent variable | Explanatory variable | Parameter estimate | Standard error | p-value |
|---|---|---|---|---|
| *l_econ* | *MHC* | 0.741 | 0.077 | 0.000 |
| | *emp* | 0.005 | 0.002 | 0.020 |
| | *cap* | 2.162 | 0.343 | 0.000 |
| | *const* | -5.783 | 3.313 | 0.081 |
| *l_soc* | *MHC* | 0.690 | 0.150 | 0.000 |
| | *ue_2007* | -17.021 | 4.492 | 0.000 |
| | *ue_2013* | -11.197 | 6.256 | 0.073 |
| | *gdp* | 0.000 | 0.000 | 0.016 |
| | *const* | 35.419 | 6.204 | 0.000 |
| *l_env* | *MHC* | 0.297 | 0.176 | 0.090 |
| | *ue_2007* | 17.333 | 6.228 | 0.005 |
| | *ue_2013* | 31.489 | 8.414 | 0.000 |
| | *enpi* | 11.624 | 6.048 | 0.059 |
| | *const* | 28.834 | 12.032 | 0.017 |

Note: The models were estimated using Stata.

The results presented in Table 2 indicate that HC is a significant factor affecting the level of economic and social development, with the impact being slightly stronger for economic development. The significance of the impact on environmental development depends on the significance level; for example, for $\alpha < 0.09$ it would be insignificant. The direction of the impact of the control variables is as expected. In particular, regions belonging to countries that joined the EU in the last two enlargements have lower levels of human development and higher levels of environmental development when compared to other regions with the same characteristics. This suggests that, on average, when compared to regions with similar levels of HC and other control variables, lower economic activity rates among the elderly and higher levels of poverty and crime, as well as higher final energy consumption in transport in relation to GDP and higher GHG emissions with a lower share of renewable energy.

## Discussion

The primary objective of this study was to estimate the impacts of HC on each of the three SD pillars: economic, social and environmental. The starting point was an analysis of differentiation in the level of regional development in economic, social and environmental dimensions, and by HC level. Notably, significant differentiation was observed in each of these areas. Analogous conclusions, albeit at the national level, were drawn from a study by Cichowicz and Rollnik-Sadowska (2018), according to which Romania was characterised as the best state for the environment; however, this country, together with Bulgaria, recorded low levels of social and economic development. Overall, the most developed countries were Slovenia, Estonia and Czechia. Estonia, Lithuania and Latvia were among the countries with the highest levels of the factor representing expenditure on education and medical services, which were among the determinants of HC in the present study. Raszkowski and Bartniczak (2019) found Czechia and Slovenia to have the best level of SD, while Estonia, Hungary, Slovakia, Poland, Lithuania, Latvia and Croatia were found to have a moderate situation, and Bulgaria and Romania had an unfavourable situation. While this study provides detailed insights into the internal variations in these countries, the findings are mostly comparable.

DOI: 10.34659/eis.2025.93.2.1099

A positive correlation between economic and social development was also found. This is in line with the findings of Stec et al. (2024) for Polish voivodeships, Ma et al. (2025) for countries in North America, Europe, Oceania and some developed countries in Asia, and Raszkowski and Bartniczak (2019) for CEE countries. The correlation between environmental and social development was proven to be insignificant, while that between environmental and economic development was either insignificant or very weakly negative, depending on the significance level. The results neither support nor contradict the Environmental Kuznets Curve (EKC). According to this hypothesis, economic growth has a corresponding effect on environmental quality, showing an inverted U-shaped relationship (Grossman & Krueger, 1995). The results of different studies are ambiguous since some have confirmed the EKC hypothesis (e.g. Dierking et al., 2020; Addai et al., 2023), while others have produced different results (e.g. Nuralina et al., 2023; Yu & Jing, 2024; Sueyoshi et al., 2022). The results seem to depend on the territorial scope of the study, phase of economic growth, considered aspects of the environment (only air and water pollution or biodiversity, ecosystems and energy efficiency) and financial development.

The positive impacts of HC on economic and social development noted in this study are confirmed in the literature (e.g. Devassia et al., 2024; Suborna, 2021; Ali et al., 2018). Devassia et al. (2024) found a positive effect of the HDI on GDP per capita in Western Balkan countries. Ali et al. (2018) considered 132 countries and proved that HC only serves a positive role in growth in the presence of better economic opportunities and high-quality legal institutions. Suborna (2021) provided an assessment of the state of HC and its relationship to economic growth for 22 emerging economies, identifying actions needed to make HC work for SD.

Positive impacts of HC on environmental development were also found, for example, by Kozera-Kowalska (2024) in the context of labour market problems in Poland, by Payab et al. (2023) for leading carbon-emitting countries, and by Kim and Go (2020), who showed that HC significantly affects a composite measure of environmental performance in 72 countries. The conclusions of the present study are not obvious in this respect. At the standard significance level of $\alpha = 0.05$, HC would not be significant; however, at $\alpha = 0.09$, it would be significant and positive.

It seems that one of the most important limitations of the present research is the availability of statistical data at the NUTS 2 level, which might have affected the results – including the ambiguous assessment of the impact of HC on environmental development. Simultaneously, environmental development is the most difficult aspect to assess at the regional level since it depends, among other things, on national regulations related to aspects such as renewable energy production and emissions trading. Further lines of research on the relationship between HC and SD could proceed using panel data models to analyse simultaneous temporal and cross-sectional changes. It would also be useful to analyse the dependence of the SDG implementation rate on the regional level of HC.

## Conclusions

The aim of this study was to empirically explore the effects of HC on three SD pillars (i.e. economic, social and environmental) in the NUTS 2 regions of the CEE countries. This objective was achieved by estimating a SUR model, whose equations describe the indicators of the SD pillars depending on HC and other control variables. The estimation process also uses the information provided by the other equations, so each SD pillar was dependent on the other two. The model estimation was preceded by the analysis of regional differentiation in HC and each of the pillars. The findings of the empirical investigation may be summarised as follows.

The greatest regional variation observed in the level of economic development is largely due to the very high economic performance of the small NUTS 2 regions comprising the capital cities of Poland, Czechia, Slovakia and Hungary. These are characterised by low unemployment rates, high GDP and high net disposable income per inhabitant. As centres of socio-economic life, they also concentrate the largest stocks of HC and are characterised by a high economic activity rate among older workers with a low percentage of persons at risk of poverty or social exclusion, which translates to the very good position of these regions in the social area. High variation in the level of economic development is also influenced by the very low *I_econ* indicators in most regions of the Balkan countries. The situation of these regions is even more unfavourable since the low level of economic development is accompanied by low levels of *HC* and *I_soc*.

DOI: 10.34659/eis.2025.93.2.1099

A characteristic feature of the CEE is the relationship between environmental and economic development. The results show a weak negative correlation (or no statistically significant correlation, depending on the confidence level) between the indicators of these pillars. In the context of the EKC, this could imply that the CEE NUTS 2 regions are in a transitional phase on average, close to the point where the negative impact of economic activity on the environment begins to diminish with further economic growth. Also noteworthy is the contrast between the situation of the Balkan and Baltic regions. These regions belong to the highest quartile group for *I_env*; however, in the Balkan region, this good situation coexists with low levels of *I_econ*, *I_soc* and *HC* indicators, while the Baltic regions are characterised by high social development and good *I_econ* and *MHC* indicators. Thus, it seems that the good environmental status in the Balkan regions is due to the low level of economic activity (especially industrial), while in the Baltic States, it may be due to appropriate environmental policies – especially the very high share of renewable energy.

The estimation results of the SUR model indicate a significant impact of HC on the economic and social pillars and a weaker impact on the environmental pillar. This is shown both by the parameter estimates and the assessment of their statistical significance. To strengthen this pillar of SD, environmental protection investments should first be increased. A significant impact of EU membership on the social and environmental pillars was also found. Later EU accession translates, *ceteris paribus*, to a worse level of social development – but simultaneously to a better level of environmental development. Since Bulgaria, Romania and Croatia (i.e. countries with a high share of the agricultural sector that are less industrialised) joined the EU in 2007 and 2013, this effect may be related to weaker economic development.

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## KAPITAŁ LUDZKI JAKO ELEMENT ZRÓWNOWAŻONEGO ROZWOJU W REGIONACH NUTS 2 EUROPY ŚRODKOWO-WSCHODNIEJ

STRESZCZENIE: Cele niniejszego badania to: skonstruowanie miar syntetycznych kapitału ludzkiego i trzech filarów zrównoważonego rozwoju (SD): gospodarczego, społecznego i środowiskowego; analiza ich regionalnego zróżnicowania; oszacowanie wpływu kapitału ludzkiego na poziom każdego z filarów SD. Analiza obejmuje regiony NUTS 2 krajów Europy Środkowo-Wschodniej w roku 2022. Konstrukcja miary kapitału ludzkiego jest wzorowana na konstrukcji lokalnego HDI. Wskaźniki filarów SD zostały wyznaczone jako średnie geometryczne zmiennych diagnostycznych. Do wyjaśnienia poziomu rozwoju każdego z filarów wykorzystano model SUR. Wyniki estymacji wskazały na silny wpływ kapitału ludzkiego na filary gospodarczy i społeczny oraz znacznie słabszy wpływ na filar środowiskowy. Stwierdzono również istotny wpływ członkostwa w UE na filary społeczny i środowiskowy. Zależność między rozwojem środowiskowym i gospodarczym okazała się być słaba ujemna lub statystycznie nieistotna, w zależności od poziomu ufności.

SŁOWA KLUCZOWE: kapitał ludzki, zrównoważony rozwój, region NUTS 2, Europa Środkowo-Wschodnia