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MULTIDIMENSIONAL ASSESSMENT OF SDI AND HDI USING TOPSIS AND BILINEAR ORDERING

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Abstract:

This study investigates how the Human Development Index (HDI) influences Sustainable Development (SD) in European Union (EU) countries by analyzing the relationship between the United Nations' HDI and a newly constructed Sustainable Development Index (SDI) by the authors. The dataset comprises 18 indicators retrieved from Eurostat for 2021. The study employs the TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) approach to calculate the SDI and utilizes bilinear ordering to visualize countries in a coordinate system based on their SDI and HDI scores. Spearman's rank correlation reveals a strong positive relationship between SDI and HDI. The study identifies disparities, with countries like Denmark and Sweden showing high SDI and HDI, while Romania and Bulgaria have lower scores. Northern and Western EU countries generally perform better, whereas Eastern and Southern countries face more challenges, highlighting the need for targeted development strategies. The results emphasize the importance of considering both human and sustainable development in policy design, offering insights for enhancing development outcomes for the EU.

Keywords:

sustainable development, human development, TOPSIS, bilinear ordering, EU, MCDM

JEL Classification: Q01, O15, R11

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1. Introduction

The fulfillment of human needs and aspirations has always been at the core of development efforts and remains a central objective in discussions on sustainability. The vast and diverse scientific discourse on sustainable development (SD) indicates the increasing global recognition of its critical importance. SD represents a balance among environmental, economic, and social objectives that contribute to the welfare of both present and future generations. It is widely recognized today that natural resources are finite and that human activity affects the environment in the short and long term (Atstaja, Susniene, and Jarvis, 2017). While the concept may initially appear comprehensible, it requires a precise, extensive discussion among both theorists and practitioners (Boons et al., 2013). The lack of a clear and useful definition for SD could offer a hidden benefit in terms of the scope and flexibility that many researchers find in this field of study (Meadowcroft, 2007).

The main objective of SD is to ensure an appropriate quality of life for the population while preserving the natural environment. This can only be achieved by addressing fundamental social issues like poverty, education, and employment, alongside environmental challenges to provide optimal living conditions for communities (Popescu et al., 2017). Government interventions in traditional sectors, such as agriculture, often rely heavily on direct subsidies. Numerous studies have shown that this can result in inefficiencies and rent-seeking behavior, and fail to promote technological progress (Herceg and Vuksanovic, 2017). For many years, the European Union (EU) has been working towards transforming into the leading knowledge-based economy globally (Kurekova et al, 2023). Therefore, implementing policies for SD is one of the EU's main aims (Grzebyk et al. 2023). In recent decades, the pursuit of sustainable development has not fully met expectations, as socio-economic imbalances and environmental degradation remain significant challenges. However, the EU has made progress in realizing the paradigm of sustainable development. Thus, it is crucial to monitor specific changes in these nations using SD indicators that have been carefully chosen. According to Cheba and Szopik-Depczyńska (2017), the goal is to clearly present the past and future progress toward accomplishing SD's objectives.

On the other hand, with the emergence of new development theories, human development (HD), or human capital, has been considered one of the most important aspects of development (Diaconu and Popescu, 2016). Although various measures have made significant contributions, this study specifically narrows its focus to the Human Development Index (HDI) of the United Nations (UN) and examines its connections with certain SD indicators. The HDI, widely recognized as a universal measurement of nations' development, evaluates three key dimensions: health, knowledge, and standard of living (Klugman, Rodriguez and Choi, 2011). It can be argued that, as a comprehensive indicator of development, the HDI should naturally have a strong positive correlation with SD. However, the HDI ignores key sustainability principles by excluding the ecological dimension. In contrast, the SDI incorporates environmental factors, measuring nations' ecological efficiency in delivering HD.

In contrast to the HDI of the UN, the complex nature of SD makes it challenging to compare and evaluate the progress of each EU country in achieving its goals, especially given the extensive number and scope of these objectives. Due to the limited number of widely recognized measures, we aimed to assess the levels of sustainable development in European Union countries synthetically. We aimed to determine the overall total of this measure

comprehensively and classify countries according to a designed synthetic measure, ultimately developing a typology of the levels of the Sustainable Development Index (SDI) for each country.

Considering all these factors, the primary goal of this paper is to determine how the HDI affects SD in EU countries, specifically by examining the relationship between the HDI score with the SDI created using selected indicators from Eurostat data. To achieve this goal, two research methods were employed. Firstly, we utilized the idea of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Hwang and Yoon, 1981) modified by Łuczak and Kalinowski (2020), to calculate a synthetic measure of SDI. Secondly, using the authors' own SDI and the UN's HDI as secondary data, bilinear ordering was applied to present the countries on a coordinate system based on the average difference index score of each country. This representation places the countries in four quadrants of the coordinate system according to their scores, allowing us to visualize and interpret the relationship between the HDI and SDI of each country. On this basis, we can also show the development positions of individual countries in relation to both SDI and HDI measures. Eurostat data from 2023 was used to construct the SDI, and HDI data from the Human Development Report of the UN (UNDP, 2024) was used. To analyze the relationship between SDI and HDI, Spearman's rank coefficient correlation analysis was conducted.

The paper consists of four parts. The first part is an introduction. The second part describes the research methods used. The third part presents the results of empirical research on the relationship between SDI and HDI. The last part is a summary that includes conclusions and recommendations.

2. Research Methodology

In this paper, one of the methods used is the MCDM based on the modified TOPSIS procedure (see Hwang and Yoon, 1981, Łuczak and Kalinowski, 2020) to assess the levels of SD. The TOPSIS method is highly effective for constructing a synthetic measure index and ranking territorial units characterized by multiple variables (Łuczak and Just, 2021). Another method applied is bilinear ordering, which involves positioning countries in a two-dimensional coordinate system based on our HDI and SDI data sets. In positional formulation, the TOPSIS procedure comprises the following steps (Table 1).

Table 1: Stages of procedure for the assessment of SDI and HDI

1	Selection of the sustainable development (SD) variables in the economic, social, and environmental fields
2	Identification of extreme values
3	Winsorization of data
4	Converting destimulants to stimulants
5	Normalization of the variables (zero unitarization)
6	Determination of Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS)
7	Calculation of the distance of each value of a country from the PIS and NIS (calculating L1 distances)
8	Construction of the synthetic index – Sustainable Development Index (SDI)
9	Linear ordering and determination of the levels of SDI
10	Bilinear ordering of SDI and Human Development Index (HDI)

Source: Own elaboration based on Wysocki (2010), Łuczak (2016).

In the first stage SD variables, as commonly accepted in the literature, were chosen to describe environmental, economic, and social phenomena and aspects (criteria) in EU countries to assess the sustainability (Alaimo and Maggino, 2020). In this stage, a decisive role is played by substantive analysis supported by a statistical analysis.

Next, extreme values are determined using the quartile criterion. After identifying extreme values in the second stage, we then moved to the third phase, where we winsorized the data by transforming the variable to limit extreme values. In the winsorization process, a specified number of extreme values in the variable are replaced with the 5th or 95th percentile value.

The fourth stage involves identifying the nature of the chosen variables. These are categorized as stimulants and destimulants. Stimulants are variables that increase the phenomenon's level, while destimulants reduce it. In the fifth stage, the variables for each criterion are normalized. This normalization involves rescaling the variables and aligning their orders of magnitude. Numerous methods exist for normalizing variables (Walesiak, 2014). Variables classified as destimulants can be converted into stimulants by applying a negative coefficient transformation (Łuczak and Wysocki, 2013):

$$x_{ik} = a - b \cdot x_{ik}^{D}, (i = 1, 2, \dots, N; K \in I_D) \quad (1)$$

where: x_{ik}^{D} – identified as *a* destimulant, for *i*-th EU country, *a* and *b* constants are 0 and 1 respectively, *N* – number of objects (EU countries), I_D – a set of subscripts for destimulants.

In the process of assessing the SDI of EU countries, variables with atypical values or significant asymmetry can arise, affecting the quality of synthetic measures. The fifth stage is normalizing values which is one way to deal with this problem (Lira, Wagner and Wysocki, 2002). Zero unitarization is one such technique that rescales the data to a common scale, between 0 and 1. By applying this method, variables are standardized to ensure that they contribute comparably to the overall measure, regardless of their original units or range. Here is the used formula for zero unitarization (Kukuła 2000):

$$z_{ik} = \frac{x_{ik} - \min\limits_{i}(x_{ik})}{\max\limits_{i}(x_{ik}) - \min\limits_{i}(x_{ik})} \quad (i = 1,2,\dots,N,\ k = 1,2,\dots,K) \quad (2)$$

where: x_{ik} is the original value of the *k*-th variable for the *i*-th EU country, $\max\limits_{i}(x_{ij})$ is the maximum value of the *k*-th variable and $\min\limits_{i}(x_{ij})$ is the minimum value of the *k*-th variable, z_{ik} is the normalized value (between 0 and 1).

The sixth stage consists of finding the positive ideal solution (PIS) and negative ideal solution (NIS) respectively (Hwang and Yoon, 1981):

$$A^{(\bullet)+} = \left(max(z_{i1}), max(z_{i2}), \dots, max\left(z_{iK^{(\bullet)}}\right)\right) = \left(z_1^+, z_2^+, \dots, z_{K^{(\bullet)}}^+\right) \quad (3)$$

$$A^{(\bullet)-} = \left(min(z_{i1}), min(z_{i2}), \dots, min\left(z_{iK^{(\bullet)}}\right)\right) = \left(z_1^-, z_2^-, \dots, z_{K^{(\bullet)}}^-\right) \quad (4)$$

Next, in the seventh stage, L1 (Manhattan) distances are calculated for each country from the PIS:

$$d_i^{(\bullet)+} = \sum_{K=1}^{K^{(\bullet)}} |z_{ik} - z_k^+| \quad (5)$$

and from the NIS:

$$d_i^{(\bullet)-} = \sum_{K=1}^{K^{(\bullet)}} |z_{ik} - z_k^-| \quad (6)$$

Looking at the eighth stage the aggregation formula proposed by (Hwang and Yoon, 1981) is used to construct the synthetic measure of sustainable development:

$$SDI_i = \frac{d_i^-}{d_i^- + d_i^+} \quad (7)$$

The synthetic index SDI_i ranges from 0 to 1 in value. The higher the values of the synthetic measure of development, the higher is the level of sustainable development.

Before the bilinear ordering phase, the ninth stage is linear ordering and determination of the levels of sustainable development. The calculated values of the synthetic measure of development are used to linearly order the EU countries and to typological classification depending on their SDI score. The entire range of the synthetic measure for SD can be divided into classes by defining numeric intervals for the measure SDI_{i_i} and similar levels of HDI_i (Table 2).

Table 2. Classes, levels of SDI and HDI, and value intervals of synthetic measure

Class number	Level of SDI or HDI	Symbol of level name of SD or HD	SDI_i or HDI_i
1	extremely high	EH	[0.9, 1.0]
2	very high	VH	[0.8, 0.9)
3	high	H	[0.7, 0.8)
4	relatively high	RH	[0.6, 0.7)
5	medium-high	MH	[0.5, 0.6)
6	medium-low	ML	[0.4, 0.5)
7	relatively low	RL	[0.3, 0.4)
8	low	L	[0.2, 0.3)
9	very low	VL	[0.1, 0.2)
10	extremely low	EL	[0.0, 0.1)

Source: Own elaboration based on Łuczak and Kalinowski (2022), UNDP (2024).

Based on the values of the synthetic measures SDI_i and HDI_i, EU countries can be bilinearly ordered as a two-dimensional to examine the relationship between SDI and HDI. By plotting SDI values on the x-axis and HDI values on the y-axis, each country's position is represented as a point in a two-dimensional space. The coordinates for each country's position on this two-dimensional plane are calculated as follows:

$$C_{SDI_i} = SDI_i - AVR_{SDI}\,,\ C_{HDI_i} = HDI_i - AVR_{HDI} \quad (8)$$

where: AVR_{SDI} and AVR_{HDI} are the reference average values for SDI_i and HDI_i respectively, C_{SDI_i} and C_{HDI_i} represent the coordinate of *i*-th country on the SDI (x-axis) and HDI (y-axis)

This subtraction provides the position of countries relative to a baseline (the average performance of EU countries for SD and the average performance of World countries for HD) to more effectively compare their sustainable and human development performance.

Four main statuses can be identified depending on which of the values of the synthetic measures (SDI and HDI) predominate:

- (SDI+ HDI+): above-average both levels of sustainable development and human development,
- (SDI− HDI+): above-average level of human development with below-average level of sustainable development,

- (SDI+ HDI−): above-average level of sustainable development with below-average level of human development,
- (SDI− HDI−): below-average both levels of sustainable development and human development.

This four-quadrant framework enables us to compare countries' performance in both sustainable and human development using a two-dimensional approach.

3. Results of the Research

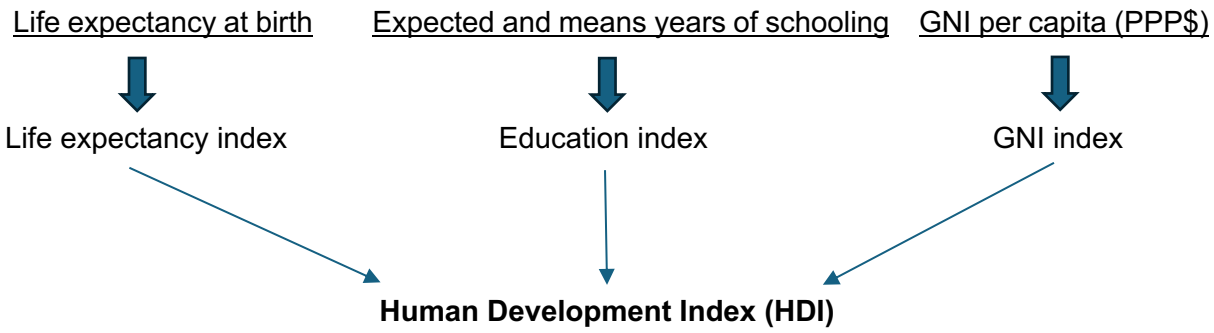
The data for the SDI was collected from Eurostat for the year 2021, covering 27 EU countries. 18 SD variables (see Table 3) were selected to provide an index score for each EU country to construct a ranking. Descriptive statistics, including the Jarque-Bera test, were calculated using the Gretl program (Cottrell and Lucchetti, 2024) (See Appendix, Table A1). On the other hand, the HDI score is derived from UNDP (2024), and the components of the index are presented graphically in Figure 1. HDI is the geometric mean of normalized indexes for each of the three dimensions.

Table 3. Selected variables to describe SDI

Name of Variables	x value	Related SDGs
In work at-risk-of-poverty rate	x_1	SDG1
Share of people with good or very good perceived health	x_2	SDG3
Standardised death rate due to tuberculosis, HIV and hepatitis	x_3	SDG3
Share of individuals having at least basic digital skills	x_4	SDG4
Share of tertiary educational attainment	x_5	SDG4
Gender employment gap rate	x_6	SDG5
Positions held by women in senior management positions rate	x_7	SDG5
Energy productivity € per kg	x_8	SDG7
Employment rate	x_9	SDG8
Real GDP € per capita	x_{10}	SDG8
Gross domestic expenditure rate on R&D sector	x_{11}	SDG9
Income distribution ratio of 20 highest and 20 lowest	x_{12}	SDG10
Recycling rate of municipal waste	x_{13}	SDG11
Average CO2 emissions per km from new passenger cars	x_{14}	SDG12
Net greenhouse gases	x_{15}	SDG13
Surface rate of the terrestrial protected areas	x_{16}	SDG15
Corruption perceptions index	x_{17}	SDG16
Official development assistance as a share of GNI	x_{18}	SDG17

Source: Own elaboration based on Eurostat (2024) and UNDP (2024)

Figure 1. Calculation and graphical presentation of the HDI



Source: Own elaboration based on (UNDP, 2024).

In Figure 1, life expectancy at birth is associated with SDG 3 (Good Health and Well-being), expected and mean years of schooling are linked to SDG 4 (Quality Education), and GNI per capita is related to SDG 8 (Decent Work and Economic Growth).

Table 4. Values of synthetic measures of HDI and SDI of EU countries in 2021

Country	SDI_i	HDI_i	C_{SDI_i}	C_{HDI_i}	Level of SD	Level of HD
Austria	0.610	0.916	0.103	0.020	relatively high	extremely high
Belgium	0.610	0.937	0.104	0.041	relatively high	extremely high
Bulgaria	0.356	0.795	-0.151	-0.101	relatively low	high
Croatia	0.434	0.858	-0.073	-0.038	medium-low	very high
Cyprus	0.441	0.896	-0.065	0.000	medium-low	very high
Czechia	0.483	0.889	-0.024	-0.007	medium-low	very high
Denmark	0.709	0.948	0.202	0.052	high	extremely high
Estonia	0.423	0.890	-0.083	-0.006	medium-low	very high
Finland	0.628	0.940	0.122	0.044	relatively high	extremely high
France	0.616	0.903	0.110	0.007	relatively high	extremely high
Germany	0.639	0.942	0.132	0.046	relatively high	extremely high
Greece	0.401	0.887	-0.105	-0.009	medium-low	very high
Hungary	0.418	0.846	-0.089	-0.050	medium-low	very high
Ireland	0.615	0.945	0.108	0.049	relatively high	extremely high
Italy	0.411	0.895	-0.095	-0.001	medium-low	very high
Latvia	0.346	0.863	-0.161	-0.033	relatively low	very high
Lithuania	0.430	0.875	-0.077	-0.021	medium-low	very high
Luxembourg	0.646	0.930	0.140	0.034	relatively high	extremely high
Malta	0.446	0.918	-0.061	0.022	medium-low	extremely high
Netherlands	0.703	0.941	0.196	0.045	high	extremely high
Poland	0.429	0.876	-0.078	-0.020	medium-low	very high
Portugal	0.434	0.866	-0.073	-0.030	medium-low	very high
Romania	0.270	0.821	-0.236	-0.075	low	very high
Slovakia	0.490	0.848	-0.017	-0.048	medium-low	very high
Slovenia	0.532	0.918	0.026	0.022	medium-high	extremely high
Spain	0.452	0.905	-0.054	0.009	medium-low	extremely high
Sweden	0.705	0.947	0.198	0.051	high	extremely high

Source: Own elaboration based on Eurostat (2024) and UNDP (2024).

After the correlation matrix analysis, some variables were removed because they were highly correlated with others, to prevent multicollinearity, which negatively affect the accuracy and reliability of the analysis. The second step assumed that six of the variables are a destimulant (x_1, x_3, x_6, x_{12}, x_{14}, x_{15}) while others are stimulants. The destimulating variables were converted into stimulants by a negative coefficient transformation. All variables were subjected to zero unitarization. Following this, distances from each object (EU country) to the positive ideal solution and negative ideal solution were used to calculate the synthetic measures.

The values of synthetic measures of HD and SD of EU countries are shown in Table 4. In 2021, the synthetic measure of HD in these countries ranged from 0.270 to 0.709, while SD ranged from 0.795 to 0.948. This allowed for the identification of six types (ranging from low to very high) for SD (Table 5), and three categories (from high to extremely high) for HDI (see Table 6). The average values for the SDI of EU countries and the World HDI were 0.50 and

0.89, respectively. The coordinates of SDI and HDI (C_{SDI_i} and C_{HDI_i}) were determined by subtracting each country's index scores from their respective means.

Table 5. Typological classes of EU countries by SD in 2021

General sustainable development level	Countries
high	Denmark, Netherlands, Sweden
relatively high	Luxembourg, Germany, Finland, France, Ireland, Austria, Belgium
medium-high	Slovenia
medium-low	Slovakia, Czechia, Spain, Malta, Cyprus, Croatia, Portugal, Lithuania, Poland, Estonia, Hungary, Italy, Greece
relatively low	Bulgaria, Latvia
low	Romania

Source: Own elaboration based on Eurostat (2024).

Table 6. Typological classes of EU countries by HD in 2021

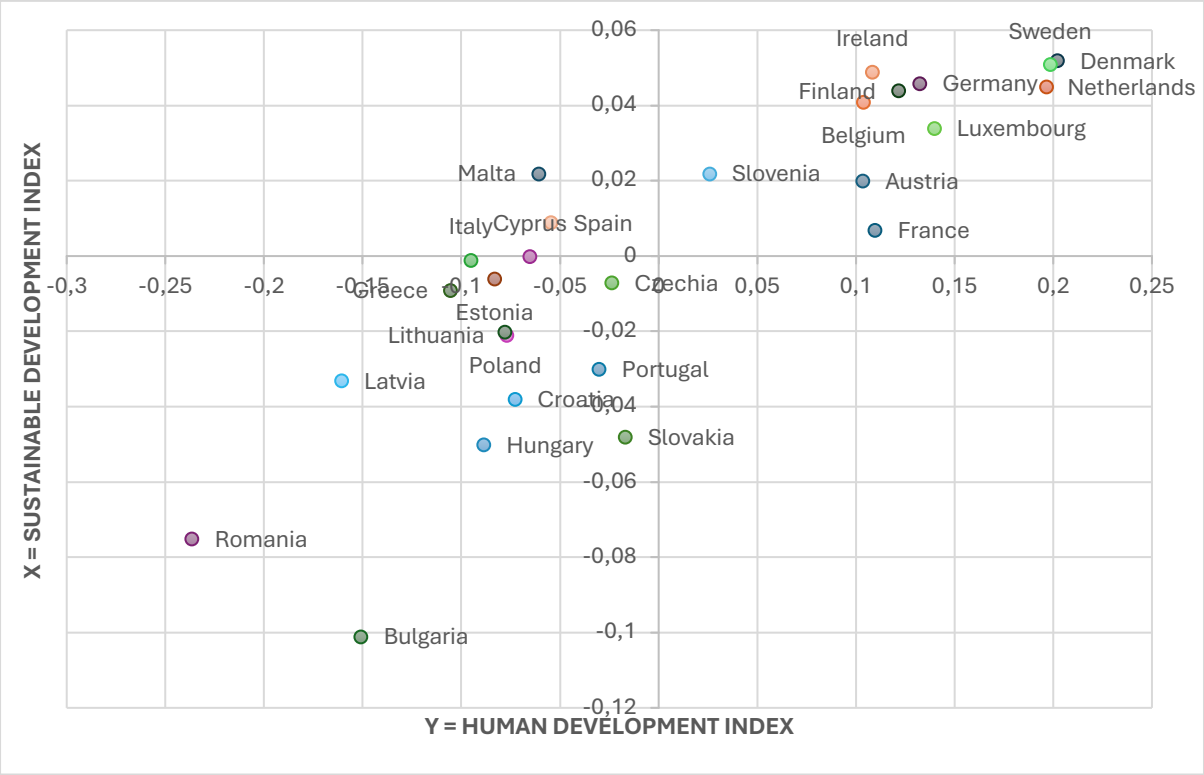
General sustainable development level	Countries
extremely high	Denmark, Sweden, Ireland, Germany, Netherlands, Finland, Belgium, Luxembourg, Slovenia, Malta, Austria, Spain, France
very high	Cyprus, Italy, Estonia, Czechia, Greece, Poland, Lithuania, Portugal, Latvia, Croatia, Slovakia, Hungary, Romania
high	Bulgaria

Source: Own elaboration based on UNDP (2024).

A group with a high level of sustainable development was made up of three countries, i.e. Denmark, Netherlands, and Sweden. It should be emphasized that Denmark ranked first in both indices, followed by Sweden. Seven countries at a relatively high level of SD: Austria, Belgium, Finland, France, Germany, Ireland, and Luxembourg. These countries achieved the most favorable average values for up to 18 output variables determining SD. However, the medium (medium-high and medium-low level) was found in ten EU countries: Slovenia, Slovakia, Czechia, Spain, Malta, Cyprus, Croatia, Portugal, Lithuania, Poland, Estonia, Hungary, Italy, and Greece. Looking at the bottom of Table 5, Romania had the lowest score in terms of SD, followed by Bulgaria, and Latvia. Additionally, Bulgaria had the lowest score in HD performance as well, placing the country alone in the high class, while all other EU countries were in the very high class. So, EU countries have achieved very high level HD. However, it should be remembered that HDI was calculated in comparison with the poorest countries in the world. Hence, the high rating of the HD level in EU countries.

The results suggest that countries in Northern and Western Europe have achieved significantly higher outcomes in terms of their ability to compete sustainably with HD compared to the countries in Eastern and Southern Europe.

Figure 2. Four quadrants for SDI and HDI for 27 EU countries



Source: Own elaboration based on Eurostat (2024) and UNDP (2024).

To examine the relationship between the positions occupied by the EU countries in Table 4, a bivariate correlation analysis was conducted using the Spearman coefficient. As demonstrated by the Spearman rank correlation coefficient (r_s = 0.852), there is a strong positive relationship between the SDI and the HDI for 27 EU countries. This suggests that countries with higher SDI values also tend to achieve higher HDI scores, supporting the idea that SD and HD are closely aligned. The statistically significant t-statistic (8.13) and p-value (0.01) further confirm this result. Similar results regarding the assessment of the level of sustainable development is presented by Diaconu and Popescu (2016) demonstrates a strong positive correlation between human capital and SD in EU countries, emphasizing the significant role of education in driving sustainable growth.

After analysing the correlation between our SDI and the UN's HDI, we applied bilinear ordering and plotted the countries on a coordinate system in Figure 2 based on each country's average difference in index scores. The coordinates of SDI and HDI (C_{SDI_i} and C_{HDI_i}) were determined by subtracting each country's index scores from their respective means.

This approach positions the countries across four quadrants according to their scores enabling us to visually assess and interpret the relationship between each country's HDI and SDI.

- Quadrant I (SDI+ HDI+): 11 EU countries (Denmark, Sweden, Netherlands, Ireland, Germany, Finland, Belgium, Luxembourg, Slovenia, Austria and France) fall into this quadrant. These nations exhibit strong performance in both SD and HD, indicating effective policies that promote economic growth while ensuring environmental sustainability and social well-being.
- Quadrant II (SDI− HDI+): Only Malta and Spain can be found in here. They demonstrate higher HD levels but struggle with sustainability. This scenario suggests a need for these countries to enhance their SD initiatives to align with their human development successes.

- Quadrant III (SDI− HDI−): There 14 EU countries, indicating significant challenges in both sustainability and HD. This highlights the need for comprehensive development strategies focused on both economic and environmental resilience.
- Quadrant IV (SDI+ HDI−): It is crucial to note that there are no states located in this quadrant, which would indicate that while they perform well in sustainability, their human development indicators are low, suggesting potential inequalities or gaps in social policies that need to be addressed.

Conclusion

The variables chosen to describe the Sustainable Development Index (SDI) cover a wide range of economic, social, and environmental aspects, aligning with various Sustainable Development Goals (SDGs). This comprehensive selection ensures a holistic assessment of sustainability in EU countries. The process involves identifying extreme values using the quartile criterion and winsorizing the data to limit the impact of outliers. This step is crucial for ensuring the robustness and reliability of the analysis.

The results present the synthetic measures of HDI and SDI for EU countries in 2021. Countries were categorized into different levels of sustainable development and human development, highlighting disparities among EU countries. For instance, countries like Denmark and Sweden have high levels of both SDI and HDI, indicating a balanced approach to sustainability and human development, while Romania and Bulgaria have the lowest HDI and SDI values. The findings indicate that Northern and Western European countries generally achieve higher scores. In contrast, countries in Eastern and Southern Europe face more significant challenges, emphasizing the need for targeted development strategies. The strong positive correlation between SDI and HDI underscores the alignment between sustainable development and human development.

Countries were plotted in four quadrants based on their SDI and HDI scores, providing a visual representation of their performance. The analysis highlights the importance of considering multiple dimensions of development. Countries with high HDI but lower SDI may need to focus more on sustainability aspects, while those with high SDI but lower HDI might need to improve human development indicators.

In conclusion, the study outlines a thorough methodology for assessing sustainability and human development in EU countries. The results indicate that while many countries achieve high levels of human development, there is variability in their sustainability performance, underscoring the need for balanced development strategies.

These studies allow for the evaluation of a country's progress in various aspects of sustainable development and quality of life. They help identify areas that need improvement and highlight successful initiatives. The findings provide valuable insights for policymakers. They help in designing and adjusting public policies aimed at improving living conditions and protecting the environment. These studies facilitate international comparisons, which are essential for understanding how different countries address sustainable development challenges. This promotes the exchange of best practices and collaborative problem-solving. These studies help identify strategies that can ensure long-term economic, social, and environmental development. Regular monitoring and evaluation of progress in SDI and HDI allow for the continuous adjustment of policies and strategies.

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Appendix

Table A1. Descriptive statistics of the input data.

Variable	Mean	Median	Min	Max	SD	CV	Skew	Ex. kurtosis	percentile %5	95%	IQR	Jarque-Bera statistics
x_1	8.02	7.5	2.8	15.5	3.22	0.4	0.45	-0.45	3.59	13.26	4.8	0.588679
x_2	67.93	69.1	47.9	81.2	8.54	0.12	-0.97	0.31	49.92	77.97	8.8	0.145312
x_3	1.87	1.12	0.38	8.21	1.95	1.04	1.93	2.62	0.456	5.344	1.17	0.00001***
x_4	56.30	55.31	27.82	79.18	12.11	0.21	-0.31	0.23	34.705	76.405	14.7	0.802889
x_5	44.54	44.2	23.3	62.6	9.85	0.22	-0.03	-0.40	29.68	61.03	13.4	0.90867
x_6	9.62	8.4	1.4	20.1	5.15	0.53	0.71	-0.32	2.51	19.62	5.9	0.345788
x_7	26.45	24.7	8.5	45.3	10.23	0.38	0.71	-0.88	9.19	38.59	15.6	0.59091
x_8	8.08	6.79	2.47	25.04	4.59	0.56	2.25	5.26	4.423	15.856	4.53	0.006***
x_9	74.56	75.5	62.6	81.7	5.11	0.07	-1.02	0.18	64.02	80.28	5.6	0.119555***
x_{10}	28480	23330	6950	86540	18772.1	0.66	1.63	2.16	10581	65699	21870	0.00036867***
x_{11}	1.75	1.46	0.47	3.43	0.91	0.52	0.59	-0.89	0.68	3.358	1.23	0.319685
x_{12}	4.76	4.41	3.2	7.45	1.21	0.25	0.66	-0.60	3.294	6.959	1.91	0.302681
x_{13}	41.06	42.2	11.3	69.3	15.55	0.38	-0.32	-0.60	13.72	61.99	24.9	0.670208
x_{14}	121.75	123.8	88.3	145.9	16.60	0.14	-0.43	-0.87	93.14	142.6	29	0.451194
x_{15}	74.89	76.8	24.2	147.2	27.46	0.37	0.31	0.36	30.75	109.98	38.7	0.767853
x_{16}	27.49	26.5	13.3	55.8	10.76	0.39	0.64	-0.18	14.14	40.82	19.2	0.428258
x_{17}	63.74	61	42	88	14.38	0.23	0.26	-1.20	43.6	87.1	21	0.389559
x_{18}	0.33	0.26	0.07	0.99	0.25	0.77	1.37	0.63	0.12	0.865	0.33	0.0190571

Note: SD – standard deviation, CV – coefficient of variation, IQR – interquartile range, *** denotes the rejection of the hypothesis that the distribution of the variable is normal at the significance level of 1%.

