Multidimensional Assessment of Sustainable Development Index and Human Development Index in EU Countries Using Topsis and Bilinear Ordering

Authors: Cihan Çalıkoğlu, PhD in Economics,
Faculty of Economics,
cihan.calikoglu@up.poznan.pl

Prof. dr. Aleksandra Łuczak,
aleksandra.luczak@up.poznan.pl

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Introduction

- This paper focuses on the construction of the Sustainable Development Index (SDI) for EU countries, integrating variables from economic, social, and environmental fields. The Human Development Index (HDI) of United Nation (UN), widely recognized as a universal measurement of nations' development, evaluates three key dimensions: health, knowledge, and standard of living.
- The SDI offers a robust framework for measuring and comparing the SD status of each country, while the HDI provides a well-established measure of human development.

Research Aim

- The primary aim of this paper is to determine how the Human Development Index (HDI) affects Sustainable Development (SD) in EU countries. Specifically, it examines the relationship between the HDI score and its dimensions with the Sustainable Development Index (SDI), constructed using selected indicators from Eurostat data.

Research Methodology

- Multi-Criteria Decision Making (MCDM): The SDI is developed using the TOPSIS procedure (Technique for Order of Preference by Similarity to Ideal Solution), modified by Łuczak and Kalinowski (2020).
- Bilinear Ordering: A graphical representation is applied to position countries within a coordinate system based on their SDI and HDI scores.
- Spearman’s Rank Correlation Analysis: Used to analyse the relationship between SDI and HDI.

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

1	Selection of the SD variables - economic, social, and environmental
2	Identification of extreme values
3	Winsorization of data
4	Converting destimulants to stimulants
5	Normalization of the values (zero unitarization)
6	Determination of Positive and Negative Ideal Solutions (PIS and NIS)
7	Calculation of the distance value from PIS to NIS (Euclidean distance)
8	Construction of the synthetic measure index
9	Linear ordering and determination of the levels of SDI
10	Bilinear ordering of SDI and HDI

Bilinear Ordering

- Bilinear ordering is done by positioning countries on a two-dimensional plane, plotting SDI values on the x-axis and HDI values on the y-axis. Countries are categorized into four quadrants, representing their relative performance in SDI and HDI:

I. Quadrant I (SDI+ HDI+): Above-average in both SDI and HDI

II. Quadrant II (SDI− HDI+): Below-average SDI but above-average HDI

III. Quadrant III (SDI− HDI−): Below-average in both SDI and HDI

IV. Quadrant IV (SDI+ HDI−): Above-average SDI but below-average HDI

Results

- The data was collected from Eurostat for the year 2021, covering 27 EU countries. A total of 18 sustainable development variables were selected to provide an index score based on SD performance for each country to construct a ranking.
- The HDI data was derived from the United Nations Development Programme. HDI is the geometric mean of normalized indexes for each of the three dimensions: (1) life expectancy, (2) education, and (3) GNI per capita. Descriptive statistics were calculated using the Gretl program.
- The correlation analysis between SDI and HDI was conducted using the Spearman rank correlation coefficient (r_s = 0.8518), which indicates a strong positive relationship. This is supported by a statistically significant t-statistic of 8.13 and a p-value of 0.01.

Table 2: Name of the SD Variables and Related SDGs

X1	In work at-risk-of-poverty rate	SDG1
X2	Share of people with good or very good perceived health	SDG3
X3	Standardised death rate due to tuberculosis, HIV and hepatitis	SDG3
X4	Share of individuals having at least basic digital skills	SDG4
X5	Share of tertiary educational attainment	SDG4
X6	Gender employment gap rate	SDG5
X7	Positions held by women in senior management positions rate	SDG5
X8	Energy productivity € per kg	SDG7
X9	Employment rate	SDG8
X10	Real GDP € per capita	SDG8
X11	Gross domestic expenditure rate on R&D sector	SDG9
X12	Income distribution ratio of 20 highest and 20 lowest	SDG10
X13	Recycling rate of municipal waste	SDG11
X14	Average CO2 emissions per km from new passenger cars	SDG12
X15	Net greenhouse gases	SDG13
X16	Surface rate of the terrestrial protected areas	SDG15
X17	Corruption perceptions index	SDG16
x18	Official development assistance as a share of GNI	SDG17

Table 3: 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

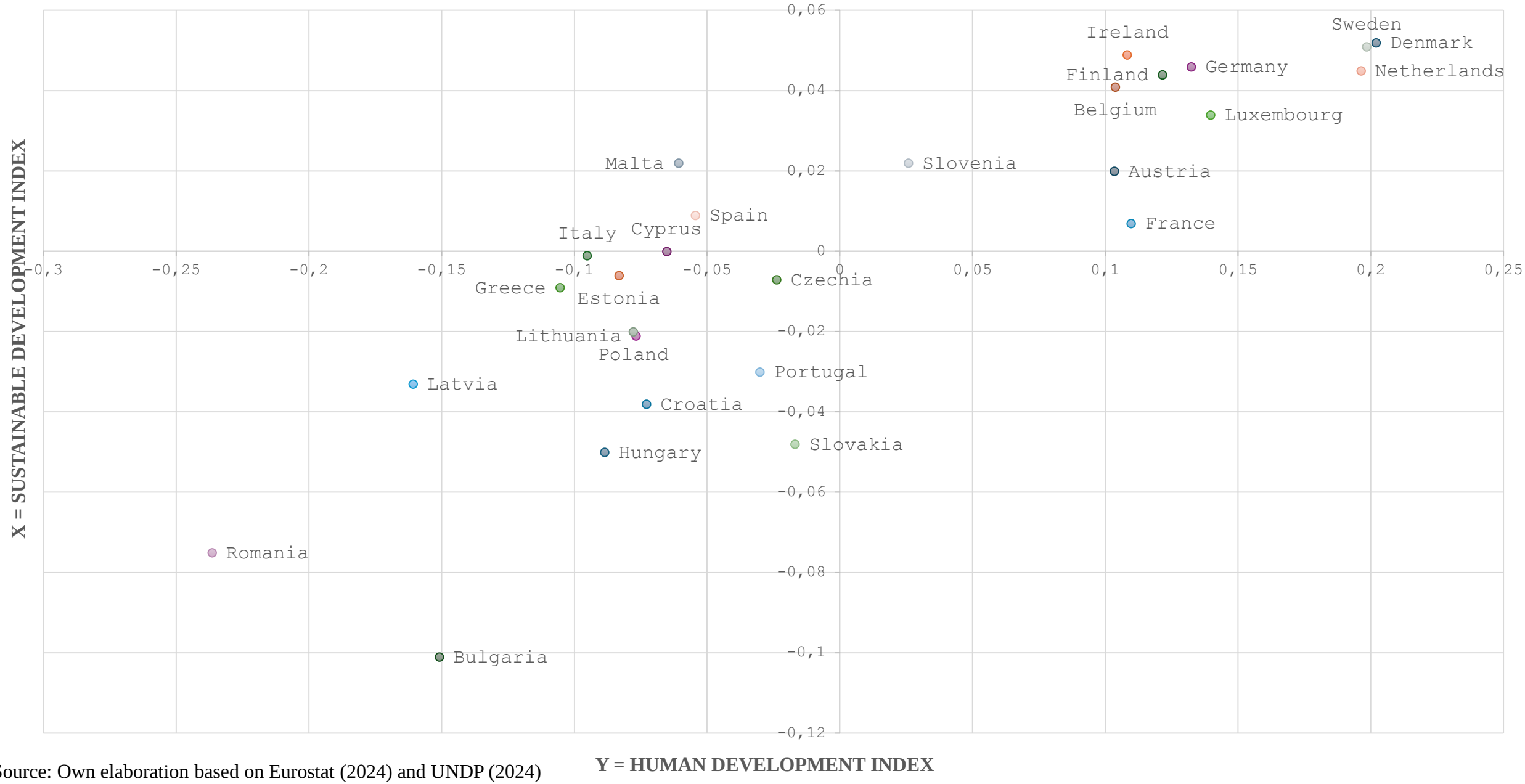
Typological classes of EU countries by SDI in 2021

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

Typological classes of EU countries by HDI in 2021

General human 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

Figure 1. Four quadrants for SDI and HDI for 27 EU



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

CONCLUSION

- Geographic Trends: Northern & Western Europe (e.g., Denmark, Sweden): Lead in both SDI and HDI, showcasing a balanced approach. Eastern & Southern Europe (e.g., Romania, Bulgaria): Face challenges, with lower scores in both dimensions.
- Notably, Quadrant IV (SDI+ HDI−) indicates no EU countries perform well in sustainability but poorly in human development.
- Positive correlation between SDI and HDI highlights the strong link between sustainability and human development. While many countries achieve high human development, sustainability performance shows significant variability.
- EU countries with high HD but lagging in sustainability, such as Spain and Malta, should focus on integrating sustainable development goals into national strategies to align their socio-economic progress with environmental and long-term resilience.

MULTIDIMENSIONAL ASSESSMENT OF SDI AND HDI USING TOPSIS AND BILINEAR ORDERING

Cihan Çalikoğlu
Poznań University of Life Sciences, Faculty of Economics, Poland
Author

Aleksandra Łuczak
Poznań University of Life Sciences, Faculty of Economics, Poland
Author

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Abstract

This study investigates how the Human Development Index (HDI)

Thank you for your attention