DOI: 10.18290/pepsi-2025-0025

Iwona Bąk*
Anna Spoz
Magdalena Zioło

Sustainable Development Levels and Convergence Patterns in EU Countries in 2015, 2019 and 2023

ABSTRACT

The aim of this article is to assess the level of sustainable development of European Union countries in 2015, 2019 and 2023 using a synthetic measure derived from economic, social, and environmental indicators, and to analyse typological changes as well as convergence patterns in the relative positioning of EU member states. Sustainable development, grounded in the principles of the 2030 Agenda and the Sustainable Development Goals (SDGs), requires coordinated action by the Member States, which makes it particularly important to examine differences and changes in overall development levels across countries rather than in individual dimensions considered separately. Existing research highlights heterogeneous and selective development trajectories within the EU, with partial convergence in some areas and persistent disparities in others. The analysis is based on Eurostat data and 15 diagnostic indicators describing sustainable development, aggregated using a robust positional approach employing the Weber median, which is resistant to outliers and distribution asymmetry and enables a reliable assessment of cross-country diversity. On this basis, country rankings

* Correspondence regarding this paper should be sent to Anna Spoz (ORCID: 0000-0001-5071-0017), Institute of Economics and Finance, John Paul II Catholic University of Lublin, e-mail: anna.spoz@kul.pl; Iwona Bąk (ORCID: 0000-0001-8959-7269), West Pomeranian University of Technology, e-mail: iwona.bak@zut.edu.pl; Magdalena Zioło (ORCID: 0000-0003-4136-046X), University of Szczecin, e-mail: magdalena.ziolo@usz.edu.pl.

and four typological groups were identified. The results reveal persistently high disparities in sustainable development levels, with Sweden consistently occupying the leading position, while Greece, Bulgaria, and Romania remain at the bottom of the ranking. Although some countries, including Slovakia and Croatia, recorded upward shifts in their typological classification, no clear tendency toward overall convergence was observed. The findings are relevant for policymakers involved in cohesion policy, the energy transition, and the implementation of the 2030 Agenda, as well as for researchers and institutions monitoring progress towards the Sustainable Development Goals (SDGs).

KEYWORDS: sustainable development; European Union; convergence; synthetic index; Weber median; SDGs

INTRODUCTION

One of the most difficult, yet crucial, challenges of our time is the implementation of sustainable development, which assumes the simultaneous achievement of economic, social, and environmental goals in a way that preserves development potential for future generations (Mensah, 2019). These principles were formally adopted in the 2030 Agenda and articulated in its Sustainable Development Goals (SDGs). This document identifies ambitious challenges, including reducing social inequalities, transitioning to low-emission energy technologies, and strengthening socioeconomic resilience. Achieving these goals is only possible if all countries take coordinated actions to increase the productivity and competitiveness of the economy, reduce emissions, improve the quality of life, reduce social inequalities and manage natural resources responsibly (D'Adamo et al., 2025). Sustainable development requires a holistic approach in which all three dimensions – economic, social and environmental – must develop in parallel and remain in mutual balance (Henderson & Loreau, 2023).

The implementation of this concept at the level of the European Union is, however, unattainable without coordinated

and collective action by all member states. In this context, the concept of convergence, understood as the process of reducing developmental disparities between countries or regions, gains particular importance. Convergence constitutes a necessary condition for achieving long-term socio-economic stability and for fully realising the objectives of sustainable development (European Commission, 2023; Monfort et al., 2021). Its absence may lead to the emergence of "development gaps" that slow the economic, ecological, and social transformation of the Union as a whole (Borović et al., 2024; Constantin et al., 2021). Moreover, convergence proceeds at varying speeds depending on the dimension under analysis: while the economic domain tends to follow equalising trajectories, the social and environmental spheres increasingly exhibit divergence (Bąk et al., 2024a; Busu & Nedelcu, 2021; Kijek et al., 2022). Economic growth therefore does not automatically translate into a higher level of sustainable development, which justifies the need for simultaneous and integrated examination of both processes.

Comparing the levels of sustainable development and convergence among EU member states makes it possible to identify developmental asymmetries, assess the effectiveness of cohesion policy and the European Green Deal, and determine which countries require more intensive institutional and financial support (Atabey et al., 2025). The results of such analyses simultaneously serve as a reference point for designing future policy interventions, enabling an assessment of whether the European Union is moving toward a more sustainable and cohesive socio-economic structure.

The main goal of this article is to assess the level of sustainable development in European Union countries in 2015, 2019 and 2023 using a synthetic measure derived from economic, social and environmental indicators, and to analyse typological changes and convergence patterns among EU member states.

The article seeks to address the following research questions:
– What is the level of sustainable development of EU member states in 2015, 2019 and 2023 as measured by a synthetic index?
– How did the positions of countries change in the rankings based on the synthetic measure over time?
– Do the observed changes in the synthetic measure suggest relative convergence among EU countries?

The article consists of the following sections: an introduction, a literature review, a description of the research methods, the presentation and discussion of results, and concluding remarks.

LITERATURE REVIEW

Research on convergence in the European Union, conducted since the 1990s, has increasingly taken the form of multidimensional analyses since 2015, going beyond the traditional approach of real GDP per capita convergence. The literature has established a distinction between nominal and real convergence, with the latter referring to the actual convergence of member states' levels of development and prosperity (Žďárek & Šindel, 2007; Bobeva, 2021; Kluth, 2023). Against this background, more recent studies emphasize that closing income and productivity gaps between the "old" and "new" EU remains a key element of integration, although – as Holobiuc (2020) points out – this process is uneven and exhibits significant spatial differentiation. The results of research on Central and Eastern European countries clearly illustrate this heterogeneity. László's (2025) analysis shows that the pace of catching up with the EU average varies significantly: in 2022, Lithuania, the Czech Republic, and Slovenia exceeded the EU average in GDP per capita, while Bulgaria and Croatia lagged far behind. Countries starting from the lowest levels grew the fastest, and forecasts indicate that Estonia may be the next country to exceed the EU average.

Szczepańska-Woszczyna et al. (2022) present similar conclusions, emphasizing that the countries that joined the EU after 2004 developed at more than twice the pace of the "old" Member States, although their growth exhibited lower stability. This picture is complemented by Velichkov and Damyanov's (2021P) study of Bulgaria, Romania, and Croatia. They show that until 2009, the divergence of their GDP expenditure structure from the eurozone was increasing, especially in the area of net exports, while convergence processes clearly intensified after the crisis. Production structures converged faster before 2009, especially in Bulgaria and Romania, but after the crisis, this dynamic weakened and became more unstable.

Findings from institutional reports and empirical studies indicate that real convergence is not an automatic process, and that meeting nominal criteria or participating in the monetary union does not guarantee a lasting equalisation of development levels (European Central Bank, 2015; Hoyo et al., 2017; Truglia & Zeli, 2025). The weak convergence observed in some euro area countries – particularly among its early members – stems from persistent productivity differentials and pre-existing macroeconomic imbalances, while durable convergence requires enhanced competitiveness, institutional improvements, and structural reforms (Coutinho & Turrini, 2020; Miron et al., 2022).

An important direction in EU convergence research concerns the identification of the types of equalising processes that occur and the countries or regions that are moving closer to one another. For this reason, β- and σ-convergence approaches, along with clustering techniques such as cluster analysis and club convergence, have gained importance. The study by Bal-Domańska (2024) shows that although signs of β-convergence in income levels are evident in many EU regions, substantial differences in the distributional structure of incomes persist, indicating that convergence remains only conditional and incomplete.

While international convergence has long been the main reference point for analyses of economic development, contemporary literature is increasingly shifting the emphasis to differentiation and convergence processes occurring at the regional and subregional levels. Research on regional inequalities and cohesion policy indicates persistent spatial disparities in the level of socio-economic development and R&D activity, which justifies the need for interventions tailored to territorial specificities (Churski, 2023; Zaucha et al. 2015). In this context, the place-based approach emphasizes the growing role of local and regional authorities in pursuing development objectives, alongside a reduction in external sources of financing, which in turn increases the importance of instruments of territorial cooperation such as Integrated Territorial Investments (Kwaśny, 2018). The results of Piętak's (2025) econometric analyses confirm a positive yet highly spatially differentiated impact of cohesion policy on subregional growth, indicating that its effectiveness does not depend linearly on the scale of allocation and may be limited or even negative in subregions receiving above-average support, including large cities and their functional areas.

Similar conclusions regarding the absence of automatic diffusion effects are supported by the study of Kisiała and Stępiński (2024), who demonstrated that although EU funds in the period 2007–2015 fostered economic growth and reduced disparities among EU regions, resources obtained by neighbouring units did not translate into a significant increase in the growth dynamics of a given locality. At the same time, these authors confirmed the presence of significant spatial effects in growth models, pointing to the complex and ambiguous nature of territorial interactions. In turn, Romanowski et al. (2023), analysing the process of β-convergence at the county (powiat) level in Poland in the years 2007–2016, identified a gradual reduction in economic inequalities that was strongly dependent on the volume of EU funds obtained for innovation. Contrary to expectations derived from the growth

diffusion concept, these funds stimulated economic development within a given county while exerting a negative impact on the growth dynamics of neighbouring units.

Taken together, the empirical evidence thus points to broad agreement on the existence of convergence processes and the importance of cohesion policy, accompanied by divergences in assessments of the direction and magnitude of spatial effects. Consequently, the literature increasingly emphasizes that effective convergence – also in the area of R&D – requires a genuine territorialisation of regional policy, one that accounts for endogenous potentials, functional relationships, and the differentiated sensitivity of regions and subregions to public intervention (Churski, 2023; Gorzelak, 2021).

An important strand of convergence research concerns club convergence, which points to the existence of groups of regions or countries following distinct developmental trajectories. The study by Kijek et al. (2022) shows that, in terms of R&D expenditure, EU regions form clearly differentiated "clubs" – highly innovative regions follow a different equilibrium path than regions with weaker knowledge potential, a pattern stemming, among other factors, from disparities in human capital, technological resources, and knowledge absorption capacity. Similar tendencies emerge in analyses of technological activity: Barrios et al. (2019) identify as many as seven convergence clubs in the domain of innovative activity across European regions, demonstrating that initial R&D investment is a key determinant of club membership even when controlling for other structural characteristics. Comparable conclusions are drawn by Cavallaro and Villani (2021), who show that productivity structures in EU countries do not converge toward a single path but instead form stable growth clusters reinforced by the effects of economic crises. Meanwhile, analyses by Xu et al. (2023) indicate that even in the field of sustainable innovativeness, critical for the EU's energy and climate transition, pronounced

regional disparities persist, along with distinct convergence trajectories in environmental innovation efficiency.

Interest has also increasingly shifted toward social convergence – the equalisation of poverty levels, income inequality, access to the labour market, and quality of life. Findings by Gryni and Marcinkiewicz (2025) indicate that despite some income convergence, many social indicators remain highly differentiated, and in some countries, including in the area of poverty risk, conditions have even deteriorated. These observations are confirmed by a more recent study by Suárez-Arbesú et al. (2023), which identifies the existence of convergence clubs in income inequality, suggesting that social integration progresses unevenly. Additionally, Cyrek's (2025) analysis shows that structural conditions – such as employment structure – determine in which countries inequality is reduced and in which social convergence remains weak or stagnates.

The cited studies point out that convergence in the EU is multipath, selective and deeply spatially conditioned, which argues for the persistence of many parallel development equilibrium states, and not for uniform convergence of the entire Union.

The importance of the concept of sustainable development means that the literature on this topic is extensive and dynamically developing. An analysis of the relevant literature allows several leading research directions to be distinguished. Primarily, these include assessing progress in achieving the 2030 Agenda (Perkowski et al., 2023) and individual Sustainable Development Goals (Grzebyk et al., 2025; Firlej et al., 2024; Krzyżanowski, 2024; Bisogno et al., 2025). A significant number of studies analyse the links between SDG goals, including studies on synergies and trade-offs between the economic, social, and environmental pillars (Mainali et al., 2018; Hegre et al., 2020; Kuc-Czarnecka et al., 2023).

Numerous studies – both those using existing SDG indicators and those constructing their own sets – classify EU countries according to their level of sustainable development. The emerging

indices range from several dozen to over a hundred indicators related to all 17 SDGs, enabling the assessment of the "sustainability maturity" of European economies. Similar approaches are being developed in sub-studies that analyse economic, social, or environmental dimensions separately (Kraak et al., 2018; Lella et al., 2024; Hamad et al., 2023).

An important research stream also examines spatial and regional differences, assessing progress in achieving the SDGs both between countries and between regions (Kanojia et al., 2025; Çelik et al., 2025). A significant body of literature also relates sustainable development to specific public policies—primarily energy transition (Grzebyk et al., 2025; Ibrahim, 2023; Ullah et al., 2024), the green economy (Sarker & Kaparaju, 2024; Chaaben et al., 2024), and sustainable consumption and production (Geng et al., 2025).

Against this background, our study represents an approach that extends existing research by integrating economic, social and environmental indicators into a single synthetic measure of sustainable development and by analysing changes in the relative positioning and typological classification of EU countries over time. This approach makes it possible to assess the overall level of sustainable development and to identify patterns of convergence at the aggregate level, rather than within individual dimensions considered separately. By focusing on relative dynamics and cross-country diversity over a longer time horizon, the study offers a more comprehensive picture of differentiation and change in sustainable development across the European Union.

MATERIAL AND METHODS

The empirical research presented in this article is based on a database created using data provided by Eurostat. This database contains statistical data on the sustainable development of European Union countries, both spatially (for individual European

countries) and dynamically (for individual years). The study utilized 15 indicators, and the impact of each of these indicators on the analysed phenomenon was identified by classifying them as either stimulating development in a given area (symbol S) or destimulating it (symbol D):

X_{1S} – GDP per capita (PPS),
X_{2S} – Gross fixed capital formation (% of GDB),
X_{3S} – Employment and activity, Age: from 20 to 64 years (% total population),
X_{4S} – Labour productivity and unit labour costs (2014=100),
X_{5S} – Gross domestic expenditure on R&D (EUR per inhabitant),
X_{6D} – Greenhouse gas emissions (Tonnes per capita),
X_{7S} – Share of renewable energy in gross final energy consumption (%),
X_{8S} – Recycling rate of municipal waste (%),
X_{9S} – Resource productivity (EUR/kg),
X_{10D} – Persons at risk of poverty or social exclusion (%),
X_{11D} – GINI coefficient of equivalised disposable income,
X_{12D} – Unemployment rates by citizenship (%),
X_{13S} – Healthy life years at birth (years),
X_{14S} – Persons aged 25-34 with tertiary educational attainment leve (%),
X_{15D} – Gender employment gap.

It should be noted that the majority of the indicators (54.5%) are stimulants, meaning variables that exert a positive influence on the phenomenon under examination.

Many indicators are characterized by significant variation, with the highest coefficient of variation for the X1S indicator, GDP per capita. This significant variation is due, among other things, to the significant differences between the maximum and minimum values. The highest value of this indicator, 320.4, was recorded for Luxembourg, while the lowest, 38.2, was recorded for Bulgaria. Furthermore, some of the indicators used in the study were

characterized by high or moderate right-sided skew, meaning that in most European countries, their values were below average. For indicators classified as stimulants, this represents a disadvantage, as they are below average for most of the analysed countries.

In this study, the standard method, using the positional approach employing the Weber median (Weber, 1971), was used to construct a taxonomic measure of development. The main reason for choosing this method was the significant diversity and strong asymmetry of characteristics describing sustainable development. Furthermore, this method is more resistant to outliers than classical methods. This method is quite frequently used in socio-economic research (Czech et al., 2017; Szopik-Depczyńska et al., 2018; Bąk et al., 2024b).

The normalization of variables using the Weber median is performed according to the following formula (Młodak, 2006):

$$z_{ij} = \frac{x_{ij} - \theta_{0j}}{1{,}4826 \cdot \tilde{\text{mad}}(X_j)} \tag{1}$$

where:
$\theta_0 = (\theta_{01}, \theta_{02}, \ldots, \theta_{0m})$ – Weber median
$\tilde{\text{mad}}(X_j)$ – median absolute deviation, which measures the distance of the variables from the corresponding coordinates of the Weber vector, which is: $\tilde{\text{mad}}(X_j) = \underset{i=1,2,\ldots,n}{\text{med}} |x_{ij} - \theta_{0j}| \; (j = 1,2,\ldots m)$

The aggregate measure is determined according to the following formula:

$$\mu_i = 1 - \frac{d_i}{d_-}, \tag{2}$$

where:
d_- =med(d)+2,5mad(d), and d = $(d_1, d_2, \ldots, d_n)$ is the vector of distances determined according to the formula:

(3) $$d_i = \underset{j=1,2,\ldots m}{\text{med}} \left| z_{ij} - \phi_j \right|$$

where:

$i = 1,2,\ldots,n$,

$\phi_j = \underset{i=1,2,\ldots,n}{max} z_{ij}$ — the coordinates of the development standard vector, defined as the maximum values of the normalized variables.

The higher the value of the metric, the higher the level of development of the object. Using the Weber median method allows for the elimination of the confounding influence of outliers, enables the determination of the contribution of individual deviations to the appropriate aggregate value, and at virtually every stage of research treats the set of diagnostic features as a single entity, striving to maximize the exploitation of all their interrelationships (Młodak, 2006).

Ordering objects using a positional metric provides the basis for grouping objects into four classes. The most commonly used positional clustering method is called three-median method. It involves determining the median coordinate vector $\mu = (\mu_1, \mu_2, \ldots, \mu_n)$, denoted by $\text{med}(\mu)$, and then dividing the set of objects into two groups, i.e., those for which the metric values exceed the median and are not greater than it. Then the intermediate medians are defined as: $med_k(\mu) = \underset{i:\Gamma_i \in \Omega_k}{\text{med}} (\mu_i)$

where k = 1,2.

Using the above method, the following groups of objects are created:

I – $\mu_i > \text{med}_1(\mu)$,
II – $\text{med}(\mu) < \mu_i \leq \text{med}_1(\mu)$,
III – $\text{med}_2(\mu) < \mu_i \leq \text{med}(\mu)$,
IV – $\mu_i \leq \text{med}_2(\mu)$.

RESULTS

Table 1 presents the values of synthetic measures characterizing the level of sustainable development in EU countries, as well as country rankings and their affiliation with typological groups. It is assumed that the higher the values of the synthetic measure, the better the situation of a given object in terms of the level of the phenomenon being studied. Consequently, objects with the highest values of the positional taxonomic measure of development are assigned to the first (best) class, while those with the lowest values are placed in the fourth (worst) group.

Table 1. Aggregate variable values, ranks, and typological groups of EU countries in 2015, 2019, and 2023

Country	2015			2019			2023		
	μ_i	Rank	Group	μ_i	Rank	Group	μ_i	Rank	Group
Austria	0,700	3	1	0,481	12	2	0,492	9	2
Belgium	0,622	7	2	0,611	4	1	0,600	3	1
Bulgaria	0,290	24	4	0,214	24	4	0,117	26	4
Croatia	0,316	21	4	0,334	20	3	0,377	13	2
Cyprus	0,340	20	3	0,408	16	3	0,317	17	3
Czechia	0,287	25	4	0,275	23	4	0,260	21	4
Denmark	0,619	8	2	0,644	2	1	0,578	6	1
Estonia	0,460	15	3	0,430	13	2	0,350	16	3
Finland	0,633	6	1	0,639	3	1	0,545	7	2
France	0,635	5	1	0,546	10	2	0,459	10	2
Germany	0,601	10	2	0,557	8	2	0,374	14	3
Greece	0,236	26	4	0,143	25	4	0,023	27	4
Hungary	0,428	16	3	0,486	11	2	0,379	12	2
Ireland	0,614	9	2	0,606	5	1	0,617	2	1
Italy	0,295	23	4	0,108	26	4	0,193	24	4
Latvia	0,466	13	2	0,290	22	4	0,276	20	3

Country	2015			2019			2023		
	μ_i	Rank	Group	μ_i	Rank	Group	μ_i	Rank	Group
Lithuania	0,467	12	2	0,338	19	3	0,369	15	3
Luxembourg	0,709	2	1	0,594	7	2	0,544	8	2
Malta	0,420	17	3	0,409	15	3	0,249	22	4
Netherlands	0,687	4	1	0,605	6	1	0,578	5	1
Poland	0,464	14	3	0,396	18	3	0,217	23	4
Portugal	0,411	18	3	0,403	17	3	0,291	18	3
Romania	0,216	27	4	0,054	27	4	0,135	25	4
Slovakia	0,304	22	4	0,410	14	3	0,394	11	2
Slovenia	0,513	11	2	0,555	9	2	0,578	4	1
Spain	0,405	19	3	0,314	21	4	0,280	19	3
Sweden	0,836	1	1	0,687	1	1	0,687	1	1

Source: own calculation

Table 2. Classification of European Union Member States into typological groups in 2015, 2019, and 2023

Typological group	Year		
	2015	2019	2023
I	Austria Finland France Luxembourg Netherlands Sweden	Belgium Denmark Finland Ireland Netherlands Sweden	Belgium Denmark Ireland Netherlands Slovenia Sweden
II	Belgium Denmark Germany Ireland Latvia Lithuania	Austria Estonia France Germany Hungary Luxembourg Slovenia	Austria Belgium Croatia Finland France Hungary Luxembourg Slovakia

III	Cyprus Estonia Hungary Malta Poland Portugal Spain	Croatia Cyprus Lithuania Malta Poland Portugal Slovakia	Cyprus Estonia Germany Latvia Lithuania Portugal Spain
IV	Bulgaria Croatia Czechia Greece Italy Romania Slovakia	Bulgaria Czechia Greece Italy Latvia Spain	Bulgaria Czechia Greece Italy Malta Poland Romania

Note. Own elaboration.

As shown in Tables 1 and 2, the only country that consistently occupied the top position in all examined years was Sweden, distinguished by the lowest greenhouse gas emissions per capita among EU member states (X_6) and the highest share of renewable energy in gross final energy consumption (X_7). The country also ranks among the leaders with respect to gross domestic expenditure on R&D (X_5). The first typological group also includes the Netherlands, which has the highest value of indicator X_9 (Resource productivity) among all EU countries. Ireland is also noteworthy, as it moved from the second group in 2015 to the first group in both 2019 and 2023. Ireland stands out due to its high gross fixed capital formation (X_2) and a very high proportion of individuals aged 25–34 with tertiary education (X_{15}).

The lowest values of the synthetic measure in 2023 were recorded for Greece, Bulgaria, and Romania. The first of these countries exhibited the lowest values among all EU member states for the following indicators across all examined years: Gross fixed capital formation (X_2) and Employment and activity, Age: 20–64 (X_3). In addition, Greece was characterized by a low level of

indicator X_4 (Labour productivity and unit labour costs) and high values of X_{12} (Unemployment rates by citizenship) and X_{15} (Gender employment gap). Bulgaria had the lowest GDP per capita (X_1) and Healthy life years at birth (X_{13}) in the EU. Romania, in turn, reported the lowest expenditure on research and development (X_5) among the countries studied and the smallest share of individuals aged 25–34 with tertiary education (X_{14}). Moreover, it was characterized by the highest proportion of people at risk of poverty or social exclusion (X_{10}) and a high level of the GINI coefficient of equivalised disposable income (X_{11}).

In the years under study, the positions of individual countries in the rankings changed frequently. In 2023, compared with 2015, only three countries retained their positions: Portugal (18th place), Spain (19th place), and Sweden (1st place). The mobility of ranking positions observed in the study for certain countries is of a relative nature and results from differentiated rates of change across the individual components of the synthetic sustainable development indicator.

The most pronounced downward shift was recorded for Poland (by nine positions). This decline can be attributed primarily to a relatively weaker improvement in environmental and social indicators, such as greenhouse gas emissions per capita, the share of renewable energy sources, and measures of inequality and the risk of social exclusion, combined with more rapid progress achieved by other EU countries in these areas.

The most substantial improvement was observed in the case of Slovakia (by eleven positions). Slovakia's advancement in the ranking resulted from improvements in economic and innovation-related indicators, including increased investment outlays, higher labour productivity, and greater expenditure on research and development, alongside a relative stability of social conditions.

Slovakia is also one of only two countries that advanced by two typological groups. The other country is Croatia, which like Slovakia, moved from group 4 in 2015 to group 2 in 2023. In the

case of Croatia, the improvement in ranking was driven primarily by progress in the social and environmental dimensions, particularly in terms of employment and the share of renewable energy, which contributed to a more balanced development structure.

These findings confirm that changes in ranking positions do not necessarily reflect unequivocal national progress but are often the result of differences in the pace of transformation across individual countries, thereby reinforcing the conclusion that convergence processes in the European Union are selective and conditional in nature.

DISCUSSION

In this study, the level of sustainable development in the 27 European Union member states was assessed for the years 2015, 2019 and 2023 using a synthetic index constructed from 15 Eurostat indicators representing economic, social and environmental dimensions. The analysis focuses on the overall level and relative dynamics of sustainable development as a multidimensional phenomenon, rather than on convergence processes within individual dimensions considered separately. The results indicate persistent polarization, with Sweden maintaining a stable leading position and Greece, Bulgaria and Romania consistently ranking at the lower end of the distribution. At the same time, no clear tendency toward overall convergence in sustainable development levels was observed, despite the typological advancement of some countries, such as Croatia and Slovakia.

When interpreting the results obtained (particularly for 2023), it is necessary to take into account the role of two successive external shocks – the COVID-19 pandemic and the war in Ukraine – which may have significantly altered the development trajectories of European Union countries, especially in the areas of energy, labour markets, poverty, and research and development activity.

The literature clearly indicates that the Russian-Ukrainian conflict has had profound and multidimensional economic consequences, with Europe suffering the most, due not only to its geographical proximity but also to its dependence on energy and raw material imports. Simchi-Levi and Haren (2022) emphasize radical disruptions in trade in energy, oil, and components, while Hamid (2025) and Haouel (2023) point to the scale of the EU's prior dependence on Russia and Ukraine with regard to energy supplies, transit, and agricultural products. The sudden interruption of supplies and the imposition of mutual sanctions translated into a sharp increase in energy prices, intensified inflationary pressures, disruptions to supply chains, and changes in labour markets.

The magnitude and asymmetric nature of these effects are confirmed by model-based analyses. Cui et al. (2023) demonstrate that the war significantly increased the risk of disruptions in the global energy supply system, generating both short-term price volatility and long-term consequences for the economic order. Their simulations indicate that trade disruptions would lead to a substantial decline in Ukraine's real GDP, while a complete halt to EU and US imports of energy from Russia would place a particularly heavy burden on European economies. In turn, Liadze et al., using the NiGEM model, estimate the cost of the war at approximately 1% of global GDP as early as 2022, accompanied by a decline in Europe's GDP of more than 1% relative to pre-war forecasts and a marked increase in inflation in 2022–2023.

Rising inflationary pressure and declining economic activity worsened financing conditions, increasing the cost of capital and constraining the fiscal space of Member States. Combined with asymmetric exposure to energy shocks, this fostered a polarization of adaptive and innovative capacities: economies with stronger endowments and better access to finance have been able to maintain advantages in R&D, while weaker economies may consolidate their position within lower-development "clubs," as highlighted by Boichenko et al. (2023). The social dimension

of this process is emphasized by Khudaykulova et al. (2022), who identify inflation, supply shortages, trade disruptions, and pressure on public debt as key channels through which social conditions deteriorated.

These macroeconomic mechanisms are corroborated by microeconomic evidence. Obrizan (2022) shows that within the first three months of the full-scale invasion, the war translated into an increased risk of unemployment and heightened income uncertainty, particularly among forcibly displaced persons and residents of conflict-affected regions. The adverse effects proved to be strongly differentiated across social groups and by gender: women, especially those without higher education, were relatively more exposed to poverty and food insecurity, and even higher education did not provide full protection against the risk of unemployment. In a similar vein, Cherevko (2024) indicates that the war interrupted the long-term trend of poverty reduction and increased the risk of poverty for millions of people.

Bartosiewicz et al. (2025 using panel models analysed sustainable development in EU countries, confirm significant and lasting disparities among member states as well as higher levels of sustainability in economies with more favourable macroeconomic conditions. Consistent with both their findings and the results of the present study, the highest levels of economic sustainability are observed in Northern European countries, whereas the lowest levels are found in Southern Europe.

Although this study does not directly test β- or σ-convergence, the observed persistence of dispersion in the synthetic measure is consistent with findings from the convergence literature. Turtureanet al. (2022), analysing sustainability using the ISDE-EU index, report only partial convergence alongside sustained heterogeneity across EU countries. Similar conclusions are drawn by Grynia and Marcinkiewicz (2025), who observe selective convergence in social outcomes accompanied by persistent intergroup differences. The present results align with these findings, suggesting

that improvements in overall sustainable development levels do not automatically translate into a reduction of cross-country disparities.

Our results also contribute to the growing trend of research using club approaches to analyse convergence in the area of sustainable development. Atabey et al. (2025), using the club convergence method to assess EU countries' progress in achieving the SDGs, demonstrate that the system is not moving toward a single common path, but rather that distinct clubs of countries with different development trajectories are forming, leading to the coexistence of convergence within and divergence between clubs. Eleftheriou et al. (2024) reached similar results when analysing club convergence in sustainable development among developed and developing countries. The authors identify several stable development clubs, the composition of which is determined by, among other factors, institutional differences and the level of human capital. The persistence of the high position of the Nordic countries and the persistence of Southern and Central and Eastern European countries in the lowest typological groups, observed in this study, is consistent with this picture of "multiple development paths" rather than a single, common line of convergence.

The concept of selective convergence is further supported by research focusing on environmental and sustainable innovation. Xu et al. (2023), examining the convergence of sustainable innovation effectiveness in EU countries, finds convergence processes, but also persistent differences between groups of countries, leading to the emergence of distinct development paths. Solarin et al. (2025) also demonstrate that only partial convergence occurs in environmental innovation, and its pace and direction depend on the level of technological advancement and institutional conditions.

CONCLUSION

Socio-economic factors are an important aspect that is paid attention to in the context of achieving sustainable development goals. Socioeconomic factors significantly determine well-being and sustainable development. Examining the relationship between socioeconomic factors and sustainable development is relevant to the categories of individual SDGs, both in the social and economic spheres. Socioeconomic factors significantly determine well-being and sustainable development. These spheres are interconnected and interact with each other. Social issues are determined by the achievements of individual countries in economic policy, and social policy, in turn, is crucial for shaping economic achievements.

The aim of this article was to assess the level of sustainable development in European Union countries in 2015, 2019 2023 using a synthetic measure based on 15 Eurostat indicators, and to analyse changes in countries' relative positions and typological classifications over time. The synthetic index was constructed using a robust positional pattern method based on the Weber median, which ensured resistance to outliers and distribution asymmetry and enabled a reliable and comparable assessment of cross-country disparities.

The analysis revealed persistent differences in the level of sustainable development across the European Union. Throughout the examined period, Northern European countries – particularly Sweden – consistently ranked among the leaders, whereas Southern and Central-Eastern European states, such as Greece, Bulgaria, and Romania, remained at the bottom of the classification. Although some countries, including Croatia and Slovakia, recorded an improvement in typological position, this did not translate into a substantial reduction in the distance between groups of states. The absence of clear evidence of broad convergence – despite an overall improvement in results – confirms the selective and conditional nature of equalisation processes, a pattern also identified

in the literature on sustainable development, innovativeness, and social convergence.

The findings indicate that the European Union is not following a single, unified path toward sustainable development but is instead characterised by the coexistence of several distinct and relatively stable developmental trajectories. This may point to the limited effectiveness of the current cohesion policy instruments and highlights the need for a more differentiated, territorially targeted approach to supporting the transition toward sustainable development.

The study, however, has certain limitations. First, it relies exclusively on SDG indicators available in Eurostat, which do not capture all relevant aspects of sustainable development, such as institutional quality, social capital, or systemic resilience. Second, although the applied synthetic index is robust and effective in ranking countries, it does not reflect the varying weights that individual states might assign to different dimensions of the 2030 Agenda.

Future research may incorporate expanded sets of indicators, including those related to innovativeness, quality of governance, and socio-economic resilience. It would also be worthwhile to apply dynamic methods such as club convergence, network models, or analyses of synergies and trade-offs among individual SDGs. Another valuable direction involves examining convergence at the regional level (NUTS 2) and assessing the impact of key EU policies – particularly the European Green Deal and NextGenerationEU instruments – on the trajectory of sustainable development processes.

The results of this article can serve as a practical analytical tool for public decision-makers at the EU and national levels, institutions responsible for implementing cohesion policy, planning the energy transition, and monitoring progress on the 2030 Agenda. The analysis may also be valuable for academic communities,

international organizations, and experts assessing the effectiveness of policies supporting sustainable transformation.

REFERENCES

Atabey, A. Ö., Gümüş Özuyar, S. E., Özen, E., & Grima, S. (2025). Divergent pathways to sustainability: Club convergence analysis of EU progress on the sustainable development goals. *Challenges in Sustainability*, *13*(2), 207–235. https://doi.org/10.56578/cis130205

Bal-Domańska, B. (2024). In search of income convergence and ideal distribution – the case of European Union regions. *Comparative Economic Research. Central and Eastern Europe*, *27*(3), 167–190. https://doi.org/10.18778/1508-2008.27.26

Barrios, C., Flores, E., & Martínez, M. Á. (2019). Club convergence in innovation activity across European regions. *Papers in Regional Science*, *98*(4), 1545–1566. https://doi.org/10.1111/pirs.12429

Bartosiewicz, A., Gniadkowska-Szymanska, A., & Kucharski, A. (2025). Sustainable development in the European Union countries: Panel data evidence from the transport and storage sector. *Environmental Sciences Europe*, *37*, Article 174. https://doi.org/10.1186/s12302-025-01206-6

Bąk, I., Wawrzyniak, K., Oesterreich, M. (2024b). Assessment of impact of use of renewable energy sources on level of energy poverty in EU countries. *Energies*, *17*(24), Article 6241. https://doi.org/10.3390/en17246241

Bąk, I., Wawrzyniak, K., & Sulikowski, P. (2024a). Sustainable development and the degree of implementation of European Union environmental directives. *Frontiers in Environmental Science*, 12, Article 1324030. https://doi.org/10.3389/fenvs.2024.1324030

Bisogno, M., Cuadrado Ballesteros, B., Manes Rossi, F., & Peña Miguel, N. (2025). Governance quality and the sustainable development goals: an assessment in Europe. *Journal of Public Budgeting, Accounting & Financial Management*, *37*(6), 193–219. https://doi.org/10.1108/JPBAFM-01-2025-0018

Bobeva, D. (2021). Nominal, Structural and Real Convergence of the EU Candidate Countries' Economies. *Journal of Central Banking Theory and Practice*, *10*(3), 59–78. https://doi.org/10.2478/jcbtp-2021-0024

Boichenko, K., Rana, U. A., Nuno Mata, M., & Gherghina, Ș. C. (2023). The EU's socio-economic development against the backdrop of the war in Ukraine.

Central European Economic Journal, *10*(57), 72–89. https://doi.org/10.2478/ceej-2023-0005

Borović, Z., Radicic, D., Ritan, V., & Tomaš, D. (2024). Convergence and divergence tendencies in the European Union: New evidence on the productivity/institutional puzzle. *Economies*, *12*(12), 1–36.

Busu, M., & Nedelcu, A. C. (2021). Analyzing the renewable energy and CO_2 emission levels nexus at an EU level: A panel data regression approach. *Processes*, *9*(1), Article 130. https://doi.org/10.3390/pr9010130

Cavallaro, E., & Villani, I. (2021). Club convergence in EU countries: A sectoral perspective. *Journal of Economic Integration*, *36*(1), 125–161. https://doi.org/10.11130/jei.2021.36.1.125

Çelik, S., Öztürk, Ö. F., Akkucuk, U., & Şaşmaz, M. Ü. (2025). Global sustainability performance and regional disparities: A machine learning approach based on the 2025 SDG index. *Sustainability*, *17*(16), Article 7411. https://doi.org/10.3390/su17167411

Chaaben, N., Elleuch, Z., Hamdi, B., & Kahouli, B. (2024). Green economy performance and sustainable development achievement: empirical evidence from Saudi Arabia. *Environment, Development and Sustainability*, *26*(1), 549–564. https://doi.org/10.1007/s10668-022-02722-8

Cherevko, A. (2024). *Ukraine and the SDGs: How the war has influenced global development*. https://unu.edu/merit/news/ukraine-and-sdgs-how-war-has-influenced-global-development

Churski, P. (2023). Trzy dekady kształtowania polskiej polityki regionalnej – refleksje, wnioski i rekomendacje. *Rozwój Regionalny i Polityka Regionalna*, (65), 37–52. https://doi.org/10.14746/rrpr.2023.65.04

Constantin, M., Dinu, M., Pătărlăgeanu, S. R., & Chelariu, C. (2021). Sustainable development disparities in the EU-27 based on R&D and innovation factors. *Amfiteatru Economic*, *23*(Special issue 15), 948–963. https://doi.org/10.24818/EA/2021/S15/948

Coutinho, L., & Turrini, A. (2020). Real convergence across the euro area: What role do macroeconomic imbalances play? *Intereconomics*, *55*(5), 301–311. https://doi.org/10.1007/s10272-020-0920-2

Cui, L., Yue, S., Nghiem, X. H., & Duan, M. (2023). Exploring the risk and economic vulnerability of global energy supply chain interruption in the context of Russo-Ukrainian war. *Resources Policy*, *81*, Article 103373. https://doi.org/10.1016/j.resourpol.2023.103373

Cyrek, M. (2025). Structural conditions of income inequality convergence within the European Union. *Sustainability*, *17*(14), Article 6318. https://doi.org/10.3390/su17146318

Czech, A., Lewczuk, J., & Bołtromiuk, A. (2017). Multidimensional assessment of the European Union transport development in the light of implemented normalization methods. *Engineering Management in Production and Services*, *8*(4), 75–85. https://doi.org/10.1515/emj-2016-0035

D'Adamo, I., Della Sciucca, M., Gastaldi, M., & Lupi, B. (2025). Indicator assessment of sustainable development goals: A global perspective. *Sustainability*, *17*(18), Article 8259. https://doi.org/10.3390/su17188259

Eleftheriou, K., Nijkamp, P., & Polemis, M. L. (2024). Club convergence of sustainable development: fresh evidence from developing and developed countries. *Economic Change and Restructuring*, *57*(2), Article 32. https://doi.org/10.1007/s10644-024-09617-w

European Central Bank. (2015). Real convergence in the euro area: evidence, theory and policy implications. *ECB Economic Bulletin*, *5*, 30–45.

European Commission. (2023). Regional trends for growth and convergence in the European Union. *Staff Working Document* 173. Retrieved from https://ec.europa.eu/regional_policy/sources/reports/swd_regional_trends_growth_convergence_en.pdf

Firlej, K. A., Firlej, C., & Luty, L. (2024). Access to sources of stable, sustainable, and modern energy as a goal of sustainable development in the European Union: Are the Scandinavian countries leading the energy transition? *Entrepreneurial Business and Economics Review*, *12*(4), 75–95. https://doi.org/10.15678/EBER.2024.120405

Geng, Y., Zhao, S., Zhang, X., Li, J., Yan, Y., & Gao, J. (2025). Sustainable consumption and production: Research status, evolvement, and trends over the recent two decades. *Sustainable Development*. https://doi.org/10.1002/sd.70270

Gorzelak, G. (2021). Regional policies in East-Central Europe. In M. M. Sischer & P. Nijkamp (Eds.), *Handbook of Regional Science* (pp. 1087–1113). Springer.

Grynia, A., & Marcinkiewicz, J. (2025, March). Real convergence in the European Union – The social dimension. *Forum Scientiae Oeconomia*, *13*(1), 93–106. https://doi.org/10.23762/FSO_VOL13_NO1_6

Grzebyk, M., Stec, M., & Caputa, W. (2025). Implementation of sustainable development goal 7 in European Union countries – A multidimensional comparative analysis. *Economics and Environment*, *94*(3), Article 906. https://doi.org/10.34659/eis.2025.94.3.906

Hamad, S., Lai, F. W., Shad, M. K., Khatib, S. F., & Ali, S. E. A. (2023). Assessing the implementation of sustainable development goals: Does integrated reporting matter? *Sustainability Accounting, Management and Policy Journal*, *14*(1), 49–74. https://doi.org/10.1108/SAMPJ-01-2022-0029

Hamid, M. N. A. (2025). The Russia–Ukraine conflict: Economic implications for the European Union. *Policy Vanguard*, *1*(1), 27–37.

Hegre, H., Petrova, K., & Von Uexkull, N. (2020). Synergies and trade-offs in reaching the sustainable development goals. *Sustainability*, *12*(20), Article 8729. https://doi.org/10.3390/su12208729

Henderson, K., & Loreau, M. (2023). A model of sustainable development goals: Challenges and opportunities in promoting human well-being and environmental sustainability. *Ecological Modelling*, 475, Article 110164. https://doi.org/10.1016/j.ecolmodel.2022.110164

Holobiuc, A. M. (2020). Real convergence in the European Union: "New" versus "old" member states. *Socioeconomic Challenges*, *4*(4), 5–17. https://doi.org/10.21272/sec.4(4).5-17.2020

Ibrahim, I. A. (2023). Energy transition and sustainable development goal 7: A legal analysis in the context of the Arab world. *Journal of World Energy Law & Business*, *16*(2), 77–90. https://doi.org/10.1093/jwelb/jwad008

Kanojia, S., Kapoor, N., Chhabra, M., & Sethi, P. (2025). Regional disparities and international spillover in achieving the sustainable development goals (SDGs) across the globe. *Discover Sustainability*, *6*(1), Article 993. https://doi.org/10.1007/s43621-025-01898-z

Khudaykulova, M., Yuanqiong, H., & Khudaykulov, A. (2022). Economic consequences and implications of the Ukraine-Russia war. *International Journal of Management Science and Business Administration*, *8*(4), 44–52. https://doi.org/10.18775/ijmsba.1849-5664-5419.2014.84.1005

Kijek, T., Kijek, A., & Matras-Bolibok, A. (2022). Club convergence in R&D expenditure across European regions. *Sustainability*, *14*(2), Article 832. https://doi.org/10.3390/su14020832

Kisiała, W., & Stępiński, B. (2024). European funds and the dynamics of economic growth among EU regions: A spatial modelling approach. *Quaestiones Geographicae*, *43*(2), 67–80. https://doi.org/10.14746/quageo-2024-0020

Kluth, K. M. (2023). Analiza konwergencji gospodarczej i społecznej krajów Unii Europejskiej w czasach kryzysu. *Optimum. Economic Studies*, (4), 220–237.

Kraak, M. J., Ricker, B., & Engelhardt, Y. (2018). Challenges of mapping sustainable development goals indicators data. *ISPRS International Journal of Geo-Information*, *7*(12), Article 482. https://doi.org/10.3390/ijgi7120482

Krzyżanowski, J. T. (2024). Sustainable development goals related to agriculture and the EU's main development strategies. *Problems of World Agriculture/Problemy Rolnictwa Światowego*, *24*(3), 26–36. https://doi.org/10.22004/ag.econ.348371

Kuc-Czarnecka, M., Markowicz, I., & Sompolska-Rzechuła, A. (2023). SDGs implementation, their synergies, and trade-offs in EU countries – Sensitivity analysis-based approach. *Ecological Indicators*, *146*, Article 109888. https://doi.org/10.1016/j.ecolind.2023.109888

Kwaśny, J. (2018). Terytorializacja polityki spójności UE – rekomendacje dla Polski. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, (536), 122–130.

László, T. (2025). Economic convergence of Central and Eastern European countries in the European Union. *Political Research Exchange*, *7*(1). https://doi.org/10.1080/2474736X.2025.2507633

Lella, L., Oses-Eraso, N., & Stamos, I. (2024). Pioneering a sustainable development goals monitoring framework for European regions. *Ecological Indicators*, *166*, Article 112248. https://doi.org/10.1016/j.ecolind.2024.112248

Liadze, I., Macchiarelli, C., Mortimer-Lee, P., & Sanchez Juanino, P. (2023). Economic costs of the Russia-Ukraine war. *The World Economy*, *46*(4), 874–886. https://doi.org/10.1111/twec.13336

Mainali, B., Luukkanen, J., Silveira, S., & Kaivo-oja, J. (2018). Evaluating synergies and trade-offs among Sustainable Development Goals (SDGs): Explorative analyses of development paths in South Asia and Sub-Saharan Africa. *Sustainability*, *10*(3), Article 815. https://doi.org/10.3390/su10030815

Mensah, J. (2019). Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. *Cogent Social Sciences*, *5*(1), Article 1653531. https://doi.org/10.1080/23311886.2019.1653531

Miron, D., Holobiuc, A. M., Cojocariu, R. C., & Budacia, A. E. (2022). Real convergence in the Euro Area: Mirage or reality? *Journal of Competitiveness*, *14*(1), 100–117. https://doi.org/10.7441/joc.2022.01.06

Młodak, A. (2006). *Taxonomic analysis in regional statistics*. Difin.

Obrizan, M. (2022). *Poverty, unemployment and displacement in Ukraine: three months into the war*. arXiv. https://doi.org/10.48550/arXiv.2211.05628

Perkowski, M., Kosicki, A., & Chrzanowski, S. (2023). Realizacja Celów Zrównoważonego Rozwoju Agendy 2030: Perspektywa regionalna. *Prawo i Więź*, (1), 32–48. https://doi.org/10.36128/priw.vi44.574

Piętak, Ł. R. (2025). Heterogeneous effects of the cohesion policy on economic growth in Poland: A panel data analysis from 2007 to 2020. *Ekonomista*, (2), 175-199. https://doi.org/10.52335/ekon/195688

Romanowski, R., Kisiała, W., & Stępiński, B. (2023). The impact of EU structural funds related to innovation in socio-economic development at a local level. *Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie*, (174), 216–231.

Sarker, N. K., & Kaparaju, P. (2024). Microalgal bioeconomy: A green economy approach towards achieving sustainable development goals. *Sustainability*, *16*(24), Article 11218. https://doi.org/10.3390/su162411218

Simchi-Levi, D., & Haren, P. (2022, March 17). *How the war in Ukraine is further disrupting global supply chains*. Harvard Business Review. https://hbr.org/2022/03/how-the-war-in-ukraine-is-further-disrupting-global-supply-chains?utm_sq=h0ecip57ep

Solarin, S. A., Kazak, H., Shahbaz, M., Akcan, A. T., & Selcuk, H. (2025). Convergence of environmental innovation in Europe with or without United Kingdom: Technological implications for the environment. *Technology in Society*, *83*, Article 103047. https://doi.org/10.1016/j.techsoc.2025.103047

Suárez-Arbesú, C., Apergis, N., & Delgado, F. J. (2023). Club convergence and factors of income inequality in the European Union. *International Journal of Finance & Economics*, *28*(4), 3654–3666.

Szczepańska-Woszczyna, K., Gedvilaitė, D., Nazarko, J., Stasiukynas, A., & Rubina, A. (2022). Assessment of economic convergence among countries in the European Union. *Technological and Economic Development of Economy*, *28*(5), 1572–1588. https://doi.org/10.3846/tede.2022.17518

Szopik-Depczyńska, K., Cheba, K., Bak, I., Stajniak, M., Simboli, A., & Ioppolo, G. (2018). The study of relationship in a hierarchical structure of EU sustainable development indicators. *Ecological Indicators*, *90*, 120–131. https://doi.org/10.1016/j.ecolind.2018.03.002

Truglia,F., & Zeli, A. (2025). Regional economic convergence in the Euro Area. *European Spatial Research and Policy*, 32(1), 5–32. https://doi.org/10.18778/1231-1952.32.1.06

Turturean, C. I., Chirilă, C., & Chirilă, V. (2022). The Convergence in the Sustainability of the Economies of the European Union Countries between 2006 and 2016. *Sustainability*, *14*(16), Article 10115. https://doi.org/10.3390/su141610115

Ullah, A., Nobanee, H., Ullah, S., & Iftikhar, H. (2024). Renewable energy transition and regional integration: Energizing the pathway to sustainable development. *Energy Policy*, *193*, Article 114270. https://doi.org/10.1016/j.enpol.2024.114270

Velichkov, N., & Damyanov, D. (2021). Structural convergence of selected South-East European economies to the Eurozone. In A. Aleksic, V. Ruzic, & Z. Baracskai (Eds.), *Economic and Social Development: Book of Proceedings* (pp. 50–60). Varazdin Development and Entrepreneurship Agency.

Xu, K., Mei, R., Liang, L., & Sun, W. (2023). Regional convergence analysis of sustainable innovation efficiency in European Union countries. *Journal*

of Environmental Management, *325*, Article 116636. https://doi.org/10.1016/j.jenvman.2022.116636

Zaucha, J., Brodzicki, T., Ciołek, D., Komornicki, T., Szlachta, J., Zaleski, J., & Mogiła, Z. (2015). *Terytorialny wymiar wzrostu i rozwoju*. Difin.

Žďárek, V., & Šindel, J. (2007). Real and nominal convergence and the new EU Member States – Actual state and implications. *Prague economic papers*, (3), 195–219.