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A decade of uneven progress toward SDG1 no poverty in the European Union

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Abstract

This article deals with the progress toward achieving Sustainable Development Goal 1 (SDG1) "No Poverty" in the member states of the European Union (EU) from 2015 to 2024. The study is divided into three main phases: the initial implementation period (2015–2019), the COVID-19 pandemic period (2020–2021), and the post-pandemic period marked by rising inflation (2022–2024). Using cluster analysis, we identify groups of countries with similar developments in poverty reduction and the fulfilment of SDG1. This approach allows us to compare individual countries and highlight emerging disparities among them. The results show that while some states achieved stable progress, other countries experienced stagnation or even regression, particularly during periods of crisis. The findings underscore the need for more targeted policies and stronger coordination at the EU level to ensure more uniform progress in the fight against poverty. This study contributes to the current scientific discourse on SDG monitoring by offering a long-term, data-driven analysis of trends within the EU.

1 Introduction

The topic of poverty and its solutions was highly relevant in the EU even before the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs), particularly SDG1: No Poverty. Several academic works had already highlighted that poverty is not only a problem in developing countries but also in developed EU states, significantly affecting social cohesion and economic growth. As early as the 1990s, extensive research was conducted (e.g., within the POVERTY 3 program), which pointed out the limitations of using only income indicators and the need to include non-monetary factors such as housing, health, and deprivation (Ramprakash 1994). Fusco, Guio, and Marlier (Fusco 2010)focused on creating multidimensional composite poverty indices that combined income, material, and labour deprivation, with their work serving as a basis for the current AROPE (At Risk of Poverty or Social Exclusion) indicator. In their study, Papatheodorou and Pavlopoulos (Papatheodorou 2003)examined the effectiveness of social protection systems in reducing the risk of poverty and social exclusion in EU countries, placing a strong emphasis on international comparisons of redistributive mechanisms. Subsequent analyses showed that the risk of poverty in the EU is primarily

influenced by economic activity, with the unemployed and pensioners being among the most vulnerable groups (Biriakova 2013). Authors like Sinfield (Sinfield 2007)and Volkert (Volkert 2006) also emphasized that an effective fight against poverty must include preventive policies and a multidimensional approach that also reflects individuals' limitations in capabilities, not just their income. These findings clearly show that the EU was aware of the complexity of the poverty problem and the need for a systemic solution even before it became part of the global UN agenda.

Currently, the EU's approach to achieving SDG1, which aims to eliminate poverty in all its forms, involves a multi-pronged strategy that includes social protection systems, access to economic resources, and building resilience. The EU's efforts are aligned with global initiatives to improve living standards, ensure access to basic services, and protect communities from economic and environmental shocks. This comprehensive approach is key to addressing the complex nature of poverty, which is interconnected with other social and environmental issues. The COVID-19 pandemic significantly impacted the achievement of SDG1 in the EU member states, primarily by worsening existing inequalities and increasing poverty rates. It disrupted economic activities, leading to a rise in unemployment and a decline in incomes, which directly affected poverty levels across the region. This situation required urgent policy responses to mitigate adverse effects and support recovery efforts. Although the pandemic presented significant challenges, it also created an opportunity for EU member states to re-evaluate and strengthen their commitment to sustainable development, which could lead to more resilient systems in the long run. However, the sharp increase in energy and food prices (a direct result of the Russian invasion of Ukraine in February 2022) became a major driver of rising poverty across the EU, once again slowing or reversing the EU's progress toward SDG1.

The aim of this article is to evaluate the extent of progress toward fulfilling SDG1 (No Poverty) in EU member countries from 2015 to 2024 and, using cluster analysis, to identify country clusters in three distinct periods (pre-pandemic years, the COVID-19 pandemic period, and the inflation period) that allow for a comparison of development and highlight existing disparities between states.

Based on the stated objective, two research questions were formulated:

RQ1: To what extent have EU Member States made progress in achieving SDG1 (No Poverty) during the period 2015–2024, and did this progress differ across the three crisis-affected sub-periods?

RQ2: How dynamic was the change in cluster membership among EU countries across the three periods, and what does this reveal about the stability and emerging disparities in efforts to reduce poverty?

2 Review of literature

The EU's commitment to eradicating poverty is a central objective of its development policy, reinforced by its commitment to implementing the 2030 Agenda. The EU supports key areas relevant to poverty eradication in developing countries, such as education, healthcare, social security, and good governance, through various instruments and programs (Latek 2019). Poverty in the EU is multidimensional, affecting not only the unemployed but also children and the working population.

The period from 2015 to 2019 was important for the EU in terms of economic recovery after the financial crisis and the subsequent Eurozone debt crisis. Achieving SDG1 in

the EU member states during this period involved a multifaceted approach that emphasized poverty mitigation and prevention. The EU's strategies during this period focused on addressing poverty and working poverty while also considering the broader dimensions of capability deprivation. The macroeconomic environment from 2015 to 2019 was characterized by moderate to strong economic growth in most EU member states. This growth was accompanied by a significant improvement in the labour market. Although employment growth is important, it is not enough on its own to eliminate poverty, as many employees continue to live in poverty due to low wages and precarious jobs (Herman 2014), McKnight et al. (McKnight 2016). The phenomenon of working poverty was identified in 16 EU countries. As Tomaszewska (Tomaszewska 2022)points out, this phenomenon can be linked to precarious working conditions and inadequate social security systems in various EU countries. Maître, Nolan & Whelan (Maître et al. 2017)also confirmed that the rate of working poverty within the EU varies significantly between states due to institutional factors such as minimum wages, collective bargaining, and redistributive mechanisms. As Kalinowski (Kalinowski 2018)states, social exclusion is also a serious issue. Approximately one in four rural residents in the EU was at risk of poverty or social exclusion, with significant differences between member states. Countries like Bulgaria and Romania showed the highest risk of poverty, while the Netherlands had significantly lower rates. Doina and Viorica (Doina and Viorica 2017)in their study point to the significant impact of public spending on poverty reduction, with social protection expenditures and the effective allocation of funds for healthcare, education, and social services being decisive in minimizing poverty levels in 2015. Miežienė & Krutulienė (Miežienė and Krutulienė 2019)also emphasizes that the effectiveness of the fight against poverty depends on a combination of the size, structure, and targeting of social transfers. Social transfers reduce poverty rates in EU countries, but their effectiveness varies greatly among states. In this context, a key milestone was the proclamation of the European Pillar of Social Rights in 2017 (European 2017). This pillar, as a set of 20 principles and rights, served as a compass for strengthening the right to an adequate income, social protection, and access to essential services. Its target was to ensure fairer and more inclusive labour markets and social security systems. The period 2015–2019 represents an era when the EU actively sought to consolidate its social policies and take advantage of favourable economic conditions to reduce poverty, achieving significant, though not complete, improvements.

The period from 2020 to 2021 was an unprecedented challenge for the EU, as it was for the entire world, brought on by the COVID-19 pandemic. This global health crisis quickly transformed into a large-scale socio-economic crisis that tested the resilience of social systems and deepened existing inequalities. The COVID-19 pandemic led to a significant increase in extreme poverty and hunger, thereby, as Hanna et al. (Hanna et al. 2024)state, reversing years of progress in poverty reduction. Economic downturns caused by lockdowns and restrictions disproportionately affected vulnerable population groups, pushing many into poverty (Yuan et al. 2023). Measures to limit the spread of the virus, such as lockdowns and travel restrictions, hit sectors based on direct human contact the hardest. The most affected sectors included hospitality, tourism, and retail, which saw massive job losses or a significant reduction in working hours. The impacts of the pandemic were not uniform. The hardest hit were already low-income households (Almeida et al. 2021; Bertsatos et al. 2025), who had limited savings and less flexibility.

Single-parent families, young people, women, and temporary workers suffered the most (Eurofound. 2020; Liedl et al. 2023). The responses of member states varied widely: some expanded benefits and job protection, while others reacted more slowly and less targeted (Aidukaite et al. 2021). While Nordic and Western countries better protected households from falling into poverty, Southern and Eastern countries faced a higher increase in poverty risk due to weaker social protection systems. The pandemic thus deepened the inequalities between member states. The pandemic exposed systemic shortcomings in the coordination of social policy within the EU. In response to these challenges, EU member states introduced various measures, including the Next Generation EU fund, aimed at supporting sustainability and addressing the economic consequences of the pandemic (Bartiromo 2023). These initiatives focus on integrating the SDGs into recovery plans, emphasizing the need for a transformative approach to achieving SDG1 (Hanna et al. 2024). The pandemic clearly showed the interconnectedness of the SDGs, suggesting that progress in one area, such as poverty reduction, is essential for overall sustainable development (Yuan et al. 2023). Future strategies must therefore prioritize reducing inequalities to ensure that recovery efforts are inclusive and sustainable (Brzyska and Szamrej-Baran 2023). Despite significant challenges, the pandemic also created an opportunity for EU member states to re-evaluate and strengthen their commitment to sustainable development, which could lead to the creation of more resilient systems in the long run. The period 2020–2021 showed the fragility of the progress made in the fight against poverty and highlighted the need for more robust and inclusive social safety nets that can effectively respond to unexpected global shocks.

The period from 2022 to 2024 was marked by new and unexpected challenges that fundamentally affected the socio-economic situation across the EU. After a relatively short phase of post-pandemic recovery, the EU had to deal with an unprecedented rise in inflation and the onset of an energy crisis, which in many ways represented a ”silent crisis” with far-reaching consequences for the population’s standard of living. The main trigger of this crisis was the sharp increase in energy and food prices, a direct consequence of the Russian invasion of Ukraine in February 2022. Geopolitical tensions and commodity supply limitations resulted in a dramatic increase in the cost of living, which was quickly felt by households across the EU (Massetti and Exadaktylos 2022). Inflation in the Eurozone reached record highs in 2022, hovering around 10%, and even exceeding 15% in some member states. Many people who were previously financially stable suddenly found themselves under significant pressure to cover their expenses (Menyhert 2022). The impacts of inflation and rising living costs were immediately reflected in poverty indicators increased levels of material deprivation and a change in consumer behaviour who were forced to adjust their purchasing decisions and priorities (Lendl, Bognar & Puljic, 2023). For many households, it became difficult, if not impossible, to afford basic housing and heating costs (Slutins et al. 2025). This problem led to a widespread awareness of the phenomenon of energy poverty, which became a new, fundamental dimension of vulnerability (Čermáková and Hromada 2022; Gros 2022; Oesterreich and Barej-Kaczmarek 2024). As a result of the pandemic and rising energy prices, trends in material deprivation and inequalities worsened. This development also significantly affected the labour market, where so-called working poverty became more pronounced, especially in the service sectors and among temporary workers (OECD. 2022), and energy poverty became a new dimension of social inequality in the EU (Menyhert 2022).

The pandemic and the energy crisis showed how resilient individual social systems are to crises. Countries with strong and extensive social programs, such as those found primarily in Scandinavia and Western Europe, were better able to protect their citizens from poverty. Conversely, states in Eastern and Southern Europe, which have weaker social systems, faced a more significant increase in inequalities and poverty during these crises (OECD. 2022).

Across all periods, authors agree that there are large differences between member states not only in the rate of poverty but also in the issue of its solution (Maître et al. 2017), Miežienė & Krutulienė (De Becker et al. 2021; Miežienė and Krutulienė 2019; Sompolska-Rzechuła and Kurdyś-Kujawska 2022). These differences are related to the structure of social systems, the level of public spending on social protection, as well as the historical and political context of individual countries. While Nordic states have long shown a lower poverty rate thanks to robust social policies, countries in Southern and Eastern Europe face greater challenges due to lower social spending, higher unemployment, and weaker targeting of measures.

This study focuses on evaluating the progress in fulfilling SDG1 "No Poverty" in all its forms, in EU countries. The analysis follows not only the overall development but also the disparities between individual member states, identifying differences in the rates of poverty, social exclusion, and working poverty. Particular attention is paid to the dynamics of change in the years 2015–2024, which include the consequences of the economic crisis, the COVID-19 pandemic, and the energy and inflation crisis after 2022. Our intention is to provide a comprehensive picture of the extent to which the EU is succeeding in fulfilling its commitments in the area of SDG1 and what key challenges remain.

3 Data and methodology

Eurostat monitors and reports on the EU's progress in achieving the SDGs, including SDG1 "No Poverty." It also provides a special database and statistical pages for the SDGs, offering detailed data and analyses of these indicators. For SDG1, Eurostat uses a set of indicators that focus on various dimensions of poverty, including monetary poverty, material and social deprivation, and household work intensity. Based on the available data, our analysis used eight indicators that capture poverty in its various forms. The use of data from the Eurostat database, due to a uniform methodology, enabled a cross-country comparison. Table 1 presents the SDG indicators that allow us to compare the performance of individual EU member states.

A descriptive analysis of these indicators helps understand the current state, differences, and trends in poverty. It provides important context for interpreting the results of PCA and cluster analysis and helps to better understand the individual and group characteristics of EU countries in the context of achieving SDG1. For data preprocessing before cluster analysis, we used Principal Component Analysis (PCA), which is one of the most frequently used techniques because it helps to streamline and improve clustering results (Ding 2004; Xhafaj and Nurja 2015). PCA reduces data to a smaller number of new variables (principal components) that contain the most important information. The first principal component captures the largest possible portion of the variability in the data, the second component captures the largest possible portion of the remaining variability on the condition that it is orthogonal (independent) of the first, and this process

Table 1 Overview of data files/data sets

	Indicator	Description	Unit
x_1	Persons at risk of poverty or social exclusion	The sum of persons who are: at risk of poverty after social transfers, severely materially and socially deprived or living in households with very low work intensity	% of population
x_2	Persons at risk of monetary poverty after social transfers	People at risk-of-poverty are persons with an equivalised disposable income below the risk-of-poverty threshold, which is set at 60% of the national median equivalised disposable income (after social transfers)	% of population
x_3	Severe material and social deprivation rate	Severe material and social deprivation rate is the proportion of the population experiencing an enforced lack of at least 7 out of 13 deprivation items	% of population
x_4	Persons living in households with very low work intensity	People living in households with very low work intensity are people aged 0–64 living in households where the adults (aged 18–64) worked less than 20% of their total work potential during the past year. Students, those who are retired or who receive any pension (except survivors pension	% of population
x_5	In work at-risk-of-poverty rate	The indicator measures the share of persons who are employed and have an equivalised disposable income below the risk-of-poverty threshold, which is set at 60% of the national median equivalised disposable income (after social transfers)	% of employed persons aged 18 or over
x_6	Housing cost overburden rate	Percentage of the population living in a household where total housing costs (net of housing allowances) represent more than 40% of the total disposable household income (net of housing allowances)	% of population
x_7	Too expensive or too far to travel or waiting list	Share of people reporting unmet needs for medical examination or treatment due to being too expensive, too far to travel or waiting lists	% of population aged 16 and over
x_8	Relative median at-risk-of-poverty gap	It is calculated as the difference between the median equivalised disposable income of people below the at-risk-of-poverty threshold and the at-risk-of-poverty threshold, expressed as a percentage of the at-risk-of-poverty threshold (cut-off point: 60)	% distance to poverty threshold

continues. In this way, PCA reduces data dimensionality and removes unnecessary noise, while also significantly increasing the speed and accuracy of clustering algorithms.

Prior to performing the PCA, the adequacy of sampling is verified using the Kaiser–Meyer–Olkin (KMO) test, which yielded values between 0.68 and 0.76 across the three analysed periods, confirming that the dataset is suitable for factor analysis. At the same time, Bartlett's Test of Sphericity is conducted and found to be statistically significant in all three cases. All communalities exceeded 0.65, indicating that the retained variables were well explained by the extracted components.

Cluster analysis represents an important analytical tool for examining and evaluating progress toward fulfilling SDG1 "No Poverty." Its suitability is confirmed by its use in several articles focused on achieving SDGs, such as Çağlar & Gürler (Çağlar and Gürler 2022), Drastichová & Filzmoser (Drastichová and Filzmoser 2019), Jena & Basel (Jena and Basel 2025), and Frączek (Frączek 2022). To identify groups of EU member countries with similar development in fulfilling SDG1, we used hierarchical cluster analysis, which allows us to discover naturally occurring clusters based on multiple variables. This method is especially suitable for detecting structural patterns in smaller datasets, such as EU countries, and in cases where we do not have a predetermined number of groups. To calculate the similarity between countries, we used the squared Euclidean distance, which places greater emphasis on larger differences between observations. The distance between two countries i and j is calculated according to the formula:

$$d_{ij}^2 = \sum_{k=1}^{n} (x_{ik} - x_{jk})^2 \quad (1)$$

where x_{ik} and x_{jk} are the values of the k-th variable for countries i and j, and n is the number of variables analysed. All variables were standardized (z-score transformation) before the analysis to eliminate the effect of different scales.

For the cluster formation, we applied Ward's agglomeration method, which is one of the most frequently used techniques within hierarchical cluster analysis. Ward's method works on the principle of minimizing within-cluster variability. At each step, it combines the two clusters whose merger leads to the smallest increase in the sum of squared distances within all clusters (the so-called within-cluster sum of squares, WCSS). This results in the formation of compact, homogeneous groups of countries that are also well distinguishable from other clusters. In our analysis, clustering based on Ward's method revealed a distinct vertical hierarchy (as illustrated in the dendrogram). Countries with similar positions along the first principal component (PC1) were grouped together in the initial stages, whereas the second principal component (PC2) further differentiated countries within broader groups that share comparable overall performance but exhibit distinct sectoral or structural features. Cluster analysis is performed separately for each of the three periods (2015–2019, 2020–2021, 2022–2024), which allows us to capture the dynamics of change and the emergence of new or persistent disparities among EU member states in different socio-economic contexts (growth, crisis, inflation). The outputs are presented in the form of dendrograms, which visualize the hierarchical structure and the evolution of clusters over time.

The selection of the three analytical periods is grounded in the occurrence of key external shocks that have profoundly influenced the progress toward SDG1 within the EU. The first period (2015–2019) corresponds to a phase of relative macroeconomic stability following the global financial crisis, as well as the initial stage of implementing the 2030 Agenda and the SDGs. The second period (2020–2021) includes the years of the COVID-19 pandemic, characterized by substantial socio-economic disruptions and extensive governmental interventions aimed at mitigating their adverse impacts. The third period (2022–2024) represents the post-pandemic phase, marked by a sharp increase in inflation, an energy crisis, and geopolitical uncertainty caused by the war in Ukraine.

All variables were converted to period averages (2015–2019, 2020–2021, 2022–2024). For each period, the value of every indicator is calculated as the arithmetic mean of annual data, with the objective of minimizing the influence of short-term fluctuations and extreme values while preserving the dominant trends within each phase. Descriptive analysis of relationships between cluster membership and structural factors is based on comparing the average values of selected structural and macroeconomic determinants for each identified cluster.

4 Results

The primary target for SDG1 (No Poverty) in the EU is to reduce the number of people at risk of poverty or social exclusion by at least 15 million by 2030, compared to 2019 levels. A complementary ambition is that at least 5 million of those reduced should be children. Figure 1 shows the development of the number of people at risk of poverty or

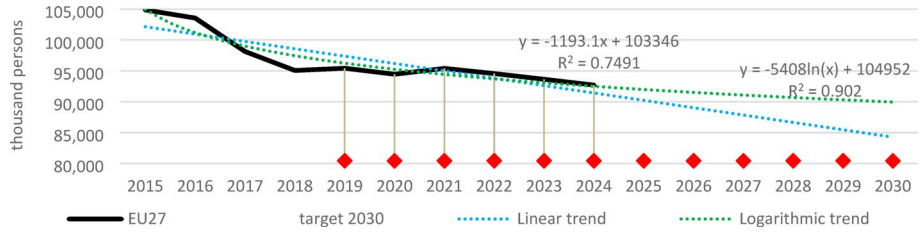

Fig. 1 Development of the number of people at risk of poverty or social exclusion in the EU (2015–2024) Source: Own processing

social exclusion in the EU since 2015, including the target value for 2030 and the projected development of the indicator for the coming years.

Based on the latest available data from Eurostat, it can be stated that in the years 2015–2024, there was a gradual decrease in the number of people at risk (from 104.877 thousand in 2015 to 92.697 thousand in 2024). The most significant decline occurred between 2015 and 2017. A milder decrease has been observed since 2019, which could have been caused by a series of global events, such as COVID-19, the inflation, and the subsequent energy crisis. This decrease is more accurately captured by a logarithmic trend. Based on past development and the projected development for the coming years, it can be expected that the target of 80.431 thousand people may not be reached by 2030, especially if the development follows a slower logarithmic trajectory. Therefore, from the perspective of EU policies, it is necessary to accelerate progress if SDG1 is to be met within the set time frame.

4.1 Poverty in the EU in the pre-COVID period (2015–2019): the beginning of the 2030 agenda

The analysis of key poverty and social exclusion indicators in the pre-COVID period (2015–2019) reveals significant disparities among EU member states. A comprehensive indicator at-risk-of-poverty-or-social-exclusion rate (x_1), showed a wide range from 12.28% in the Czech Republic to 41.56% in Romania, which underscores the diversity in living conditions. Although the monetary poverty rate after social transfers (x_2) was less variable than the indicator x_1, it still showed significant differences, again with the best result for the Czech Republic (9.64%) and the worst for Romania (24.32%). One of the highest variabilities (91.51%) and extreme differences between countries was shown by the material and social deprivation rate (x_3), where Sweden (1.14%) was significantly different from Romania (31.02%). In the area of low work intensity (x_4), Slovenia performed the best (5.14%), while Ireland was the worst performer for this indicator (15.76%) (Table 2).

The phenomenon of in-work poverty (x_5) ranged from 3.06% in Finland to 17.22% in Romania. Extreme differences were also visible in the indicator for housing costs (x_6), where Malta had the lowest rate (1.64%), while Greece faced an enormous burden (40.26%). This is also confirmed by the coefficient of variation (CV 78.51%), which is the second highest and indicates that the burden of housing costs is significantly higher in some EU countries than in others. The highest variability of all indicators (CV 115.23%) is for access to services (x_7), which ranged from 16% in the Netherlands to 14.34% in Estonia, indicating enormous differences in the availability of basic services. The relative median poverty risk gap (x_8), which measures how much income falls below the poverty

Table 2 Descriptive statistics 2015–2019
Source: Own processing

	Range	Min	Max	Mean	Std. deviation	Variance	Skewness	Kurtosis	CV
x_1	29.28	12.28	41.56	22.52	6.76	45.73	1.22	1.58	30.02
x_2	14.68	9.64	24.32	16.81	3.96	15.66	0.26	-0.96	23.54
x_3	29.88	1.14	31.02	8.23	7.53	56.75	1.98	3.79	91.51
x_4	10.62	5.14	15.76	8.79	2.93	8.61	0.87	−0.02	33.37
x_5	14.16	3.06	17.22	8.27	3.19	10.19	0.75	0.89	38.61
x_6	38.62	1.64	40.26	9.19	7.22	52.11	3.29	13.50	78.51
x_7	14.18	0.16	14.34	2.86	3.30	10.88	2.22	5.36	115.23
x_8	21.44	13.98	35.42	22.76	5.42	29.36	0.49	−0.51	23.81

Table 3 Correlation matrix of indicators assessed (2015–2019)
Source: IBM SPSS

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
x_1	1.000	0.868	0.910	0.217	0.739	0.404	0.397	0.789
x_2	0.868	1.000	0.620	0.138	0.717	0.217	0.474	0.774
x_3	0.910	0.620	1.000	0.092	0.588	0.423	0.253	0.687
x_4	0.217	0.138	0.092	1.000	−0.081	0.396	−0.006	0.057
x_5	0.739	0.717	0.588	−0.081	1.000	0.363	0.343	0.788
x_6	0.404	0.217	0.423	0.396	0.363	1.000	0.334	0.427
x_7	0.397	0.474	0.253	−0.006	0.343	0.334	1.000	0.290
x_8	0.789	0.774	0.687	0.057	0.788	0.427	0.290	1.000

threshold, ranged from 13.98% in Finland to 35.42% in other countries. Overall, these data emphasize that although the EU has made efforts in the fight against poverty, deep regional disparities persist, requiring targeted policies.

Countries such as Romania and Bulgaria consistently showed high values across most poverty indicators (x_1, x_2, x_3, x_5, x_8), which ranked them among the countries with the worst situation regarding SDG1. Greece stood out with an extremely high rate of housing cost overload (x_6). Conversely, countries like the Czech Republic, Finland, and Sweden generally had low values for poverty indicators, indicating their better position. Estonia showed a specifically high value for x_7, confirming that access to services was a specific problem for this country during this period.

4.1.1 Hierarchical cluster analysis 2015–2019

In the first evaluation period, at the beginning of the 2030 Agenda for Sustainable Development and before the COVID-19 pandemic, we observed strong positive correlations (Table 3) between most indicators related to poverty and social exclusion (x_1, x_2, x_3, x_5, x_8). For example, x_1 (at-risk-of-poverty-or-social-exclusion rate) showed very strong correlations with x_3 (severe material and social deprivation, 0.910) and x_2 (monetary poverty after social transfers, 0.868), as well as with x_8 (relative median poverty risk gap, 0.789). This suggests that these aspects of poverty moved in a similar direction across EU countries. The indicator x_4 (low work intensity) showed weaker correlations with other indicators, suggesting that the dynamics of households with low work intensity were relatively independent of direct poverty during this period. x_6 (housing costs) and x_7 (access to services) had moderate but positive correlations with other indicators, pointing to their partial connection with the overall socio-economic situation (Fig. 2).

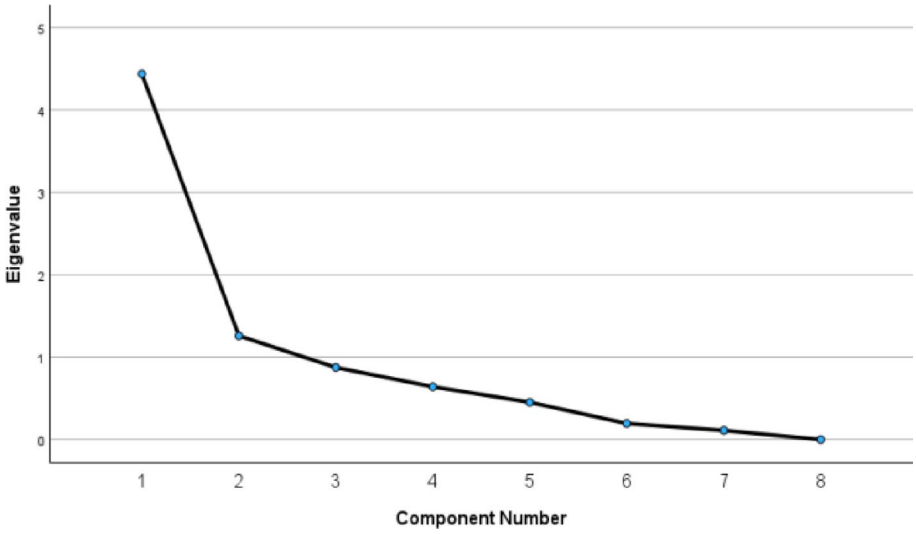

Fig. 2 Scree Plot (2015–2019)
Source: IBM SPSS

Table 4 PCA (2015–2019)
Source: IBM SPSS

Component	Initial eigenvalues		
	Total	% of variance	Cumulative %
1	4.443	55.537	55.537
2	1.263	15.783	71.320
3	0.878	10.981	82.301
4	0.644	8.055	90.356
5	0.456	5.701	96.057
6	0.198	2.475	98.532
7	0.114	1.427	99.959
8	0.003	0.041	100.000

Before conducting the PCA, the suitability of the data for factor analysis was verified. The Kaiser–Meyer–Olkin (KMO) test yielded a value of 0.756, confirming the adequacy of the sampling. In parallel, Bartlett's Test of Sphericity was performed and found to be statistically significant (Approx. Chi-Square = 205.645; $df = 28$; Sig. < 0.001), indicating that the correlations among the variables were sufficiently strong and that PCA was appropriate for the dataset. All communalities exceeded 0.65, suggesting that the retained variables were well explained by the extracted components.

Based on the PCA results, two principal components were extracted, jointly explaining 71.32% of the total variance. The first component (PC1) explains 55.54% of the variance (Table 4) and exhibits strong loadings on most variables (x_1, x_2, x_3, x_5, x_8), which capture factors related to the macroeconomic dimension of poverty (all loadings > 0.8). The variable x_7 is also associated with PC1, with a loading of 0.502. The second component (PC2) explains 15.783% of the variance and is primarily defined by a high loading on x_4 (0.885) and a moderate loading on x_6 (0.608). PC2 reflects a dimension capturing factors of economic constraint.

The dominant share of variance explained by PC1 (55.537%) compared to PC2 suggests that the resulting clusters are primarily differentiated according to the macroeconomic

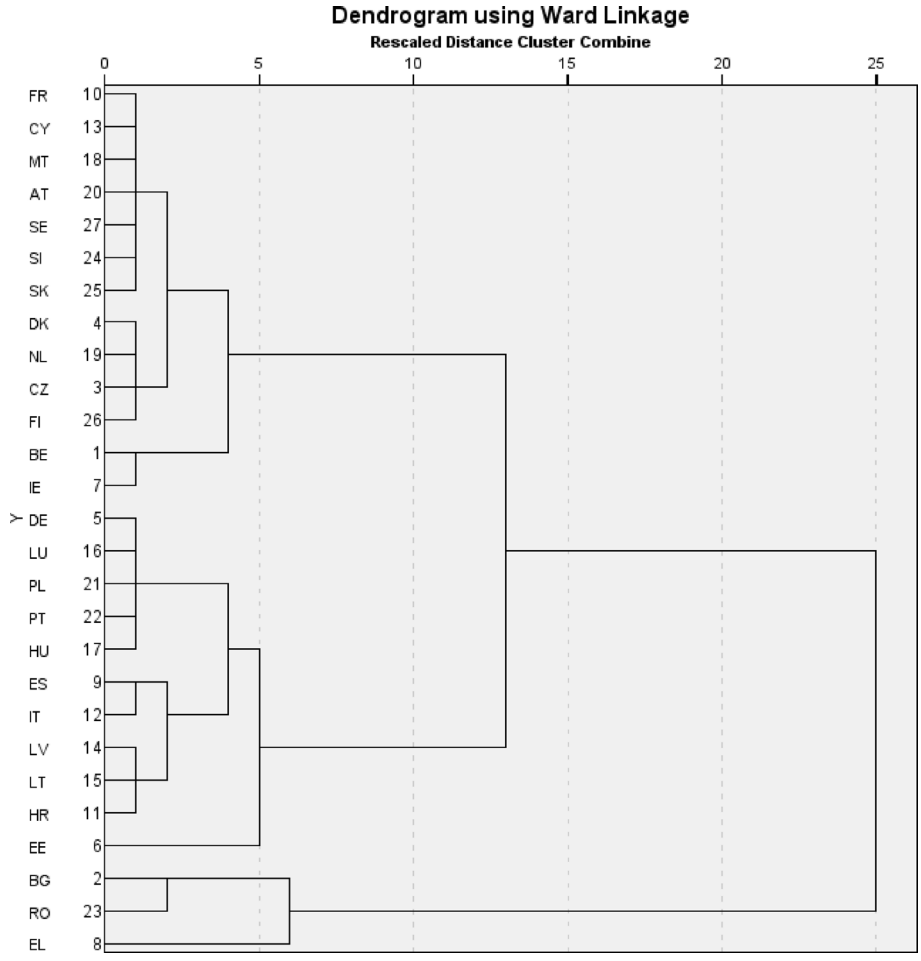

Fig. 3 Dendrogram (2015–2019)
Source: IBM SPSS

Table 5 Centroids (2015–2019)
Source: Own processing

Cluster 2015–2019	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Number of countries	**13**	**10**	**1**	**2**	**1**
x_1	17.9	24.13	23.46	39.63	31.30
x_2	13.8	18.61	21.58	23.45	19.84
x_3	4.45	8.42	3.80	29.98	17.24
x_4	8.86	8.62	5.54	8.08	14.32
x_5	5.88	9.81	9.64	13.39	12.32
x_6	6.94	8.28	4.98	14.98	40.26
x_7	1.52	2.40	14.34	4.33	10.46
x_8	18.68	25.6	21.22	32.27	29.78

dimension of poverty (PC1). Member states are grouped based on the similarity of their PC1 and PC2 scores.

A dendrogram for the period 2015–2019 (Fig. 3) visually shows the clustering of countries. Based on the dendrogram's structure and the distances between clusters, it's possible to identify 5 clusters, as shown in the table of centroids (Table 5). This division reflects the relatively stable socio-economic situation before global shocks.

Cluster 1 (FR, CY, MT, AT, SE, SI, SK, DK, NL, CZ, FI, BE, IE) is the largest and includes 13 countries. It represents a group of countries with relatively low values across all poverty and social exclusion indicators for SDG1. It achieves the best results for five indicators and the second-best results for two indicators. These are countries with developed social systems and stable economies. The weakest point of this cluster is working poverty (x_4), where it had the second-worst average rating among all clusters (8.86).

Cluster 2 (DE, LU, PL, PT, HU, ES, IT, LV, LT, HR) consists of 10 countries. This is a more heterogeneous group that includes some Western countries with slightly higher poverty values than Cluster 1, as well as countries from Central, Eastern, and Southern Europe that are trying to catch up. For two indicators (x_1, x_7), it has the second-lowest average values, and for six indicators, it has the third-lowest values among all clusters.

Cluster 3 (EE) consists of a single country, Estonia. As we already noted in the descriptive statistics, Estonia showed a specifically high value for x_7 (access to services) during this period, which distinguishes it from other countries. For indicators x_3, x_4, and x_6, Estonia achieved the lowest values compared to the average values of the other clusters.

Cluster 4 (BG, RO) includes Bulgaria and Romania. These two countries consistently show the highest values in most poverty and social exclusion indicators (x_1, x_2, x_3, x_5, x_8), which ranks them among the countries with the worst situation in the EU in terms of SDG1. The work intensity indicator (x_4) can be considered positive, as it is the second lowest in this cluster.

Cluster 5 (EL) is also formed by a single country, Greece. Its dominant problem during this period was the extremely high rate of housing cost overload (x_6), which significantly distinguishes it from other countries (40.26).

4.2 Poverty in the EU during the COVID period (2020–2021): changes caused by the pandemic

The COVID-19 pandemic period (2020–2021) brought a slight improvement in the overall risk of poverty and social exclusion (x_1) in the EU, likely due to government support measures. The average at-risk-of-poverty-or-social-exclusion rate dropped from 22.52 to 20.62%, with the Czech Republic recording the lowest value (11.15%) and Romania the highest (35.00%). Similarly, the monetary poverty rate after social transfers (x_2) slightly decreased to an average of 16.25%, with the Czech Republic again leading with 9.05%, Romania and Bulgaria at the bottom with 22.95%. A surprising and significant drop occurred in the area of material and social deprivation (x_3), whose average fell from 8.23 to 6.10%. This may indicate targeted assistance or a change in the perception of material deficiencies and material deprivation. Finland achieved the best results (1.45%), while Romania continued to show the highest deprivation (24.20%). Low work intensity (x_4) also saw a decrease to an average of 7.50%, indicating the impact of changes in the labour market and support schemes. Slovenia led with 3.75%, while Belgium was at the opposite end with 12.10% (Table 6).

Working poverty (x_5) slightly decreased to 7.93%, with Finland (2.95%) again performing the best and Romania (15.20%) the worst. Despite the overall decrease in average values, significant regional disparities persisted. Although housing costs (x_6) decreased on average to 7.18%, the range of problems was still extremely wide (from 2.75% in Malta to 31.05% in Greece), indicating persistent structural problems in some member states. Similarly, in access to services (x_7), although the average dropped to 2.27%,

Table 6 Descriptive statistics 2020–2021
Source: Own processing

	Range	Min	Max	Mean	Std. deviation	Variance	Skewness	Kurtosis	CV
x_1	23.85	11.15	35.00	20.62	5.56	30.87	0.90	0.85	26.94
x_2	13.90	9.05	22.95	16.25	3.94	15.57	0.24	−1.01	24.28
x_3	22.75	1.45	24.20	6.10	5.57	31.07	2.16	4.63	91.43
x_4	8.35	3.75	12.10	7.50	2.61	6.80	0.32	−1.08	34.77
x_5	12.25	2.95	15.20	7.93	2.97	8.85	0.46	−0.04	37.52
x_6	28.85	2.20	31.05	7.18	5.62	31.64	3.20	12.65	78.33
x_7	10.50	0.05	10.55	2.27	2.35	5.53	1.97	4.93	103.51
x_8	21.35	13.45	34.80	22.08	5.41	29.26	0.33	−0.56	24.49

Table 7 Correlation matrix of indicators assessed (2020–2021)
Source: IBM SPSS

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
x_1	1.000	0.898	0.844	0.210	0.771	0.351	0.245	0.737
x_2	0.898	1.000	0.568	0.074	0.762	0.172	0.286	0.686
x_3	0.844	0.568	1.000	0.081	0.557	0.387	0.145	0.675
x_4	0.210	0.074	0.081	1.000	−0.101	0.481	−0.086	−0.083
x_5	0.771	0.762	0.557	−0.101	1.000	0.252	0.180	0.697
x_6	0.351	0.172	0.387	0.481	0.252	1.000	0.192	0.251
x_7	0.245	0.286	0.145	−0.086	0.180	0.192	1.000	0.147
x_8	0.737	0.686	0.675	−0.083	0.697	0.251	0.147	1.000

huge differences remained, with the Netherlands (0.05%) performing best and Estonia (10.55%) worst. Lastly, the relative median poverty risk gap (x_8) slightly decreased to 22.08%, with Finland achieving the lowest value (13.45%) and Romania the highest (34.80%).

Overall, it can be concluded that the average values for most poverty indicators slightly improved or stabilized during the COVID period. This likely reflects the extensive government support measures and social transfers aimed at mitigating the economic impacts of the pandemic. Romania and Bulgaria continued to show the highest values in poverty indicators (x_1, x_2, x_3, x_5, x_8). Greece maintained an extremely high value for x_6 (housing cost overload), confirming that this problem persisted during the pandemic. Estonia continued to have a significantly high value for x_7 (access to services), indicating persistent challenges in this area. On the other hand, the Czech Republic, Finland, and the Netherlands achieved some of the best values for several indicators.

4.2.1 Hierarchical cluster analysis 2020–2021

During the COVID period, the correlation patterns changed slightly. We still observe strong correlations between x_1, x_2, x_3, x_5, and x_8, indicating a persistent link between different aspects of poverty (Table 7). However, a slight decrease in some correlations can be observed (e.g., x_3 with x_2 and x_5 compared to the previous period), which may suggest that the pandemic affected individual poverty indicators with slightly different intensity. X_4 (low work intensity) continues to maintain weak correlations with most indicators, although the correlation with x_6 (housing costs) strengthens (0.481), which may reflect the impact of work restrictions on the ability to pay for housing.

As in the previous period, the suitability of the data for PCA was re-evaluated prior to analysis. The Kaiser–Meyer–Olkin (KMO) test produced a value of 0.724, indicating

Table 8 PCA (2020–2021)
Source: IBM SPSS

Component	Initial eigenvalues		
	Total	% of variance	Cumulative %
1	4.106	51.329	51.329
2	1.446	18.073	69.402
3	0.974	12.179	81.580
4	0.595	7.438	89.018
5	0.440	5.506	94.525
6	0.280	3.505	98.029
7	0.154	1.921	99.950
8	0.004	0.050	100.000

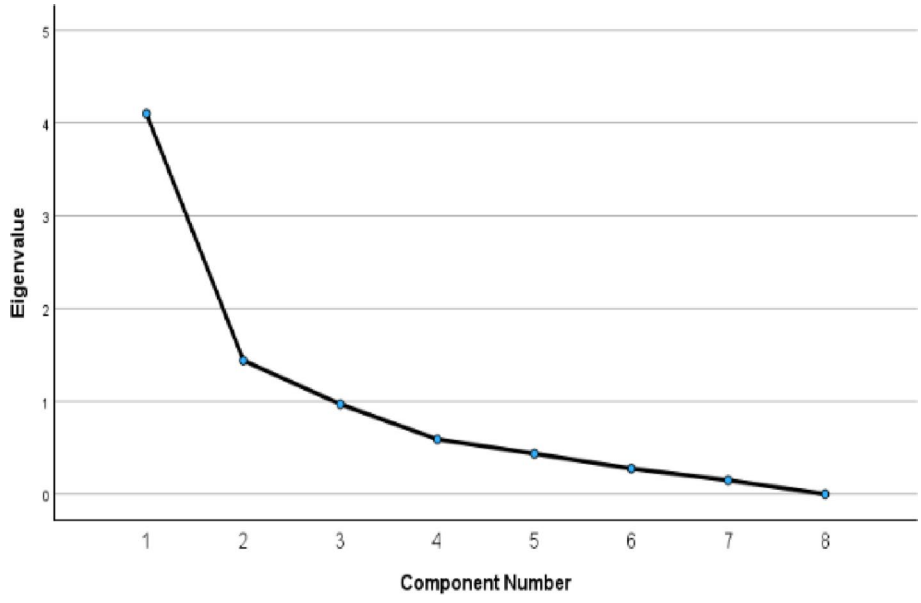

Fig. 4 Scree Plot (2020–2021)
Source: IBM SPSS

adequate sampling adequacy. Bartlett's Test of Sphericity was statistically significant (Approx. Chi-Square = 185.757; $df = 28$; Sig. < 0.001), confirming that the correlations among the variables were sufficient to justify the application of PCA. The communalities after the extraction of two components were sufficiently high, with all extracted values exceeding 0.67, indicating that the components explained a large proportion of the variance in these variables (e.g., × 1: 0.940; × 2: 0.794; × 8: 0.744).

From the PCA, two principal components were extracted, cumulatively explaining 69.40% of the total variance. The first component (PC1) explains 51.329% of the variance (Table 8) and is defined by very high loadings on the variables x_1, x_2, x_3, x_5, and x_8 (similarly to the previous period). The variable x_7 is also associated with PC1, with a loading of 0.308. The second component (PC2) explains 18.073% of the variance and shows the highest loadings on x_4 (0.892) and x_6 (0.723).

As illustrated by the Scree Plot (Fig. 4), the elbow is clearly visible after the second component (eigenvalue 1: 4.106; eigenvalue 2: 1.446; eigenvalue 3: 0.974). The decision to extract two components (PC1 and PC2) is further supported by Kaiser's criterion (eigenvalue > 1). These two components define the space in which the clusters are formed. The

dominant influence of PC1 (51.329% of variance) again indicates that the main clustering of countries is primarily determined by the macroeconomic dimension of poverty. The pronounced depth and branching in the dendrogram reveal a clear division among groups of countries with high, medium, and low levels of the macroeconomic dimension of poverty. The PC2 component subsequently helps to differentiate countries within these main groups that exhibit similar overall levels (PC1) but differ in terms of economic constraint factors (PC2).

A dendrogram for the COVID period (Fig. 5) shows some rearrangement of countries compared to the 2015–2019 period. We can see that some countries previously in one cluster may now be grouped differently. For example, BE, IE, and DK cluster at a very low distance level, while other countries like EL, NL, FI, CZ, DE, HR, CY, SE, FR, AT, SK, MT, SI, EE, LV, HU, PT, LU, PL, IT, LT, ES, BG, and RO group into larger but different clusters. The identification of 6 clusters suggests that the pandemic affected countries in various ways and led to greater fragmentation in their socio-economic situation (Table 9).

Cluster 1 (BE, IE, DK) is a new grouping of three countries characterized by relatively low poverty rates, but slightly higher work intensity (x_4) and housing costs (x_6) compared

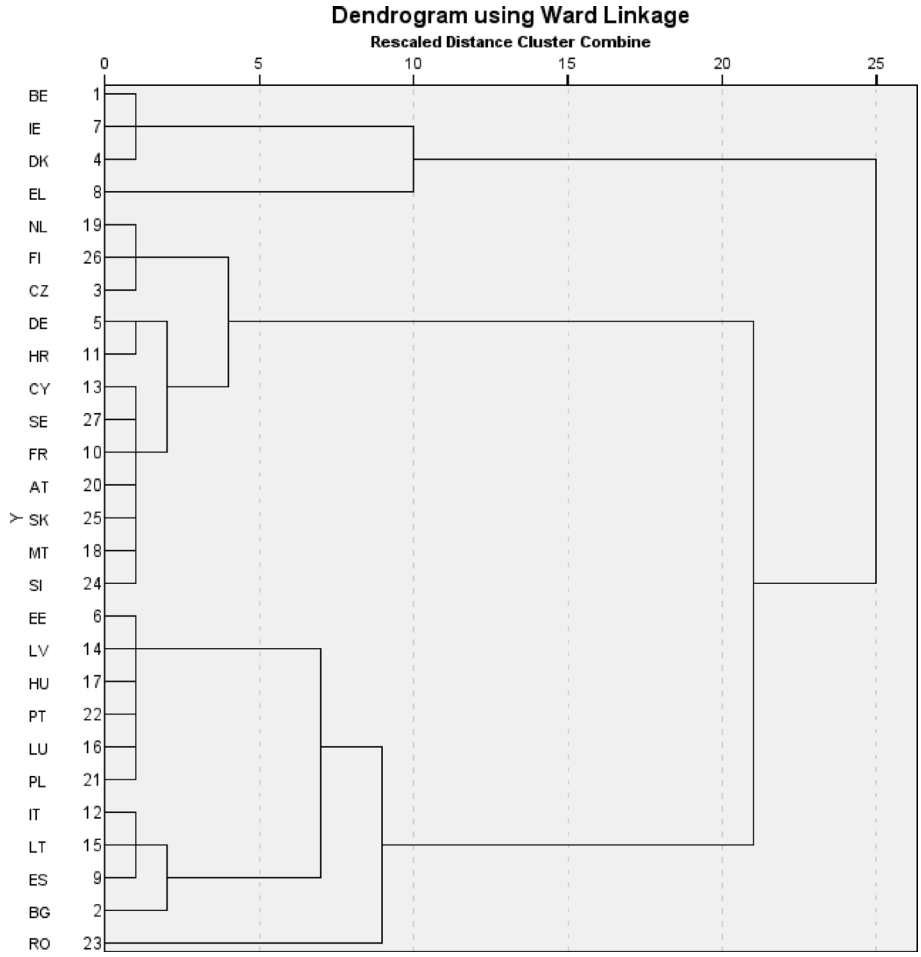

Fig. 5 Dendrogram (2020–2021)
Source: IBM SPSS

Table 9 Centroids (2020–2021)
Source: Own processing

Cluster 2020–2021	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Number of countries	**3**	**1**	**12**	**6**	**4**	**1**
x_1	18.65	27.85	16.90	21.02	27.26	35.00
x_2	12.80	18.65	14.05	17.58	21.20	22.95
x_3	5.08	14.40	3.27	4.87	10.58	24.20
x_4	11.13	11.95	6.90	5.47	9.34	4.10
x_5	5.03	10.70	6.09	9.83	10.25	15.20
x_6	8.62	31.05	5.65	5.00	7.99	7.30
x_7	1.68	6.45	1.55	3.48	1.45	4.55
x_8	16.45	26.85	19.75	23.63	26.63	34.80

to the best clusters from the previous period. These countries managed to maintain a relatively good situation despite the pandemic.

Cluster 2 (EL) consists only of Greece. It is characterized by an extremely high rate of housing cost overload ($x_6 = 31.05$), which confirms a persistent problem in this area even during the pandemic.

Cluster 3 (NL, FI, CZ, DE, HR, CY, SE, FR, AT, SK, MT, SI) is the largest and includes 12 countries. This is a group of countries that maintained a relatively good social situation during this period, with the lowest values for poverty indicators (especially x_3 and x_7). We see a shift of some countries from the original Cluster 1 (e.g., NL, FI, CZ, SE, FR, AT, SK, MT, SI) and Cluster 2 (e.g., DE, HR, CY), which indicates their ability to adapt to pandemic conditions.

Cluster 4 (EE, LV, HU, PT, LU, PL) includes 6 countries. These are countries with slightly increased poverty values (x_1, x_2, x_5, x_8) compared to Cluster 3. The shift of Estonia (EE) from its own cluster in the pre-pandemic period to this grouping is interesting, which may indicate that the specific problem with access to services became less dominant compared to the overall poverty situation.

Cluster 5 (IT, LT, ES, BG) consists of four countries. The strong point of this cluster is the access to services indicator (x_7), in which the countries achieved the lowest average score. Conversely, they have the second-worst results in indicators x_1 and x_2 and the third-worst in the remaining five. Bulgaria shifted from Cluster 4 (2015–2019) to this cluster, which indicates that its situation slightly improved compared to Romania.

Cluster 6 (RO) consists of Romania forming a separate cluster in the COVID period. It emerged from the original Cluster 4 (2015–2019) and shows the highest values for poverty indicators (x_1, x_2, x_3, x_5, x_8) and low work intensity (x_4), which indicates the worst situation regarding SDG1 during the pandemic.

4.3 Poverty in the EU during the period of inflation and the energy crisis (2022–2024): mixed trends and persistent disparities

The latest period (2022–2024), marked by inflation and the energy crisis, brings mixed, but mostly stable or slightly worsening trends in EU poverty indicators. The at-risk-of-poverty-or-social-exclusion rate (x_1) slightly increased to an average of 20.46% (from 20.62% in the previous period), indicating the beginning of a negative impact from inflation. The Czech Republic maintained the lowest risk (11.70%), while Romania continued to show the highest values (31.43%). The monetary poverty rate after social transfers (x_2)

remained stable on average at 16.21%, with the Czech Republic having the best result (9.83%) and Latvia the worst (22.20%).

An interesting finding is the slight decrease in material and social deprivation (x_3) to an average of 5.95%, although significant disparities between countries persist (from 1.73% in Slovenia to 20.43% in Romania). This decrease may signal targeted measures or changes in consumer behaviour. Conversely, low work intensity (x_4) further decreased to an average of 6.85%, which may reflect improvements in the labour market situation after the pandemic, with Slovenia performing best (3.70%) and Belgium worst (11.10%) (Table 10).

Working poverty (x_5) recorded a slight increase to 7.98%, with Finland (2.70%) still having the lowest rate and Luxembourg (13.70%) the highest. Housing costs (x_6) increased slightly on average to 7.91%, a likely direct consequence of the energy crisis and inflation. Differences between countries remain significant, from Cyprus (2.50%) to Greece (28.03%).

Access to services (x_7) worsened, with the average rising to 2.88%. Nevertheless, extreme differences between countries remain (from 0.10% in Cyprus to 10.90% in Greece), underscoring persistent problems with availability. The coefficient of variation is as high as 100.96%. Finally, the relative median poverty risk gap (x_8) slightly improved to 21.82%, with Finland (15.43%) having the lowest value and Romania (32.23%) the highest.

Overall, the results of the descriptive analysis suggest that inflation and the energy crisis impacted the risk of poverty in the EU. Some areas show a slight worsening, while others improve or remain stable. Indicators x_1, x_5, x_6, and x_7 show a slight increase, which may be linked to inflationary pressures, while others (x_3, x_4, x_8) have either stabilized or even slightly improved. This suggests that the impacts of inflation and the energy crisis are complex and do not have a uniform effect on all aspects of poverty. The persistent significant disparities between member states point to the need for targeted and flexible policies. Countries like Romania and Bulgaria continue to maintain high values in poverty indicators. Similarly, Greece shows an exceptionally high rate of housing cost overload (x_6) and a high value for x_7 (access to services). Estonia also maintains a high value for x_7. Conversely, the Czech Republic, Cyprus, Finland, and Slovenia are among the countries with the lowest values in many indicators, suggesting their resilience to recent crises.

Table 10 Descriptive Statistics 2022–2024
Source: Own processing

	Range	Min	Max	Mean	Std. deviation	Skewness	Kurtosis	CV
x_1	19.73	11.70	31.43	20.46	4.77	0.65	0.25	23.32
x_2	12.37	9.83	22.20	16.21	3.59	0.24	−1.18	22.13
x_3	18.70	1.73	20.43	5.95	4.66	1.97	3.72	78.31
x_4	7.40	3.70	11.10	6.85	2.28	0.09	−1.41	33.30
x_5	11.00	2.70	13.70	7.98	2.816	0.19	−0.25	35.24
x_6	25.53	2.50	28.03	7.91	4.90	2.88	10.82	61.93
x_7	10.80	0.10	10.90	2.88	2.91	1.62	2.09	100.96
x_8	16.80	15.43	32.23	21.82	4.24	0.39	−0.18	19.43

Table 11 Correlation matrix of indicators assessed (2022–2024)
Source: IBM SPSS

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
x_1	1.000	0.874	0.797	0.184	0.723	0.302	0.316	0.675
x_2	0.874	1.000	0.460	−0.021	0.747	0.112	0.365	0.670
x_3	0.797	0.460	1.000	0.113	0.501	0.410	0.182	0.564
x_4	0.184	−0.021	0.113	1.000	−0.284	0.344	0.123	−0.173
x_5	0.723	0.747	0.501	−0.284	1.000	0.195	0.155	0.604
x_6	0.302	0.112	0.410	0.344	0.195	1.000	0.372	0.075
x_7	0.316	0.365	0.182	0.123	0.155	0.372	1.000	0.121
x_8	0.675	0.670	0.564	−0.173	0.604	0.075	0.121	1.000

Table 12 PCA (2022–2024)
Source: IBM SPSS

Component	Initial eigenvalues		
	Total	% of variance	Cumulative %
1	3.869	48.358	48.358
2	1.601	20.018	68.376
3	0.889	11.106	79.482
4	0.708	8.848	88.330
5	0.453	5.664	93.994
6	0.339	4.236	98.230
7	0.134	1.675	99.904
8	0.008	0.096	100.000

4.3.1 Hierarchical cluster analysis 2022–2024

In the period from 2022 to 2024, characterized by the renewed start of economies after the pandemic crisis, but also by the onset of high inflation and the subsequent energy crisis, we see further changes in correlation patterns. Although strong correlations between the main poverty indicators (x_1, x_2, x_3, x_5, x_8) persist, their strength is slightly reduced compared to previous periods. For example, the correlation between x_1 and x_3 (Table 11) fell to 0.797 from 0.910 (2015–2019) and 0.844 (2020–2021). This may indicate that inflation and the energy crisis could have had a differentiated impact on various aspects of poverty, leading to slightly different dynamics between the indicators. The correlation of indicator x_4 with other indicators remains low, even with negative values for x_5 and x_8, which may reflect more complex interactions between employment and poverty during this turbulent period. Indicator x_6 (housing costs) shows a very low correlation with indicator x_8 (0.075), suggesting that the impact of housing costs on the total poverty risk gap may have weakened or become less direct.

The suitability of the data for PCA was verified prior to execution. The Kaiser–Meyer–Olkin (KMO) test produced a value of 0.680, while Bartlett's Test of Sphericity was statistically significant (Approx. Chi-Square = 166.436; $df = 28$; Sig. < 0.001). These results confirm that the correlations among the variables were sufficient to justify the meaningful application of PCA. The communalities after extraction exceeded 0.640, indicating that the retained components adequately explained the variance in the variables.

In this evaluation period, the first principal component (PC1) explains 48.358% of the variance, which is the lowest among the three analysed periods. The cumulative variance explained by the first two components amounts to 68.38% (Table 12). Although two components remain relevant according to Kaiser's criterion, the decrease in the variance explained by PC1 suggests that the effects of inflation and the energy crisis further

increased the complexity and heterogeneity of the data. As in the previous periods, PC1 is strongly defined by high loadings on the variables x_1, x_2, x_3, x_5, and x_8. The second component (PC2) explains 20.018% of the variance and exhibits the highest loadings on x_4 (0.800) and x_6 (0.706). The variable x_7 is also associated with PC2, with a loading of 0.443.

The decision to extract two components is again supported by Kaiser's criterion (both eigenvalues > 1) and by the clear inflection point in the Scree Plot (Fig. 6) after the second component. The substantially higher proportion of variance explained by PC1 (48.358%) compared to PC2 (20.018%) indicates that the main differences between clusters are driven primarily by macroeconomic performance.

The cluster analysis using Ward's method divides countries primarily according to their levels on PC1 (macroeconomic performance). Subsequently, PC2 helps to group countries within these main clusters based on similarities in their specific structural or sectoral profiles. For example, DK, DE and FR form a closely related group with IE and NL, which differs from the cluster comprising AT and PL, even though these countries may occupy a similar position along PC1.

A dendrogram for the 2022–2024 period (Fig. 7) shows further regrouping of clusters. The structure appears more dispersed, indicating that countries reacted to the inflation and energy crisis in different ways. This led to new groupings. For example, we see that ES, LV, EE, LT, IT, BG, RO, and EL are grouped into one larger cluster, while CY, SI, MT, SK, HR, Y, LU, PT, AT, PL, HU, BE, FI, DK, DE, FR, SE, IE, NL, and CZ form other, often smaller clusters. The identification of 4 clusters suggests some consolidation, but with different characteristics reflecting the impact of inflation and the energy crisis.

Cluster 1 (ES, LV, EE, LT, IT, BG, RO) includes 7 countries in this period (Table 13). This is a group of countries with the highest values for poverty indicators (x_1, x_2, x_5, and x_8) and the second highest for indicators x_3 and x_7. Interestingly, countries like Spain and Italy, which were previously in clusters with more moderate poverty, have shifted to this cluster, which may indicate a worsening of their situation due to inflation. Bulgaria and

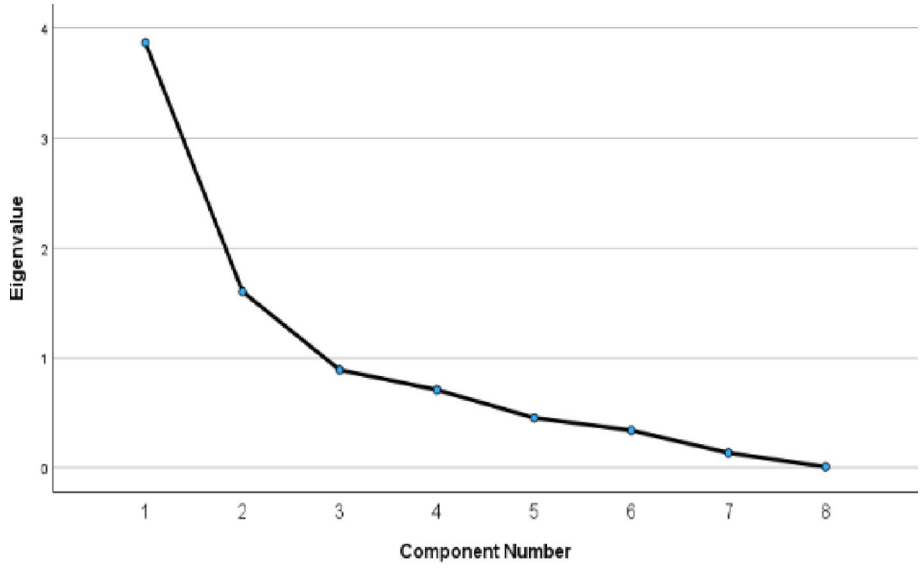

Fig. 6 Scree plot (2022–2024)
Source: IBM SPSS

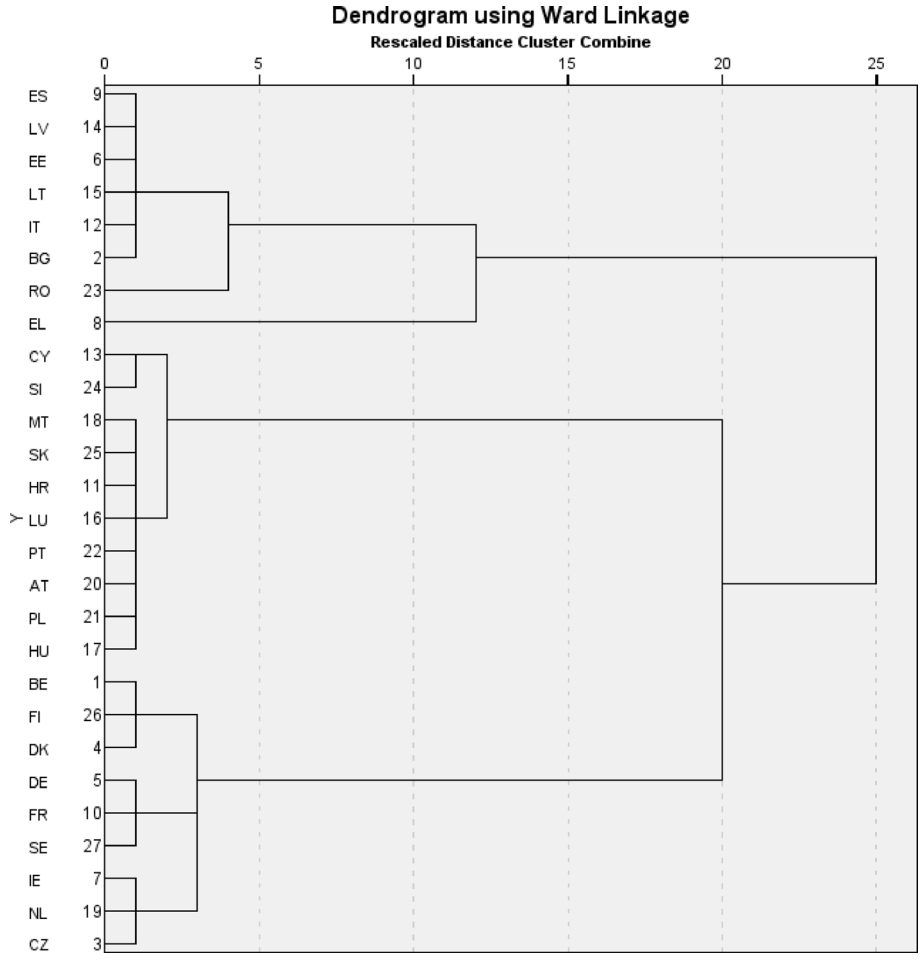

Fig. 7 Dendrogram (2022–2024)
Source: IBM SPSS

Table 13 Centroids (2022–2024)
Source: Own processing

Cluster 2022–2024	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Number of countries	**7**	**1**	**10**	**9**
x_1	26.55	26.43	18.18	17.60
x_2	20.94	19.10	15.34	13.17
x_3	9.51	13.80	4.11	4.34
x_4	7.31	8.43	4.62	8.78
x_5	10.52	10.40	8.27	5.40
x_6	7.35	28.03	5.57	8.71
x_7	4.23	10.90	1.63	2.34
x_8	25.93	23.20	21.82	18.47

Romania remain in a high-poverty cluster. Estonia has also moved again and is now part of this cluster. It suggests that its problems with access to services may have merged with the overall increase in poverty during this period.

Cluster 2 (EL) also consists of only Greece in this period, with an extremely high rate of housing cost overload ($x_6 = 28.03$), a high rate of access to services ($x_7 = 10.9$), and high material deprivation ($x_3 = 13.8$). This confirms that this specific problem persists and is dominant for Greece.

Cluster 3 (CY, SI, MT, SK, HR, LU, PT, AT, PL, HU) includes 10 countries. These are countries with relatively low values for poverty (especially x_3 and x_7), low work intensity (x_4), and relatively lower housing costs (x_6). We observe a shift of countries that were in Cluster 3 (e.g., CY, SI, SK, AT, MT) and Cluster 4 (e.g., HU, PT, LU, PL) during the COVID period, which indicates their ability to stabilize or improve their position compared to Cluster 1.

Cluster 4 (BE, FI, DK, DE, FR, SE, IE, NL, CZ) consists of nine countries. These are the countries with the lowest values for most poverty indicators (x_1, x_2, x_5, x_8) and high work intensity (x_4). They represent the best-performing countries in terms of SDG1 during this period, having managed to maintain or improve their position despite external shocks. Many of them were already in the top clusters in previous periods.

4.4 Relationships between cluster membership and structural factors (2015–2024)

Building on the identified cluster structure, the following empirical analysis focuses on identifying and quantifying the key structural determinants (economic and social factors) that explain the differing allocation of EU member states into clusters characterized by varying levels of success in achieving SDG1. The analysis aims to determine and quantify the main factors that account for why individual EU countries, across the observed periods (2015–2019, 2020–2021, 2022–2024), were classified into clusters with better, average, or weaker performance in fulfilling SDG1. This descriptive analyse enable the establishment of direct empirical links between countries' structural resilience and vulnerability and their dynamics in poverty and social exclusion outcomes.

In the period 2015–2019, the cluster distribution is clearly associated with macroeconomic performance and social protection. The most pronounced differences are determined by fundamental economic strength. Cluster 1 is characterized by the highest values of GDP, social benefits, and income, which directly translate into the best poverty outcomes (Table 14). These factors confirm that economic strength and the extent of social protection were key structural determinants of low poverty levels. This cluster

Table 14 Structural factors—period 2015–2019 (Pre-COVID)
Source: Own processing (Eurostat. 2025)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Median income before social transfers (EUR)	17,632.28	11,720.48	8454.60	3008.70	7371.80
Social protection receipts (EUR per inhabitant)	4789.11	3757.82	2211.83	931.49	2380.06
Unemployment rate (%)	6.90	8.43	5.78	6.92	21.66
Inflation (%)	1.01	1.11	2.06	1.15	0.26
Employed persons working part-time (% of total employment; 20–64 years)	17.52	11.56	9.74	3.18	9.58
GDP per capita	35,909.08	27,731.00	18,574.00	8725.00	16,598.00
Final consumption expenditure of households (EUR)	16,770.15	13,174.20	9266.00	5305.00	11,166.00
Early leavers from education and training (% of population; 18–24 years)	8.02	9.64	12.02	15.39	5.78
Gross debt-to-income ratio of households (%)	119.67	72.79	67.77	33.02	89.17
Electricity, gas and other fuels (HICP rate of change)	0.97	− 0.37	0.50	3.26	− 1.34
Share of housing costs in disposable household income—Single person with dependent children	28.37	29.29	22.44	36.05	60.56
Share of housing costs in disposable household income—2 adults with 3 or more dependent children	16.51	18.62	13.16	27.3	43.96
Gini coefficient of equivalized disposable income (scale 0 to 100)	26.95	31.89	32.04	37.04	33.04

also exhibited the lowest Gini coefficient (26.95), indicating lower income inequality even before social transfers. Despite high prosperity and low unemployment, this cluster shows the second-worst average rating in work-related poverty (x_4), which quantitatively corresponds to the highest share of part-time employment (17.52%). This highlights the challenge associated with economic insecurity in flexible employment arrangements.

Cluster 4 (Romania, Bulgaria) represents the exact opposite, where the lowest values across all three factors explain the poorest outcomes. Cluster 5 (Greece) is specifically defined by an extremely high unemployment rate and an exceptionally high share of housing costs relative to disposable income. These values are substantially higher than in other clusters, confirming the dominance of the housing cost burden as a structural problem.

The period 2020–2021, strongly affected by the COVID-19 pandemic, shows distinct structural patterns. Countries in the highest-performing clusters (particularly Cluster 1 and Cluster 3) exhibit a higher share of part-time employment and greater household indebtedness compared to other clusters, characteristics typical of flexible labour markets and countries with high housing costs (Table 15). These clusters also display the highest levels of social benefits, confirming that the strength and scope of social systems were key structural factors mitigating the impact of the pandemic.

Cluster 2 (Greece) again clearly correlates with the highest unemployment rate (16.15%), which remains a critical structural problem. Membership in Cluster 5 (Italy, Lithuania, Spain, Bulgaria) is directly associated with the highest Gini coefficient (35.46). This indicates that high income inequality is the dominant structural factor driving higher poverty rates, even though GDP per capita is not the lowest (Cluster 6).

Table 15 Structural factors—period 2020–2021 (Pandemic COVID-19)
Source: Own processing (Eurostat. 2025)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Median income before social transfers (EUR)	24,916.00	8341.50	17,469.75	13,204.33	10,765.25	4301.50
Social protection receipts (EUR per inhabitant)	5146.50	2227.60	5270.80	3946.64	2786.59	1480.33
Unemployment rate (%)	5.82	16.15	6.02	5.78	9.51	5.85
Inflation (%)	1.28	−0.35	1.61	2.42	1.78	3.20
Employed persons working part-time (% of total employment; 20–64 years)	20.40	8.40	15.75	8.95	9.81	3.60
GDP per capita	60,086.67	16,505	33,135.42	32,826.67	20,961.25	12,060
Final consumption expenditure of households (EUR)	21,795.00	11,260.00	15,857.08	13,018.33	11,750.00	7310.00
Early leavers from education and training (% of population; 18–24 years)	7.03	3.50	7.73	8.41	11.49	15.45
Gross debt-to-income ratio of households (%)	139.09	79.45	102.09	76.39	58.21	25.86
Electricity, gas and other fuels (HICP rate of change)	4.45	0.90	1.42	3.25	3.86	6.25
Share of housing costs in disposable household income—Single person with dependent children	28.73	54.90	26.63	22.32	25.80	20.45
Share of housing costs in disposable household income—2 adults with 3 or more dependent children	15.13	38.90	16.78	14.16	18.51	16.40
Gini coefficient of equivalized disposable income (scale 0 to 100)	26.32	31.90	27.09	30.49	35.09	34.05

For the period 2022–2024, the impact of inflation and the energy crisis led to a new consolidation of clusters, with inflation emerging as the key structural factor. Cluster 4 represents the economic core of the EU, which managed to maintain the best position in achieving SDG1 despite inflationary pressures. It exhibits the highest median income, GDP per capita, social benefits, and the highest share of part-time employment (Table 16).

Although Cluster 1 is geographically heterogeneous, all member countries are linked by a marked deterioration in their situation, primarily driven by inflation, which acted as a critical structural shock that outweighed existing social structures. This cluster includes both chronically vulnerable countries (Bulgaria, Romania) and countries that experienced a decline.

Greece, forming a solitary cluster, is a clear example of a persistent structural crisis, which manifests not only in macroeconomic terms but especially in the social sphere. This cluster is defined by the highest housing cost burden (x_6)—a key structural problem for Greece—and the highest unemployment rate, representing a long-term structural strain. Despite these challenges, Greece shows the lowest share of early school leaving, indicating that the problem stems from a lack of economic opportunities and extremely high living costs, rather than low population qualifications (Table 17).

5 Discussion of results

Based on the results of the descriptive analysis and a comparison of the pre-COVID, COVID, and post-COVID periods (the latter being influenced by high inflation and the energy crisis), we can identify significant disparities and several key changes in cluster groupings and the structure of principal components. The analysis of poverty and social exclusion indicators in EU member states reveals significant differences in their resilience and vulnerability to economic shocks.

During the periods studied, the "core" and "periphery" of poverty essentially remained the same. Romania and Bulgaria are characterized by consistently high rates of poverty and social exclusion, which points to their lasting vulnerability to economic shocks.

Table 16 Structural factors—period 2022–2024 (Inflation and energy Crisis)
Source: Own processing (Eurostat. 2025)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Median income before social transfers (EUR)	10,982.14	9264	16,472.9	24,109.89
Social protection receipts (EUR per inhabitant)	2757.55	2386.04	4462.54	6925.42
Unemployment rate (%)	7.07	11.8	4.87	5.08
Inflation (%)	10.86	6.75	8.98	7.34
Employed persons working part-time (% of total employment; 20–64 years)	8.60	7.55	9.81	20.53
GDP per capita	23,887.14	20,500	36,829	53,961.67
Final consumption expenditure of households (EUR)	13,453.57	13,920	16,793.5	23,160
Early leavers from education and training (% of population; 18–24 years)	10.54	3.90	7.25	7.78
Gross debt-to-income ratio of households (%)	47.72	63.67	77.78	118.32
Electricity, gas and other fuels (HICP rate of change)	27.82	16.90	15.80	23.26
Share of housing costs in disposable household income —Single person with dependent children	25.58	55.15	24.70	29.94
Share of housing costs in disposable household income —2 adults with 3 or more dependent children	16.90	37.20	16.54	17.57
Gini coefficient of equivalized disposable income (scale 0 to 100)	33.59	31.60	28.00	27.02

Table 17 The best and worst EU countries in the 8 SDG1 indicators assessed
Source: Own processing

x_1—Person at risk of poverty or social exclusion					
2015–2019		2020–2021		2022–2024	
Best	Worst	Best	Worst	Best	Worst
CZ (12.28%)	RO (41.56%)	CZ (11.15%)	RO (35.00%)	CZ (11.70%)	RO (31.43%)
x_2—Persons at risk of monetary poverty after social transfers					
CZ (9.64%)	RO (24.32%)	CZ (9.05%)	BG, RO (22.95%)	CZ (9.83%)	LV (22.20%)
x_3—Severe material and social deprivation rate					
SE (1.14%)	RO (31.02%)	FI (1.45%)	RO (24.20%)	SI (1.73%)	RO (20.43%)
x_4—Persons living in households with very low work intensity					
SI (5.14%)	IE (15.76%)	SI (3.75%)	BE (12.10%)	SI (3.70%)	BE (11.10%)
x_5–In work at-risk-of-poverty rate					
FI (3.06%)	RO (17.22%)	FI (2.95%)	RO (15.20%)	FI (2.70%)	LU (13.70%)
x_6–Housing cost overburden rate by poverty status					
MT (1.64%)	EL (40.26%)	MT (2.75%)	EL (31.05%)	CY (2.50%)	EL (28.03%)
x_7–Too expensive or too far to travel or waiting list					
NL (0.16%)	EE (4.34%)	MT (0.05%)	EE (10.55%)	CY (0.10%)	EL (10.90%)
x_8—Relative median at-risk-of-poverty gap					
FI (13.98%)	RO (35.42%)	FI (13.45%)	RO (34.80%)	FI (15.43%)	RO (32.23%)

Both countries persist in the clusters with the highest poverty rates, indicating deeper structural problems that are resistant to short-term changes. Similar conclusions were formulated in studies by Kasprzyk (Kasprzyk 2024)and Bąk & Barej-Kaczmarek (Bąk and Barej-Kaczmarek 2024). The causes of these problems have been addressed by several authors who pointed to the inadequate access to quality education, insufficient decent work opportunities and insufficient social support systems (Bąk and Barej-Kaczmarek 2024; Ciucu et al. 2024).

Conversely, the Czech Republic, Finland, and the Netherlands have consistently maintained low values for poverty indicators, reflecting stronger and more effectively functioning social systems with the ability to absorb external shocks. Their stable and effective social policies in the fight against poverty and social exclusion are also highlighted in studies by Greve et al. (Greve et al. 2021), Gřundělová (Gřundělová 2022)and Goderis & Vlekke (Goderis and Vlekke 2023).

The influence of crisis periods is particularly evident. We noted a decrease in the explained variance of the first component from 55.537% in the 2015–2019 period to 48.358% in the 2022–2024 period. This trend suggests that the overall situation regarding SDG1 has become more heterogeneous and complex. While in the pre-COVID period, one strong factor of "general poverty" dominated, in the post-COVID periods, the effects of the pandemic, inflation, and the energy crisis manifested more differentially, requiring the consideration of multiple dimensions. Changes in correlation patterns also confirm this. Although strong correlations between the main poverty indicators persist across the periods, their strength is slightly decreasing. This indicates that individual aspects of poverty may have become more independent as a result of the crises or were affected by different mechanisms. Notably, indicators like low work intensity (x_4) and housing costs (x_6) show more dynamic changes in their correlations, reflecting a more direct impact of economic shocks.

The pandemic period of 2020–2021 paradoxically brought a slight improvement in some average values of poverty indicators (e.g., x_1, x_3, x_4, x_6, x_7). This development can be attributed to extensive government support measures that temporarily mitigated

negative social impacts. Job retention schemes shielded many workers from unemployment, influencing welfare attitudes and support for unemployment protection during the economic challenges posed by COVID-19 (Zola et al. 2024). Van Helden et al. (Van Helden et al. 2025)in their study indicates that these support programs positively affected the number of bankruptcies and employment figures across selected European countries.Pappa, Ramos & Vella (2024) have even created a comprehensive database that categorizes announcements of fiscal measures related to COVID-19. According to their findings, direct spending during the pandemic and measures aimed at maintaining employment levels generated significant output and employment multipliers and improved business sentiment without leading to inflationary costs.

However, the subsequent period of inflation (2022–2024) indicates a slight increase in some indicators (x_1, x_5, x_6, x_7), which may be a reflection of the rising cost of living. The impact of energy prices and inflation as new factors increasing the risk of poverty and changing consumer behaviour was also confirmed in research by Slutins et al. (Slutins et al. 2025), Arsenopoulos et al. (Arsenopoulos 2025)and Szczygieł, Harbiankova & Manso (Szczygieł et al. 2024).Bąk, Wawrzyniak and Oesterreich (2024) specifically analysed countries in Central and Eastern Europe, which were particularly affected by rising energy prices.

The impact of the crises was also reflected in cluster mobility. In the 2020–2021 pandemic period, we observed an increase in the number of clusters (to 6), indicating greater fragmentation and specialization in countries' responses to the pandemic. In the 2022–2024 period (inflationary period), the number of clusters slightly decreased (to 4), but with different centroid characteristics, indicating a new consolidation, but based on new socio-economic challenges. Some countries, like Spain and Italy, shifted to clusters with higher poverty rates during the inflation period (2022–2024), suggesting that inflationary pressures and the energy crisis had a more significant negative impact on them. Tassinari, Molina & Di Carlo (Tassinari et al. 2024)indicates in their study that inflation in Spain had less regressive distributional effects compared to Italy, suggesting that while both countries faced challenges, the increase in poverty due to inflation and the energy crisis was more pronounced in Italy. Amores et al. (Amores 2025) confirm that the inflationary shock following the pandemic hit low-income households particularly hard in these two countries, and although fiscal measures were designed to mitigate this problem, they were not effectively targeted at the poorest, which limited their protective impact.

Some countries were able to move from clusters with worse results to clusters with better results (e.g., some Central and Eastern European countries in Cluster 3 in the 2022–2024 period). This shift suggests that even countries that have long faced high social risks can achieve improvement through more targeted social policies, effective use of European funds, and adaptive strategies to new challenges (e.g., energy crisis, inflation).

Indicators such as material and social deprivation (x_3), housing costs (x_6), and access to services (x_7) show the highest variability among member countries in all periods. This indicates that although the average values at the EU level may change slightly, the differences between the best and worst-performing countries remain significant. These areas represent key challenges that require more targeted and specific policy interventions. The impact of specific indicators was fully evident in the case of Greece. A

"Greek" cluster appears in every period with extremely high housing costs (x_6), indicating a persistent and specific problem for this country. This is also confirmed by Radin (Radin 2024)and Simón-Moreno et al. (Simón-Moreno et al. 2024). Similarly, Estonia showed specific problems with access to services (x_7), although its position in the clusters changed. Estonia has long been among the EU countries with a high proportion of people who report unmet healthcare needs due to cost and waiting times (European 2021; Filina-Kossat 2017), while the main barriers to access to healthcare include long waiting times and high out-of-pocket payment.

The conducted descriptive analysis clearly demonstrates the empirical relationships between cluster membership and structural factors for each period. The results indicate that GDP per capita and social benefits are consistent and the most influential explanatory factors for the differences between "good" clusters (Cluster 1/2015–2019, Clusters 1 and 3/2020–2021, Cluster 4/2022–2024) and "poor" clusters (Cluster 4/2015–2019, Cluster 5/2020–2021, Clusters 1 and 2/2022–2024) across all three periods. Higher social spending emerges as a key determinant of structural resilience, particularly during the crisis years of 2020–2021. In the "poor" clusters, dominant specific factors include structural unemployment (Cluster 5/2015–2019, Cluster 2/2020–2024), income inequality (Cluster 5/2020–2021, highest Gini coefficient), and inflation (Cluster 1/2022–2024, highest inflation), which drive adverse outcomes.

6 Conclusion

Poverty is an extremely current and multifaceted issue, extending beyond a purely theoretical framework. It is often considered in terms of social justice, solidarity, and equal opportunity. It is perceived as a multidimensional socio-economic phenomenon that impacts society, the labour market, and education. The issue spans multiple macroeconomic and microeconomic dimensions, intersecting with other areas such as marketing, management, and corporate social responsibility, and thus has practical, ethical, and social implications.

The results of the analyses confirm that recent crises (the pandemic, inflation, and the energy crisis) have significantly affected the socio-economic situation in EU countries and have led to a rearrangement of their positions regarding SDG1. The principal component analysis points to the growing complexity of the problem, while the cluster analysis reveals dynamic changes in country groupings, which underscores the need for a targeted and adapted policy response.

Finland and the Czech Republic are repeatedly ranked among the states with the lowest values for poverty and social exclusion indicators. This stable performance points to the effectiveness of their social policies and their ability to maintain robust social protection mechanisms over the long term, even in the face of economic shocks. In contrast, Romania and Bulgaria are consistently ranked among the countries with the highest values for the indicators studied, reflecting the persistent structural weaknesses of their social systems. Greece shows specific and persistent problems, particularly in the areas of housing costs and access to basic services, which worsens the social situation of its population.

The results of this study point out that, although progress toward SDG1 in the EU is uneven (as noted in the literature), the structural component of this progress remains stable. By applying PCA and cluster analysis across three periods, we found that the

structure of the two principal factors defining progress (PC1—the macroeconomic dimension of poverty and PC2—factors of economic constraint) did not change significantly between the periods 2015–2019 and 2020–2024. This empirically demonstrates that approaches to poverty reduction that were effective in one period remain relevant in structurally different periods.

An original contribution of this study is the dynamic comparison, which goes beyond static analysis. The study compares cluster composition across three distinct economic periods (2015–2019, 2020–2021, 2022–2024), allowing us to observe the evolution and stability of country groups (clusters) in response to external shocks and crises (financial crisis, COVID-19 pandemic, war in Ukraine). To date, no study has provided such a dynamic classification of progress toward SDG1 in the EU context. This approach, in terms of typologizing success in achieving SDG1, has not been previously explored in detail and therefore provides new, time-based empirical insights.

The insights gained provide valuable insight into how member states have addressed with the challenges of sustainable development in a changing global context. These conclusions represent an important starting point for expert discussion and the formulation of effective policy recommendations, for example in terms of targeted funding, policy design, benchmarking and assessments of institutional capacities to absorb external shocks. In the context of targeted funding, identifying "chronically" problematic countries within clusters highlights where fund allocation (e.g., Cohesion Fund, Recovery Plan) must not only be higher but also monitored over the long term. The observed stability in the structure of PC1 and PC2 suggests that poverty reduction policies should be stable and long-term, combining social protection with stimuli for economic activity. Effective use of public expenditure can substantially contribute to reducing poverty, improving living standards, and promoting inclusive economic growth.

The primary aim of this article was to evaluate the extent of progress toward fulfilling SDG1 (No Poverty) in EU member countries from 2015 to 2024 and, using cluster analysis, identify country clusters across three distinct periods. This objective has been successfully met. The analysis of the three chosen periods (pre-pandemic years, the COVID-19 pandemic period, and the inflation period) highlighted the varying speed of poverty reduction and the increasing divergence among EU member states.

Concerning the first research question (RQ1), which examines the extent of progress towards SDG1 in EU member states from 2015 to 2024, the findings indicate a highly uneven and fragile trajectory. The initial implementation period (2015–2019) saw modest yet generally stable progress across most countries. However, this positive momentum was substantially disrupted by subsequent crises. The COVID-19 pandemic (2020–2021) and the inflationary shock (2022–2024) resulted in stagnation or even regression in a significant number of states, particularly those heavily reliant on temporary social measures that ultimately proved unsustainable.

Regarding the second research question (RQ2), which considers the dynamics of cluster membership and prevailing disparities, a clear trend of increasing divergence emerges. Analysis of country transitions between clusters shows that high-performing countries (BE, IE, DK) largely retained their positions, whereas substantial movement occurred among medium- and low-performing clusters (IT, ES, PT, PL, HU). This pronounced volatility within lower-performing groups underscores that the impact of crises was not uniform across the EU. In countries such as EL, RO, and BG, pre-existing

structural inequalities were further deepened, thereby widening the geographical divide across EU regions.

We realize that our research and its results have several limitations that could be addressed in future studies. The study therefore offers several starting points for follow-up research activities. For example, it is possible to expand the group of indicators included in the analysis, as a wider set of indicators could better capture the multidimensional aspects of poverty and social exclusion (e.g. access to digital services, intergenerational transmission of poverty, financial literacy, gender inequality in income and labour market conditions, institutional factors). It is also possible to focus not only on the EU, but further research could compare the EU's progress in the fight against poverty with other regions of the world, which would provide a broader global context. We also see scope for further research in the analysis of specific types of poverty, such as energy poverty, housing cost overload or access to services. Another option is to compare the performance of the EU with other OECD regions or global regions, which could provide valuable insights into the relative effectiveness of European social protection systems.

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Data availability
The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The research presented in this article is based solely on publicly available secondary data. No experiments involving human participants or animals were conducted. Hence, approval by an ethics committee and consent to participate were not required.

Consent for publication
The study uses only publicly available aggregate data and does not include any individual or identifiable information. Accordingly, consent for publication was not applicable.

Competing interests
The authors declare no competing interests.

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