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Original Paper

Multivariate analysis of socio-economic condition of new EU members NUTS-2 regions: Case study

Mária Májek*, Michaela Soóki

Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Institute of Statistics, Operations Research and Mathematics, Slovakia

ABSTRACT

The paper aims to provide a comparative analysis of NUTS-2 regions in the new EU member states from the point of socio-economic condition. We assess 61 NUTS-2 regions of new EU members based on 8 socio-economic indicators. Secondary data are obtained from the public databases of Faostat and Eurostat in the period of 2021-2022 and standardized to the same direction of development. The findings indicate that when it comes to investments and GDP, the majority of the examined regions fall short of the EU, but the overall employment and unemployment rates are at least average than EU. Slovenia and the V4 regions perform better than the EU average on indicators of social exclusion and poverty. The dimension in the database was decreased through factor analysis after varimax rotation, resulting in the reduction of the eight original indicators to two factors. Using them, the regions were typologized into four groups according to the outcomes of Ward's cluster analysis approach. The best results are achieved by the first group, which included 9 regions of the capitals of the new member countries. The largest group is the second cluster, which includes 23 regions located in the western part of the V4 countries and one northern region of Romania. The third cluster includes 18 regions mainly located in the eastern part. The last cluster consists of 11 regions, mainly of Bulgaria, Romania, together with Eastern Slovakia, Latvia, and one region of Lithuania. The given group had the worst socio-economic situation on average compared to other clusters.

KEYWORDS: society, economy, sustainability, development, NUTS-2

JEL CLASSIFICATION: C10, H00

INTRODUCTION

Global changes, including political, economic, social, and national upheavals, cause depressed reactions in numerous regions of the world in response to crisis outcomes, including coronavirus-related ones [12]. One of the primary challenges to a nation's socioeconomic development objectives is the volatility of the external environment affecting its regional and

* Corresponding author: Mária Májek, Institute of Statistics, Operations Research and Mathematics, Faculty of Economics and Management, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, e-mail: xvargovam2@uniag.sk

national economy [11]. Thus, monitoring on and analyzing socioeconomic development metrics are essential activities. In the context of the economic crisis, socio-political instability, social tension, and exponential dynamism, they aid in the implementation of national and regional development goals [18]. Currently, a growing number of indicators are available that enable an assessment of the overall picture of inequalities, such as access to infrastructure, health care, and education. The European Union has maintained the GDP indicator as the main criterion for allocating funds for cohesion policy, but additional criteria have also been added, such as youth unemployment, low educational attainment, climate change, income, and migrant integration [17]. According to the European Union's perspective, the empirical study [6] supported the beneficial influence of exchanging innovative technologies on economic development. For evaluating the goal in the field of social inclusion, an overall indicator of poverty or social exclusion was developed. According to the analysis of non-stationary time series on data from the Czech Republic [2], the degree of risk of poverty or social exclusion is directly influenced by the growth rate of real gross domestic product, inflation, unemployment rate or social benefits. Previous studies demonstrated significant inequalities in the development of nations and regions [3], [8]. A stronger cohesion strategy faced new obstacles because the GDP per capita of the twelve new member states was less than half that of the existing member states. Although the EU as a whole has gone forward, certain areas are trailing behind or have even fallen backwards in terms of reaching the goals of the Europe 2020 Strategy. Finland and Sweden have the best-performing regions. On the contrary, regions of Spain, Italy, Bulgaria, and Romania are the worst-performing [1]. Two categories of below-average development regions are presented in the EU Commission's report on trailing regions. Slow economic development characterizes the first group, which is primarily composed of Southern European areas, while low earnings are the characteristic of the second group, which is primarily composed of Eastern European EU members. Due to inadequate innovation systems and skills, both groups are less competitive, and migration is causing a population drop in low-income areas [4]. Using only social and economic indicators to assess socioeconomic growth in the modern era is becoming insufficient, due to great intertwine of information and communication technology [5]. To accomplish the Sustainable Development Goals (SDGs) and prepare for climate change, socioeconomic development must take the environment into consideration. The implementation of programs and financing are also necessary to lessen the ecological imprint [13], [16].

MATERIAL AND METHODS

The contribution's goal is to analyze the socioeconomic conditions in the NUTS-2 regions of the new European Union member countries. The given goal consists of the following partial goals:

- Comparative analysis of new member countries based on their regional performance with the EU average individually in terms of each indicator. Identification of regional disparities in individual countries. Classification of regions into homogenous groups.
- Comparative analysis of groups of regions in terms of individual indicators.

We evaluate 61 NUTS-2 territorial units of 11 EU countries: Croatia, Slovenia, Romania, Bulgaria, Lithuania, Latvia, Estonia, Czech Republic, Poland, Hungary and Slovakia. All of

the selected countries have joined European Union since 2004, so we believe the socio-economic development of these countries is comparable. However, differences could occur on regional scale, e.g. the NUTS-2 territorial units. Table 1 lists the selected countries and their NUTS-2 regions.

Table 1 List of selected countries and their NUTS-2 regions

Country	NUTS-2 regions	Country	NUTS-2 regions
Croatia	HR02 – Pannonian Croatia	**Slovenia**	SI01 – Eastern Slovenia
	HR03 – Adriatic Croatia		SI02 – Western Slovenia
	HR05 – City of Zagreb	**Bulgaria**	BG31 – Northwestern
	HR06 – Northern Croatia		BG32 – Northern Central
Romania	RO11 – North-West		BG33 – Northeastern
	RO12 – Centre		BG34 – Southeastern
	RO21 – North-East		BG41 – Southwestern
	RO22 – South-East		BG42 – Southern Central
	RO31 – South Muntenia	**Lithuania**	LT01 – Capital Region
	RO32 – Bucuresti - Ilfov		LT02 – Central and Western Lithuania Region
	RO41 – South-West Oltenia	**Latvia**	LV00 – Latvia
	RO42 – West	**Estonia**	EE00 – Estonia
Czechia	CZ01 – Prague	**Poland**	PL21 – Lesser Poland Voivodeship
	CZ02 – Central Bohemia		PL22 – Silesian Voivodeship
	CZ03 – South-West		PL41 – Greater Poland Voivodeship
	CZ04 – North-West		PL42 – West Pomerian Voivodeship
	CZ05 – North-East		PL43 – Lubusz Voivodeship
	CZ06 – South-East		PL51 – Lower Silesian Voivodeship
	CZ07 – Central Moravia		PL52 – Opole Voivodeship
	CZ08 – Moravian Silesia		PL61 – Kuyavian-Pomerian Voivodeship
Hungary	HU11 – Budapest		PL62 – Warmian-Masurian Voivodeship
	HU12 – Pest		PL63 – Pomerian Voivodeship
	HU21 – Central Transdanubia		PL71 – Lodz Voivodeship
	HU22 – Western Transdanubia		PL72 – Swietokrzyskie Voivodeship
	HU23 – Southern Transdanubia		PL81 – Lublin Voivodeship
	HU31 – Northern Hungary		PL82 – Subcarpathian Voivodeship
	HU32 – Northern Great Plain		PL84 – Podlaskie Voivodeship
	HU33 – Southern Great Plain		PL91 – Warsaw capital
Slovakia	SK01 – Bratislava Region		PL92 – Masovian Regional
	SK02 – Western Slovakia		
	SK03 – Central Slovakia		
	SK04 – Eastern Slovakia		

Source: Eurostat (2023); data code reg_area3

Secondary data for the years 2021–2022 are obtained from the public EUROSTAT's databases. The examined indicators are separated into maximization and minimization categories based on the anticipated aims they meet.

We consider the following indicators to be maximizing:

- government expenditures to R&D (% from GDP),
- gross domestic product (PPS per inhabitant),
- employment rate (% of total; 15-64 years-old),
- tertiary educational attainment (% of total; 25-34 years old).

We consider the following indicators to be minimizing:

- unemployment rate (% of total; 15-64 years old),
- at risk of poverty rate (% of total population),
- persons living in households with very low work intensity (% of total; 0-64 years old),
- severe material and social deprivation rate (% of total population).

Correlations between pairs of original variables were analyzed using Pearson's correlation coefficients based on the following equation:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x}) \sum (y_i - \bar{y})}} \tag{1}$$

where:
r is a coefficient of correlation,
$\bar{x}$ is the mean value of xth indicator,
$\bar{y}$ is the mean value of yth indicator,
x_i is the selected xth indicator,
y_i is the selected yth indicator.

Before multivariate analysis, in order to preserve comparability, the minimization indicators were multiplied by a coefficient of -1 and subsequently all data were standardized using the following equation:

$$z = \frac{x - \mu}{\sigma} \tag{2}$$

where:
μ is the mean value of the selected indicator,
σ is the standard deviation of selected indicator.

The factor analysis model was estimated by the method of principal components after varimax rotation. The resulting common factors can be written through the following expression:

$$F_j = a_{j1}X_1 + a_{j2}X_2 + ... + a_{jq}X_k \tag{3}$$

where:
F_j for $j = 1, \ldots, s$ is the j^{th} common factor,
a_{ji} for $k = 1, ..., q$ and $j = 1, \ldots, s$ is a factor weight estimating influence of j^{th} common factor on i^{th} indicator,
X_i for $i = 1, \ldots, k$ is the i^{th} indicator.

NUTS-2 regions are divided into clusters using Ward's hierarchical clustering method, based on the loss of information that occurs during clustering. The given method merges clusters based on the minimum sum of squared deviations of each object from the center of gravity of the cluster.

RESULTS AND DISCUSSION

Figure 1 compares the analyzed nations based on the EU average and regional disparities according to maximizing indices.

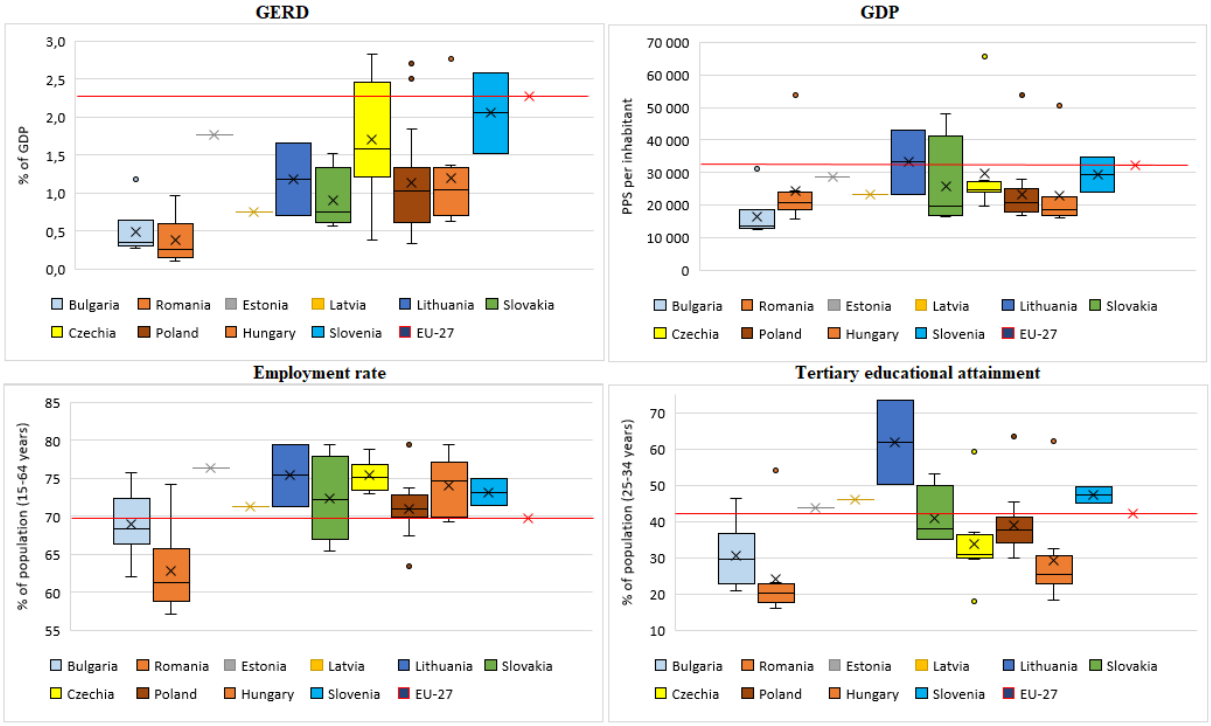

Figure 1 Boxplots of selected maximizing indicators
Source: authors' elaboration

In the monitored period, Government expenditures on R&D in the EU are on average at the level of 2.27% of GDP, although the average GDP share of all the nations under analysis was lower than that of the EU. The regions of Bulgaria and Romania invest the least in R&D, whereas Slovenia and the Czech Republic invest on average the highest share of GDP to R&D. These countries also show the biggest regional variances in terms of NUTS-2. In terms of GDP per inhabitant in PPS, Lithuania and some regions of Slovakia are above the EU average (32.400 PPS per inhabitant). However, in these countries there are also the greatest regional disparities. The regions with the lowest GDP in terms of PPS per person are in Bulgaria, Romania, Latvia, Hungary, and Poland. On the contrary, in terms of employment rate, all countries achieve better results than the EU average (69.8%), except for Bulgaria and Romania, where the regional differences are most obvious. We also noticed large regional differences between Slovak regions, where the employment rate ranges from 65.5% in Eastern Slovakia to 79.5% in the Bratislava region. Tertiary educational attainment reaches an average level of 42% in the EU, while the regions of the Baltic countries, led by Latvia, as

well as Slovenia, achieve on average better results than the EU. Slovakia and Poland are just below the EU average, and the lowest rate of tertiary education was recorded in Romania and Hungary (Figure 1). Figure 2 shows boxplots of minimizing indicators of by NUTS-2 regions of new member countries.

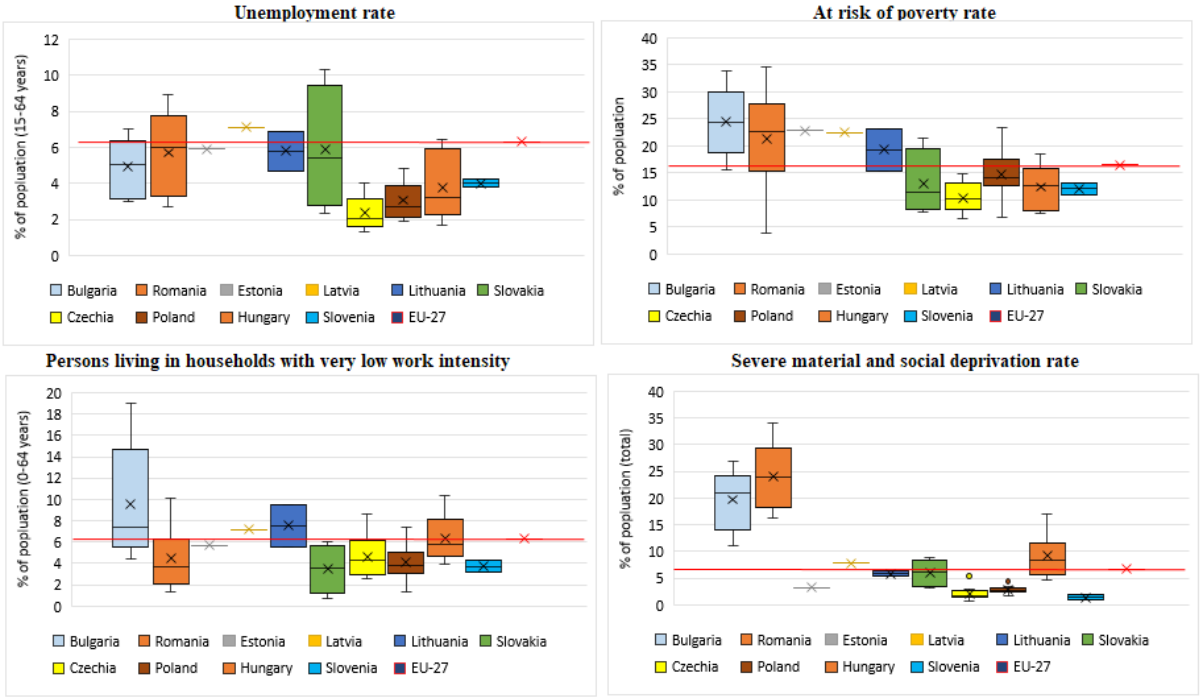

Figure 2 Boxplots of selected minimizing indicators
Source: authors' elaboration

With the exception of Latvia, all analysed nations had higher average unemployment rates than the EU for the monitored period, which stands at 6.3%. The lowest unemployment rate was reported in the Czech Republic and Poland, and the highest in the Baltic nations, as well as Romania, Slovakia and Bulgaria. Simultaneously, Slovakia has the greatest regional disparities for the unemployment rate, varying from 2.3% in the Bratislava Region to 10.3% in the Eastern Region. When it comes to the tt risk of poverty rate, which measures monetary poverty, Slovenia and the regions of the V4 nations do better on average than the EU average (16.5%). Bulgaria, Romania and the Baltic countries achieve worse results than the EU average in terms of the given indicator. At the same time, Romania has the most significant regional differences, where the monetary poverty indicator ranges from 3.9% in the Bucuresti-Ilfov region to 34.7% in the Sud-Vest Oltenia region. The average performance of the regions of Bulgaria, Latvia, and Lithuania in relation to the indicator of persons living in households with very low work intensity is lower than the EU average (8.3%). The largest regional differences were observed in Bulgaria, where the value of the indicator ranged from 4.4% in the capital city region of Yugozapaden to 19% in the region of Severozapaden. From the point of view of the north material and social deprivation indicator, the regions of Bulgaria and Romania achieve the worst results, where we also recorded the largest regional differences. Above the EU average (6.7%) is also Latvia and of the V4 countries Hungary, which probably contributed to the high growth of inflation in the given country (Figure 2). Part of the paper's objective is to divide the regions in homogenous groups according to all the

indicators that have been examined. We employed cluster analysis to achieve this aim, and we also standardised the input data to follow the same development track. Using Pearson's correlation coefficients, we were verified the hypothesis regarding the uncorrelation of the input variables in the cluster analysis (Table 2).

Table 2 Pearson's correlation coefficients of analysed indicators

Pearson Correlation Coefficients, N = 61 Prob > |r| under H0: Rho=0								
	GERD	GDP	EmpRate	TerEduc	UnempRate	AROP	VLWI	SMSD
GERD	1.00 (-)	0.69 (***)	0.65 (***)	0.67 (***)	-0.49 (***)	-0.61 (***)	-0.39 (**)	-0.59 (***)
GDP	0.69 (***)	1.00 (-)	0.58 (***)	0.76 (***)	-0.39 (**)	-0.59 (***)	-0.43 (***)	-0.30 (*)
EmpRate	0.65 (***)	0.58 (***)	1.00 (-)	0.60 (***)	-0.69 (***)	-0.74 (***)	-0.37 (**)	-0.63 (***)
TerEduc	0.67 (***)	0.76 (***)	0.60 (***)	1.00 (-)	-0.27 (*)	-0.45 (***)	-0.35 (**)	-0.52 (***)
UnempRate	-0.49 (***)	-0.39 (**)	-0.69 (***)	-0.27 (*)	1.00 (-)	0.70 (***)	0.42 (***)	0.47 (***)
AROP	-0.61 (***)	-0.59 (***)	-0.74 (***)	-0.45 (***)	0.70 (***)	1.00 (-)	0.63 (***)	0.64 (***)
VLWI	-0.39 (**)	-0.43 (***)	-0.37 (**)	-0.35 (**)	0.42 (***)	0.63 (***)	1.00 (-)	0.37 (**)
SMSD	-0.59 (***)	-0.30 (*)	-0.63 (***)	-0.52 (***)	0.47 (***)	0.64 (***)	0.37 (**)	1.00 (-)

Source: authors' elaboration

From Table 2, we can conclude that the correlations between individual pairs of indicators are significant, therefore Principal factor analysis was used in order to reduce the dimension and obtain uncorrelated inputs. We obtained the resulting common factors after varimax rotation (Table 3).

Table 3 Eigenvalues of correlation matrix and rotated factor pattern after varimax rotation

Eigenvalues of correlation matrix				Rotated factor pattern		
Factor	Eigenvalue	Proportion	Cumulative	Indicator	Factor 1	Factor 2
1	4.79	0.60	0.60	GERD	0.46	**0.73**
2	1.02	0.13	**0.73**	GDP	0.27	**0.85**
3	0.76	0.10	0.83	EmpRate	**0.70**	0.51
4	0.59	0.07	0.90	TerEduc	0.19	**0.92**
5	0.32	0.04	0.94	UnempRate	**0.86**	0.11
6	0.24	0.03	0.97	AROP	**0.85**	0.35
7	0.19	0.02	0.99	VLWI	**0.64**	0.22
8	0.09	0.01	1.00	SMSD	**0.67**	0.36

Source: authors' elaboration

The first two common components are significant and together explain 73% of the variability in the data, according to the eigenvalues of the correlation matrix. Employment rate,

unemployment rate, at risk of poverty rate, persons living in households with very low work intensity and severe material and social deprivation rate are significantly correlated with the first common factor. It might be collectively call as the factor of social and economic inclusion. Indicators of government spending on research and development, GDP and tertiary educational attainment are significantly correlated with factor 2, and we can collectively call it the economic educational innovation factor (Table 3). The given factor scores for individual regions served as inputs to the cluster analysis, on the basis of which we divided the regions into 4 homogeneous groups using Ward's method (Figure 3). The individual groups were subsequently compared individually in terms of the centroids of the original indicators (Table 4).

HU23, HU31, HU32

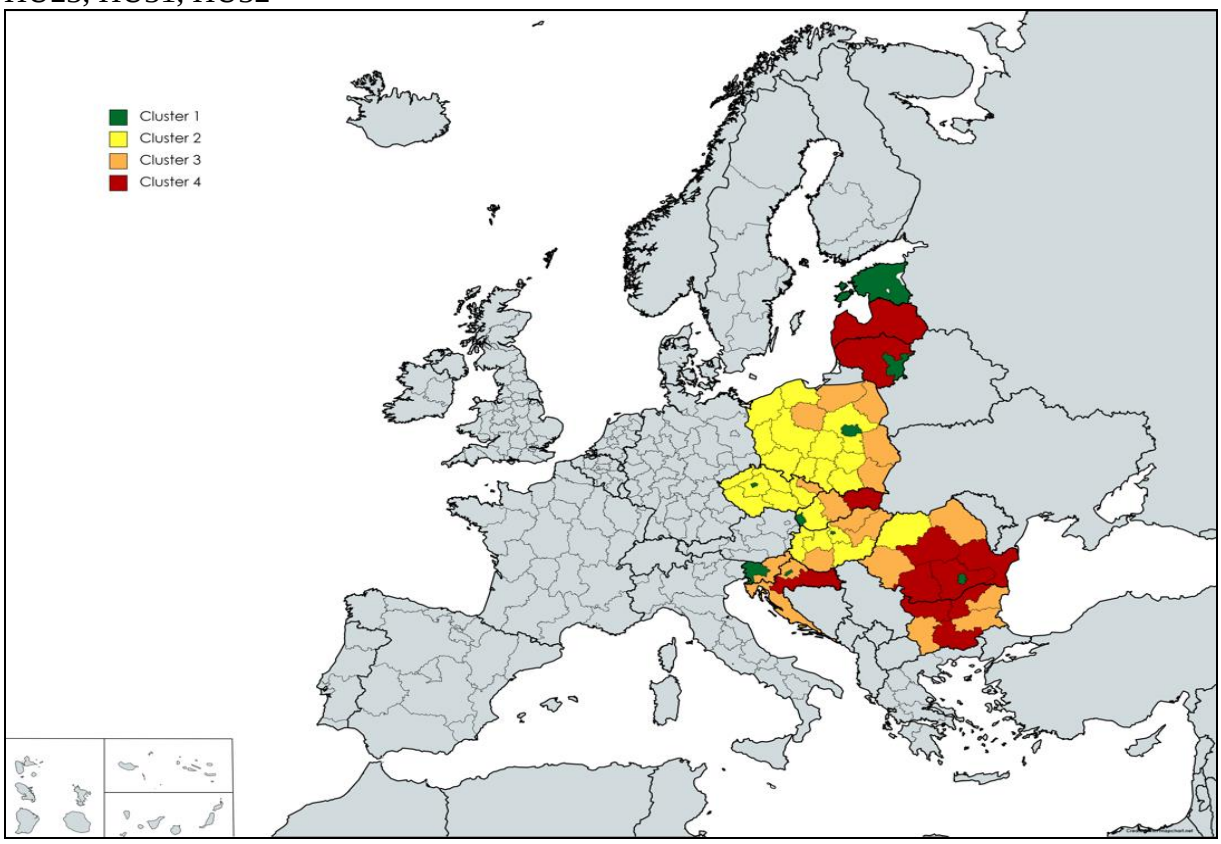

Figure 3 Groups of NUTS-2 regions based on Ward cluster analysis results
Source: authors' elaboration

Table 4 Cluster centroids of individual indicators

Cluster	GERD (% of GDP)	GDP (PPS per inhabitant)	EmpRate (%)	TerEduc (%)	UnempRate (%)	AROP (%)	VLWI (%)	SMSD (%)
1	2.12	46822	77	57	3.43	10.12	3.37	4.63
2	1.14	22791	73	33	2.67	11.75	4.09	4.04
3	0.89	19139	69	32	4.81	18.42	5.64	9.28
4	0.4	17655	64	29	7.35	26.09	8.91	19.43

Source: authors' elaboration

The first cluster consists of 9 NUTS-2 regions of nine countries, except of Latvia and Bulgaria, where the capital cities are located (HR05, SI02, RO32, LT01, EE00, CZ01, PL91, HU11, SK01). From the all NUTS-2 regions of countries that have joined EU sice 2004, these regions are most socio-economically developed, according to the data from 2021-2022. These regions achieved the best results in terms of GERD, GDP, employment rate, tertiary educational attainment, at risk of poverty rate and in terms of the very low work intensity indicator. They achieve the second best results in terms of unemployment rate and severe material and social deprivation rate. This is mainly due to the fact that strategic companies, institutions, and universities are concentrated in the given regions, and thus the income and standard of living are the highest in them. The second cluster represents 23 regions of the Czech Republic (CZ02, CZ03. CZ04, CZ05, CZ06, CZ07), Poland (PL21, PL22, PL41, PL42, PL43, PL51, PL52, PL63, PL71, PL72, PL92), Hungary (HU12, HU21, HU22, HU33), Slovakia (SK04) and Romania (RO11). In comparison with the other clusters, they achieve the best results in terms of the unemployment rate and the rate of severe material and social deprivation, while in terms of the other monitored indicators, they achieve the second best results. In terms of comparison with the EU average, they achieve better results in terms of employment, unemployment and indicators of poverty and social exclusion. On the contrary, investments in research and development, GDP and tertiary education are on average lower than the European average in the given regions. The third group consists of 18 regions from Czechia (CZ08), Slovakia (SK03), Poland (PL61, PL62, PL81, PL82, PL84), Hungary (HU23, HU31, HU32), Slovenia (SI01) Croatia (HR03, HR06), Bulgaria (BG33, BG41, BG34), and Romania (RO21, RO42). In terms of comparing the centroids of the indicators with other clusters, the given regions are in third place, and in terms of comparison with the EU average, they achieve better results only in terms of the unemployment rate and the indicator of persons living in households with very low work intensity. The last cluster is formed by 11 regions, mainly from Romania (RO12, RO22, RO3, RO41) and Bulgaria (BG31, BG32, BG42) together with 1 region from Croatia (HR02), Slovakia (SK04), Latvia (LV00) and Lithuania (LT02). In comparison with other clusters and the EU average, this group achieved the worst results in terms of all indicators, it is dominated by low investments and GDP, low employment, high unemployment, a low rate of tertiary education and a high proportion of the population at risk of poverty and social exclusion. These results indicate that regional disparities are not only on the national level, but also on the regional scale.

CONCLUSIONS

The contribution aims to assess the socio-economic conditions in the NUTS-2 regions of new EU member countries, by conducting comparative analysis of regional performance with EU-average, classification regions into homogenous groups and comparing centroids of these groups individually by each region. When compared to the EU average, more than 50% of NUTS-2 regions of selected countries fall behind in terms of investments in research and development as well as GDP. However, concerning employment and unemployment rates, they generally outperform the EU average, except for regions located in Romania and Bulgaria. The regions of V4 countries and Slovenia exhibited above-average results in indicators of poverty and social exclusion, while regions of Romania, Bulgaria, and the Baltic countries achieve below-average results in these indicators. The results of cluster analysis showed that regions could be divided into four groups. The first cluster includes 9 regions where the capitals of selected countries are situated, except from Bulgaria and Latvia (HR05,

SI02, RO32, LT01, EE00, CZ01, PL91, HU11, SK01). These regions performed well across various indicators due to the concentration of strategic entities. These results are in line with various studies [7], [14], [15]. The second cluster comprises regions from the Czech Republic (CZ02, CZ03. CZ04, CZ05, CZ06, CZ07), Poland (PL21, PL22, PL41, PL42, PL43, PL51, PL52, PL63, PL71, PL72, PL92), Hungary (HU12, HU21, HU22, HU33), Slovakia (SK04) and Romania (RO11). These regions excelled in unemployment and deprivation but lagged in research, GDP, and education compared to the EU average. The third group consists of regions from the Visegrad Group (CZ08, SK03, PL61, PL62, PL81, PL82, PL84, HU23, HU31, HU32), Slovenia (SI01), Croatia (HR03, HR06), Bulgaria (BG33, BG41, BG34) and Romania ((RO21, RO42), ranking third among clusters and surpassing the EU average only in unemployment and low work intensity. The fourth cluster, dominated by regions from Romania ((RO12, RO22, RO3, RO41) and Bulgaria (BG31, BG32, BG42), along with Eastern Slovakia (SK04), Latvia (LV00), Lithuania (LT02) and Croatia (HR02) exhibited the poorest results across all indicators, including low investments, GDP, employment, and high poverty rates. Several studies have highlighted the existence of regional disparities between NUTS2 regions of Visegrad countries, focusing on various socio-economic indicators [10], [9]. These studies are in line with our findings. In the future, the study could broaden its scope to include the regions of the initial EU member countries, providing a more thorough understanding of the variations in socio-economic development within the European Union. The study's primary limitation lies in its restricted temporal analysis, encompassing only the years 2021-2022. This narrow timeframe may not adequately reflect the longitudinal socio-economic dynamics within NUTS-2 regions of countries that joined EU since 2004. Furthermore, the socio-economic indicators employed in this analysis are likely influenced by the extraordinary circumstances of the COVID-19 pandemic and the geopolitical tensions arising from the Russian-Ukrainian conflict, potentially biasing the findings. Future research should endeavor to broaden the temporal scope to more accurately capture the evolution of regional development. Additionally, incorporating regions from economically more advanced EU member states, such as Austria, could enrich the comparative dimension of the study, offering deeper insights into the diverse trajectories of regional development within the European Union.

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