DOI: 10.32559/et.2024.1.2

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Are the Member States of the European Union Converging or Diverging Demographically?

In our study, we have compared the demographic processes in the Member States that joined the European Union before and after 2004 with the variables total fertility rate, life expectancy, net migration and old-age dependency ratio. The demographic prospects for the new Member States are bleak, with high emigration and low total fertility rates, which may make ageing problems more pronounced among the Member States joining after 2004 than among those that joined earlier. Our cluster analysis has shown that the newly acceding countries, both in 2004 and today, show some degree of separation from the centre countries in terms of the demographic variables examined, but the stability of the clusters is relatively low depending on the methodologies used.

Keywords: European Union, cluster analysis, demographic processes

Introduction

Hungary's relative economic development in the European Union is one of the most important issues in Hungarian economic analysis and public policy debates. Our relative economic development also has a significant impact on our long-term share of EU funding and on the potential adoption of the euro. Of these, looking at the deviation from the GDP per capita in the European Union is one of the simplest ways to reconstruct the catching-up of the Central and Eastern European countries since their accession to the European Union, identifying which Member States have moved closer or further away from the centre countries in terms of economic development.

However, in addition to the analysis of economic indicators, it is also very important to analyse the demographic situation of our region in the context of the European Union. In particular, while the Central and Eastern European (CEE) countries have been converging with the core countries in terms of GDP per capita over the past decades,[2] the demographic situation shows rather negative trends. Since joining the European Union, millions of people from the CEE region have moved to the EU core countries, significantly

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2 Medgyesi–Tóth 2020; Alcidi 2019.

reducing the region's labour force,[3] and the region's childbearing rate has remained below that of Western European countries for many years,[4] so it is projected that in the coming years, the 10 countries with fastest declining populations in the world will all be Eastern European, with seven of these countries joining the EU in 2004 and later.[5] These trends paint one of the bleakest pictures of the region's demographic situation in the world, as confirmed by the UN (2024) estimate: The countries of Southern, Eastern and Central Europe may be depopulated the fastest in the coming years. By 2100, the populations of Northern Macedonia, Ukraine, Lithuania, Latvia and Moldova could be less than half of today's levels.[6] Within our more immediate region, the UN projects a population decline of around 50% in Poland and 38% in Slovakia, while in the Czech Republic and Hungary, roughly a quarter of the population could disappear by the end of the century. The deteriorating demographic picture could also have a significant impact on the region's economic catch-up in the long term: according to the analysis of Batog et al. (2019), the GDP per capita in the Central, Eastern and South-Eastern European Member States could rise from the current 52% of the Western European average to 60% by 2050, but without the adjustment by demographic effects, the development could reach even 74%. Smaller aggregate population and employment, lower productivity and rising fiscal expenditure due to ageing could lead to a roughly one percentage point lower GDP growth per year in the region's Member States.[7]

The aim of this paper is to analyse the demographic situation in the European Union: in addition to presenting trends, we use cluster analysis to examine how the differences in key demographic indicators between Western and Eastern Europe have changed since the EU accession. Thus, we use data from 2004 and 2022 to analyse the composition of clusters in EU countries. In the second chapter of the paper, we briefly describe our variables and their main trends in the EU and in the western and eastern regions of the Community, in the meantime also presenting the literature on the subject. In the third chapter we describe the methodology of cluster analysis and the framework of our analysis. In the fourth chapter, we outline our main findings and conclude our analysis with a summary.

Demographic trends among older and newly acceding Member States

Population restructuring and the increasing ratio of the ageing population in society is a fundamental phenomenon in developed countries, which are already posing serious challenges to national economies, even calling into question the long-term sustainability of pension systems.[8] The extent to which society is being restructured is illustrated by the fact that for every three working-age people in the European Union today, there is

[3] BATOG et al. 2019.
[4] Eurostat data.
[5] MOHDIN 2018.
[6] UN, World Population Prospects 2024, see: https://population.un.org/wpp/
[7] BATOG et al. 2019: 46–49.
[8] BAJKÓ et al. 2015; GÁL–RADÓ 2019; KREISZNÉ HUDÁK et al. 2015; VARGA 2014.

less than one pensioner, but by 2050, there will be less than two working-age people to support one pensioner.[9] The rate and speed of ageing varies among European countries, but by 2050, all European countries without exception will see a significant increase in the proportion of older people in the society. The typical demographic trends are illustrated by Hungary's age structure, which has become increasingly beehive-shaped in recent decades, and the proportion of young people may continue to decline while the proportion of older people may increase in the future.

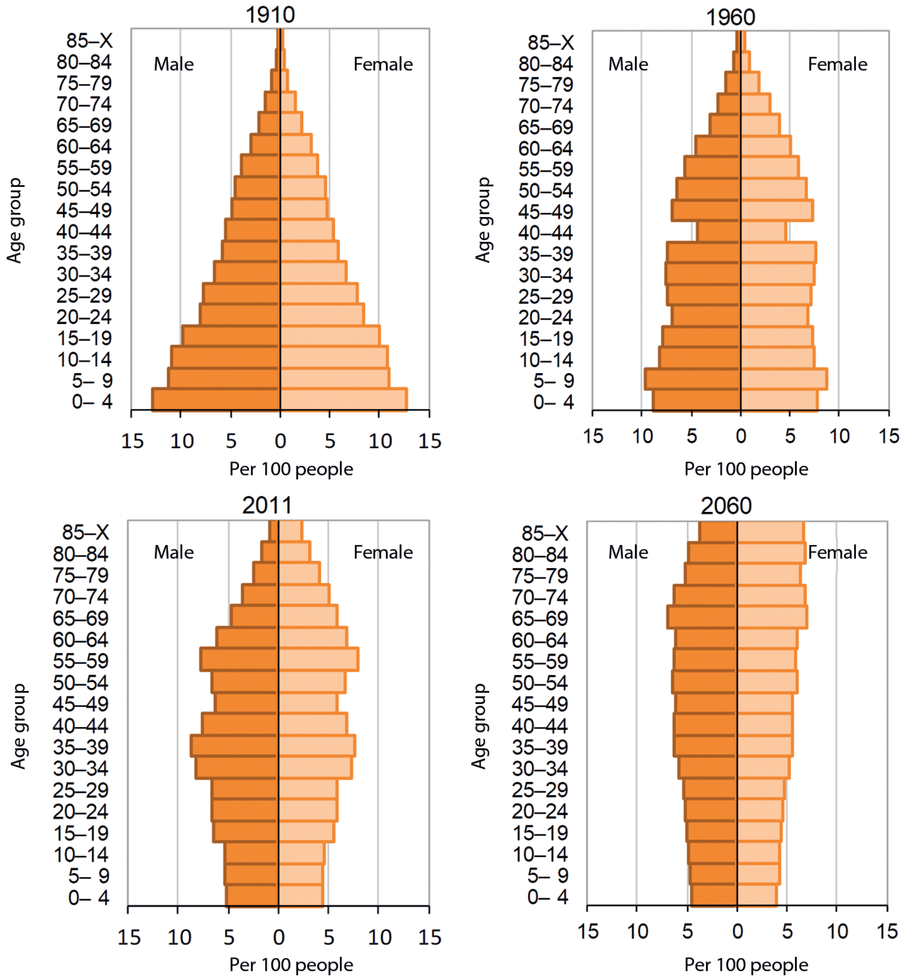

Figure 1: Changes in the age composition of the population of Hungary, 1910–2060

Source: KAPITÁNY *2015*

9 Eurostat data.

According to the theory of demographic transition, demographic characteristics of countries should converge in the long run, as the death and birth rates in each country stabilise at low levels at the end of the transition. This is partly supported by Wilson's paper, which shows that in the second half of the 20th century, despite the remaining economic differences, the differences in fertility, mortality and life expectancy between developed and developing countries decreased considerably, and by the end of the century we see fairly similar demographic figures for most developing and developed countries.[10] Major regions of the world follow similar trajectories at different stages of the demographic transition, with the overall global catching-up faster for fertility and slower for mortality.[11] In contrast, Moser and his co-authors showed a modest convergence in mortality, which was reversed in 1980,[12] while Dorius was only able to show statistically significant convergence in fertility rates after 1990.[13] Through cohesion policy, the European Union aims to reduce demographic disparities at regional level, thus contributing to the reduction of regional differences.[14]

The dynamics of population structure change are influenced by three main variables: the number of children born, the evolution of mortality rates and migration processes. In the following, we will present the evolution of these three variables in the light of data from Hungary, the EU27, the older and the newly acceded Member States, and show the trends in the old-age dependency ratio, which approximates the ageing ratio of society. We will also use these four variables in our cluster analysis later on, where we will approximate the child-bearing rate by the *total fertility rate,* which indicates the number of children a woman would give birth to during her lifetime if fertility figures for the given year remained constant. In addition, the *average life expectancy at birth* variable, which reflects the evolution of mortality rates, and the *old-age dependency ratio,* which measures the proportion of elderly people (over 65) in relation to the working-age population (aged 15–64), are included in our analysis. Finally, the *net migration rate per 1,000 persons* provides the framework for the subsequent grouping, which compares the difference between immigration and emigration in a given period with the average annual population. The data required for the analysis were obtained from the Eurostat database, and mainly 2004 and 2022 data were used. In the cluster analysis that follows, the focus is on the individual Member States, so in this chapter the main demographic indicators of the older European Union Member States (acceded before 2004 – EU14) and the newly joined Member States (acceded in 2004 or later – EU13) are presented as a simple average of the demographic indicators of each Member State. For the EU27, official population-weighted values are given, except where only country-weighted values are available.

The long-term reproductive level of a society is determined by the evolution of the number of children born within the society, the change in which per woman of child-bearing age is usually measured by the total fertility rate. The decline in the total fertility rate due to changing cohabitation trends and social changes[15] has been a global phenomenon

10 Wilson 2001.
11 Wilson 2011.
12 Moser et al. 2005.
13 Dorius 2008.
14 Kashnitsky et al. 2017.
15 Buck–Scott 1994; Cherlin 1992; Rosenfeld–Birkelund 1995; Furstenberg 1995.

in recent decades,[16] and by now, in all Member States of the European Union, the total fertility rate is well below replacement level, even in France, with the highest total fertility rate, parents have an average of only 1.79 children.[17] The gap in the total fertility rate of the Member States that joined the EU after 2004 has been completely closed in recent years; while the weighted average total fertility rate per country for the EU14 countries fell from 1.6 to 1.43 between 2004 and 2022, the indicator rose from 1.33 to 1.47 in the countries joining after 2004 (EU13) (Figure 2). Hungary's relative position has improved significantly over the past eighteen years: while in 2004 our total fertility rate was 22nd in the EU27, the 2022 data now place us 6th. However, the extent of the improvement is misleading, as the total fertility rate in Hungary, adjusted by time and parity, has rather tended to decline in the 2000s,[18] and the number of children per woman of childbearing age, up to a certain age, has not increased either.[19] In all countries, the number of children born are less, by a greater or lesser extent than the numbers of the previous generations, which has led to an increase in the median age. No Member State is estimated to reach reproductive levels approaching replacement level in the future, so the median age in Western Europe could rise from 39.5 years in 2005 to 43.2 years in 2023, and even up to 45.8 years by 2050.[20]

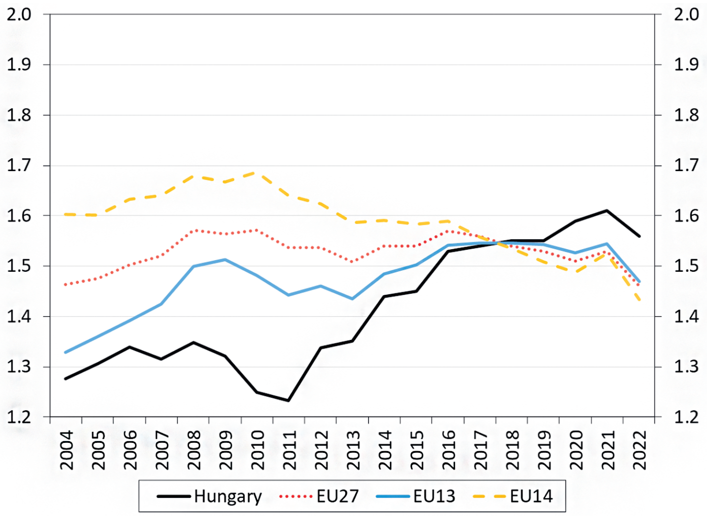

Figure 2: Trends in total fertility rates in Hungary and in the EU27, EU13 and EU14 countries, weighted by country, 2004–2022
Source: compiled by the author based on Eurostat data

16 DRABANCZ 2020.
17 See: https://ec.europa.eu/eurostat/databrowser/view/demo_find__custom_13911606/default/table?lang=en
18 BERDE–NÉMETH 2015.
19 KSH 2016.
20 See: https://ec.europa.eu/eurostat/web/population-demography/population-projections/database

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Moreover, the low total fertility rates observed in the Member States today are barely above the 1.3 value defined by Kohler and his colleagues as "lowest low fertility", which, if maintained over the long term, other variables remaining constant, halves the population in 45 years.[21] However, in Europe, the increase in life expectancy and the positive migration process are partly offsetting the low fertility rate: according to Eurostat's 2023 projections, the population of the European Union could be only 0.8% below its current level in 2050.

A key factor in maintaining the stagnant population is the increase in life expectancy in recent years that is expected to continue in the future (Figure 3). It is important to point out that life expectancy in the new Member States has increased only slightly faster than in the older Member States over the past fifteen years, so people in the newly acceded Member States can still expect to live roughly 4 years less than citizens of the EU14 states. Unfortunately, there is no significant catching-up in Hungary either, since while in 2004 the citizens of the EU27 Member States lived 5.3 years longer, by 2022, this gap will have narrowed only moderately to 4.6 years.[22]

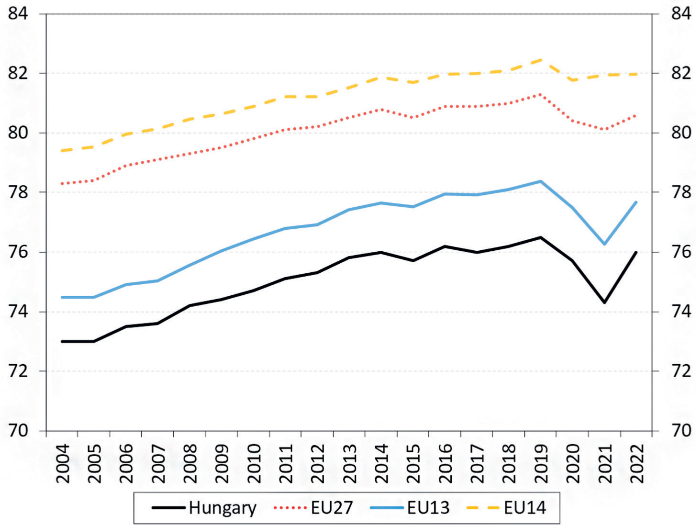

Figure 3: Trends in life expectancy in Hungary and in the EU27, EU13 and EU14, weighted by country, 2004–2022.

Source: compiled by the author based on Eurostat data

21 KOHLER et al. 2002.

22 See: https://ec.europa.eu/eurostat/databrowser/view/demo_mlexpec__custom_13911739/default/table?lang=en

In terms of net migration, the backlog of newly joined Member States is decreasing over time, but is still significant.[23] Until 2018, more people emigrated from the newly joined countries as a whole than the number of arrivals. This trend reversed in 2018, according to Eurostat data, but the positive migration balance is still significantly below that of Western Europe, and is probably largely due to the return of some of the citizens who have earlier migrated to Western Europe, rather than a significant turn in migration. Indeed, the accession to the European Union in the 2000s significantly accelerated migration from Central and Eastern Europe towards Western Europe. Atoyan and his fellow authors estimate the rate of emigration from the CEE countries to be at 0.5–1% per year relative to the 1990s population, which rate, however, accelerated significantly after the EU accession, and according to their calculation, the overall emigration from the countries of the region could have been as high as 8% of the 1990s population.[24] Comparing net migration data for 2004 and 2022, among the new Member States, the net migration rates for Bulgaria and Croatia have decreased significantly, while emigration has increased substantially, possibly due to the fact that in 2004 the European Union's markets were not yet open to nationals of these Member States. In other countries of the region, on the other hand, emigration was significant in the 2010s, but since the end of the decade there has been a slight positive migration balance. In addition to exacerbating demographic challenges, high emigration from the region to Western Europe also has a negative impact on the economic potential of the region, as emigrants tend to be younger and better educated than the population of their country of origin.[25] With the exception of 2022, Hungary has had a small positive migration balance throughout the period, but it has remained significantly below the average of the earlier acceded countries.

There has been a substantial catching-up by the newly joining countries towards the centre countries in respect of old-age dependency ratio. While in 2004, the ratio of the elderly compared to the working-age population was roughly 2.7 percentage points lower in the newly joining countries, by 2022 this has dropped roughly to its third, that is, to 0.9 percentage points. Looking ahead, according to Eurostat forecasts, the new Member States will be exposed to ageing at a slightly higher rate, with an old-age dependency ratio that will possibly be 1.4 percentage points higher in 2050 than that of the older Member States due to the trends observed in the three variables mentioned above. It is important to note that according to Eurostat's forecast, Hungary could perform better than the surrounding countries in this indicator, as the country's old-age dependency ratio in 2050 could be 3.7 percentage points lower than the average of the EU13 countries.

23 Malta and Cyprus show a significant shift over the period and are therefore excluded from the calculation of the aggregate value for the newly acceded Member States. Due to the high volatility of migration figures, the net migration rate for a given year is defined as the ratio of the average net migration over 3 years divided by the average population.

24 Atoyan et al. 2016.

25 Medgyesi–Tóth 2020: 25.

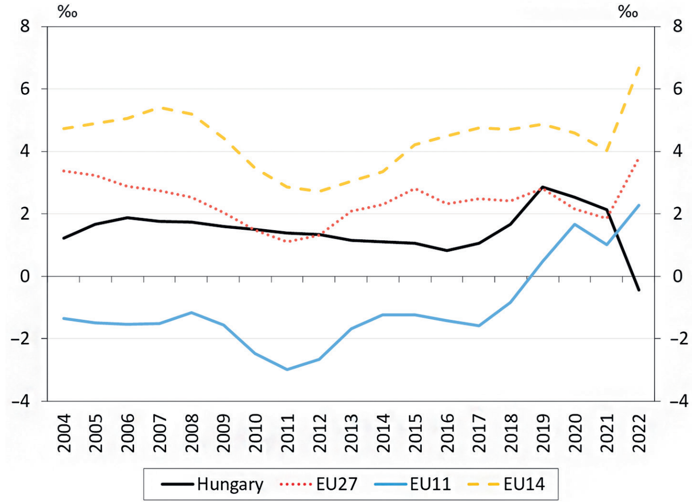

Figure 4: Net migration trends per mil in Hungary and in the EU27, EU11 (EU13 excluding Cyprus and Malta) and EU14, weighted by country, 2004–2022
Source: compiled by the author based on Eurostat data

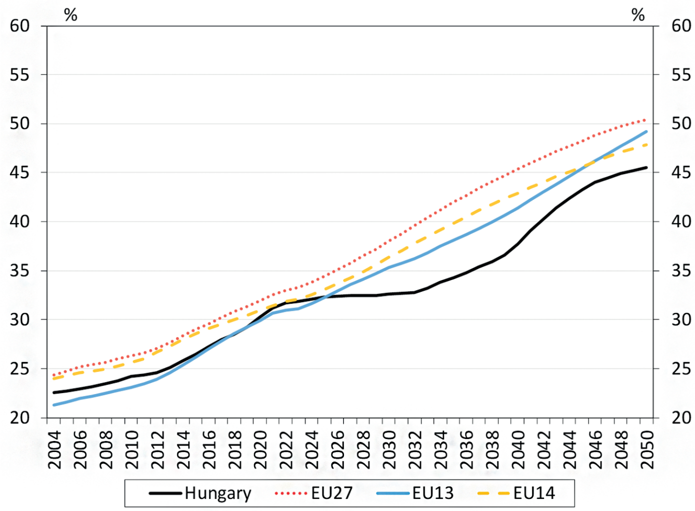

Figure 5: Trends in old-age dependency ratio in Hungary and among the EU27, EU13 and EU14 countries, weighted by country, 2004–2050
Source: compiled by the author based on Eurostat data

Methodology

In the following, we present the cluster analysis used in the study, a procedure that groups the observed population into the most similar clusters along the variables under examination. The procedure was run with 2004 and 2022 data. Our analysis may shed light on which groups of countries are most similar in terms of the demographic variables examined, and how the country blocks have changed between the two points in time.

Cluster analysis can be used with several algorithms, distance metrics and data manipulation tools.[26] In this study, a hierarchical cluster analysis was performed on data standardised by Ward's method, in which the program is optimised based on squares of Euclidean distances of points. The requirement of the cluster analysis is that the maximum number of elements should not exceed the root of the observations ($\sqrt{27} \approx 5.196$), besides, the $k \leq \sqrt{\frac{n}{2}}$ ($\sqrt{\frac{27}{2}} \approx 3.674$) rule of thumb is also used to select the desired number of elements.[27] In our study, we therefore examine the results with three and five clusters.

The cluster analysis was carried out for the European Union Member States. For the total fertility rate, life expectancy and old-age dependency ratio, 2004 and 2022 data were used, while the 2004 value of the net migration indicator is the average of the years 2002–2003 and 2004, and the 2022 data is the average of the years 2020–2021 and 2022, due to the relatively high inter-annual standard deviation of this indicator.

With one exception, the correlation between each of the four variables remained below 0.6 and it also shows relatively high variability in respect of time, which may make the separating property of cluster analysis more valid (Table 1). The direction of the correlation is broadly in line with intuition, since, for example, the primary destinations for higher net migration are likely to be the most developed Member States, where life expectancy is therefore also high, and this correlation may explain the positive correlation of 0.5 and 0.7 between the two variables.

Table 1: Correlations between each of the four demographic variables based on 2022 (2004) data

	Total fertility rate	**Life expectancy**	**Net migration**	**Old-age dependency ratio**
Total fertility rate	1 (1)			
Life expectancy	−0.31 (0.5)	1 (1)		
Net migration	−0.37 (0.29)	0.46 (0.74)	1 (1)	
Old-age dependency ratio	−0.1 (−0.01)	−0.1 (0.2)	−0.46 (−0.06)	1 (1)

Source: compiled by the author based on Eurostat data

26 Kovács 2014.
27 Kovács 2014.

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Results

In the clustering exercise, we first looked at the formation of three clusters for the 2004 data, then the formation of five clusters, and then did the same for the 2022 data. In the first run, based on 2004 data, 10, 11 and six countries were grouped together, respectively (Table 2). The first group includes only EU Member States that were members before 2004, while the second group includes only newly joined Member States. This somewhat confirms our initial assumption that the demographic characteristics of old and new Member States may greatly differ. However, the hypothesis is weakened by the fact that when using different distance metrics (e.g. nearest/farthest neighbour, centroid/median method), cluster groups show a high degree of variability. The third group consists of Austria, Cyprus, Ireland, Luxembourg, Malta and Spain, the common characteristics of which were that in 2004 they had relatively low old-age dependency ratio and a high positive net migration balance. For while in all the countries together, the values of the two variables were 22.71 and 2.4, in these countries the average old-age dependency ratio was only 20.14 and the average net migration value per 1,000 inhabitants was 9.08 (see Table A.1 in the Annex).

Table 2: Hierarchical cluster analysis using Ward's method with four demographic variables, 27 observations, three clusters, 2004

cluster 1	Belgium, Denmark, Finland, France, Greece, Netherlands, Germany, Italy, Portugal, Sweden
cluster 2	Bulgaria, Czech Republic, Estonia, Croatia, Poland, Latvia, Lithuania, Hungary, Romania, Slovakia, Slovenia
cluster 3	Austria, Cyprus, Ireland, Luxembourg, Malta, Spain

Source: compiled by the author based on Eurostat data

If five clusters were created, the first and second clusters in a 3-cluster case were split into further clusters (see Table 3 for the formation of cluster 1 and cluster 4, and cluster 2 and cluster 3). The first group of core countries consisted mainly of countries with higher fertility rates, and slightly lower life expectancy, old-age dependency ratios and net migration, while the fourth group included the other older EU Member States (see Annex Table A.2). Among the newly joined countries, group 3 has a relatively better demographic situation, except for the total fertility rate, while group 2 has a worse demographic situation, since new Member States with higher life expectancy, net migration and lower old-age dependency ratios were included in group 3. The six countries in the fifth cluster have not changed after the new run.

Table 3: Hierarchical cluster analysis using Ward's method with four demographic variables, 27 observations, 5 clusters, 2004

cluster 1	Belgium, Denmark, Finland, France, Netherlands, Sweden
cluster 2	Bulgaria, Estonia, Croatia, Latvia, Lithuania, Hungary, Romania
cluster 3	Czech Republic, Poland, Slovakia, Slovenia
cluster 4	Greece, Germany, Italy, Portugal
cluster 5	Austria, Cyprus, Ireland, Luxembourg, Malta, Spain

Source: compiled by the author based on Eurostat 2024

Performing the three-cluster group analysis regarding 2022 data, each group was formed by 12, six and nine countries, respectively. Most of the countries that were EU members before 2004 became part of the first cluster, with the addition of Slovenia. The second cluster was formed by the newly admitted Member States that are (with the exception of the total fertility rate) demographically in a worse situation, while the third cluster that included the six countries that were already together in 2004 was joined by Lithuania, Estonia and Poland (Table 4). The group averages of cluster 1, which is largely composed of older Member States, and cluster 2, which is composed of new Member States, show the largest variance in life expectancy (cluster 1: 81.48; cluster 2: 75.75) and net migration (cluster 1: 5.33; cluster 2: –3.54). In contrast, the differences among the cluster averages of the total fertility rate and of the old-age dependency ratio are smaller (see Annex Table A.3), although it is important to note that cluster 2, which includes the newly joined Member States, has the highest total fertility rate of all cluster averages. Cluster 3 countries have in common a low total fertility rate, a low old-age dependency ratio and a very high net positive migration balance, however in the case of older Member States (Estonia, Lithuania, Poland) the latter is probably a unique phenomenon – a wave of refugees due to the Russian–Ukrainian war.

Table 4: Hierarchical cluster analysis using Ward's method with four demographic variables, 27 observations, 3 clusters, 2022

cluster 1	Belgium, Czech Republic, Denmark, Finland, France, Greece, Netherlands, Germany, Italy, Portugal, Sweden, Slovenia
cluster 2	Bulgaria, Croatia, Latvia, Hungary, Romania, Slovakia
cluster 3	Austria, Cyprus, Estonia, Ireland, Lithuania, Poland, Luxembourg, Malta, Spain

Source: compiled by the author based on Eurostat data

If 5 clusters were created, the first and third clusters in a three-cluster case were split into further clusters (see Table 5 for the formation of cluster 1 and cluster 5, and cluster 3 and cluster 4). When the first cluster was broken up, the new first cluster included countries with typically higher total fertility rates and net migration, while the fourth cluster included countries with presumably higher life expectancy and old-age dependency ratios. The split in cluster 3 is likely to have been determined by life expectancy at birth, separating the more developed older (except Cyprus and Malta) and the less developed newly joined Member States.

Table 5: Hierarchical cluster analysis using Ward's method with four demographic variables, 27 observations, five clusters, 2022

cluster 1	Belgium, Czech Republic, Denmark, France, Netherlands, Germany, Portugal, Sweden, Slovenia
cluster 2	Bulgaria, Croatia, Latvia, Hungary, Romania, Slovakia
cluster 3	Estonia, Lithuania, Poland
cluster 4	Austria, Cyprus, Ireland, Luxembourg, Malta, Spain
cluster 5	Finland, Greece, Italy

Source: compiled by the author based on Eurostat data

Summary

In our paper, we analysed the demographic homogeneity of the European Union countries using cluster analysis; we examined whether or not the demographic situation of the countries that joined the EU before 2004 and after 2004 differs substantially. The factors that contribute most to population change: changes in the total fertility rate, changes in life expectancy and net migration were included in the analysis, supplemented with the old-age dependency ratio.

The age pyramid in the European Union countries becomes increasingly urn-shaped: low fertility rates are reducing the ratio of young people within the society in all countries, while due to increasing life expectancy, the number of elderly people grows. Overall, net migration contributes positively to population growth in the European Union, but within the EU, migration from less developed to developed countries has led to a significant decline in the ratio of young people in the societies of some of the most recently joined EU Member States. In terms of total fertility rates, the new Member States have caught up with the older Member States over the last 15 years. There has been only minimal catching-up in life expectancy in the region, since children born in older Member States are still expected to live roughly 4 years longer than those born in Member States that joined the EU since 2004. The old-age dependency ratios in the newly joined countries have converged significantly over the past fifteen years to those of the older Member States, but the proportion of the elderly per working-age population is still slightly higher among those who joined before 2004. There were significant differences in net migration between the older and the newer Member States both in 2004 and in 2022. This difference is even more pronounced for the most recent acceding countries, with Bulgaria and Croatia showing a negative trend in net migration when comparing 2004 and 2022 data.

The results of the cluster analysis show a certain degree of demographic homogeneity between older and newly acceding Member States in respect of the above variables. During the individual runs, the Member States that joined the EU in the 20th century and those that joined in the 21st century mainly clustered separately. The similar demographic structure is more observable in the 2004 data and less in the 2022 data, and the stability of the cluster groups formed is rather weak, as the clusters formed showed significant variations with different distance metrics.

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Annexes

Table A.1: Hierarchical cluster analysis using Ward's method with four demographic variables, 27 observations, three clusters, 2004, group averages

	Fertility rate	**Life expectancy at birth**	**Old-age dependency ratio, %**	**Net migration rate**
cluster 1	1.61	79.41	25.16	2.51
cluster 2	1.31	73.62	21.87	–1.34
cluster 3	1.54	79.33	20.14	9.08
Overall average	1.47	77.03	22.71	2.40

Source: compiled by the author based on Eurostat data

Table A.2: Hierarchical cluster analysis using Ward's method with four demographic variables, 27 observations, five clusters, 2004, group averages

	Fertility rate	**Life expectancy at birth**	**Old-age dependency ratio, %**	**Net migration rate**
cluster 1	1.78	79.35	23.95	2.13
cluster 2	1.34	72.51	23.52	–2.36
cluster 3	1.24	75.55	18.99	0.44
cluster 4	1.35	79.50	26.98	3.09
cluster 5	1.54	79.33	20.14	9.08
Overall average	1.47	77.03	22.71	2.40

Source: compiled by the author based on Eurostat data

Table A.3: Hierarchical cluster analysis using Ward's method with four demographic variables, 27 observations, three clusters, 2022, group averages

	Fertility rate	**Life expectancy at birth**	**Old-age dependency ratio, %**	**Net migration rate**
cluster 1	1.49	81.48	34.04	5.33
cluster 2	1.58	75.75	31.80	–3.54
cluster 3	1.32	80.59	27.73	11.29
Overall average	1.45	79.91	31.44	5.35

Source: compiled by the author based on Eurostat data

Table A.4: Hierarchical cluster analysis using Ward's method with four demographic variables, 27 observations, five clusters, 2022, group averages

	Fertility rate	**Life expectancy at birth**	**Old-age dependency ratio, %**	**Net migration rate**
cluster 1	1.55	81.44	33.11	6.89
cluster 2	1.58	75.75	31.80	–3.54
cluster 3	1.32	77.03	30.77	9.31
cluster 4	1.31	82.37	26.22	12.28
cluster 5	1.29	81.60	36.83	0.67
Overall average	1.45	79.91	31.44	5.35

Source: compiled by the author based on Eurostat data