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Analysis and Prognosis of Population Ageing in V4 Countries in the 2050 Horizon

Análise e prognóstico do envelhecimento da população nos países V4 para 2050

Análisis y pronóstico del envejecimiento de la población en los países V4 para 2050

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Abstract: The issue of the paper is ageing in individual NUTS 2 regions in the Visegrad Group and the ageing prognoses. The Visegrad Group (V4) is an alliance of four Central European countries: Czech Republic, Hungary, Poland, and Slovakia. The V4 was established to further the European integration of its participants and to encourage their military, economic and energy cooperation. The current and future population ageing process is presented over time using various demographic indicators (proportional values of individual age groups, index indicators, and multivariate statistical methods). It also points out the causes of ageing and its consequences. Population ageing is the 21st century's dominant demographic phenomenon. The goal of the paper is to point out the ageing of the population in the countries of Visegrad Group (V4), its impact on the demographic situation in these countries, but also on the trends and forecasts of further development by using appropriate theoretical and methodological approaches. On the basis of selected ageing indicators, we compare changes in population ageing from 2001 to the present, as well as future development trends. Declining fertility, increasing longevity, and the progression of large-sized cohorts to the older ages are causing elder shares to rise throughout the world.

Keywords: Ageing Indicators. Ageing Typology. Population Ageing. Visegrad Group.

Resumo: O artigo aborda o envelhecimento e os prognósticos de envelhecimento nos países V4, tendo por base as NUTS 2. O Grupo de Visegrado (V4) é uma aliança de quatro países da Europa Central: a República Checa, a Hungria, a Polónia e a Eslováquia. O V4 foi criado para fomentar a integração europeia dos seus participantes e para promover a sua cooperação militar, económica e energética. O processo de envelhecimento atual, e futuro, da população, é apresentado cronologicamente, utilizando vários indicadores demográficos (valores proporcionais de grupos etários, indicadores de índice e métodos estatísticos multivariados). O artigo também aponta as causas do envelhecimento populacional e as suas consequências. O envelhecimento da população é o fenómeno demográfico dominante do século XXI. O objetivo do artigo é apontar o envelhecimento da população nos países do Grupo de Visegrado, o seu impacto sobre a situação demográfica nesses países, mas também assinalar as tendências e previsões de desenvolvimento futuro, usando abordagens teóricas e metodológicas apropriadas. Com base em indicadores de envelhecimento selecionados, comparamos as mudanças no envelhecimento da população de 2001 até o presente, não esquecendo as tendências para o futuro. O declínio da fertilidade, o aumento da longevidade e a progressão de grupos muito numerosos de população de idade avançada, incrementam a proporção de idosos em todo o mundo.

Palavras-chave: Indicadores de envelhecimento. Tipologia do envelhecimento. Envelhecimento da população. Grupo de Visegrado.

Resumen : El tema del documento es el envejecimiento en las regiones NUTS 2 individuales del Grupo de Visegrado y los pronósticos de envejecimiento. El Grupo de Visegrado (V4) es una alianza de cuatro países de Europa Central: República Checa, Hungría, Polonia y Eslovaquia. El V4 se creó para impulsar la integración europea de sus participantes y fomentar su cooperación militar, económica y energética. El proceso actual y futuro de envejecimiento de la población se presenta a lo largo del tiempo utilizando diversos indicadores demográficos (valores proporcionales de los distintos grupos de edad, indicadores de índices y métodos estadísticos multivariantes). También se señalan las causas del envejecimiento y sus consecuencias. El envejecimiento de la población es el fenómeno demográfico dominante del siglo XXI. El objetivo de este

documento es señalar el envejecimiento de la población en los países del Grupo de Visegrado (V4), su impacto en la situación demográfica de estos países, pero también en las tendencias y previsiones de desarrollo futuro utilizando enfoques teóricos y metodológicos apropiados. Sobre la base de indicadores de envejecimiento seleccionados, comparamos los cambios en el envejecimiento de la población desde 2001 hasta la actualidad, así como las tendencias de desarrollo futuro. El descenso de la fecundidad, el aumento de la longevidad y la progresión de cohortes de gran tamaño hacia edades más avanzadas están provocando un aumento de la proporción de personas mayores en todo el mundo.

Palabras clave: Indicadores de envejecimiento. Tipología del envejecimiento. Envejecimiento de la población. Grupo de Visegrado.

Introduction

The process of population ageing is one of the key population processes that affect European countries with impacts on overall development of their society. The latest report of the World Population Prospects (2022) on the ageing of the world's population clearly points to the dynamism of this phenomenon in the 21st century, while an increase in the number and share of senior citizens can be identified in almost all countries of the world. In this regard, Europe with the world's oldest population has been in a special position for a long time. Currently, people aged 60 and over make up almost a quarter of the entire European population, with an expected increase of almost 35% by 2050. Thus, population ageing in the European area represents one of the most significant phenomena of the 21st century, affecting essentially all aspects of the local society's development. The results of the available population forecasts point to the dynamism and deepening of this process (Ondačková et al. 2018). Increasing proportion of elderly people in the population and the increase in the median age of the population are partly due to the low birth rate. The increasing average life expectancy together with the decreasing number of live births are two simultaneously applied demographic principles in most populations, the result of which is the process of population ageing. The complexity of the age structure of the population is manifested through multicausal relationships with many population and social phenomena. The current age structure reflects the long-term development of many population phenomena and processes.

The goal of the paper is to point out the ageing of the population in the countries of Visegrad Group (Czech Republic, Hungary, Poland and Slovakia), its impact on the demographic situation in these countries, but also on the trends and forecasts of further development by using appropriate theoretical and methodological approaches. On the basis of selected ageing indicators, we compare changes in population ageing from 2001 to the present, as well as future development trends. The ageing indicators can be synthesized and the ageing typology of NUTS 2 regions of the V4 countries can be done by means of a multivariate statistical method of the cluster analysis. For the synthesis, following

indicators were used: share of 0-14 year olds, share of 65+ year olds, ageing index, median age, life expectancy, old-age dependency ratio, Billeter's index and 80+ category. Graphical representation of the clustering process is the so-called dendrogram, in which the NUTS 2 regions are grouped into clusters. The population ageing will be identified to the NUTS 2 level, distinguishing regions with unfavourable high population ageing and those with low population ageing.

Theoretical baselines

The process of population ageing has become the issue in the centre of attention in European countries. However, it is not only a demographic topic, but regarding the deepening of ageing; other dimensions of this process are also coming to the fore. Therefore, as added by Lutz, Sanderson, and Scherbov (2008), population ageing becomes not only an important demographic, but also a social, economic, health, or even cultural topic due to its scope and impacts.

The population ageing causes intensive changes in demographic behaviour that have appeared in Europe at the end of the 20th and the beginning of the 21st century, also calling these changes revolutionary. Population development in the countries of V4 group was influenced by the common history of the Eastern Socialist Bloc. Isolation from the countries of Western and Northern Europe caused differences in demographic behaviour. The main reason for the difference was the onset of the second demographic transition, which manifested itself in changes in reproductive and family behaviour in the countries of Western and Northern Europe already in the 1960s (Reher 2011; Sanchez-Barricarte and Fernandez-Carro 2007). After loosening the political regimes at the beginning of the 1990s, the incipient second demographic transition can be observed in the countries of Central Europe and thus in the V4 countries as well. This change in demographic behaviour was characterised by a decrease in the fertility level, increase in the median age of women at giving birth, increase in the median age at birth, and many other factors that resulted in intensification of the population ageing process. The decline in fertility levels was evident in a decreased number of children born in the third order. In post-communist countries, including the V4 countries, the decrease in fertility

was also a result of rapidly developing urbanization. Former communist regimes in these countries realized policy aimed in increasing the birth rate (direct child benefit, maternity benefit, preferential benefits for families with children in the allocation of state-owned apartments, establishment of nurseries for children up to 3 years of age, etc.), which has been called the Eastern European Reproductive Pattern (Sobotka 2011). After the fall of communism, the birth rate has declined due to the delayed founding of families, which was related to a higher median age at marriage and thus also to a higher age of women at childbirth. In the 1990s, a transformation took place in these countries that created a market economy and a multi-party political system. Two waves of enlargement of the European Union in 2004 and 2007 completed the process of political and economic transformation in Central and Eastern Europe with ten post-communist countries becoming members. After 1989, not only the political map of Europe was redrawn, but also the demographic one. According to Goldstein, Sobotka, and Jasilioniene (2009) the birth rate increased only after 2000, even though there was a growing share of women with one child. One-child families have become most common in the V4 countries, Eastern Europe and the Baltic states.

The population ageing affects all aspects of society (health aspect, social aspect, education aspect, socio-cultural activities, family life, labour market, etc.). Progress in medicine, health care, increasing awareness of responsibility for one's own health is also related to the life extension and change in the number of years that a person of a certain age has (can) still live (Bongaarts 2008). According to the UN World Population Prospects (2022) the average life expectancy of the ageing European population has been increasing linearly for almost 150 years already. It is estimated that the number of old people in Europe aged 65 and over will increase by 45% by 2050. The V4 countries are no exception in this regard. Several population forecasts constructed by experts in the given issue (e.g. Bleha et al. 2018; Šídlo, Šprocha, and Ďurček 2020), or institutions (e.g. Czech Statistical Office 2022; Eurostat 2019; Eurostat 2020; Hungarian Central Statistical Office 2022; Statistical Office of the Slovak Republic 2022; Statistics Poland 2022) expect a relatively significant acceleration of population ageing, as a result of which the V4 countries should gradually be included

in the “above-average old” populations not only on a European, but also on a global scale. Even though the process of population ageing has been going on for a long time in the V4 countries, especially as a consequence of its present-day dynamics, the population ageing and its social impacts are becoming one of the central topics both in the demographic and sociological research and in the increasing number of analyzes concerning geography, economics, healthcare, law and other more or less related scientific disciplines.

Methodological approaches

In this paper, the issue of population ageing was explored using multivariate statistical methods of cluster analysis. The objective of cluster analysis is to find similar groups of subjects, where “similarity” between each pair of subjects means some global measure over the whole set of characteristics (Kaščáková et. al. 2010). The task of this mathematical-statistical method was to merge the units of the set into groups (clusters) according to the monitored indicators with their internal homogeneity and the differences between the clusters being simultaneously as large as possible. The number of clusters at the beginning of the clustering algorithm is equal to the number of NUTS 2 and at the end all NUTS 2 regions form one cluster. At the same time, each cluster at a lower level is part of a cluster at a higher level. The aim of the cluster analysis is to achieve, through appropriate cluster distribution, that objects within each cluster are as similar as possible to each other and, conversely, objects from different clusters similar as little as possible. To assess the extent to which the cluster analysis objective is achieved, the intra-cluster variability matrix, the inter-cluster variability matrix and the total variability matrix are used (1):

$$E = \sum_{h=1}^{k} \sum_{i=1}^{nh} (\vec{x}_{hi} - \vec{x}_h)^2, \quad (1)$$

cluster variability matrix (2):

$$B = \sum_{h=1}^{k} n_h (\vec{x}_h - \vec{x})^2, \quad (2)$$

and total variability matrix (3):

$$T = E + B = \sum_{h=1}^{k}\sum_{i=1}^{nh}(\vec{x}_{hi} - \vec{x})^2. \quad (3)$$

In these formulars, the value vector for the i-th object in the h-th cluster $\vec{x}_{hi}\vec{x}_{hi}$, the average vector for the h-th cluster $\vec{x}_h\,\vec{x}_h$ and the average vector for the whole $\vec{x}_h\vec{x}_h$ data set are used. If we have p characzeristics available, then these are p-membered vectors, and E, B, T are symmetric matrices of the p-th order (4). The formation of relatively maximum distant clusters can be formally expressed by the minimum of the sum of squares of deviations of all values from the respective cluster average (Kaščáková et al. 2010).

$$stE = \sum_{h=1}^{k}\sum_{i=1}^{nh}\sum_{j=1}^{p}\left(x_{hij} - \vec{x}_{hj}\right)^2 \quad (4)$$

This method is called the Ward´s criterion and is frequently used. Ward's method says that the distance between two clusters, A and B, is how much the sum of squares will increase when we merge them (Shalizi 2011). A newly created cluster can form another cluster with either another object or a different cluster. To divide objects into clusters, the criterion of mutual similarity was chosen, using a distance mesure among objects in n-dimensional space as object similarity / dissimilarity measure. To calculate the similarity-expressing distance measure, the Euclidean distance was used:

$$d_{jk} = \sqrt{\frac{\sum_{i=1}^{p}\delta_{ijk}^2}{p}} \quad (5)$$

In the data analysis, characteristics with different scales (percentages, age, etc.) occur frequently. To eliminate the influence of these scales, all data are transformed into the same point scale through the standard deviation. As mentioned above, the cluster analysis is based on formation of clusters of objects where objects in a certain cluster are as similar to each other as possible and at the same time the least similar to objects in other clusters. To study the similarity of objects, measures of similarity / dissimilarity (distance) are used. The similarity measures for objects x_i and x_j is written as $S(x_i,$

x_j), simply S_{ij}, and $S_{ij} = S_{ji}$. Ideally, the similarity measure values ranges within the interval <0, 1>, with 0 expressing the maximum difference between objects and 1 the maximum identity. The object similarity can be measured by means of association, distance or correlation, where the association measure and the correlation measure are classified as object similarity measures and the distance measure expresses dissimilarity of objects. In our paper, the object similarity is expressed through the correlation measure. The basic correlation measure used in the cluster analysis is the Pearson correlation coefficient, which takes values <–1, 1> (6):

$$r_{xy} = 1 - \frac{6\sum_{i=1}^{n}(x_i - y_i)^2}{n.(n^2-1)} \quad (6)$$

The higher the value of the correlation coefficient, the higher the similarity of objects is. A negative value of the correlation coefficient points out to indirect dependency, a positive value indicates a direct dependency.

Based on Tab. 1, following interpretation of the Pearson correlation coefficient can be derived:

Tab. 1: Values of the Pearson correlation coefficient

r = 0	No dependency	0.5 ≤ r < 0.7 –0.7 ≤ r < 0.5	High dependency positive High dependency negative
0 < r < 0.3 –0.3 ≤ r < 0	Weak dep.* positive Weak dep.* negative	0.7 ≤ r < 1.0 –1.0 ≤ r < 0.7	Very high dependency positive Very high dependency negative
0.3 ≤ r < 0.5 –0.5 ≤ r < 0.3	Medium dep.* positive Medium dep.* negative	r = 1.0 r = –1.0	Strong dependency positive Strong dependency negative
Negative value – indirect dependency *dep. - dependency Positive value – direct dependency;			

Source: Cohen 1988

The research was carried out for the period of 2001–2020. We worked with the average value of each indicator that we obtained by means of a chronological average. In addition to this period, we have also prepared a prognosis for 2050. We worked with eight indicators of ageing. To find out the dependency among them, the Pearson coefficient was used. Cluster analysis, however, requires uncorrelated indicators as inputs. To satisfy this requirement, factor analysis was applied.

To assess the suitability of input indicators for factor analysis, the KMO measure (Kaiser-Meyer-Olkin measure = Kaiser's Measure of Sampling Adequacy) is used. It is an index that compares the size of correlation coefficients to the size of partial correlation coefficients (7):

$$KMO = \frac{\sum_{i \neq j}^{p} \sum_{i \neq j}^{p} r_{ij}^2}{\sum_{i \neq j}^{p} \sum_{i \neq j}^{p} r_{ij}^2 + \sum_{i \neq j}^{p} \sum_{i \neq j}^{p} a_{ij}^2} \quad (7)$$

where rij is paired correlation coefficient; aij is the partial correlation coefficient. KMO values are not tested, but the Kaiser (1974) table of recommendations is used as it is presented in Tab. 2:

Tab. 2: Recommendations for KMO values

KMO	recommendations for KMO values	KMO	recommendations for KMO values
≥ 0.9	marvelous	<0.6; 0.7)	mediocre
<0.8; 0.9)	meritorious	<0.5; 0.6)	terrible
<0.7; 0.8)	average	< 0.5	unacceptable

Source: Kaiser 1974

Recommended values of the KMO measure are above 0.5, while a higher value indicates more appropriate use of the relevant indicator (the maximum value is 1).

The research included following indicators:

1. ≤14 population ratio - number of inhabitants aged 14 and under to the total number of inhabitants multiplied by 100.

2. 65 and above population ratio - number of inhabitants aged 65 and over to the total number of inhabitants multiplied by 100.

3. Ageing index - number of inhabitants aged 65 and over per 100 inhabitants aged ≤14 years. The higher the ageing index (> 100), the older the population.

4. Median age - weighted arithmetic average of the number of years that members of a given population have lived up to a given moment.

5. Life expentancy - estimate of the average number of additional years that a person of a given age can expect to live. The most common measure of life expectancy is life expectancy at birth.

6. Old-age dependency ratio - expresses the burden on the productive part of the population aged 15–64 by seniors aged 65 and above. The higher the old-age dependency ratio, the higher the number of residents aged 65 and above per one „provider" aged 15–64.

7. Billeter´s index - ratio of the difference between the population aged ≤14 years and 65 and above and the population in the productive age 15–64 years. If the Billeter´s index reaches negative values, the population aged 65 and above is higher, thus indicating a higher level of ageing.

8. 80 and above population ratio - number of inhabitants aged 80 and over to the total number of inhabitants multiplied by 100.

Graphical representation of the clustering process is the so-called dendrogram (similarity tree, hierarchical tree or tree diagram), in which the NUTS 2 regions are grouped into clusters. The grouped objects displayed in the dendrogram can be arranged vertically (below each other) or horizontally (next to each other). The hierarchical clustering algorithm starts with as many clusters as there are objects (each object is a separate cluster). It first connects the two closest objects, then the next pair of objects, and so on. According to several authors (Kráľ et al.. 2009; Kaščáková et al.. 2020, a.o.), the ideal number of clusters is chosen visually so that the clustering distance is not too large. The source of statistical databases for the evaluated indicators was EUROSTAT, which coordinates statistical activities at the European Union level. The data used in the research were interpreted by IBM SPSS Statistics, STATISTICA CZ and ArcMap 10.2.2 programs.

Basic characteristics of V4

The Visegrad Group or the Visegrad Four is an alliance of four Central European states established in 1993: Czech Republic, Hungary, Poland and Slovakia. Their goal was to approach the West-European standard of living as quickly as possible. All countries managed to fulfil the goal. While thirty years ago the level of living standard in these

countries was only one fifth to one third of that in the European Union, today it is 70-90% of the EU average. Regarding this, all V4 economies have successfully approached the EU average in living standards. From economic point of view, the countries of the V4 group can be said to be standard market economies with a relatively high standard of living, a stable price level and a relatively solid state of the labour market. In 2004, all countries joined the European Union, Slovakia – as the only V4 country – adopted a single European currency EURO.

The European Union has created a common nomenclature of territorial units for statistical purposes known as NUTS, which enables the collection, compilation and dissemination of harmonized regional statistics in the EU. The NUTS nomenclature is hierarchical in that it divides individual member states into three levels: NUTS 1, NUTS 2 and NUTS 3. This hierarchically constructed system is also used for socio-economic analyzes of regions and when proposing measures within the EU cohesion policy. Comparability of regional statistics requires the territorial regions to be of comparable size considering their population. Their current political, administrative and institutional situation has also to be taken into account. Thus, economic, social, historical, cultural, geographical or environmental aspects of the non-administrative units must be taken into account when appropriate. Based on the above, the NUTS 2 regions of the V4 countries consist of 37 regions - 17 regions in Poland, 8 regions each in the Czech Republic and Hungary, and only 4 regions in Slovakia (Figure 1).

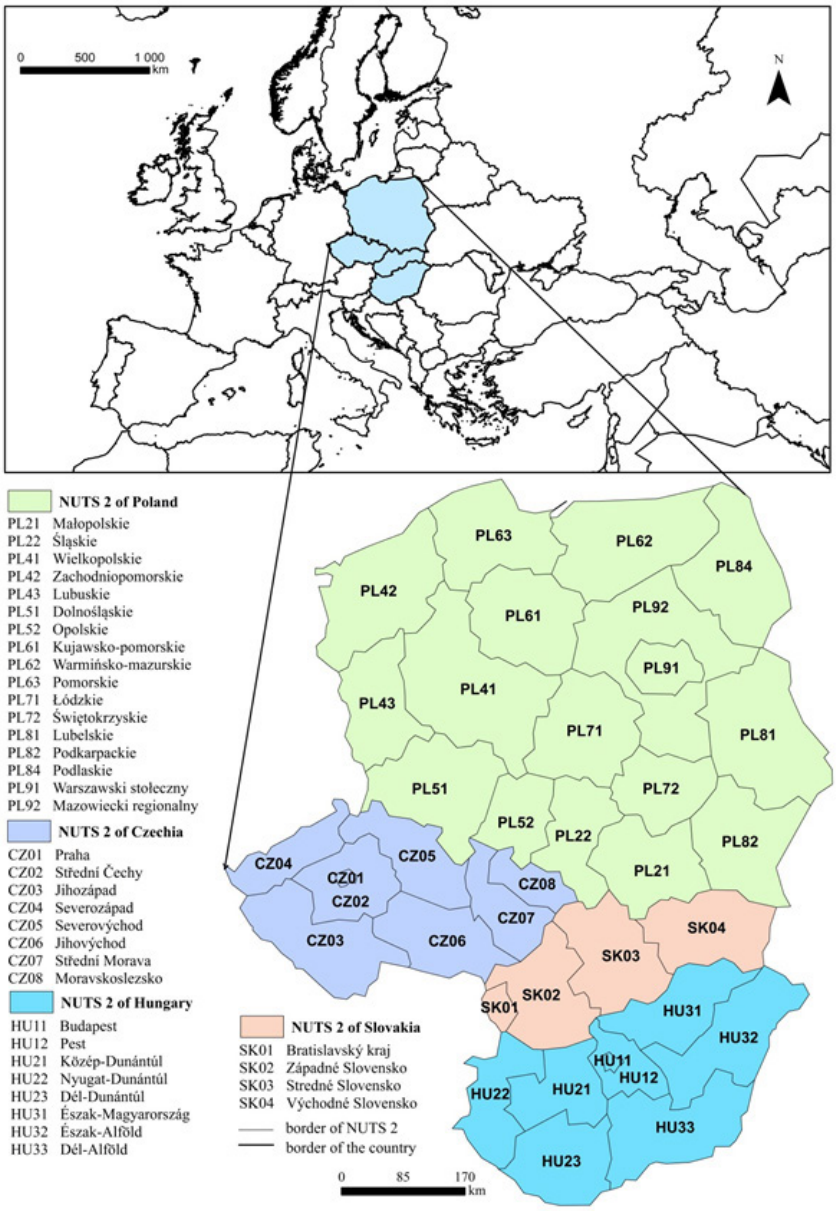

Figure 1 NUTS 2 regions of V4 countries

Results

Population ageing in V4 countries

Comparison of the years 2020 and 2050 brought significant changes in the population age structure. A shift of the population to higher age categories and subsequently a decrease in the proportion of the child-age population can be observed there. In 2020, the age pyramid of the population in the V4 countries represented a regressive age structure determined by constantly decreasing number of

children born. A higher proportion of residents can be seen in the age groups from 30 to 49 years. This fact is based on the strong years of the 1970s, when pronatal measures were introduced in the V4 countries. Before the 1970s, the stronger age groups occurred in the 1950s, which were associated with the post-war baby boom. Potential changes in the age structure are also visible for the year 2050. Figure 2 points to a decline in the child-age population, a shift of stronger age groups to higher age categories, which documents the ageing of the V4 population. The baby boomers rejuvenated society for a short time, but they are gradually being moved to higher age categories and the 65+ age group is strengthening.

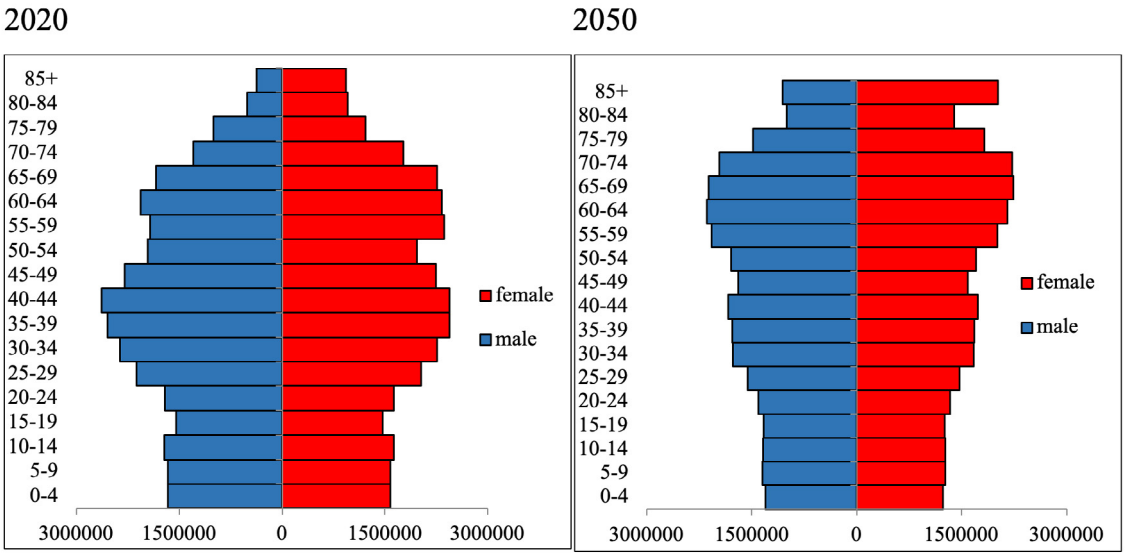

Figure 2 Age pyramid of V4 countries in 2020 and 2050

Source: Data of Eurostat, compiled by the author.

As far as all 37 NUTS 2 regions is concerned, an increase in the age group under 14 occurred only in 6 regions, with more significant growth in the regions where the capital cities of the individual V4 countries are located (Figure 3). The most populated is the area of Central Czech Republic , which includes the NUTS2 regions CZ01 Praha and CZ02 Střední Čechy. In recent years, this region has seen an influx of foreign migrants, mainly from Slovakia and Ukraine, who permanently settle in the wider hinterland of the capital city of Czech Republic – Prague (Praha). According to the Czech Statistical Office (2022), this region is the only one where the number of children

under the age of 0-14 outnumbers senior citizens. A situation in the vicinity of the cities of Bratislava (capital city of Slovakia) and Budapest (capital city of Hungary) is alike. In the regions NUTS2 SK01 Bratislavský kraj and HU11 Budapest, the increased number of children results from higher fertility related to growing internal and international migration. In the other regions, the number of children under the age of 14 in the observed time sequence of 2001-2010 and 2011-2020 decreased, and this trend in births will continue in the V4 countries until 2050. With the exception of the capital city regions, the age pyramids in the other NUTS 2 regions are of a regressive character. According to the prognosis, the growth of the population aged 80+ is expected. In 2050, the group of inhabitants over 80 will be the fastest growing senior group; its size will be 2.6 times larger when compared to the current numbers. This population ageing results in increasing average life expectancy as well.

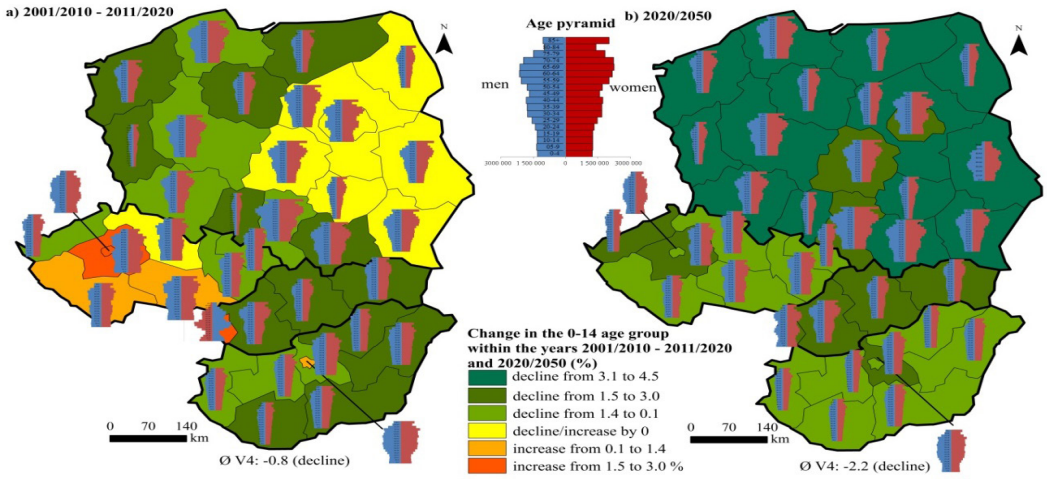

Figure 3 Change in the 0-14 age group in NUTS 2 regions of V4 countries in 2001-2050

The increase in average life expectancy affects the increasing age of the population with the expected decrease in mortality. Regular increases in life expectancy in higher age categories are becoming the norm in several countries of the world. The development trend of life expectancy at birth indicates improving mortality ratios in all the V4 countries. The best situation is in the Czech Republic, which had the highest average life expectancy among the V4 countries with the

smallest difference between the sexes, thus approaching the average of the European Union. Hungary has the lowest life expectancy, although it is gradually increasing. Slovakia and Poland have a similar development of the average life expectancy of their inhabitants. According to Kurek (2011) there was a sharp increase until the middle of the 1960s, which was related to the improvement of the social and health situation after the Second World War. Subsequently, the average life expectancy stagnated in the 1970s and 1980s, and then increased again in the early 1990s. The positive trend in mortality ratios is also expected in the next decades. According to the population prognosis (Figure 4), the average life expectancy at birth in 2050 could reach the level of 81-85 years, and for women it could be 84-89 years (according to the prognosis variant). Similarly, the continuous extension of life is expected for people aged 65, up to 20 years for men and 23-24 years for women.

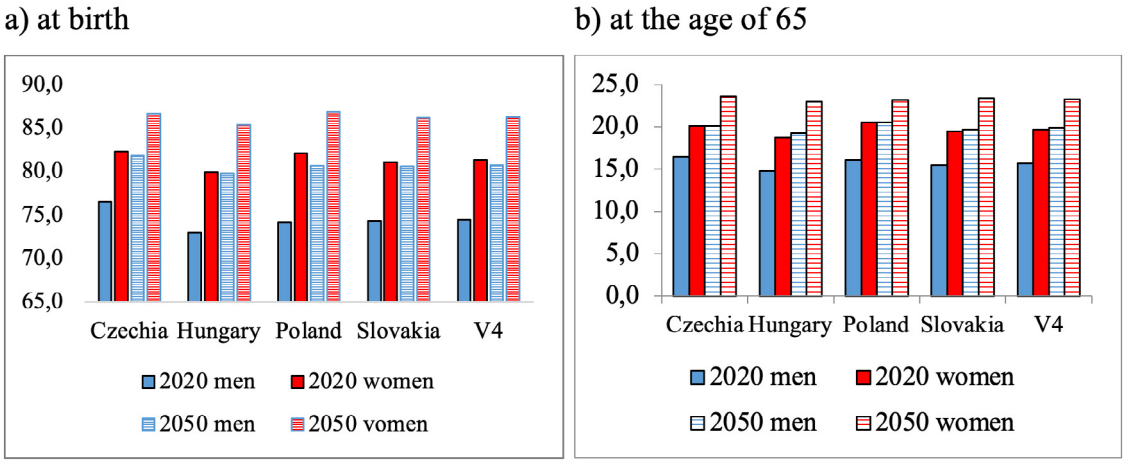

Figure 4 Life expectancy in V4 countries in 2020 and 2050

Source: Data of Eurostat, compiled by the author

Intensity of the ageing process is comprehensively documented by the development of the median age, evident increase of which is a common feature of all countries. Regarding the median age of the population in 2001, the lowest was in the Slovak Republic (34.4 years) and the highest in Hungary (38.6 years). At the beginning of the monitored period, Poland and the Czech Republic had the median age that was by 2-3 years higher than that of the population in Slovakia. By 2020, the median age has increased in all countries,

but the placing of the countries did not change: the lowest median age was in Slovakia again (41.0 years), in Poland it was similar (41.3 years), and the median age above 43 years was observed in the Czech Republic and in Hungary. According to the prognosis, the median age is forecasted to increase by an average of 4-8 years by 2050 (Figure 5). The growth will be highest in Slovakia, which has kept the median age at its lowest level for the past 20 years. By 2050, it will grow to 49.4 years, which will also be the highest median age among the V4 countries. This is related to the assumed decline in the population by 2050, continual postponement of fertility timing due to higher marital age, which is 32 years at present Other V4 countries will also see the increasing median age by 2050; the highest increase (more than 20%) being recorded in Polish regions, the lowest in Hungarian regions (Figure 5). According to the UN World Population Prospects (2022), to stop population decline in the V4 countries and in the entire European Union, it is necessary to increase the birth rate from the current 1.5 to 2.1 children.

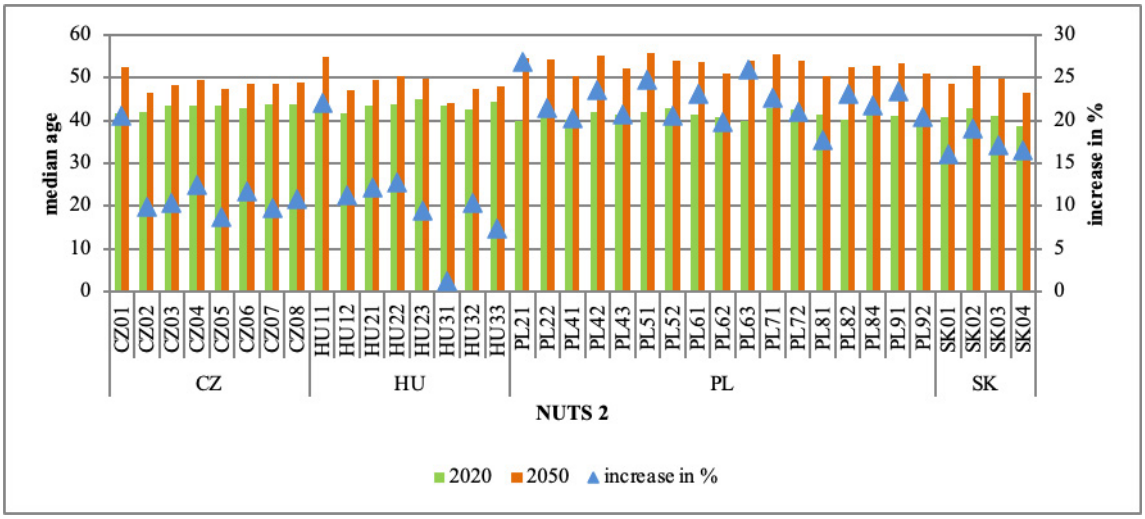

Figure 5 Median Age in Regions of NUTS2 in V4 countries in 2020 and 2050

Source: Eurostat, 2022, compiled by the author

Similarly, as the median age and the population aged 65+ increases, so does the ageing index. The higher the value, the more intense the ageing is. The situation of the population ageing will continue to worsen and even intensify until 2050. This increase will be evident in every NUTS 2 region, most intensively in the territory

of Slovakia (Figure 6). This confirms the assessment from previous analyzes that Slovakia will be one of the oldest V4 countries, as well as of the whole Europe. Again, the only exception is NUTS2 SK01 Bratislavský kraj, due to the intensive internal and external migration of mainly young people, and thus the higher birth rate. According to the Statistics Poland (2022), a high rate of the population ageing is also evident in NUTS 2 regions in Poland; the country is expected to experience a population decline by 6 million inhabitants by 2050. One of the two reasons is emigration (mainly to the United Kingdom and Ireland) in an attempt to gain greater financial security. Another reason is the low birth rate, as there are 1.32 children per woman, which is significantly below the population replacement level, which is 2 children per woman (Leszko, Zajac-Lamparska, and Trempala 2015). In the V4 countries, this situation of the constant increase in elderly populations and declining birth rates, that causes a big pressure on health care and pension systems, has prompted a nationwide effort to focus on these issues. The retirement age ceiling has already been introduced by all V4 countries except Slovakia. In the Czech Republic and Hungary, the retirement age stops growing when it reaches 65 years, in Poland it is 65 years for men and 60 years for women. However, these measures will mean that, for example, Poland will have the lowest retirement age among the V4 countries, but at the same time, the amount of the pension will not even reach a quarter of the average wage (Ministry of Finance of the Slovak Republic 2022). The countries have decided to introduce changes in the pension system with the aim of balancing economic growth by postponing retirement and extending the working life of seniors through education, e.g. universities of the 3rd age (learning English, social sciences, informatics, etc.).

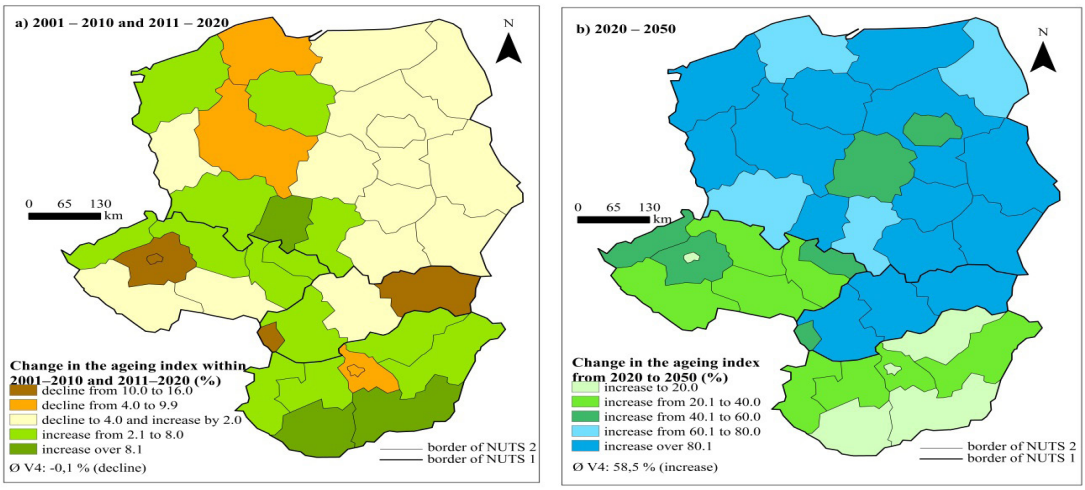

Figure 6 Change in the ageing index in NUTS 2 regions of V4 countries in 2001 – 2050

Ageing of the population, emigration of young people and declining birth rate create challenges that affect the economy of individual V4 countries as well as their health care and pension systems. Currently, the old-age dependency ratio of persons aged 65+ to the working population of productive age of 15-64 is 28.4 persons per 100 working people, but the ratio assumed by 2050 is over 50 persons per 100 working people (Table 3).

Tab. 3: Old-age dependency ratio in V4 countries in 2020 and 2050

years	Czechia	Hungary	Poland	Slovakia	V4
2020	31.1	30.3	27.5	24.5	28.4
2050	49.8	47.5	52.2	51.4	50.2

Source: Data of Eurostat, compiled by the author

An increase in the economic dependency index of older population will occur in all NUTS2 regions; significant worsening of the situation is assumed in NUTS2 SK03 Stredné Slovensko and SK04 Východné Slovensko, as well as in PL62 Warminsko-Mazurskie. The increase of this index will be up to twofold in the mentioned regions (Figure 7). The higher the economic burden index, the more economically dependent the population is. High unemployment creates economic dependents even among people of productive age. The strong

population years from the communist era will gradually move to the pensioners and will be replaced by the weak post-revolutionary generations.

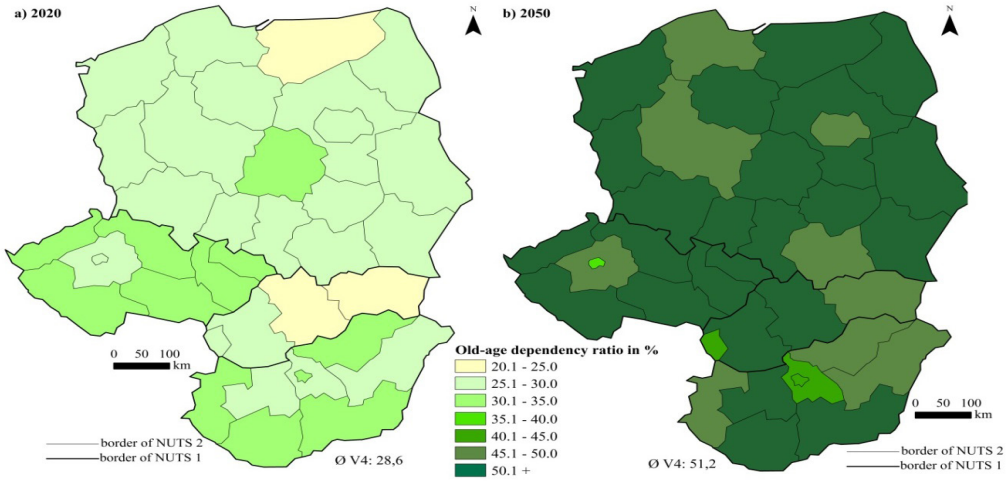

Figure 7 Old-age dependency ratio in NUTS 2 regions of V4 countries in 2020 and 2050

Typology of NUTS 2 regions of V4 countries according to population ageing

As we stated in the methodology above, similarity of objects can be expressed by the correlation measure (Pearson correlation coefficient). Negative value of the correlation coefficient indicates indirect dependency; positive value direct dependency. Values of the Pearson correlation coefficient of individual NUTS 2 regions are presented in the correlation matrix (Tab. 4).

In the period of 2001–2020, a very high direct dependency (r = 0.955), which approaches the number 1, is manifested between the population age group 65 and above and the ageing index, and a very high indirect dependency (r = –0.956) is manifested between the Billeter's index and the population age group 65 and above. On the contrary, very weak dependency occurs in individual indicators with the life expentancy. This indicator appears to have no impact on population ageing in combination with other indicators in the 2001–2020. Similarly, we monitored the impact of indicators on the population ageing in 2050 (Tab. 4).

Tab. 4: Pearson correlation coefficient of NUTS 3 regions of V4 countries in 2001–2020 and 2050 (correlation matrix)

Indicator / period	≤14	≤14	65 and above		median age		ageing index		Life expectancy		80 and above		old-age dependency ratio		Billeter's index	
	2001–2020	2050	2001–2020	2050	2001–2020	2050	2001–2020	2050	2001–2020	2050	2001–2020	2050	2001–2020	2050	2001–2020	2050
≤14	1.0	1.0	-0.8	0.9	-0.7	0.3	-0.9	-0.1	0.0	-0.1	-0.6	0.9	-0.6	-0.2	0.9	0.1
65 and above	-0.8	0.9	1.0	1.0	0.6	0.5	1.0	0.2	-0.2	-0.2	0.8	1.0	0.9	0.1	-1.0	-0.2
median age	-0.7	0.3	0.6	0.5	1.0	1.0	0.6	0.6	0.1	-0.4	0.1	0.5	0.4	0.3	-0.7	-0.6
ageing index	-0.9	-0.1	1.0	0.2	0.6	0.6	1.0	1.0	-0.2	-0.4	0.8	0.3	0.9	0.8	-1.0	-1.0
Life expectancy	0.0	-0.1	-0.2	-0.2	0.1	-0.4	-0.2	-0.4	1.0	1.0	-0.3	-0.2	-0.4	-0.1	0.1	0.3
80 and above	-0.6	0.9	0.8	1.0	0.1	0.5	0.8	0.3	-0.3	-0.2	1.0	1.0	0.9	0.1	-0.8	-0.3
old-age dependency ratio	-0.6	-0.2	1.0	0.1	0.4	0.3	0.9	0.8	-0.4	-0.1	0.9	0.1	1.0	1.0	-0.8	-0.9
Billeter's index	0.9	0.2	-1.0	-0.2	-0.7	-0.6	-1.0	-1.0	0.1	0.3	-0.8	-0.3	-0.8	-0.9	1.0	1.0

Source: Compiled by the author in IBM SPSS Statistics

In 2050, a very high direct dependency (r = 0.968), approaching the number 1, occurs between the population in 65 and above and the population in age group 80 and above and very high indirect dependency (r = –0.862) occurs between the Billeter's index and old-age dependency ratio. Other dependencies can be derived from Tab. 4. On the contrary, very weak dependency occurs in individual indicators with the life expentancy. This indicator appears to have no impact on population ageing in combination with other indicators in the 2050.

In order to fulfil the cluster analysis requirement, that the variables should be uncorrelated, we used the factor analysis. To assess the suitability of its input indicators, we used the KMO measure. Resulting values for our variables are presented in Tab. 5.

Tab. 5: Results of KMO ratio and Bartlett´s test of sphéricity in the 2001–2020 period and in 2050

KMO and Bartlett's Test	2001–2020	2050
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.62	0.64

Source: Compiled by the author in IBM SPSS Statistics

The overall KMO ratio is higher than 0.5. Therefore, these input data can be considered suitable for the factor analysis use (Tab. 5).

The ageing indicators described above can be synthesized and the ageing typology of NUTS 2 regions of the V4 countries can be done by means of a multivariate statistical method of the cluster analysis. For the synthesis, following indicators were used: share of 0-14 year olds, share of 65+ year olds, ageing index, median age, life expectancy, old-age dependency ratio, Billeter's index and since we had found out from previous analyzes that potentially in 2050 a category of old residents over 80 years will be significant, we also included 80+ category. Due to the number of created clusters, we chose the most suitable cluster distance as the cluster distance of 6, as a starting point for the created typology of NUTS 2 regions according to demographic indicators. After the clusters had been created, types of regions were formed in the V4 countries according to the observed demographic indicators of ageing, which were classified from the point of view of demographic development into a group of positive and negative indicators. The group of positive demographic indicators (compared to the average of the V4 countries) includes a high proportion of the population aged 0-14, above-average life expectancy, low median age, low rate of 65+ year olds, low rate of 80+ year olds, low ageing index, low old-age dependency ratio and a low Billeter´s index. The indicators showed negativity (compared to the average of the V4 countries) when there was a low share of 0-14 year olds, below-average life expectancy, high median age, high share of 65+ year olds, high share of 80+ year olds, high ageing index, high old-age dependency ratio and high Billeter´s index. As far as the ageing of the V4 population at a cluster distance of 6 is concerned, 5 types of regions (A – E) forming the typology of unevenness were created in the monitored period of 2001-2020 (Figure 8) and 6 types of regions (A – F) forming the typology of unevenness in 2050 (Figure 9).

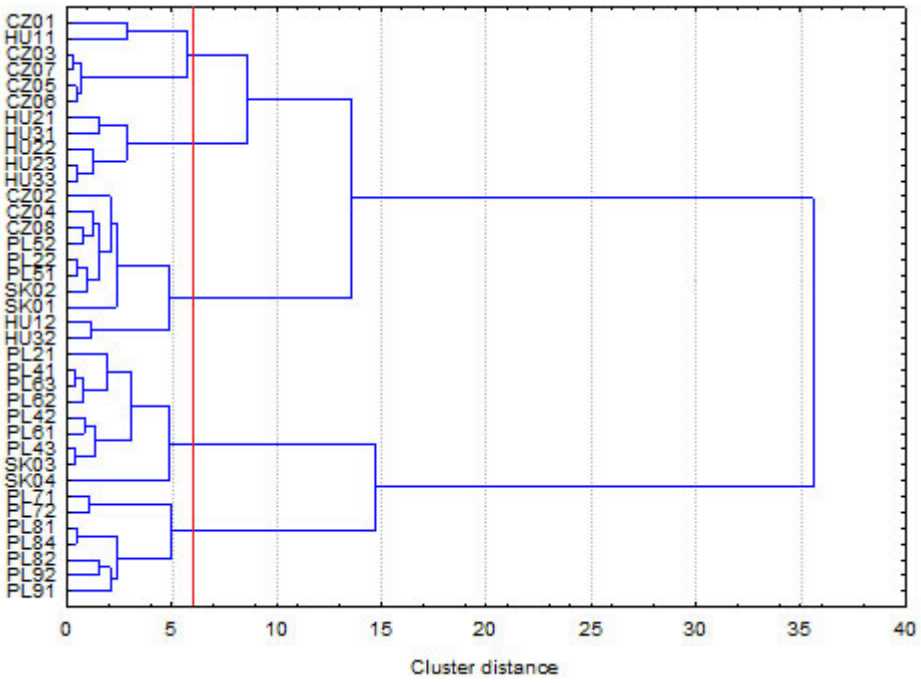

Figure 8 Dendrogram of population ageing in NUTS 2 regions of V4 countries in 2001-2020

Source: Data of Eurostat, compiled by the author

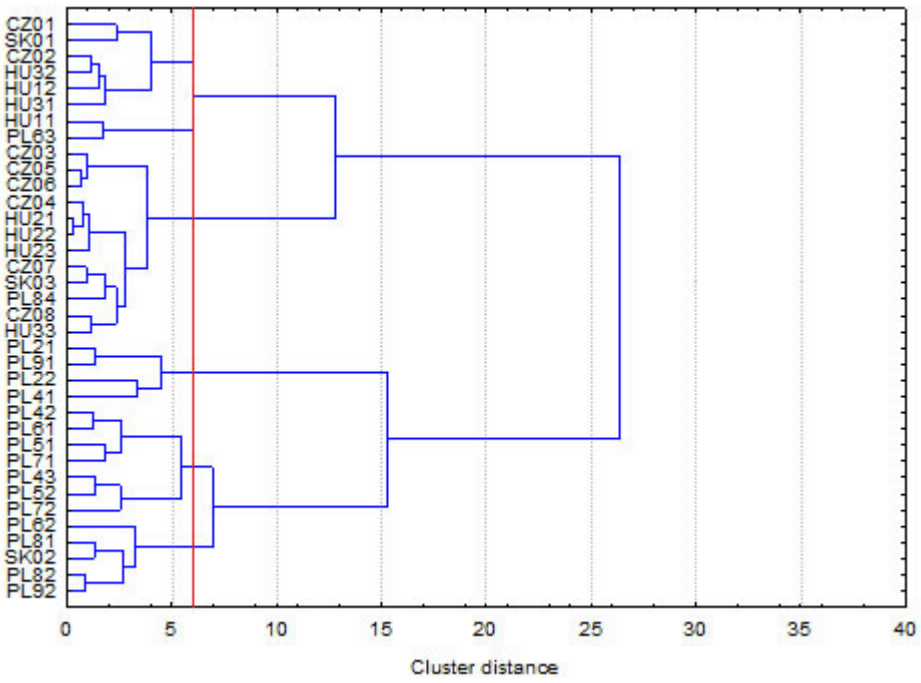

Figure 9 Dendrogram of population ageing in NUTS 2 regions of V4 countries in 2050

Source: Data of Eurostat, compiled by the author

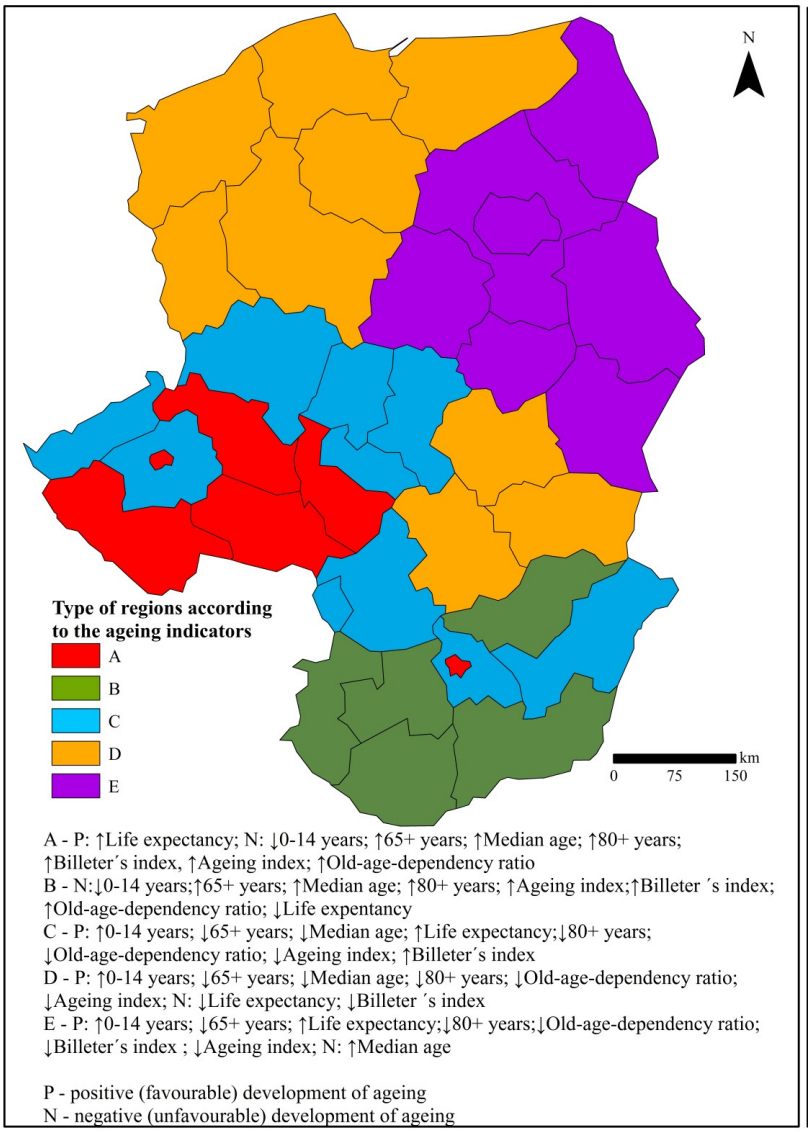

Figure 10 Typology of NUTS 2 region in V4 countries according to ageing indicators in 2001-2020

For the regions belonging to the type B, there was only an unfavourable development of ageing in the years 2001-2020 (Figure 10). Five Hungarian NUTS 2 regions belong to this type. These regions are characterized by low rate of the population under the age of 14, high rate of the population aged 65+ and 80+, high ageing index, high Billeter´s index, high old-age dependency ratio, high median age and low life expectancy. A definitely favourable development of ageing is noticeable in the type D, which includes 7 Polish and 2 Slovak regions. All these regions are characterised by high rate of 0-14 year olds, low numbers of 65+ and 80+ year olds, low median age, and high

average life expectancy. In the type A, the only favourable indicator was average life expectancy; this type comprises 5 Czech regions and 1 Hungarian region, including the regions of capital cities. In the type C, there is also only 1 favourable indicator, which is high rate of 0-14 year olds, the other indicators were recorded as unfavourable. In the type E, all indicators were favourable with the exception of high median age. This type occurs in the eastern part of Poland.

Using this typology, the population ageing appears to be more diverse in 2050 (Figure 11), when the process of ageing will be more considerable and many indicators will be less favourable. There will be no type with exclusively favourable indicators. The type A will be characterized by low rate of children under 14 and low average life expectancy, other indicators will be positive (low rate of population aged 65+ and 80+, low median age, low ageing index and old-age dependency, and low Billeter´s index). This type includes 2 regions in the Czech Republic and 3 regions in Hungary. The type B is characterized by unfavourable high median age, high rate of the population over 80 and low average life expectancy. In this type, however, there is high rate of children and low ageing index. It includes the HU 11 Budapest region in Hungary and the PL63 Pomorskie region in Poland. The type C includes the vast majority of Czech regions, 4 Hungarian and 1 Slovak region. This type has only 5 favourable indicators, they are low number of 65+ and 80+, low median age, low ageing index and high average life expectancy. The type D occurs only in 4 Polish regions, in which the ratio of positive and negative indicators is balanced. Fewer positive indicators are found in the type E, this type has high rate of children and low rate of population aged 65 +. Regions with a purely unfavourable situation are represented in the type F, where almost half of Polish and half of Slovak NUTS2 belong.

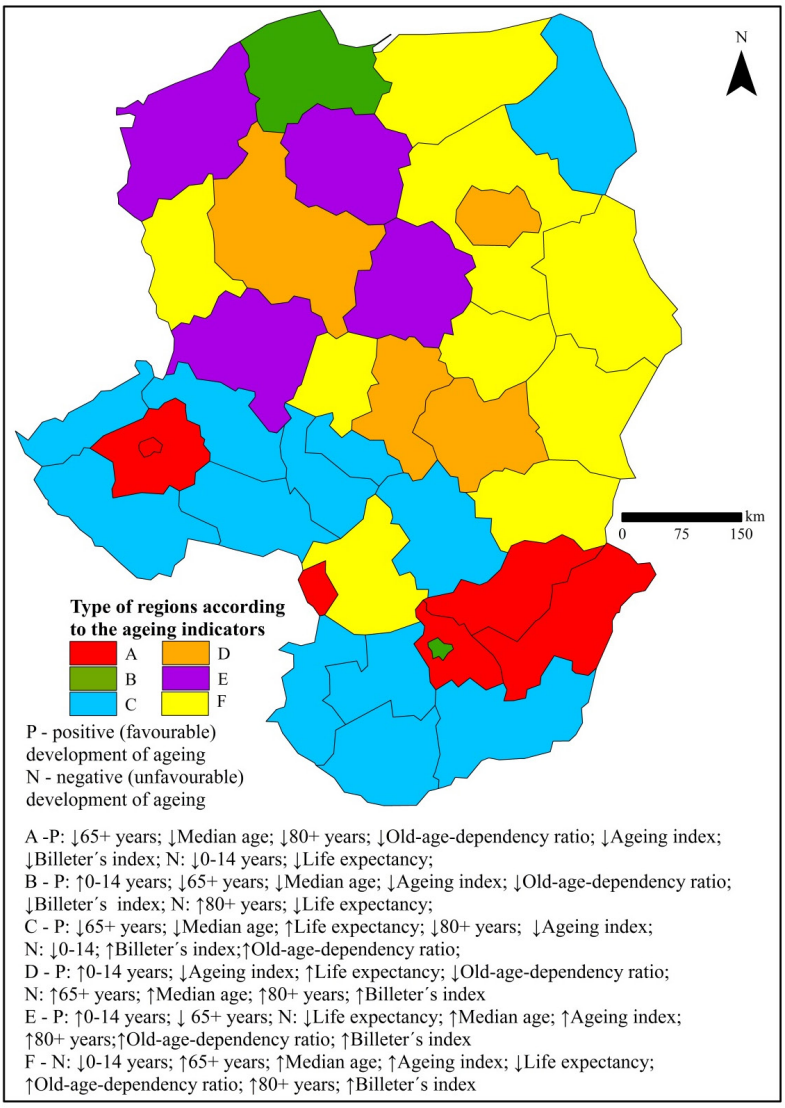

Figure 11 Typology of NUTS 2 region in V4 countries according to ageing indicators in 2050

Based on the indicators above, regions with 3 types of populations can be classified (Figure 12):

-The 1st type includes regions with young population and low degree of ageing. These are regions where positive ageing indicators predominate.

-The 2nd type includes regions with medium degree of ageing. These are NUTS 2 regions, in which the ratio of positive and negative indicators is balanced.

-The 3rd type includes regions with old population and high degree of ageing, in which negative indicators prevail.

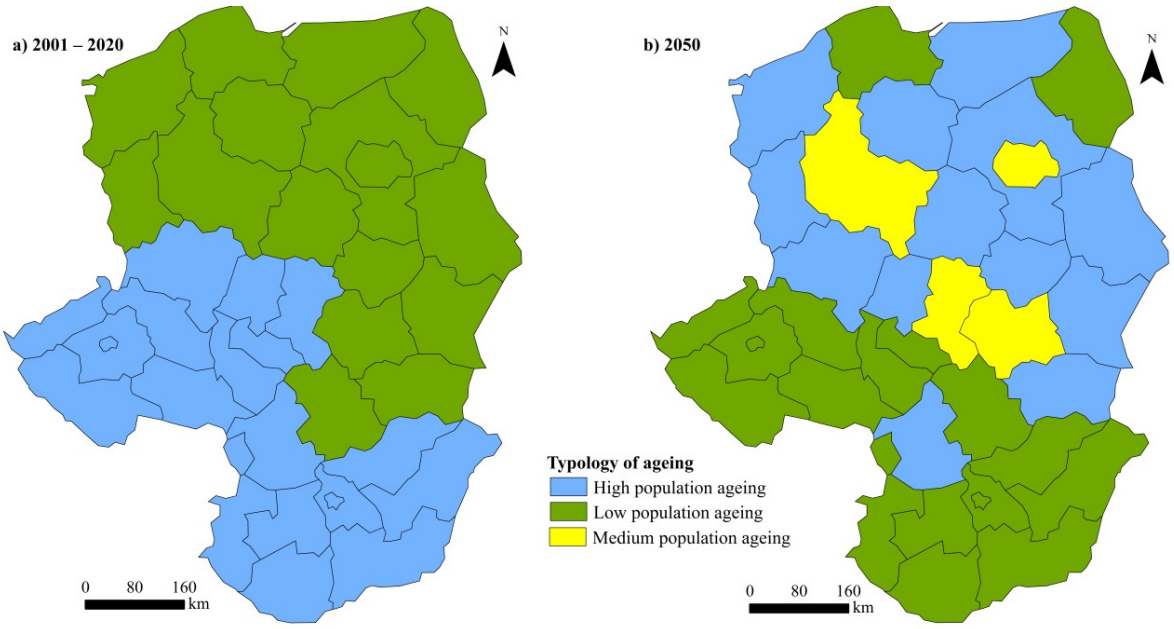

Figure 12 Typology of ageing in NUTS 2 regions of V4 countries in 2001-2020 and in 2050

Comparing the periods of 2001-2020 and 2050, several differences in the regions occur. While the population in the Czech Republic and Hungary has been getting older significantly by 2020, the situation will be the opposite by 2050 and some improvement will occur in these countries. Even before 1980, the population ageing in these two countries was approaching the countries of Western Europe. The later onset of this phenomenon was evident in the more conservative populations of Slovakia and Poland. Due to the migration dynamics, the Czech Republic and Hungary have achieved a positive effect of migration on population rejuvenation. The situation is expected to worsen in Poland and in the regions of NUTS 2 SK02 Západné Slovensko and SK04 Východné Slovensko by 2050. This fact is also proven by the change in the median age, which will increase by almost 25% in Poland. This is the highest increase among the V4 countries until 2050. According to several experts (Kreyenfeld 2014; Morgan and King 2001; Shoven and Goda 2008), the starting point to prevent this unfavourable trend is to adopt pro-family measures, reconcile work and parenthood, increase the availability of housing for young families, raise the country's standard of living and thereby support foreign migration.

Discussion

After two decades of intensive changes, reproductive behaviour in CEE is still in flux. In the nearest future, economic recession and its aftershocks, especially persistent high unemployment and government cuts on family-related social spending, are likely to keep a downward pressure on fertility and slow-down or reverse the observed recent rise in period fertility rates (Sobotka 2011).

World-wide, the proportion of people age 60 and over is growing faster than any other age group. According to the "Grand Challenges of Our Aging Society" workshop, Jackson (2010) remarked that the age grading of society will change because of both the increased longevity and declining fertility. Thus, not only will people live longer, but they will live in a radically different society. Jackson's emphasis was on the myriad connections and mutual influences of global flows in trade, capital, and migration as well as intergenerational linkages. He then underscored the importance of a life-course perspective and consideration of cohort and period events that occur to different groups. Jackson also asserted that as society has "essentialized" certain ages (such as 62 for early retirement, 65 for full retirement), this has precluded thinking in new ways about retirement and other issues. Similarly, he suggested a rethinking of retirement as a status. If only people who are economically productive are valued, where does that leave retirees? He suggested further thinking about the different reasons for exiting retirement, ranging from economic necessity to self-actualization, since these would result in very different experiences. Börsch-Supan (2008) in the "Grand Challenges of Our Aging Society" workshop also offered perspectives underscoring in part the research agenda he had earlier outlined. These include the study of age and productivity: Is it economically profitable to work to age 75? What happens at age 30 or 40 to make people more productive at older ages? What is the gap between productivity and payment at older ages? A final essential issue, Börsch-Supan acknowledged, is the structural lag of institutions and the inability to reform them as well as the structural lag in behavior. Very important is the question of the comparison of the productive population categories – the inflow of young age categories as well

as the changes in the count of the older age categories (Barclay and Myrskilä 2022). Will the numbers of economically active population change with respect to the population at pension age? There is also the quantitative relation between the "parents" and their "children".

The increase in population ageing has also been confirmed by the age pyramids, that clearly show an increase in the 65 and above population and more significant increase in the 80 and above population. We have pointed out that by 2050, the 80 and above age group will be the fastest-growing senior group, its size will be 2.6 multiple of its current size. The results of our research using the cluster method confirmed the views of individual authors dealing with this issue only partially. Mládek, Káčerová and Stankovičová (2018) evaluated this issue till the level of individual European countries; the authors pointed out ageing in 1950 and 2010 on the basis of selected indicators. A more detailed analysis till the level of NUTS 2 regions of the V4 countries was carried out by Káčerová, Ondačková and Mládek (2012). In their paper, they pointed out the ageing indicators from 1960 to 2012, expressing the relative representation of the pre-working age, working age and post-working age of population components till NUTS 2 level in the past and in 2012. These are the ageing results from 2012 that the authors observed, which coincide with our period, when we found that the oldest population is that of the Czech Republic and Hungary; better situation regarding the population ageing is in Slovakia and Poland. Population ageing in the NUTS 2 regions of the V4 countries was also discussed by Repaská (2022), who also pointed out the population ageing prognosis through ageing indicators. Using the Ossan's triangle, she divided the NUTS 2 regions into six types. Population ageing and its prognoses in Poland and Slovakia were confirmed despite the fact that this process evaluating methodology was different and the cluster method was used. Similarly, the improving situation in the Czech Republic and Hungary by 2050 has been confirmed. These were the countries that had an earlier onset of population ageing, as Sobotka (2011), Scherbov and Sanderson (2016) also pointed out, while the remaining two countries were more conservative with a stronger link to the traditional family and a younger age structure.

Conclusion

The ageing of the population is a phenomenon of the 21st century, which is irreversible, very dynamic and impacting the whole society for the coming years. The crucial reason for the ageing is retirement of numerous post-war age-groups and arrival of less numerous age-groups born during the 1990s to the labour market. This process will deepen even more by 2050. Numerously stronger age-groups born in the 1970s and 1980s will begin to retire, and due to persistently low fertility, there will be no adequate replacement for them on the labour market. In the V4 countries, an increase in the population aged 65+ is evident, along with a decline in the productive-age population and under the age of 14, and increase in the population over 80+ and old-age dependency ratio.

One of the basic processes that would reduce and slow down the ageing is the birth rate. Individual EU countries have implemented various policies over the past decades to increase the birth rate. In these countries, the family support system is used not only in the form of cash benefits, but also through concessions in the tax system. The system of reducing the tax assessment base is also used, as well as the system of reducing the tax itself. In Slovakia, the Income Tax Act allows the taxpayer to claim a “tax bonus” (tax reduction) for each supported child from the tax base during the annual tax return. In the Czech Republic and Poland, a tax reduction is also applied in the case of dependent children, and it is differentiated, the more children there are, the higher the tax reduction is. In the short term, the birth rate was indeed increased in Poland, but it has been falling again since 2018. In Hungary, they also apply a reduction in income tax; the state also introduced the highest VAT in Europe (27%) to finance interest-free family loans or subsidy schemes for families with more children. A novelty in the country is that from 1 January 2020 all women with at least four children are completely exempt from personal income tax until retirement. This exemption applies to income from employment. That is, the V4 countries tried to contribute to the increase in the birth rate with tax breaks. When compared to the countries of Western Europe, France has the highest birth rate (10.9 ‰ in the year 2021, in V4 countries 10.0

‰), which has reduced the tax burden on families. Although the country has a significantly shorter period of maternity leave, which is six weeks before and ten weeks after the birth of a child, French family policy emphasizes day care for children in facilities already a few months after birth. In Germany, Belgium, and Denmark, both parents are recipients of parental allowance at the same time. In Belgium, parents are also legally entitled to a nursery place when the child turns 1, so they can integrate into working process and still receive child benefit. In Denmark, children between the age of six months and five years receive a place in subsidized childcare facilities (Abrahamson and Wehner 2008). Denmark met current EU targets concerning the childcare and women's labour force participation in the late 1970s already.

Currently, it appears that the setting of internal and also foreign migration will be decisive for the subsequent population development, since the preponderance of the number of births over deaths is already a thing of the past and the increase in the birth rate is insufficient. However, the countries have to transform due to the increased influx of immigrants, mainly from the countries outside the EU, and deal with the question what type of immigrants their immigration policy should focus on. According to the OECD report (2021), the foreign migration raises several controversial opinions. It touches many areas of social life, including economics, demography, national security, culture and religion. Through its quantity, it can change qualitative characteristics. The V4 countries welcome migrants mainly from the third countries; their goal is to gain new experience for their professional growth, improve their foreign language and work skills in a qualified environment. After the war conflict in Ukraine has arisen, the V4 countries also became the target of political migration. The EU Council has adopted particular measures to help refugees (mechanism for temporary protection of persons fleeing war, humanitarian aid, support in the field of civil protection, financial and technical support for the member states receiving refugees, etc.). Regarding the V4 countries, the highest influx of immigrants is into Poland (more than 1.3 million), 35% of which are planning to stay there for a year and another 17% permanently (Statistics Poland 2022). Almost half a million Ukrainians

immigrated to the Czech Republic, almost 100,000 to Slovakia and almost 30,000 to Hungary. In general, the population migration to the target countries has a positive demographic effect, especially on the immediate demographic situation of the population. Since the vast majority of migrants migrate at their productive age, the share of young people in the overall population structure increases. The rising number of immigrants coerces the target countries into creating and improving their immigration policy. It can be assumed that the more favourable the situation in the countries, the higher the standard of living, the fewer residents will leave, and the more foreigners will be interested in immigrating. This could also prevent the outflow of highly qualified professionals, who are in demand in all populations, to Western countries. In the past, students used to go abroad for foreign internships as part of their university studies at the home university. Currently, selected students go to foreign universities immediately after the graduation (OECD 2021). The V4 countries are gradually trying to ensure that the graduates and highly qualified experts do not leave their countries for good. Brain drain can have a negative impact on the sending region, such as reduction of human capital, limited capacity to innovate, reduced economic growth, demographic shifts, and a higher cost of public goodsThe Committee of the Regions therefore suggests that Local and Regional Authorities develop instruments and promote measures to increase the attractiveness of the regions facing a Brain drain and to set up local alliances, which can help in drafting and implementing of local policies in order to mitigate brain drain (Shubhaangi 2020).

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