DIFFERENCES AND SIMILARITIES IN PATTERNS OF AGEING SOCIETY IN THE EUROPEAN UNION

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Abstract: *Population ageing is a demographic issue that emphasises the need to be interested in the lives of the most vulnerable population group: the elderly population. The paper investigates the ageing process and their relations among the European Union member countries from 2009 to 2019. These countries are assessed and dispersed to the appropriate clusters according to several indicators related to the areas that affect the lives of the elderly population: namely, the health status, the labour market conditions, and financial security. The focus is on the age group 55 years and over as it is a disadvantaged age group in the job application process regarding ageing society. It is a significant aspect of public finance system. The European Union Statistics on Income and Living Conditions, the Labour Force Survey, and the European System of Integrated Social Protection Statistics data are involved. The quantitative approaches are applied in the cluster analysis and followed by the panel data linear regression analysis. The dendrograms visualise the three clusters representing the mutual relations and the ageing patterns among the explored countries. The heat maps are created to prove the potential relations among the observed countries. The panel regression model demonstrates that the three variables – part-time employment, the income inequality, and the material and social deprivation – are statistically significant in all the regression models for the whole area and the three clusters. The analytical outcome could be applied as a valuable resource to government and national representatives. It can help identify the objectionable determinants for a custom policy and implement appropriate measures to improve the situation of the elderly population.*

Keywords: *Ageing, life expectancy, cluster analysis, regression analysis, European Union.*

JEL Classification: *C33, I14, J14.*

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Introduction

Population ageing currently represents a phenomenon that is occurring around the world. It can also be defined as a consequence of the fertility rate decline and the increasing life expectancy, resulting in an increasing number and a proportion of the population in the post-productive age. For the first time, the

elderly population will be predominant over the younger people (World Health Organization, 2020). The ongoing demographic changes are going to characterise the upcoming decades. This process will affect the different areas from the population's health status through the health systems, the conditions in the labour market, the changing consumption patterns, and the need to provide the system reforms related to higher demand for public resources and finance. Ageing creates deep pressure on fiscal sustainability. It will put unprecedented stress on public finance to fund the pension system, the health system and the long-term care expenditures (Organisation for Economic Co-operation and Development, 2019). The burden on public finance lies precisely in need to increase government spending on the pension system, which plays a crucial role in ensuring the living standard requirements of the elderly population. Unfortunately, one in seven pensioners is at risk of poverty in the European Union member countries nowadays (Eurostat, 2021a). Ageing is mainly associated with a growing number of the population in the post-productive age. Therefore, it is essential to know the elementary characteristics and the socioeconomic indicators of this age group. An overview of the recent studies shows that the health status, labour conditions and financial security appear to be the most critical areas for the elderly population.

This paper contributes to the current scientific literature by evaluating the ageing process and the demographic changes in the European Union territory. It classifies its member countries with similar ageing characteristics into different clusters. It also outlines the financial, health, and social indicators with the highest importance for the lives of the elderly population. All these three aspects are important as the public resources spent in the fields which these aspects are related to, that is, mainly public and government spending. The main objective of this paper is to detect a potential mutual relation between the European Union member countries as Europe is characterised by almost the oldest population in the world. If this were proved, the purpose would be to review which of the explored countries behave similarly and hence; the analogous policy could be applied for them. Above and beyond this, the development of the last ten years is examined too. Therefore, a partial goal is to analyse the selected variables related to the ageing population and cluster the observed countries according to this. Such a process can reveal the possible common succession of the steps in order to prepare the social conditions for all the age groups of the population in the given countries. The main research question is to reveal the relations related to the explored dimensions. Fundamentally, the hypotheses are stated in a way that the involved variables behave statistically significant for the explanatory variable representing old-age dependency. This represents an aspect of the public finance system that plays a key role in the financing processes. It creates a part of the whole issue of ageing society as this phenomenon covers many fields of life. Moreover, this should create a basement for a potential mutual public policy of the institutions of the European Union. Hence, the rules accepted by the European Union are not only funded by higher amount of financial resources, but also are backed by stronger legislative. In the submitted paper, an investigation of the impact of given variables is carried out with its significance in the particular countries. The paper is structured as follows: the second section offers the literature review, the third section describes the data, and the fourth section the methodology applied. The analytical outcome of the discussion is demonstrated in the fifth section. Finally, the sixth section represents the conclusion with a summary of the obtained findings.

1. Theoretical Background

The demographic changes are very rapid globally, and the sheer number of pensioners is increasing faster than it is often thought (Officer et al., 2020). The developed world is subject to two simultaneous processes.

Population growth is slowing, and the population's age structure is changing in many countries (Broniatowska, 2019). By 2030, a quarter of the developed world's population will be of age over 65 years (United Nations, 2019b). Moreover, the European continent possesses one of the oldest populations, as many European countries have the lowest fertility rates and the highest life expectancy rates globally (Marois et al., 2020).

Numerous previous research was centred on the demography changes and process of population ageing in the countries of the European Union (Cristea et al., 2020; Ebbinghaus,

2021; Estevens, 2018; Gómez-Costilla et al., 2021; Jakovljevic et al., 2018; Kluge et al., 2019; Lutz et al., 2019; Pascual-Saet et al., 2020; Sanderson & Scherbov, 2016; Skibiński, 2017). Most studies confirm that demographic changes are a challenge for many policy areas: labour market, health and long-term care, lifelong learning, family policy, social protection, and pension systems.

A population decline can be examined through several aspects to explore its potential consequences (Coleman & Rowthorn, 2011; Fukuda & Okumura, 2020; Janus et al., 2022; Kikuchi et al., 2022). The fertility rate level itself cannot illustrate the whole situation because several other dimensions should be considered (Striessnig & Lutz, 2013). This field needs new approaches to quantify the crucial figures to determine the future policy (Sanderson & Scherbov, 2015). The scientific literature also emphasises the importance of studying the life of the elderly and focuses on healthy and active ageing.

On the contrary, attention is also paid to the problems of social security and increased demand for pension payments. These are the result of the state confirmed by the Organisation for Economic Co-operation and Development (2019) that old-age dependency ratios will rise in all the 27 European Union member countries in the following decades, putting the financing of adequate pensions, health, and long-term care under high pressure. The increased burden on the social security system represents the expected consequence of an ageing population from the point of view of economics (Skibiński, 2017).

The critical challenges of ageing regarding the way it shapes society are the financial security in retirement, the disease burden in old age, and the shrinking labour force in the productive age (Aguilar-Palacio et al., 2018; Kratt & Kirnos, 2020; Park et al., 2022). These challenges are domains included in the Active Ageing Index (Ortega, 2020; United Nations, 2019a). Lyons et al. (2018) focused on the impact of population ageing on the financial security of households that are most like to be vulnerable.

Financial inclusion and technological usage are considered essential tools to ensure the financial security of the elderly. Also, financial security tends to be linked to the population ageing crisis (Khan, 2019; Mura et al., 2019; Pascual-Saez et al., 2020; Rupeika-Apoga & Thalassinos, 2019). In the context of the labour market situation, there are questions of who, how many and with what skills will work in Europe in the upcoming decades (Lutz et al., 2019).

The ageing process and retirement significantly transform the situation in the labour market. To encourage the elderly to work longer, postpone retirement and provide them with the opportunity to be employed part-time seems to be the apparent policy solution (Moen, 2020; Sewdas et al., 2017). However, internal policy solutions such as increased retirement age or longer working hours were unsuccessful in many countries. Comparing differences of the role of retirement by the motive or the form for retirement claimed that the fully retired population showed a significantly lower sense of purpose than those who are still working or are just partially retired (Best & Hill, 2020).

In recent years, several studies have been focused on the factors influencing the quality of life and life satisfaction of the elderlies (Leeuwen et al., 2019). For evaluating the life satisfaction of elderlies, it is crucial to recognise the factors that influence their quality of life, emphasising that older people tend to prefer the quality of life over a long period.

Several studies found a negative association of age and health of elderlies, but a positive association with the difficulties and the limitations in daily activities. Although, this is disputable because of the selection bias occurrence. Some have also proved a direct impact of social support on self-perceived health, especially among the elderly (Giang et al., 2020; Le et al., 2020; Loichinger & Pothisiri, 2018). Also, the depressive symptoms are markedly connected to the quality of life (Bornet et al., 2017). Life satisfaction of the elderly population is negatively affected even in the case of low financial or material support, when they suffer from emotional stress or when they lose support provided by children (Liu et al., 2019). Hence, it is recommended to give special attention to studying the social differences in life expectancy at the age of 50 or 65 years and disability-free life expectancy.

The aim is to estimate the contributions from the disability and mortality effects through the differences between the income groups. The gradient of income inequality is sharper for healthy life years than life expectancy. As

income inequality is increasing, disability-free life expectancy by income appears to be an important indicator that can monitor social inequality in the accretive share of elderlies (Brønnum-Hansen et al., 2021). Ageing also results in increased expenditures on healthcare services and welfare (Li et al., 2020). Therefore, it is valuable to focus on the lives of the elderly population, identify the most likely influential factors, and find out the purpose of retiring as it is connected to many physical and mental health implications (Best & Hill, 2020).

2. Methodology

Several quantitative methods are applied, focusing on the cluster analysis and the sensitivity analysis in the form of panel data regression analysis as the primary approaches.

Firstly, to provide that data are mutually comparable, the normalisation of the data is necessary. The maxima are the model outputs, while the minima are defined as the lowest performance benchmarks, and thus, they are determined as the worst possible scenario.

The indicators are standardised into a consistent scale from zero to one according to Williamson and Piattoeva (2018) and Grannis et al. (2019) and proximity-to-target methodology:

$$I_{x_i} = \frac{(\max x_i - x_i)}{(\max x_i - \min x_i)} \quad (1)$$

where: I_{x_i} – the standardised value of the given indicator; x_i – *i*-th value of the variable to be standardised.

If the indicator growth represents an undesirable trend, the following modification is ready to be applied:

$$I_{x_i} = \frac{(x_i - \max x_i)}{(\max x_i - \min x_i)} \quad (2)$$

where: the comprised variables possess the same meaning as the previous equation.

Secondly, the similarity of the territories is computed through the Euclidean distance:

$$D(c_1, c_2) = \sqrt{(c_{1_x} - c_{2_x})^2 + (c_{1_y} - c_{2_y})^2} \quad (3)$$

where: c_1 – the first country; c_2 – the second country; $D(c_1, c_2)$ – the mutual Euclidean distance of the c_1 country and the c_2 country; c_{1x} – the *x* coordinate of the c_1 country; c_{2x} – the *x* coordinate of the c_2 country; c_{1y} – the *y* coordinate of the c_1 country; c_{2y} – the *y* coordinate of the c_2 country.

Thirdly, the clusters are determined according to the following methods:

- The Ball-Hall index (Ball & Hall, 1965);
- The McClain-Rao index (McClain & Rao, 1975);
- The point-biserial correlation coefficient (Milligan, 1981).

The Ball-Hall index is computed in this way:

$$BHI = \sum_{i=1}^{n} [(v_i - c_i)(v_i - c_i)^t] n^{-1} \quad (4)$$

where: *BHI* – the Ball-Hall index; *n* – a number of the countries; *i* – the particular country; v_i – a vector of the *i*-th country in the particular cluster; c_i – a centroid of the *i*-th cluster; *t* – a modification parameter.

The McClain-Rao index is calculated as follows:

$$MRI = \frac{D_w P_w^{-1}}{D_b P_b^{-1}} \quad (5)$$

where: *MRI* – the McClain-Rao index; D_w – a sum of the within cluster distances; P_w – a number of the country pairs of the observations belonging to the within cluster; D_b – a sum of the between cluster distances; P_b – a number of the country pairs of the observations belonging to the between cluster.

The point-biserial correlation coefficient is computed like this:

$$PBCC = \frac{(\overline{D_w} - \overline{D_b}) \sqrt{\left[\frac{P_w P_b}{(P_w + P_b)^2}\right]}}{SD_D} \quad (6)$$

where: *PBCC* – the point-biserial correlation coefficient; D_w – a sum of the within cluster distances; D_b – a sum of the between cluster distances; P_w – a number of the country pairs of the observations belonging to the within cluster; P_b – a number of the country pairs of the observations belonging to the between cluster; SD_D – a standard deviation of all the distances.

The construction of the clusters is based on Ward's minimum variance method. The dendrograms and heat maps represent the graphical outcome of the cluster analysis.

The second methodological approach applied is sensitivity analysis. Within it, the regression model of a linear form for the panel data is constructed. The input data set for the modelling process possesses a form of panel data, including the two dimensions: a territorial one and a time one. The first difference method is applied in the linear regression. The regression analysis is carried out with a presence of a constant value. The sequential elimination method is the primary modelling technique, so the variable with the lowest statistical significance is excluded from the other modelling process. The elimination factor is represented by the *p*-value of the particular independent variable. The sequential elimination is related to the elementary altogether model for the whole set of the explored countries. It implies that the cluster regression models aimed at the clusters are adapted to the elementary model. Therefore, it involves the variables in the final model of the modelling row that was not compulsory to meet the statistical significance required for the particular regression model.

Verification of statistical significance of the obtained results is confirmed by the four separate test statistics calculated to decide about the appropriateness of the created regression models – the Shapiro-Wilk test, the Durbin-Watson statistic, the White test, and the variance inflation factor (Durbin & Watson, 1951; Shapiro & Wilk, 1965; White, 1980). The tests mentioned above also contribute to the other analytical studies to verify the statistical significance of the study outcome (Marsillas et al., 2017; Michnevic, 2016; Milanez, 2020; Okely et al., 2018; Ray et al., 2018; Sala, 2020).

The whole analysis is executed in the R statistical environment through the programming language R (R Core Team, 2022) with the additional help of the *NbClust* package (Charrad et al., 2014), the *plm* package (Croissant & Millo, 2008; Croissant et al., 2017), and the *RColorBrewer* package (Neuwirth, 2015).

3. Data Description

The data comes from the three following databases – the European Union Statistics on Income and Living Conditions, the European Union Labour Force Survey, and the European System of Integrated Social Protection Statistics. The first one collects the timely and comparable cross-sectional and longitudinal multidimensional microdata on income, poverty, social exclusion and living conditions. The second one is the extensive household sample survey that provides the data on labour participation of the population aged 15 and over and on the inactive individuals in the labour market. The third one enables the comparison of the national administrative data on social protection at the international level. It provides a coherent comparison between the European countries of the social benefits to households and their financing.

The analysis covers two dimensions: a territorial angle of a view involving the 27 countries of the European Union with an omission of the United Kingdom, and the time perspective represented by the period from 2009 to 2019. The data are composed annually. An observed set of the area involved in the analysis consists of the following countries: Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (GR), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), the Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), and Sweden (SE) (International Organization for Standardization, 2013). The United Kingdom is omitted because the future agenda and the policies supplied by the European Union do not cover this former member.

The following indicators determining the ageing society, which are related to people aged 55 years and over, are observed in the analysis: old-age dependency ratio (OADR), elderly employment (EE), part-time employment (PTE), weekly work hours (WWH), life expectancy (LE), disability-free life expectancy (DFLE), personal health (PH), health problem limitation (HPL), net income (NI), social protection expenditure (SPE), income inequality (II), at-risk-of-poverty population (PP), and material and social deprivation (MASD).

The following variables represent the involved indicators:

- Old-age dependency ratio (tps00198): the ratio of the population aged 65+ and the population aged 15 to 64 years expressed per 100 people of the working age from 15 to 64 years (Eurostat, 2021n);
- Elderly employment is designated as the employment rate of older workers (tesem050): a percentage of employees aged

55–64 years in the total population of the same age group (Eurostat, 2021b);
- Elderly part-time employment designated as persons employed part-time (tps00159): a percentage of part-time employees aged 55–64 years in the total employment of the same age group (Eurostat, 2021c);
- Weekly work hours designated as the average number of usual weekly hours of work in the main job (lfst_r_lfe2ehour): average weekly work hours per employee (Eurostat, 2021d);
- Life expectancy designated as life expectancy at age 65 (tps00026): the average number of years remaining to be lived by a person who is aged 65 years (Eurostat, 2021e);
- Disability-free life expectancy designated as disability-free life expectancy at 65 (tepsr_sp320): the number of years that a person aged 65 is still expected to live in a healthy condition (Eurostat, 2021f);
- Personal health is designated as self-perceived health (hlth_silc_10): the subjectively perceived health by the population aged 55+ years who report the level of their health status as good or very good (Eurostat, 2021g);
- Health problem limitation designated as self-perceived long-standing limitations in usual activities due to health problem (hlth_silc_12): the subjective perception of limitations due to health problems by people aged 55+ years who report the level of activity limitation as some or severe (Eurostat, 2021h);
- Net income designated as mean equalised net income (ilc_di3): the average net income regarding social transfers and including pensions in purchasing power standard (Eurostat, 2021i);
- Social protection expenditure designated as expenditure on social protection per inhabitant (tps00100): the expenditures on social benefits, administration costs and other expenditures measures in purchasing power standard per inhabitant (Eurostat, 2021j);
- Income inequality is designated as income inequality for older people (tespn080): the ratio of total equalised disposable income received by the 20% of the population aged 65+ years with the highest income and the 20% of the population aged 65+ years with the lowest income meaning comparing the top and the lowest quintile (Eurostat, 2021k);
- At-risk-of-poverty population or social exclusion (ilc_peps01): the at-risk-of-poverty population aged 55+ years or severely materially deprived whose equalised disposable income is below 60% of the national median after social transfers (Eurostat, 2021l);
- Material and social deprivation rate (ilc_mdsd07): the rate of people aged 55+ years who feel materially or socially deprived and they experience at least 4 out of 9 following deprivations items, which cannot afford to pay rent or utility bills, keep home adequately warm, face unexpected expenses, eat meat, fish or a protein equivalent every second day, a week holiday away from home, a car, a washing machine, a colour television or a telephone belong among (Eurostat, 2021m).

The indicators applied in the analysis are also involved in many other studies regarding the ageing society. The most common are those related to the participation of the older employees in the labour market as turning the elderly into an active workforce seems like an opportunity to face the challenges of an ageing population (Been & Vliet, 2017; Laun, 2017; Soong, 2020). Then, the indicators that assess the financial security of the elderly are proven to be significant both in the analysis and the other researches (Antonelli & Bonis, 2019; Guido et al., 2020; Heuvel & Olaroiu, 2017). Their mutual relations and correspondence represent a supportive element of the analytical outcome. Because ageing is a multidimensional process, the main focus is on the so-called technical aspect of the ageing society as there are many other views on this issue.

4. Research Results, Discussion, and Limitations

The analytical process consists of the two main phases – the cluster analysis that distinguishes the explored countries into the clusters and regression analysis to construct the panel regression models assigned to the particular clusters.

4.1 Cluster Analysis

Several clusters are qualified applying the selected approaches – the Ball-Hall index, the McClain-Rao index, and the point-biserial correlation coefficient. The number of clusters

Tab. 1: The numbers of clusters of the observed countries according to an ageing society

Method	Test statistic	Test statistic value	Clusters
Ball-Hall index	Barycentre mean dispersion	268.8438	3
McClain-Rao index	Denominator	0.6965	3
Point-biserial coefficient	Correlation	0.6613	3

Source: own

representing the ageing society indicators among the observed countries is set up to three (Tab. 1).

The list of most similar and the most dissimilar pairs of countries according to the Euclidean distance values of all the possible pairs of the European Union member countries is summarised in Tab. 2. The six countries create the most similar pairs (Spain, Italy, Latvia, Lithuania, Denmark, and Finland). The most extreme pairs are represented by Spain and Italy. The most similar pair mutually, the nearest one of the explored spans, are created by Latvia and Lithuania in 2012. The five countries represent the most different countries – Netherlands, Bulgaria, Sweden, Latvia, and Lithuania. The most considerable disproportion during the whole observed period is found between the Netherlands and Bulgaria in 2010. Latvia and Lithuania appear on both sides as they created the nearest pair and the outermost pair several times. The similarity of Italy and Spain in the case of the ageing population is observed since 2009 in the analysis. By 2019, these two countries are characterised by the most significant similarity among all the European Union member countries eight times. In recent years, several authors have tested the differences and the similarities between these two countries. Tomassini and Lamura (2009) confirm that Italy and Spain are the countries where the proportion of the older population, the median age of the population, and the ageing index achieve the highest values. The other studies point to the relatively similar informal care from outside the household, while their long-term care public benefits systems are different. Also, these two countries have equal ratios of long-term care

Tab. 2: The most similar and the most dissimilar countries according to an ageing society

Year	Nearest pair of countries			Outermost pair of the country		
	Distance	Country 1	Country 2	Distance	Country 1	Country 2
2009	1.49230	ES	IT	9.02643	NL	BG
2010	1.62560	LV	LT	9.34777	NL	BG
2011	1.85518	ES	IT	9.05030	NL	BG
2012	1.18115	LV	LT	9.14514	SE	BG
2013	1.32540	ES	IT	9.20414	NL	BG
2014	1.22483	ES	IT	8.67009	LV	SE
2015	1.20303	ES	IT	8.85431	NL	BG
2016	1.42708	ES	IT	8.55801	NL	BG
2017	1.58530	DK	FI	8.55027	LV	SE
2018	1.34759	ES	IT	8.52485	LV	SE
2019	1.21543	ES	IT	8.58197	LT	SE

Source: own

public spending as a percentage of the gross domestic product (Courbage et al., 2020). Moreover, the diversity of the Netherlands and Bulgaria is also confirmed. When clustering the European Union member countries according to the indicators based on the active ageing index, the Netherlands are involved in the cluster with the highest performance, while Bulgaria is assigned to the third cluster with the countries that achieve the lower performance (Thalassinos et al., 2019).

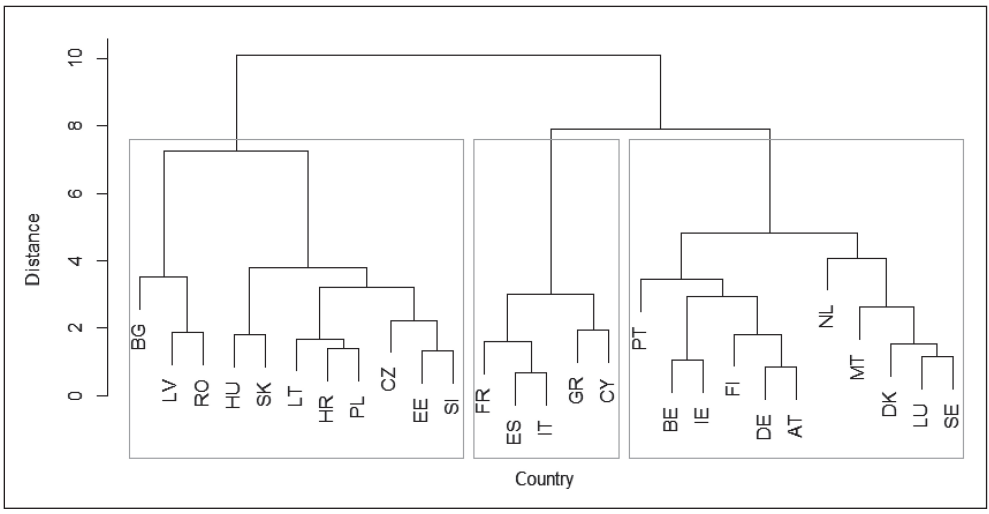
The conditions at the beginning of the analysed period are shown in Fig. 1. The first cluster consists of countries with similar historical backgrounds, namely the Baltic countries, the Visegrad Group countries, and the South-Eastern European countries. A similar situation appears in the second cluster, created by the Mediterranean countries. The third cluster contains mainly the Benelux countries and the Scandinavian countries.

When comparing to the end of the analysed period in 2019, changes in the distribution of clusters are visible in Fig. 2. Homogeneity of the created clusters has disappeared throughout the observed period. Only the Visegrad Group countries have remained in the first cluster. It is probably related to these countries joining the European Union considerably later than the remaining countries in 2004. Assignment of the other countries has dispersed all over the European Union area. The critical dissimilarity is found at the end of the examined period, and hence, the influence of the original grouping of the European Union member countries plays a more important role here.

The summarising scenario is created according to the mean Euclidean distances between the individual countries during the observed period, as shown in Fig. 3. It clarifies the classification of the countries, which are similar in an area of ageing society during the whole observed period. The results of the summarising view underline the importance of the original geographical grouping of the European countries and their neighbourhood. Also, there is a group of the transitive economies visibly related mutually in the first cluster. It does not significantly differ from those at the initial or terminated point of the explored time.

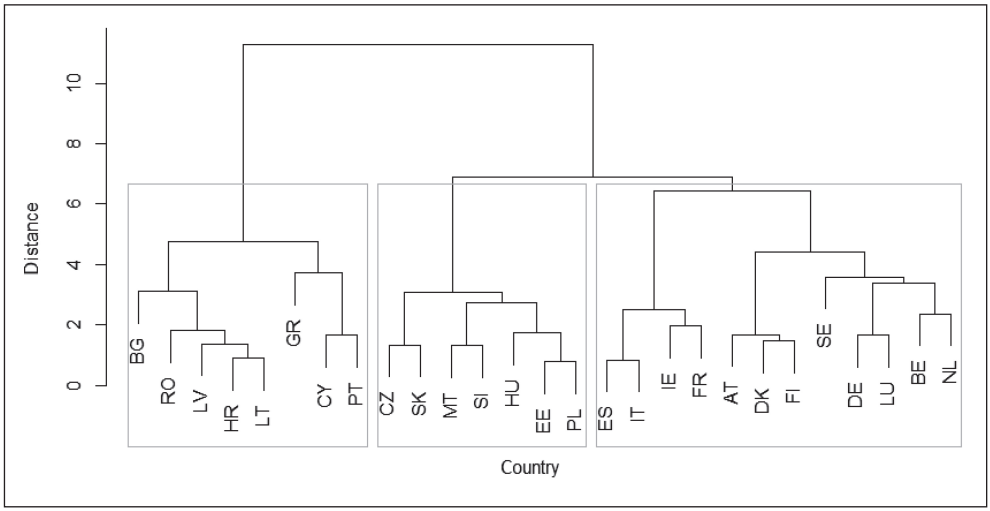
The following heat maps illustrate the similarity between each possible pair of encompassed countries. Each cell is assigned the shade of grey – the darker colour, the more distant pair of the countries. It means such countries were more similar in ageing society indicators. The first heat map visualised a situation at the beginning of the explored period in

Fig. 1: **The dendrogram of ageing society similarity according to the explored countries for the year 2009**



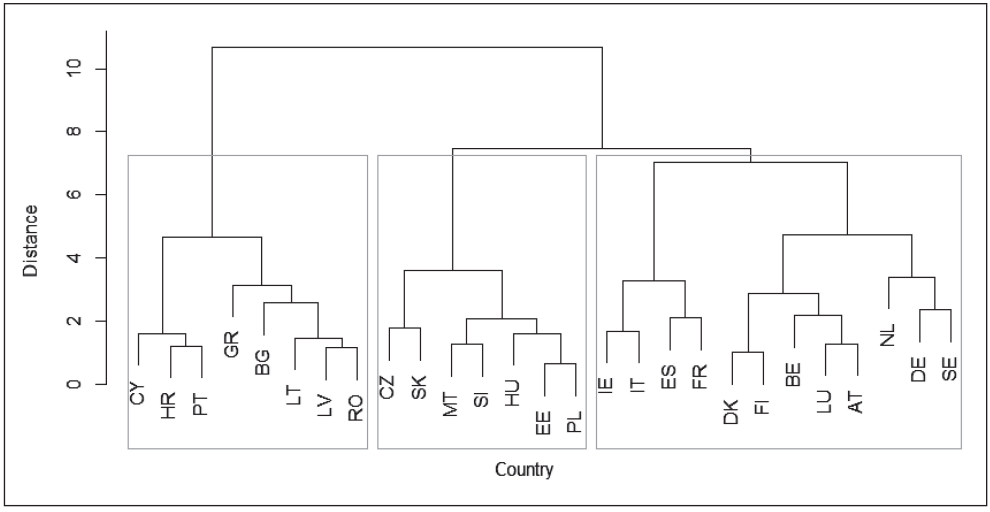
Source: own

Fig. 2: **The dendrogram of ageing society similarity according to the explored countries for the year 2019**



Source: own

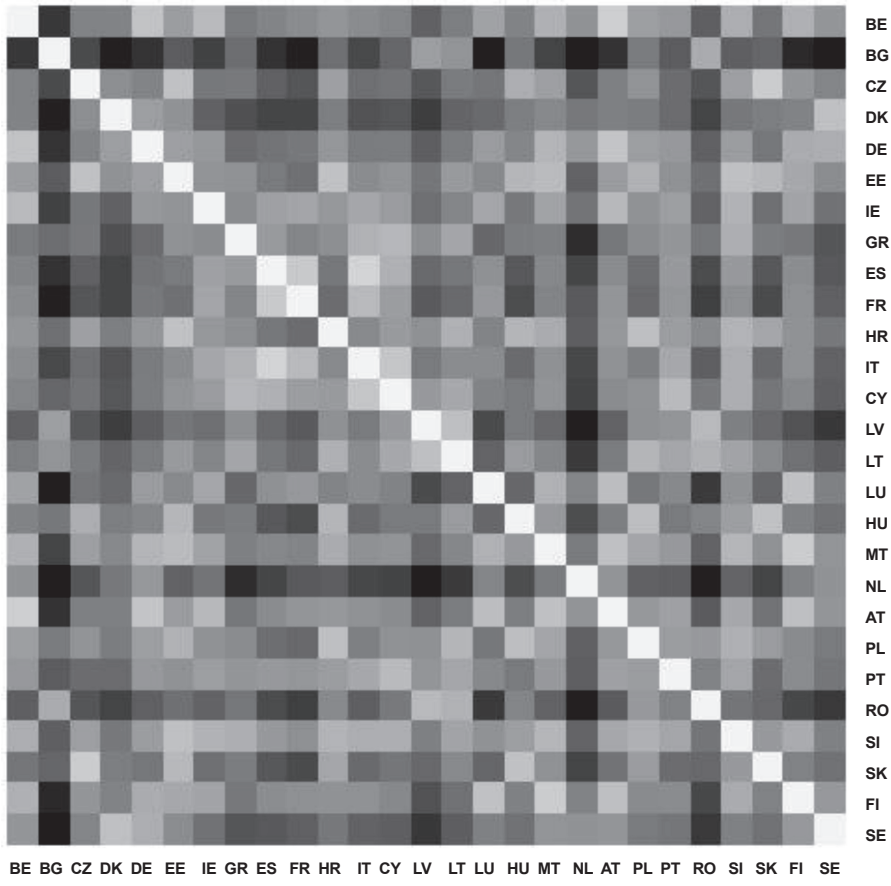
Fig. 3: **The dendrogram of ageing society similarity according to the explored countries for the whole observed period**



Source: own

2009. As it can be seen from the heat map in Fig. 4, there were countries which are in contrast with the other countries – Bulgaria with the average mutual distance to all the other countries (distance 5.40579), Romania (distance 5.01617), and the Netherlands (distance 4.48775).

Fig. 4: **The heat map of the ageing society according to the explored countries for the year 2009**



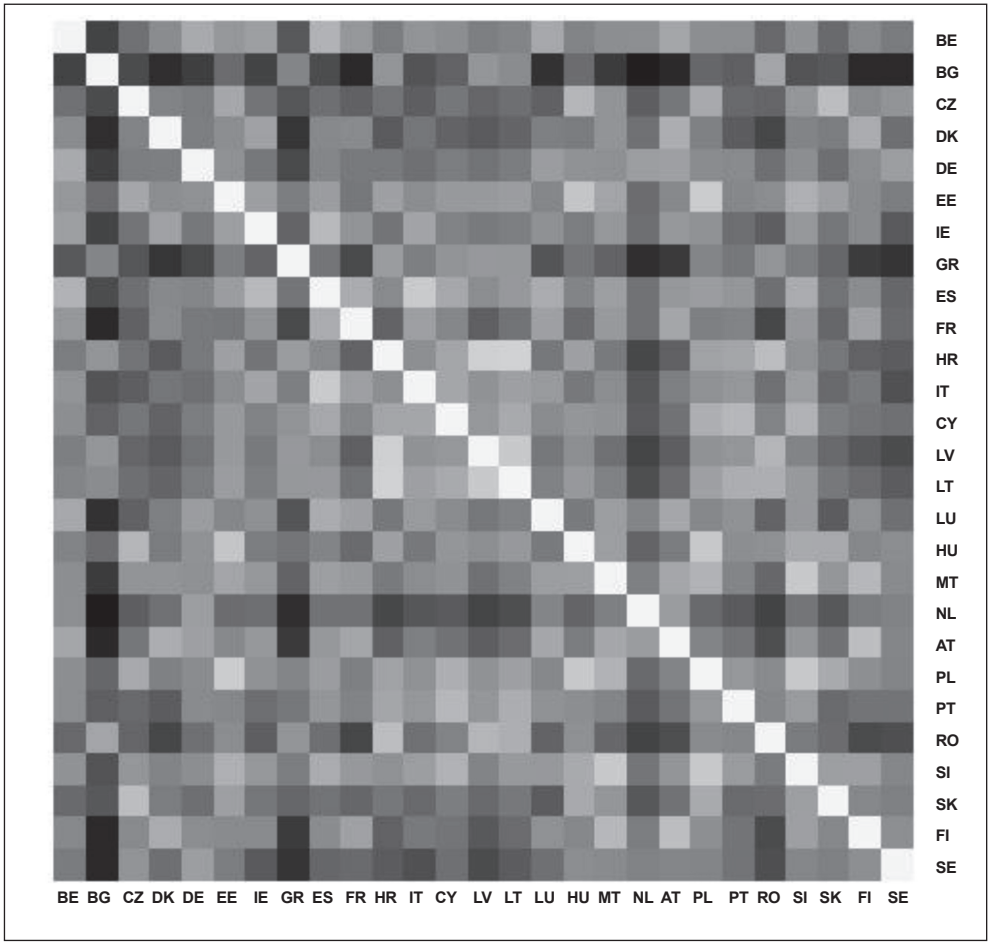
Source: own

The second heat map visualises a situation at the end of the explored period in 2019. Fig. 5 demonstrates the final situation in the analysed area. Bulgaria, with the average mutual distance to all the remaining countries in the data set (distance 5.12743), is the outermost entity, followed by Romania (distance 4.71721), Greece (distance 4.38031), the Netherlands (distance 4.36651), and Latvia (distance 3.74384).

The third heat map visualises a situation according to the mean values of the observed countries for the whole explored period from 2009 to 2019. The final heat map in Fig. 6 demonstrates the average situation of the whole analysed period. The outermost country was Bulgaria. It lies the most distantly at a level of 4.93820 Euclidean units. It is followed by the Netherlands (distance 4.54661), Romania (distance 4.53767), France (distance 4.34287), and the Czech Republic (distance 4.08510).

Each country should aim to accommodate a wide range of elderly population needs related to social security, health assistance, education, housing policy, or social safety. It should be an essential part of public spending in a system investigating to redistribute the resources of a

Fig. 5: **The heat map of the ageing society according to the explored countries for the year 2019**



Source: own

country to reduce income inequality and social exclusion (Quattrociocchi et al., 2020).

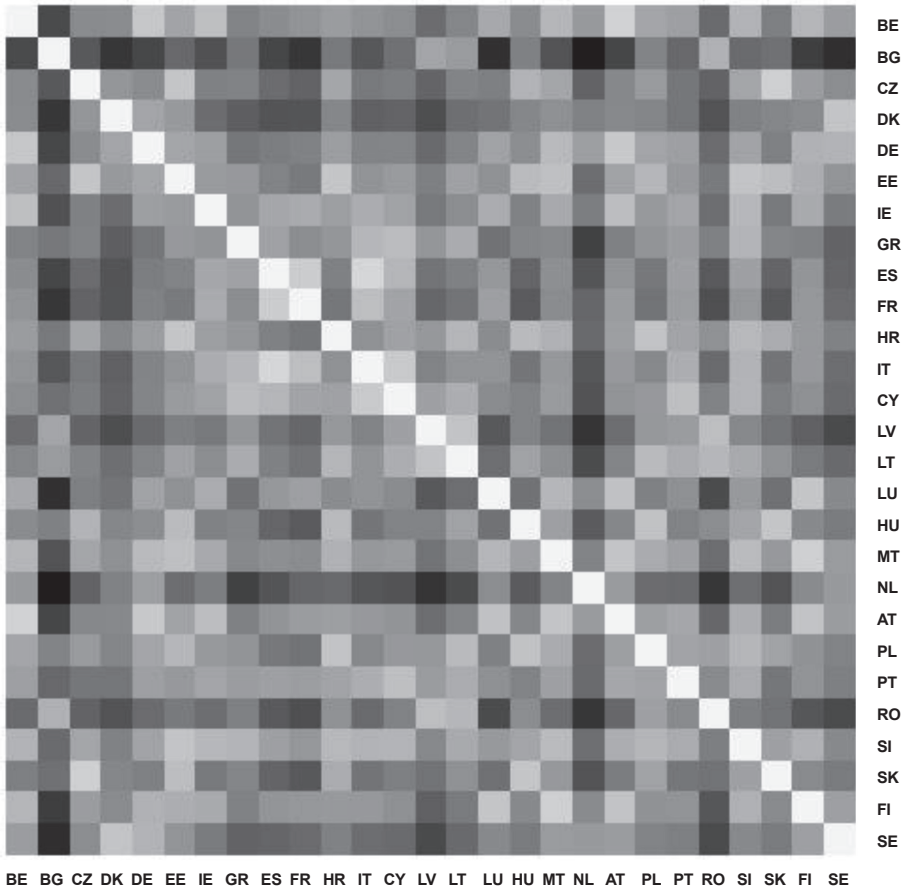
4.2 Panel Data Regression Models

The regression analysis demonstrates the significant associations between the individual explored dimensions.

Tab. 3 visualises the regression coefficients of the variables involved in the first differences regression models with their standard errors and *p*-values. The first data column shows the estimated coefficients of the whole model, followed by particular cluster regression models.

The first notable fact is that five of the explored variables do not appear in the final regression model. The regression analysis variables considered to be not statistically significant are the elderly employment, the disability-free life expectancy, personal health, the health problem limitation, and the social protection expenditure. Tab. 3 consists of the statistically significant variables only for either of the regression models. The three variables are statistically significant for all the regression models: part-time employment, income inequality, and material and social deprivation.

Fig. 6: **The heat map of the ageing society according to the explored countries for the whole observed period**



Source: own

Unusually, these variables possess different signs in the individual clusters, but this confirms the importance of such an analytical procedure. Hence, this supports the successive use of further analytical approaches. Among the remaining parameters, only the life expectancy possesses the same sign for all the clusters. Nevertheless, a potential future analysis could reveal more relations among the explored parameters.

In Tab. 3, the numbers with fewer lower than two functional digits on the first five decimal points are shown in a scientific notation.

According to the altogether regression model, the final composition of the regression models is based on the fact of statistical significance. Successively, the regression models with the exact composition of the regressors were executed. The general overview of the table expresses several effects in the individual clusters. In the four cases, the second cluster possesses an opposite sign as the remaining two clusters. There are the same signs; only a sole variable is life expectancy. The weekly work hours are almost not statistically significant in all the individual cluster regression models,

Tab. 3: The first difference panel linear regression models

Regressor	Value	Altogether	Cluster 1	Cluster 2	Cluster 3
Constant value	Coefficient	−0.05632	−0.40682	0.28973	−0.87946
	Standard error	0.26046	0.21287	0.30222	0.56862
	P-value	0.82896	0.05829*	0.34412	0.12589
PTE	Coefficient	−0.07772	0.22646	−0.24672	0.25343
	Standard error	0.02803	0.07032	0.03052	0.10795
	P-value	0.00593**	0.00163**	1.311×10^{-9}***	0.02137*
LE	Coefficient	1.79946	1.58316	0.42285	4.96893
	Standard error	0.23242	0.21346	0.37745	0.53685
	P-value	1.824×10^{-13}***	1.651×10^{-11}***	0.27001	2.763×10^{-14}***
II	Coefficient	0.90778	1.56197	−1.21407	−2.71574
	Standard error	0.33995	0.26794	0.68710	0.80801
	P-value	0.00803**	4.513 × 10−8***	0.08571*	0.00119**
WWH	Coefficient	−0.30693	0.04146	−0.23721	0.20303
	Standard error	0.06133	0.06591	0.12751	0.14522
	P-value	9.944×10^{-7}***	0.53046	0.07103*	0.16595
NI	Coefficient	−0.00105	−0.00053	−0.00037	0.00032
	Standard error	0.00015	0.00030	0.00014	0.00050
	P-value	6.329×10^{-11}***	0.07835*	0.01172*	0.53813
MASD	Coefficient	0.17358	0.11962	−0.38467	0.57418
	Standard error	0.03348	0.03334	0.17014	0.11119
	P-value	4.169×10^{-7}***	0.00048***	0.02990*	1.73×10^{-6}***
PP	Coefficient	−0.10778	−0.07260	0.50445	−0.10017
	Standard error	0.05355	0.04438	0.08672	0.22110
	P-value	0.04510*	0.10443	1.22×10^{-6}***	0.65175

Source: own

Note: ***$P \leq$ **0.001**; **$p \in$ (**0.001, 0.01**); *$p \in$ (**0.01, 0.1**).

but it is statistically significant in the altogether regression model. The elementary hypotheses are not refused for the mentioned variables that are statistically significant.

Tab. 4 demonstrates the outcome of testing the fundamental assumptions to declare clarity of the estimated regression coefficients.

As seen in Tab. 4, almost all the assumptions meet the requirements stated by the provided tests. The null hypothesis of the Shapiro-Wilk test means that the residuals from the normal probability distribution are dismissed in the altogether regression model and the first cluster regression model, whilst the origin of the residuals of the second cluster regression model and the third cluster regression model is not rejected. The serial correlation inspected by the Durbin-Watson statistic shows no presence in all the regression models as its null hypothesis states the regression model without serial correlation is not rejected. Finally, the White test also possesses the same result in all the cases, that is, rejection of the null hypothesis expressing that error variance is equal for the whole

Tab. 4: Testing outcome

Test	Value	Altogether	Cluster 1	Cluster 2	Cluster 3
Shapiro-Wilk test	Test statistic	0.9866000	0.9540000	0.9740000	0.9861000
	P-value	0.0093780	0.0002066	0.4144000	0.4725000
Durbin-Watson statistic	Test statistic	2.6025000	2.6773000	2.8716000	2.2525000
	P-value	1.0000000	1.0000000	0.9995000	0.9290000
White test	Test statistic	20.678000	20.500000	10.7240000	57.1660000
	P-value	3.234×10^{-5}	3.536×10^{-5}	0.004692	3.86×10^{-13}

Source: own

Tab. 5: Multicollinearity testing

Variable	Altogether	Cluster 1	Cluster 2	Cluster 3
PTE	2.511528	2.964859	5.128456	4.722094
LE	3.576185	3.426138	2.144480	2.593588
II	1.987517	3.414904	2.376383	1.915993
WWH	3.529132	4.370734	4.695865	3.060295
NI	1.965843	1.676250	2.423342	3.494627
MASD	6.517149	7.298859	4.958214	6.021108
PP	3.958510	5.712361	5.821688	5.624345

Source: own

time series resulting in the opposite relationship between the explanatory variable change and the error variance.

The final testing process step is related to investigating the presence of multicollinearity in the regression models as visualised in Tab. 5.

Only the two variables in Tab. 5 overstep the critical region threshold at a level of 5. They are the material and social deprivation and the at-risk-of-poverty population. In the first case, the second cluster regression model fulfilled the threshold, and the latter case of the altogether regression model met this requirement. The remaining cases of these variables showed the presence of multicollinearity. All the other variables were free of multicollinearity in all the explored regression models.

Tab. 6 demonstrates the ratio of the regression coefficients assigned to the individual clusters regression models to the altogether regression model. It shows the relative intensity of the relation between the cluster and a whole.

Tab. 6 demonstrates the ratios, and hence, the signs could be omitted. They only express an arithmetical direction of the specific relation. The constant value was statistically insignificant except for the first cluster regression model, which was excluded from the subsequent comparison. The highest multiplication was seen in the case of the at-risk-of-poverty population in the second cluster regression model. From an indicator perspective, part-time employment is the most interesting as the second cluster performs oppositely as the remaining clusters regression model. It should be a subject of further research activities. Oppositely, the at-risk-of-poverty population behaves also differently. This regressor influences the second cluster much more than the remaining clusters.

Moreover, an arithmetic direction is reverse. The weekly work hours and the net income perform the most similar to the altogether model. Although the lowest change is at a level of 13.51% in weekly working hours and a level

Tab. 6: The estimated coefficient ratios of the individual clusters regression models to the base altogether regression model

Regressor	Cluster 1	Cluster 2	Cluster 3
Constant value	7.22303	−5.14411	15.61458
PTE	−2.91391	3.17458	−3.26092
LE	0.87980	0.23499	2.76135
II	1.72066	−1.33742	−2.99165
WWH	−0.13508	0.77286	−0.66151
NI	0.49935	0.35239	−0.29549
MASD	0.68917	−2.21614	3.30795
PP	0.67357	−4.68029	0.92933

Source: own

of 29.55% in net income, these values can be considered noteworthy still.

Tab. 7 illustrates the overall statistical significance of the constructed regression models through the coefficient of determination together with its adjusted form.

The achieved levels of the coefficient of determination are high enough to interpret the estimated regression coefficients. The base altogether regression model explains the lowest portion of the data variability. It is understandable as it needs to cover all the explored countries, whilst the individual clusters regression models cover only a partial area. Nevertheless, almost a third of the whole data set variability represents still an undeniable value. The second cluster regression model is the most potent interpretation, followed by the first and third cluster regression models. The values of the adjusted version of the *p*-values were all lower.

As each study possesses potential limitations, also this investigation bears a few ones. Firstly, from a theoretical point of view, this is not the final analytical outcome. It represents the introduction to the further investigative steps instead. The explored area can serve as a suitable subject to examine. Secondly, a selection of the input variables is based on the previously carried out researches. An update done in this field according to the results of the current regression models can enhance the coverage of the analytical outcome. Thirdly, a methodological aspect is essential as a succession of the performed steps can influence the analytical outcome in a certain way. For instance, the contrary view could be employed to execute the individual regression models for the separate clusters. Finally, the altogether model would contain only the statistically significant variables from either the partial regression model or all the regression models concurrently. Last but not least, a view of the externalities possibly affecting the involved dimensions and their relations to them is also an interesting point. To sum it all up, many other aspects are ready to be investigated.

Tab. 7: Statistical significance of the models

Type	Coefficient of determination	Adjusted coefficient of determination
Altogether model	0.33863	0.32197
Cluster 1 model	0.78836	0.77642
Cluster 2 model	0.87866	0.85507
Cluster 3 model	0.71540	0.69050

Source: own

Conclusions

Population ageing is a common experience of all the European Union member countries, and there are several differences among them from a perspective of the involved indicators. These are noticeable whether they are the health indicators, the labour conditions for the elderly population, or the financial security for pension in each country. This paper investigates the ageing process in the European Union and the differences and similarities between the selected countries. The similarity of the countries is assessed through seven statistically significant indicators belonging to the characteristics of the society. The focus is on the age group of 55+ as it represents the elderly population group that is disadvantaged from a perspective of age. The quantitative methods are applied using cluster analysis and sensitivity analysis. It was found that the most similar pairs of the countries during the observed period were Latvia with Lithuania and Italy with Spain. On the contrary, the most considerable disparities were found in the case of Bulgaria and the Netherlands. The Visegrad Group member countries and the Baltic countries keep their positions in the first cluster during the whole explored period. Also, the Scandinavian countries were localised in the third cluster for the whole explored period. It suggests that similar trends within the population ageing have long been presented in the given geographical areas. The panel regression model also demonstrates that not all the variables are statistically significant in the individual cluster of panel data regression models. The statistically significant ones are the part-time employment, the life expectancy, the income inequality, the weekly work hours, the net income, the material and social deprivation, and the at-risk-of-poverty population. They are all assigned to the age group of 55 years of age and over. Only the three of them, which the part-time employment, the income inequality, and the material and social deprivation belong among, are significant in all the regression models for the whole area and the three clusters. The obtained results could serve as a resource for the research and the national policies focused on the quality of life and the living conditions of the elderly population as it can help them to identify the objectionable determinants and to implement the appropriate measures in order to improve the situation and position of this population group.

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