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SPATIAL DIFFERENTIATION OF THE ELDERLY POPULATION IN POLAND'S VOIVODESHIPS IN THE YEARS 2000-2016[1]

Summary

Purpose – The aim of this paper is to analyse the direction and pace of changes in the segment of people in identified age groups within the overall population of Polish voivodeships during the years 2000-2016 with the use of rates that describe demographic ageing phases. The analysis presents changes in the structure of the population aged 60 and -more from a regional perspective. In this structure, three age groups were distinguished: 60-74 years, 75-84 years and 85 and over.

Research method – The analysis was carried out using the demographic ageing rate, coefficients representing the old age phase, sigma-convergence analysis based on the coefficient of variation and Ward's non-linear clustering method. Data from the Local Data Bank of the Central Statistical Office were used for analyses. The data was analysed in a static approach for the selected years 2000, 2010 and 2016 and in dynamic terms for the years 2000-2016.

Results – The results of the analyses show that the changes taking place in the population ageing process have different intensity in individual voivodeships. During the analysed period, the process of population ageing can be observed in all voivodeships (a growing percentage of people aged 60 and more in the total population). There are also changes in the age structure of the population in the indicated groups of demographic ageing. Gradual spatial convergence of the country with respect to the components of the structure of the elderly is evident.

Keywords: ageing process, old age indicators, regional differentiation, silver economy

JEL Classification: J11, C40

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1. Introduction

For many years, in Poland as well as all over Europe, a population ageing process has been observed, which may be defined as an increase in the number and the share of people aged 60 (WHO) or 65 (UN, Eurostat) and more(the elderly) in the total population. The literature on the subject recognises numerous measures and classifications of the population ageing advancement process. The most frequently applied measures are classical ones, based on population structure broken down by biological age groups (0-14, 15-64, 65 and more) or working age groups (0-14, 15-59, 60 and more), i.e. the demographic ageing rate (DAR), the ageing index, demographic dependency ratios, the young-age dependency ratio, the old-age dependency ratio and generational support ratios [Clarke, 1965; Kowaleski, 2011; Długosz, 1998; Kurek, 2008; Roszkowska, 2018]. The analysis of the degree of demographic ageing and the population ageing process also relies on statistical measures, such as median, deciles, quartiles, the Gini coefficient of concentration, the synthetic age structure index and the coefficient of skewness [Cieślak, 2004; Abramowska-Kmon, 2011; d'Albis, Collard, 2013]. Remaining measures include the measure of relative ageing gap, the index of dissimilarity and the method of structure similarities [Podogrodzka, 2014; Roszkowska, 2018].

The demographic process of population ageing in Poland is associated with changes in the number and structure of the elderly. In individual Polish voivode-ships the process occurs at a different pace. Several works have been dedicated to an analysis of the process of Poland's population ageing from a regional perspective [Wasilewska, 2017; Podogrodzka, 2014, 2016a, 2016b; Potrykowska, 2003; Wolań-ska, 2013; Kowaleski, 2011]. Such research mainly focuses on the assessment of spatial differentiation in population structure by age and gender, broken down by biological or working age groups.

It should be considered, however, that the elderly population is not uniform. This group of people may be divided into categories that reflect the level of their activity, which determines the spectrum of their needs (e.g. groups aged 60-74, 75-84, 85 and more). The literature on the subject does not include studies dedicated to spatial differentiation of Poland's voivodeships in terms of age structure of the elderly population, i.e. taking account the share of the population in identified groups of the elderly, nor the pace or direction of these changes over time. Neither has the published foreign language literature to date analysed the subject of regional differentiation or analysis of convergence (divergence) of territorial units within the scope of identified age groups of the elderly. Despite the fact that the progressing society ageing process and its consequences on the social security system, seniors' income or the labour market have been a subject of analyses carried out for many years, for example in the European Union, the subject defined in this paper, namely in-country age differentiation of the elderly, has been disregarded [e.g. *Population ageing in Europe Facts…*, 2014; Crespo et al. 2016].

The results of such analysis may be particularly useful in developing adequate regional social policies. They should be reflected in a differentiated policy, pursued

by local and central governments and entities operating within the market, which is directed at satisfying the needs of the elderly, depending to the ageing stage. People aged 60 have significantly different requirements than people aged 75 or 85.

This became an impulse to take up this subject. The main aim of this paper is to present the pace of change in the demographic ageing process, regional differentiation of the age structure of the elderly population in identified groups of the elderly in the total population during the years 2000-2016, and assessment of similarity of voivodeship structures of the elderly population. This article attempts to answer the following questions:

1. Are Poland's voivodeships differentiated in terms of the degree of demographic ageing advancement?
2. Can we observe an increase or a decrease in the differentiation of Poland's voivodeships in terms of the age structure of the elderly?
3. Is the clustering of Poland's voivodeships by age structure of the elderly stable or varying over time?

The old age threshold was adopted at the level of 60 years of age and age ranges of the elderly were distinguished, taking into account three old age phases [*Raport na temat sytuacji osób…*, 2012]: the young old (YO) – people aged 60-74, the old old (OO) – people aged 75-84, the oldest old (ODO) – people aged 85 and more. In order to determine the scope of regional differentiation of demographic ageing advancement in Poland, a conventional ageing rate was used, which expresses the ratio of population aged 60 and more to the total population [*Raport na temat sytuacji osób …*, 2012] and three ratios of: young old, old old and the oldest old, which take into account the ageing phases.

The analysis relies on annual data for voivodeships derived from the Local Data Base of the Central Statistical Office (GUS) [www 2]. The data were analysed in a static approach for selected years: 2000, 2010, 2016 and in dynamic terms for the period 2000-2016. The analysis was carried out using the demographic ageing ratio, coefficients representing the old age phase, the sigma-convergence analysis based on the coefficient of variation and Ward's non-linear clustering method.

2. Population ageing stages (phases)

Ageing of an individual is a process which may be analysed from biological, psychological and a social perspective. The basic characteristics of an individual's ageing are: the significant decrease of an individual's adaptation capacity in biological and psycho-social dimension, the progressing reduction of independence in living, and the gradual intensification of dependency on the environment. Thus, an analysis of the number of those people, but also of the age structure in that population group is significant from the perspective of recognising and planning actions for the elderly. Differentiated age structure of the elderly determines the scope and structure of their different needs, which should be satisfied to a large extent by public sector institutions.

The complexity of the population ageing processes (especially in the aspect of an individual's ageing) makes it difficult to unambiguously determine the beginning and the phases of ageing. Representatives of various disciplines define old age stages and the moment it starts in different ways. Typically, the assumption is that the beginning of old age happens at the age of 60 or 65, as it is the moment of discontinuing professional activity – achieving the age of retirement. The elderly population is usually divided into several age groups which reflect the degree of their activity affecting the scope of their needs. Several approaches to defining ageing phases can be found in the literature. For example, Dzienino considers the period of "initial ageing as the age of 60 to 69, the interim age between initial ageing and the age of limited fitness – between 70 to 74 years of age, advanced ageing from 75 to 84 years of age, and infirm ageing from the age of 85 and more" [Szatur – Jaworska et al., 2006]. In the first identified period, referred to as the period of initial ageing (elderly age), people maintain considerable fitness, they are often professionally or socially engaged and usually do not require assistance. The period between 75 and 84 years of age is referred to as advanced age (old age), when often significant limitation of all activity and substantial fitness reduction occur and problems with engaging in daily activities intensify. Persons of that age frequently require assistance and care. The age above 85, however, may be referred to as infirmity (longevity). Persons in this age group usually require continuous care and assistance in their basic, daily activities.

According to the World Health Organisation, three ageing stages may be distinguished [www 1]:
1. Early ageing, which starts at the age of 60 and continues until 74 years of age,
2. Intermediate ageing (75-89),
3. Late ageing or longevity (according to gerontologists) starts at the age of 90 and continues until death.

Ageing phases identification has been evolving over time. It is strictly dependent on various conditions that particularly affect extending both life expectancy, average lifetime of the population as well as healthy life expectancy. An analysis of seniors' age structure according to defined ageing phases seems significant from the perspective of their needs and the degree of satisfying the same, especially given the fact that significant change has been taking place in the share of people in identified age groups of the elderly population. An analysis of the population ageing process, considering seniors' age structure, creates better grounds for planning and organising the provision of goods and services to satisfy their needs, both by the public and the private sector. This specifically applies to healthcare and social care organisations.

For the purposes of this paper, the ageing threshold was adopted at 60 years of age, and subgroups of the elderly were identified taking into consideration three ageing phases[2] [*Raport na temat sytuacji osób…,* 2012; compare: Abramowska-Kmon, 2011]:

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[2] Taking into account the regulations included in the Act on the Elderly of 15 September 2015.

- the young old (YO) – persons aged 60-74, who most often are still fully physically and psychologically capable,
- the old old (OO) – persons aged 75-84, who usually require assistance with some everyday activities such as shopping, cleaning, making laundry,
- the oldest old (ODO) – persons aged 85 and more, who need continuous assistance with most of their activities; these are potential customers of institutionalised forms of assistance.

3. Methods of analysis

In order to address the first research question, for the purposes of assessing Poland's voivodeship differentiation in terms of demographic ageing process advancement, the **demographic ageing rate** DAR_t was adopted as the basic measure which defines the share of people aged 60 and more in the overall population in period t, i.e.

$$DAR_t = \frac{P_t(+60)}{P_t} \, 100\% \tag{1}$$

$P_t(+60)$– population aged 60 and more in period t
P_t – population in period t
t – period covered by the study $(t = 2000, ...,2016)$

In order to address the second research question, the conventional ageing rate was decomposed, in order to identify the ratios corresponding to identified ageing phases:

- the young old ratio (YOR), which describes the share of the young old in the population:

$$YOR_t = \frac{P_t(60-74)}{P_t} \cdot 100\% \tag{2}$$

- the old old ratio (OOR), which describes the share of the old old in the population:

$$OOR_t = \frac{P_t(75-84)}{P_t} \cdot 100\% \tag{3}$$

- the oldest old ratio (ODOR), which describes the share of the oldest old in the population:

$$ODOR_t = \frac{P_t(+85)}{P_t} \cdot 100\% \tag{4}$$

where:

$P_t(60-74)$ – population aged 60-74 in period t
$P_t(75-84)$ – population aged 75-84 in period t
$P_t(+85)$ – population aged 85 and more in period t
P_t – population in period t
t – period covered by the study ($t = 2000, ...,2016$).

They were used as the basis for assessment of voivodeship differentiation in terms of the share of people in identified subgroups of the elderly and its changes over time. Additionally, in order to determine the tendencies of changes in the share of people in identified subgroups of the elderly for Polish voivodeships, sigma-convergence analysis was applied, which consists in evaluation of dispersion of the examined phenomenon over time[3]. Sigma-convergence evaluation required assessing the measure of disparity of the phenomenon in subsequent periods under analysis. For the purpose of analysis, a statistical measure of sigma-convergence was selected, i.e. coefficient of variation [Laskowska, 2012, pp. 90-91; Kusideł, 2013]:

$$V_t = \frac{s_t}{\bar{y}_t} \tag{5}$$

where: s_t – standard deviation of examined variable in time (a year) t, $\bar{y}_t$ – average level of variable y in time t for $i = 1, ..., n$ – number of variables. In order to verify occurrence of regional *sigma*-convergence in terms of demographic ageing rate, young old, old old and the oldest old, a linear model was set for the value of coefficient of variation for these ratios, in conformity with the following formula (6).

$$V_t = \alpha_0 + \alpha_1 t + \varepsilon_t \tag{6}$$

where: α_0, α_1 – equation parameters, ε_t – random equation component, t – time variable ($t = 1, ..., T$). *Sigma* convergence occurs when equation parameter α_1 is negative and statistically significant [Kusideł, 2013].

In order to address the third research question, voivodeships have been classified based on Ward's agglomerative hierarchical clustering procedure, which is a non-linear method of clustering multi-feature objects [Wójcik, 2009]. The Ward's method enabled dividing Poland's voivodeships into clusters of regions which were most similar to one another within the clusters in terms of the above discussed demographic ageing rates, and the ones that were most differentiated. The clusters created using the Ward's method are characterised by minimal within-cluster variance. The results of such clustering were compared for the years 2000, 2010 and 2016.

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[3] More about convergence analysis [Kusideł, 2013, p. 63].

4. Regional differentiation of Poland's voivodeships
in the years 2000-2016 in terms of demographic ageing rate

Selected statistics that characterise inter-regional differentiation of demographic ageing rate are presented in table 1.

TABLE 1

Inter-regional differentiation of demographic ageing rate
in the years 2000-2016

DAR_t (in %)	Range	Mean	Standard deviation	Coefficient of variation
2000	4.38	16.62	1.46	8.79
2001	4.30	16.74	1.44	8.60
2002	4.21	16.80	1.41	8.38
2003	4.18	16.85	1.40	8.31
2004	4.17	16.93	1.42	8.38
2005	4.20	17.01	1.43	8.43
2006	4.52	17.39	1.40	8.04
2007	4.63	17.86	1.37	7.67
2008	4.67	18.39	1.33	7.22
2009	4.58	18.93	1.27	6.72
2010	4.58	19.43	1.24	6.40
2011	4.55	20.10	1.24	6.16
2012	4.51	20.76	1.24	5.98
2013	4.51	21.44	1.26	5.88
2014	4.43	22.13	1.28	5.77
2015	4.32	22.84	1.30	5.69
2016	4.20	23.52	1.33	5.64

Source: own elaboration based on: [www 2].

The ageing rate values in the regions during the years 2000-2016 range from 4.17% in 2004 to 4.67% in 2008. A continuous tendency of reducing inter-regional differentiation in terms of the share of people aged 60 and more in the total population can be observed (table 1). In the period covered by the analysis, the share of these people in Poland increased by 6.9 percentage points, with the greatest increase in the Zachodniopomorskie voivodeship (8.94 percentage points) and the smallest increase in the Podlaskie voivodeship (3.03 percentage points). In the years 2000-2016 all voivodeships experienced an increase, although with a different intensity, in the share of people aged 60 and more in the population. The highest percentage of the elderly in 2000 is a characteristic of the Lubelskie, Łódzkie, Świętokrzyskie, Mazowieckie and Podlaskie voivodeships (above 18%), while in 2016 – of the Łódzkie, Świętokrzyskie, Śląskie, Dolnośląskie voivodeships (above 24%). The smallest share of the elderly in 2000 was recorded in the Lubuskie and

Warmińsko-Mazurskie voivodeships (below 14%), and in 2016 in the Warmińsko-Mazurskie and Podkarpackie voivodeships (below 22%). The difference between the biggest and the smallest share during the period covered by the study for Poland amounts to 6.77 percentage points.

Changes may be observed in spatial presentation of the demographic ageing rate in Poland (Fig. 1). In 2000, the voivodeships characterised by high ageing rate values were predominantly situated in the eastern part of the country, and by the lowest values in the north-western part of the country. In 2016, the increase of the ageing rate value, compared to 2000, was the fastest in northern and south-western Poland, and the slowest in the eastern and central part of the country. Zachodniopomorskie, Lubuskie and Śląskie are among voivodeships which experienced the most intense demographic ageing in the years 2000-2016. The process of population ageing in that period was the slowest in the Podlaskie and Mazowieckie voivodeships (compare: table 1). In 2016, Łódzkie, Świętokrzyskie, Śląskie and Dolnośląskie could be classified as demographically oldest voivodeships.

CHART 1

Division of Poland's voivodeships into classes based on the percentage of people aged 60 and more – years 2000, 2010, 2016
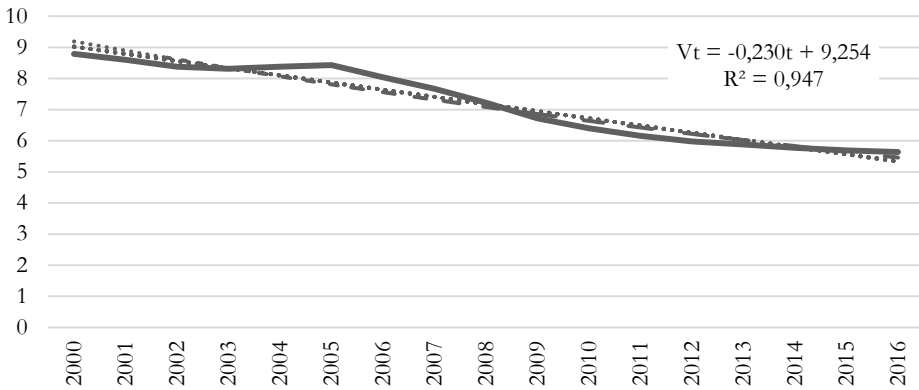

Source: own elaboration based on: [www 2].

The results of inter-voivodeship sigma-convergence analysis of the DAR variable, considering the trend model for coefficient of variation of that variable, are presented in chart 2.

CHART 2
Graphic presentation of sigma-convergence analysis results for the DAR variable in the years 2000-2016 – coefficient of variation

Source: own elaboration based on: [www 2; compare table 1].

The results of assessment of sigma-convergence regression model for the DAR variable are presented in table 2.

TABLE 2
The results of assessment of sigma-convergence regression model parameters for DAR variable – in the years 2000-2016

Model		Non-standardised coefficients		Standardised coefficients	t	Significance
		α_1	Standard error	α_1		
Dependent variable V_t	(Constant)	9.254	0.144		64.139	0.000
	Time (t)	-0.230	0.014	-0.973	-16.366	0.000

Source: own elaboration based on: [www 2].

The slope of the trend line on the chart, negative and statistically significant value of parameter α_1, confirm the existence of regional convergence for the DAR variable. This means that disparities in the share of people aged 60 and more in the total population for Polish voivodeships show a declining tendency over time.

5. Differentiation of Poland's voivodeships in the years 2000-2016 in terms of the young old ratio

The basic statistical measures which describe inter-regional differentiation of the young old ratio (YOR) in Poland, in the years 2000-2016 are presented in table 3.

TABLE 3

Inter-regional differentiation of the young old ratio in the years 2000-2016

YOR_t (in %)	Range	Mean	Standard deviation	Coefficient of variation
2000	2.37	12.15	0.89	7.30
2001	2.31	12.07	0.88	7.28
2002	2.23	11.94	0.86	7.16
2003	2.33	11.77	0.86	7.31
2004	2.52	11.62	0.87	7.50
2005	2.59	11.45	0.87	7.59
2006	2.59	11.61	0.81	6.97
2007	2.72	11.87	0.79	6.61
2008	2.80	12.25	0.76	6.23
2009	2.75	12.64	0.74	5.82
2010	2.80	13.04	0.77	5.90
2011	2.83	13.54	0.80	5.91
2012	2.85	14.07	0.84	5.97
2013	3.02	14.62	0.89	6.10
2014	3.17	15.19	0.94	6.19
2015	3.38	15.81	1.00	6.29
2016	3.46	16.43	1.04	6.34

Source: own elaboration based on: [www 2].

Obtained YOR values for the years 2000-2016 fit within the range [2.23%; 3.46%]. An analysis of YOR coefficient of variation shows insignificant fluctuations: a decrease in the period 2000-2002 and 2006-2009, and an increase in the period 2003-2005 and 2010-2016 (table 3). This means that in the last years covered by the analysis the level of voivodeships differentiation in terms of YOR had been slightly increasing. In 2016, compared to 2000, it increased in all voivodeships, although at a different pace. The share of people aged 60-74 in the total population in Poland increased by 4.21 percentage points, with the greatest increase in the Zachodnio-pomorskie voivodeship (6.14 percentage points), and the smallest increase in the Podlaskie voivodeship (2.19 percentage points). The highest percentage of people in this age group covered by the analysis in 2000 is a characteristic of the Łódzkie, Mazowieckie, Świętokrzyskie voivodeships (above 13%), while in 2016 of the Dolnośląskie, Łódzkie, Zachodniopomorskie voivodeships (above 17.5%). The

smallest share of people aged 60-74 in 2000 was recorded in the Lubuskie, Wielko-polskie, Warmińsko-Mazurskie voivodeships (below 10%), and in 2016 in the Małopolskie and Podkarpackie voivodeships (below 15%).

Changes in the spatial process of population ageing in Poland's voivodeships were observed in identified youngest group of the elderly (chart 3).

CHART 3

Division of Poland's voivodeships into classes based on the percentage of people aged 60-74 – years 2000, 2010, 2016
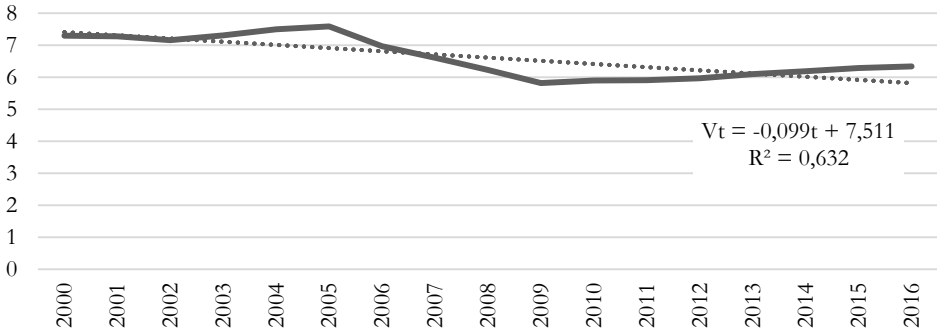

Source: own elaboration based on: [www 2].

In 2000, voivodeships characterised by the biggest share of that group of people were predominantly situated in the eastern and south-eastern part of the country, and by the smallest share – in the north-western part of the country. The values of the young old rate in the years 2000-2016 had been increasing most rapidly in the north-western and least rapidly in the eastern and central part of Poland. Among voivodeships with the fastest YOR growth rate are Zachodniopomorskie and Lubuskie, while the Podlaskie and Małopolskie voivodeships have the slowest YOR growth rate. In 2016 the group of voivodeships with the highest interest of people aged 60-75 people was joined by the Zachodniopomorskie and Dolnośląskie voivodeships, and the lowest percentage of the young old was recorded in the Mało-polskie and Podkarpackie voivodeships.

The results of inter-voivodeship sigma-convergence analysis of the YOR variable, considering the trend model for coefficient of variation of that variable, are presented in chart 4.

CHART 4

**Graphic presentation of sigma-convergence analysis results for the
YOR variable in the years 2000-2016 – coefficient of variation**

$$V_t = -0{,}099t + 7{,}511$$
$$R^2 = 0{,}632$$

Source: own elaboration based on: [www 2; cf. table 3].

The results of assessment of sigma-convergence regression model for the YOR variable are presented in table 4.

TABLE 4

**The results of assessment of sigma-convergence regression model
parameters for the YOR variable – in the years 2000-2016**

Model		Non-standardised coefficients		Standardised coefficients	t	Significance
		α_1	Standard error	α_1		
Dependent variable V_t	(Constant)	7.511	0.201		37.414	0.000
	Time (t)	-0.099	0.020	-0.795	-5.076	0.000

Source: own elaboration based on: [www 2].

Negative and statistically significant value of parameter α_1 indicates regional convergence for the YOR variable. This means that the differences in the proportion of people aged 60-74 in the total population for Polish voivodeships show a declining tendency over time.

6. Differentiation of Poland's voivodeships in the years 2000-2016 in terms of the old old ratio

The basic statistical measures, which describe the differentiation of Poland's voivodeships in the years 2000-2016 in terms of the old old ratio (OOR), are presented in table 5.

Inter-regional differentiation in terms of the old ratio in the years 2000-2016

OOR_t (in %)	Range	Mean	Standard deviation	Coefficient of variation
2000	1.58	3.57	0.51	14.28
2001	1.59	3.79	0.52	13.71
2002	1.59	4.02	0.53	13.28
2003	1.56	4.26	0.54	12.76
2004	1.55	4.45	0.56	12.59
2005	1.52	4.65	0.57	12.22
2006	1.53	4.81	0.58	12.01
2007	1.51	4.92	0.58	11.69
2008	1.45	4.98	0.56	11.15
2009	1.46	5.04	0.54	10.78
2010	1.41	5.06	0.52	10.21
2011	1.42	5.13	0.51	9.85
2012	1.39	5.18	0.49	9.48
2013	1.35	5.20	0.49	9.34
2014	1.34	5.21	0.48	9.22
2015	1.45	5.20	0.49	9.35
2016	1.55	5.16	0.49	9.50

Source: own elaboration based on: [www 2].

The value of the ratio covered by the analysis in the years 2000-2016 ranges from 1.34% in 2014 to 1.59% in the years 2001-2002 (table 4). Inter-voivodeship differentiation in terms of OOR in the period covered by the study had decreased. The share of people aged 75-84 in the total population in Poland increased by 1.55 percentage points, with the greatest growth in Śląskie (2.47 percentage points) and Opolskie voivodeships (2.92 percentage points), and the smallest growth in Wielkopolskie (1.05 percentage points) and Łódzkie voivodeships (1.06 percentage points). The highest percentage of people aged 75-84 in 2000 is a characteristic of the Łódzkie voivodeship (4.5%), while in 2016 – of the Opolskie voivodeship (6.01%). The smallest share of people in that age group in 2000 was recorded in the Warmińsko-Mazurskie voivodeship (2.92%), and in 2016 in the Wielkopolskie voivodeship (4.47%).

Similarly, as in the case of the above discussed ratios, there are differences in the spatial ageing process between Poland's voivodeships, due to an increasing share of people aged 75-84 (chart 5).

CHART 5

**Division of Poland's voivodeships into classes based on the percentage
of people aged 75-84 – years 2000, 2010, 2016**

Source: own elaboration based on: [www 2].

In 2000, voivodeships characterised by high OOR values were predominantly situated in the eastern and south-eastern part of the country, and by the lowest OOR values – in the north-western part of the country. Voivodeships which experienced the greatest increase in the share of people in the age group covered by the analysis in the years 2000-2016 include Opolskie and Śląskie, which in 2016 joined the group of voivodeships with the biggest share of people aged 75-84. The lowest OOR increase in the period covered by the study was recorded in the Łódzkie, Lubelskie and Mazowieckie voivodeships. A voivodeship with the lowest share of people in the analysed age group in 2016 is Wielkopolskie.

The results of inter-voivodeship sigma-convergence analysis of the OOR variable, considering the trend model for coefficient of variation of that variable, are presented in chart 6.

CHART 6

**Graphic presentation of sigma-convergence analysis results for the OOR
variable in the years 2000-2016 – coefficient of variation**

$$V_t = -0{,}329t + 14{,}222$$
$$R^2 = 0{,}961$$
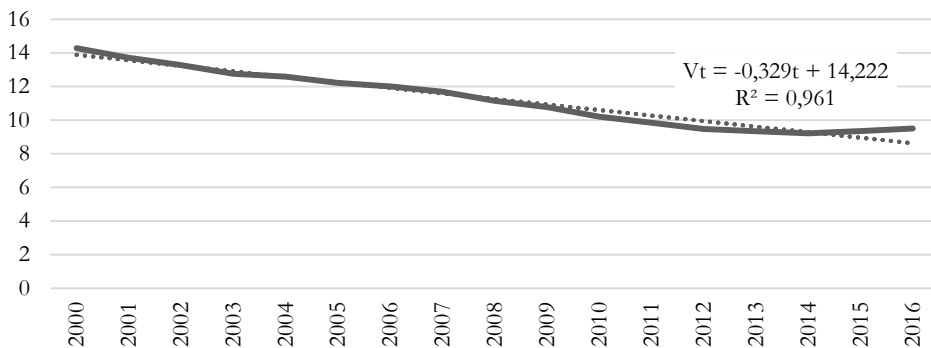
Source: own elaboration based on: [www 2; cf. table 5].

The results of assessment of sigma-convergence regression model for the OOR variable are presented in table 6.

The results of assessment of sigma-convergence regression model parameters for the OOR variable – in the years 2000-2016

Model		Non-standardised coefficients		Standardised coefficients	t	Significance
		α_1	Standard error	α_1		
Dependent variable V_t	(Constant)	14.222	0.175		81.099	0.000
	Time (t)	-0.329	0.017	-0.980	-19.231	0.000

Source: own elaboration based on: [www 2].

Negative and statistically significant value of parameter α_1 indicates regional convergence for the OOR variable, i.e. differentiation in terms of the share of people aged 75- 84 in the total population for Polish voivodeships shows a declining tendency over time.

7. Differentiation of Poland's voivodeships in the years 2000-2016 in terms of the oldest old ratio

The basic statistical measures which describe voivodeship differentiation of the oldest old ratio (ODOR) are presented in table 7.

Inter-regional differentiation of the oldest old ratio (ODOR) – years 2000-2016

ODOR$_t$ (%)	Range	Mean	Standard deviation	Coefficient of variation
2000	0.60	0.90	0.18	20.42
2001	0.54	0.87	0.17	20.12
2002	0.49	0.84	0.17	20.24
2003	0.45	0.82	0.16	19.75
2004	0.44	0.85	0.16	18.54
2005	0.45	0.91	0.16	17.35
2006	0.45	0.97	0.16	16.24
2007	0.45	1.06	0.16	14.68
2008	0.47	1.16	0.16	14.10
2009	0.48	1.24	0.16	13.23

ODOR$_t$ (%)	Range	Mean	Standard deviation	Coefficient of variation
2010	0.49	1.34	0.18	13.52
2011	0.49	1.43	0.19	13.23
2012	0.50	1.52	0.20	13.15
2013	0.55	1.62	0.21	13.01
2014	0.61	1.72	0.22	12.89
2015	0.70	1.83	0.23	12.69
2016	0.74	1.93	0.24	12.55

Source: own elaboration based on: [www 2].

Obtained ODOR range values for the years 2000-2016 fit within the range [0.44%; 0.74%]. Inter-voivodeship differentiation in terms of ODOR in the period covered by the study had decreased. (table 7). In 2016, compared to 2000, for all voivodeships an increase was observed in the share of people aged 85 and more in the total population, although at a different pace. The population in that age group increased more than 2 times, with the Zachodniopomorskie voivodeship recording the biggest increase (nearly threefold), and the Wielkopolskie voivodeship recording the smallest increase (1.65 times). The highest percentage of people aged 85 and more in 2000 is a characteristic of the Podlaskie (1.20%), Mazowieckie (1.12%) and Łódzkie (1.11%) voivodeships, while in 2016 – the Podlaskie (2.36%) and Święto-krzyskie (2.27%) voivodeships. The smallest share of people in the age group covered by the analysis in 2000 was recorded in Zachodniopomorskie (0.60%) and Warmińsko-Mazurskie voivodeships (0.66%), and in 2016 in Wielkopolskie (1.62%) and Lubuskie voivodeships (1.68%).

CHART 7

Division of Poland's voivodeships into classes based on the percentage of people aged 85 and more – years 2000, 2010, 2016

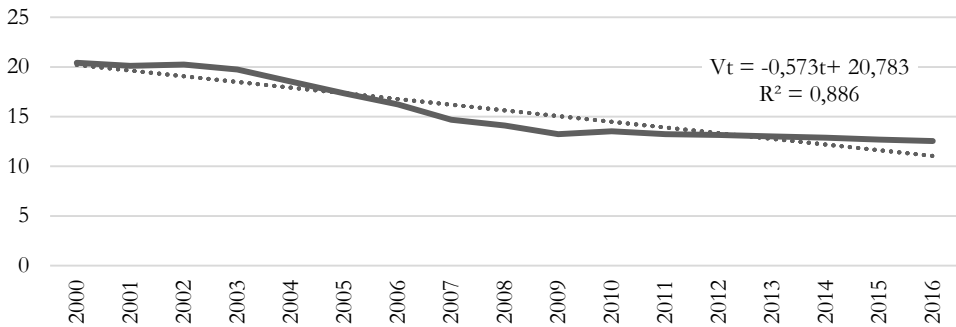Source: own elaboration based on: [www 2].

Also, in case of the share of people in that age group, changes in spatial distribution may be observed below (chart 7).

In 2000 and 2016, voivodeships characterised by high ODOR values were predominantly situated in the eastern and south-eastern part of the country, and the lowest ODOR values – in the north-western part of the country. Zachodniopomorskie and Warmińsko-Mazurskie are among voivodeships which recorded the biggest increase in the share of people aged 85 and more in the years 2000-2016, and the Wielkopolskie voivodeship recorded the smallest increase. In 2016, Podlaskie was the voivodeship with the highest share of people aged 85 and more.

The results of inter-voivodeship sigma-convergence analysis of the ODOR variable, considering the trend model for coefficient of variation of that variable, are presented in chart 8.

CHART 8

Graphic presentation of sigma-convergence analysis results for the ODOR variable in the years 2000-2016 – coefficient of variation

$$V_t = -0{,}573t + 20{,}783$$
$$R^2 = 0{,}886$$

Source: own elaboration based on: [www 2; cf. table 7].

The results of assessment of sigma-convergence regression model for the ODOR variable are presented in table 8.

Negative and statistically significant value of parameter α_1 indicates regional convergence for the ODOR variable, i.e. differentiation in terms of the percentage of people aged 85 and more in the total population for Polish voivodeships shows a declining tendency over time.

TABLE 8

The results of assessment of sigma-convergence regression model parameters for the ODOR variable – in the years 2000-2016

Model		Non-standardised coefficients		Standardised coefficients	t	Significance
		α_1	Standard error	α_1		
Dependent variable V_t	(Constant)	20.783	0.544		38.177	0.000
	Time (t)	-0.573	0.053	-0.941	-10.776	0.000

Source: own elaboration based on: [www 2].

8. Clustering of Poland's voivodeships by the structure of the elderly using Ward's method

The next step of the analysis involved clustering voivodeships based on Ward's agglomerative hierarchical clustering procedure [Wójcik, 2009]. Using variables which explain the level of demographic ageing of voivodeships, considering the ageing phases standardised using a standardisation method, a join tree presented in charts 9-11 was obtained.
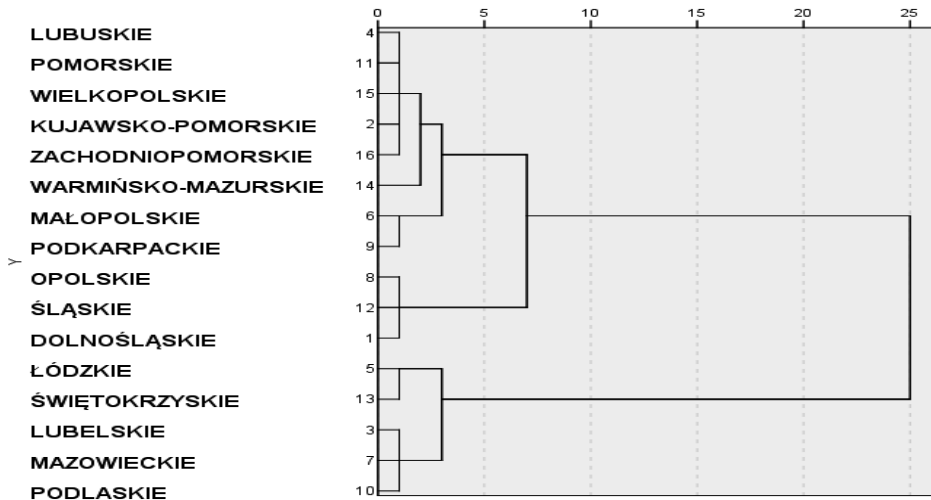
CHART 9

Clustering of Poland's voivodeships using Ward's clustering method by demographic ageing rates – the year 2000
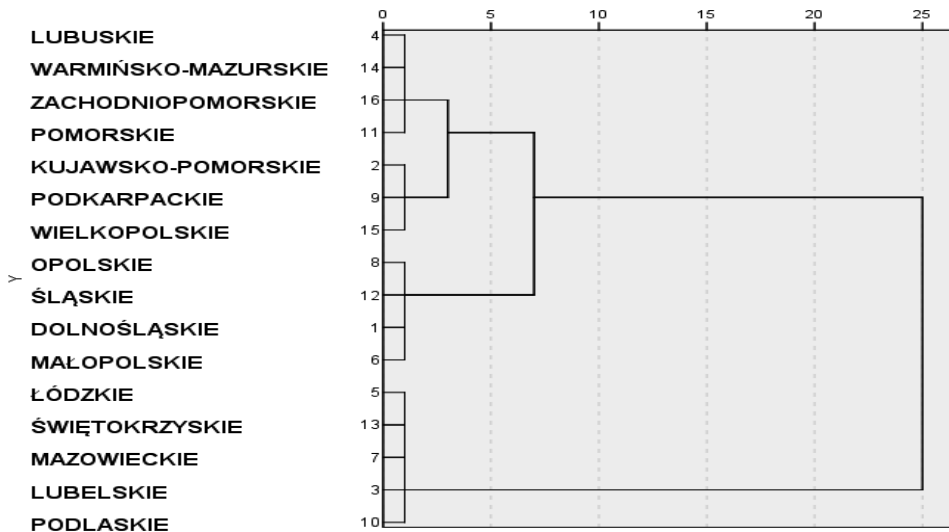
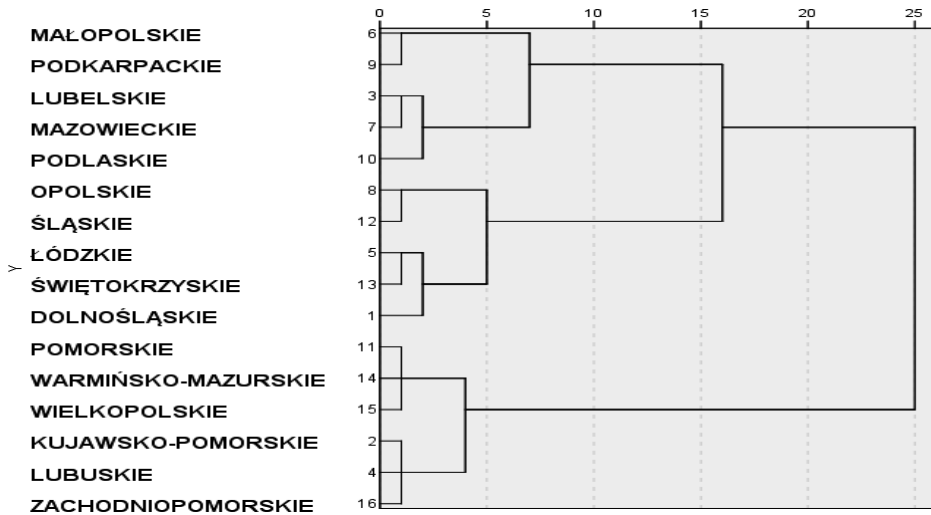Source: own elaboration.

CHART 10

**Clustering of Poland's voivodeships using Ward's clustering method
by demographic ageing rates – the year 2010**

Source: own elaboration.

CHART 11

**Clustering of Poland's voivodeships using Ward's clustering method
by demographic ageing rates – the year 2016**

Source: own elaboration.

Using the Ward's method, Poland's voivodeships may be divided into groups of similar units in terms of age structure of the elderly in identified phases of demographic ageing (demographic ratios). In 2000 these were (chart 9):

–   group 1: **Warmińsko-Mazurskie, Zachodniopomorskie, Pomorskie, Kujawsko-Pomorskie, Wielkopolskie, Lubuskie**, Podkarpackie

–   group 2: **Opolskie, Śląskie, Dolnośląskie** and Małopolskie,

–   group 3: **Mazowieckie, Podlaskie, Lubelskie**, Łódzkie, Świętokrzyskie.

In 2010 these were (chart 10):

–   group 1: **Warmińsko-Mazurskie, Zachodniopomorskie, Pomorskie, Kujawsko-Pomorskie, Wielkopolskie, Lubuskie**, Małopolskie and Podkarpackie,

–   group 2: **Opolskie, Śląskie, Dolnośląskie**,

–   group 3: **Mazowieckie; Podlaskie, Lubelskie**, Łódzkie, Świętokrzyskie.

While in 2016 these were (chart 11):

–   group 1: **Warmińsko-Mazurskie, Zachodniopomorskie, Pomorskie, Kujawsko-Pomorskie, Wielkopolskie, Lubuskie**,

–   group 2: **Opolskie, Śląskie, Dolnośląskie**, Łódzkie and Świętokrzyskie,

–   group 3: **Mazowieckie, Podlaskie, Lubelskie**, Podkarpackie and Małopolskie.

Analysis of the results indicate moderate differentiation of voivodeship delimitation in the period covered by the study, in terms of the structure of the elderly. In every year covered by the analysis voivodeships with similar co-existence of characteristics were divided into 3 clusters. For voivodeships classified in group 1 using Ward's method, the level of individual demographic ageing rates (YOR, OOR, ODOR) is usually low, in group 2 – medium, and in group 3 – high.

Obtained results allow addressing question 3, which concerned stability of clustering Poland's voivodeships according to the age structure of the elderly.

In the years covered by the analysis, 12 voivodeships demonstrated stability in terms of their association with clusters (voivodeships marked in bold font on the list of voivodeship clusters in 2000, 20010 and 2016). In the remaining four voivodeships: Podkarpackie, Małopolskie, Łódzkie, Świętokrzyskie – no stability in cluster affiliation was observed. The results confirm the previous analysis of inter-regional differentiation according to the pace of changes in demographic ageing rate, considering identified ageing phases (compare: charts 1, 3, 5). The values of demographic ageing rates (DAR) for Poland in the years 2010-2016 are shown on chart 12.

The data presented on chart 12 confirms that in the period covered by the study the process of population ageing in Poland's voivodeships occurred at a different pace, which eventually led to voivodeships becoming increasingly similar in terms of the structure of the elderly.

CHART 12

Ageing rates for Poland in the period 2010-2016
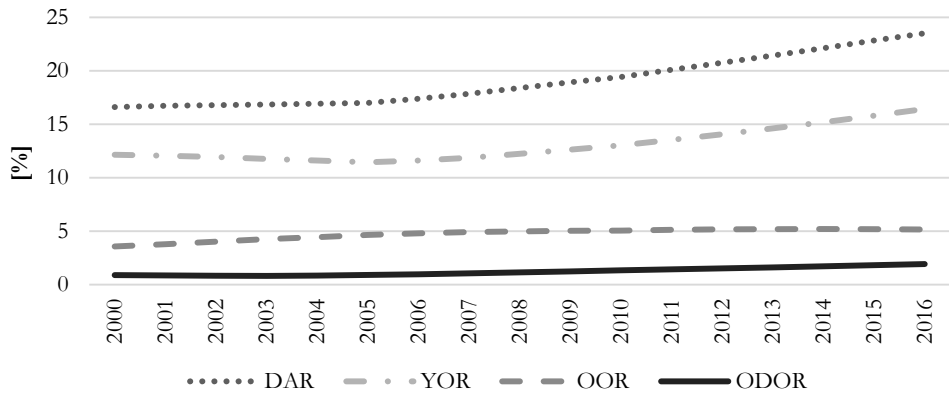
Source: own elaboration based on: [www 2; cf. table 1, 3, 7].

9. Conclusions

The considerations presented in this paper on the subject of voivodeship diffe-rentiation of the elderly population in Poland and the pace of changes in the share of population in identified groups of the elderly in the years 2000-2016 allow addressing all research questions posed in the introduction.

Poland's voivodeships are differentiated in terms of the degree of demographic ageing advancement. Differentiation of voivodeships was observed in terms of the share of population in particular age groups corresponding to different ageing phases in the total population, whereas the biggest disproportions manifested in the share of people aged 85 and more (charts 1, 3, 5, 7). In 2016, the highest share of people aged 60 and more and 60-74 was recorded in Łódzkie, 75-84 in Opolskie, and 85 and more in the Podlaskie voivodeships. In the same year, the lowest share of people aged 60 and more was recorded in Warmińsko-Mazurskie, 60-74 in Podkarpackie, 75-84 and 85 and more in the Wielkopolskie voivodeships. The population's age structure, reflecting identified demographic ageing groups, is becoming increasingly similar over time. In voivodeships where the share was small, ageing progresses faster, and where the share was relatively big – it progresses more slowly.

The differentiation in terms of the proportion of population in identified age groups of the elderly in Polish voivodeships shows a declining tendency. In the years 2000-2016 a reduction was observed in disproportions between voivodeships, while changes in the coefficient of variation occurred at a different pace (charts 2, 4, 6, 8). Poland's voivodeships become more similar in terms of the share of people in identified age groups of the elderly. The most significant reduction of inter-voivode-ship differentiation was observed in the share of people aged 85 and more in the total population.

The delimitation of voivodeships by the structure of the elderly is moderately stable. Results of the analyses show moderate differentiation of voivodeships, during the period covered by the study, by structure changes, which indicates there is a progressing population ageing process.

An observation can be made that the changes in the population ageing process occur at a different pace, as a consequence of which there is a change in spatial distribution of population aged 60 and more and in identified groups of the elderly by voivodeship.

It should be emphasized that assessment of Poland's differentiation by age structure of the total population, measured by the share of people in specific groups of the elderly, in space and over time, performed using selected statistical tools, constitutes a form of diagnosis of the situation in the scope covered by the analysis and raises numerous research questions. Searching for responses to these questions is a stimulus for further studies. The following questions seem particularly significant:

– what are the reasons of changes in the share of the elderly in Poland and in individual voivodeships?
– what are the reasons of initial voivodeship differentiation in terms of advancement of demographic ageing process?
– what are the reasons behind different changes in the age structure of identified demographic ageing phases, also including voivodeship perspective?
– what is the reason of decreasing inter-regional differentiation in the age structure of the elderly under analysis?

Declining differentiation in terms of the share of the elderly and the age structure reflecting identified demographic ageing phases in Poland's individual voivodeships could be an indication for standardisation and centralisation of actions in favour of the elderly. However, even insignificant differences between voivodeships justify differentiating actions taken by the government, specifically the local government, to satisfy specific needs of that population in local government units [SP, 2018]. Not only should these actions consider the share of population aged 60 and more in the region, but also the age structure that provides for ageing phases i.e. the young old, the old old, the oldest old. Given the similarity between age structures of the elderly and the age structure of the elderly in Poland or between regions, conducted analysis enables taking joint actions, directed at regional economy, in voivodeships with a similar structure. In case there is no similarity between structures, priority tasks of local governments may be determined that should be adapted to the needs of the population of a specific age in each region. The rapidly progressing process of population increase in the oldest age groups covered by the analysis should incline the government to take actions specifically aimed at improving availability of healthcare services (geriatric care) and social care services (caretaking services). In the case of younger age groups of senior citizens, it is necessary, among others, to take actions aimed at professional activation due to shrinking labour resources as a result of population ageing, or developing cultural, educational and sport services addressed to the elderly.

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