REGIONAL DIFFERENCES IN POPULATION AGING IN EUROPE VIEWED THROUGH PROSPECTIVE INDICATORS

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With 6 figures and 2 tables
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Summary: Demographic aging has been one of the most discussed aspects of population development in recent decades. Complex changes in reproductive behaviour and their impact on both age structure and future population development are often the source of concerns about the stability of socioeconomic systems (e.g. pension systems, healthcare and the labour market). Frequently reinforced by the development and use of standard demographic aging indicators and comparisons over time and space and/or between populations, this one-sided view is problematic given significant changes in population mortality and health. Population aging has moreover traditionally been analysed in relation to national and regional differences, with specificities frequently being overlooked. Using new methods for analysing demographic aging based on prospective age, which accounts for changes in life expectancy over time and therefore more accurately captures demographic aging, we attempt to identify the main spatial patterns of regional differentiation in aging in Europe (at the NUTS2 level). We also attempt to create a typology of Europe's regions using the main aging indicators and thereby identify the areas most affected by demographic aging.

Zusammenfassung: Die demographische Alterung ist in den letzten Jahrzehnten einer der am häufigsten diskutierten Aspekte der Bevölkerungsentwicklung. Komplexe Veränderungen des generativen Verhaltens und die Auswirkungen auf Altersstruktur und zukünftige Bevölkerungsentwicklung geben oft Anlass zur Sorge um die Stabilität der Sozialsysteme (z.B. Rentensystem, Gesundheitsversorgung und Arbeitsmarkt). Die Verwendung von Standardindikatoren hat sich gerade unter Aspekten raum-zeitlicher Analysen als problematisch erwiesen, weil sich angesichts signifikanter Veränderungen der Mortalität und dem Gesundheitszustand der Bevölkerung zwangsläufig Verzerrungen ergeben. Die Alterung der Bevölkerung wurde zudem traditionell vorzugsweise im Hinblick auf nationale und regionale Unterschiede analysiert, wobei Besonderheiten häufig übersehen wurden. Mit neuen Methoden zur Analyse der demographischen Alterung auf der Grundlage des voraussichtlichen Alters, welches die Veränderungen der Lebenserwartung im Laufe der Zeit berücksichtigt und somit die demographische Alterung genauer erfasst, versuchen wir, die wichtigsten räumlichen Muster der regionalen Differenzierung des Alterns in Europa (auf NUTS2-Ebene) zu identifizieren. Wir versuchen zudem, eine Typologie der Regionen Europas unter Verwendung der wichtigsten Alterungsindikatoren zu erstellen und so die Gebiete zu identifizieren, die am stärksten von demographischer Alterung betroffen sind.

Keywords: population aging, prospective age, European regions (NUTS2), typology, demography

1 Introduction

Demographic aging is one of the most important and most discussed aspects of population development (e.g. Avramov and Maskova 2003; Gavrilov and Heuveline 2003; Lutz et al. 2008; Lutz 2009; Sanderson and Scherbov 2008). The dynamic and extensive way in which it is determining society-wide change is unparalleled in human history (UN 2001). Almost every society in the world has a growing proportion of elderly people in the population, making population aging one of the most important global factors behind social transformation in the twenty-first century, and its effects are manifest in almost all areas (UN 2015).

Population aging is a complex, multidimensional process. However, the general debate on demographic aging has for many years relied on standard metrics (e.g. median age and the old-age and economic burden indices) which deal only with age structure, ignoring age-specific characteristics (Sanderson and Scherbov 2008; 2015b).

In an era of falling mortality rates, better health and longer life spans, standard chronological age-based tools (number of years lived since birth) are becoming increasingly less objective and not just for analysing aging. This is because the mortality rate has improved, altering both the distribution of age structure in the population and potential years of life (Spijker 2015). The standard tools used, based on

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chronological age and an arbitrary old-age limit (e.g. 65 years) assume that the internal age-specific characteristics of a population do not change over time, across space or between populations (Sanderson and Scherbov 2013). However, today's 60-year-olds have a longer life expectancy, are healthier and have better cognitive ability than people of a similar age thirty to forty years ago (Sanderson and Scherbov 2013). Future 60-year-olds will also differ (in relation to assumed mortality rates). This applies to international and regional comparisons of populations with different mortality rates. Relying only on chronological age as one of the components of aging and overlooking other available characteristics produces a restricted view of reality, which may not even be suitable for use in academic research or to inform important policy decisions (Sanderson and Scherbov 2013).

Attempts to resolve this issue, particularly in recent years (e.g. Sanderson and Scherbov 2008, 2010, 2015a, 2015b; Scherbov and Sanderson 2016; Lutz 2009; Shoven 2007; Shoven and Goda 2010; d'Albis and Collard 2013; Spijker and MacInnes 2013; Riffe 2015) have led to the emergence of a new set of tools in which standard chronological age is no longer the only means of defining old age but which also encompass a looking-forward approach and the concept of prospective age. Here the decisive factor is not only the number of years a person has lived since birth, but also the number of years of life remaining according to current mortality rates. Sanderson and Scherbov (2013, 675) see potential in this newly emerging paradigm for conceptualising population aging. The advantages of the prospective approach are that, like standard indicators, it is based on relatively simple calculations and the results are easily interpreted, making it comprehensible to the general public and the fact that it introduces a new dimension into demographic analysis better able to reflect biological and behavioural aspects.[1)]

The prospective approach is important not only for analysing temporal changes in aging but also for international and regional analyses. The European space is characterised by relatively large differences in within-country population age structures, as standard aging indicators have shown (Długosz 2011; European Commission 2015; Kashnitsky et al. 2017). However, Kashnitsky et al. (2017) has shown that convergence has been taking place in the European area at regional level (NUTS2) in recent years and we can expect this trend in the next three decades. According to their analysis convergence in aging mainly depends on changes in the population structure of East-European regions and the major role in promoting convergence will play the cohort turnover. In addition, Kashnitsky et al. (2017) also point to the importance of the differences in mortality in working ages. Several papers (e.g. Meslé and Vallin 2002; Vallin and Meslé 2004; Šprocha et al. 2015) confirmand marked differences in mortality rates and therefore lifespan and other age-specific characteristics in European regions. Including these characteristics in analyses will result in a more objective and realistic view of spatial differences in aging. There is currently no paper to address in detail the issue of population aging in a prospective view at regional level in Europe. The aim of this article is therefore to analyse differences in the level of demographic aging in Europe's regions at the NUTS2 level, using both the standard and the new prospective age indicators and then create a regional typology based on the main aging indicators. We attempt to identify the main areas that are most and least affected by demographic aging using the two approaches.

2 Theoretical concept of prospective age

The looking-forward approach to population aging has been elaborated in the main by Sanderson and Scherbov (e.g. 2008, 2013, 2015a, 2015b, 2016) and then further developed by others (e.g. Lutz 2009; Spijker 2015; Spijker and MacInnes 2013). Its essence is based on work by Hersch (1944), who introduced the concept of potential years of life, which holds that at a given age (x) life expectancy can be derived from life tables (ex), and above all on a classic study by Ryder (1975) on stationary populations. Ryder considered chronological measures of age to be appropriate only from birth to adulthood, and to be an inadequate guide to the socioeconomic characteristics of the population later in life. Instead he proposed that adult age should be measured in terms of remaining life expectancy. For many years the idea of prospective age was either overlooked or used only rarely (e.g. Fuchs 1984; Siegel and Davidson 1984; Siegel 1993). It was not until 2005 in *Nature* that Sanderson and Scherbov (2005) 'rediscovered' the significance of this approach, further expanding it in subsequent work. In an independent effort, Shoven (2007, 2008) and Shoven and Goda (2010) amongst others also worked on a similar principle.

[1)] Although analysis is based on periodic life tables, Sanderson and Scherbov (2007, 32–33) examined the difference between the calculation based on periodic and cohort life tables and considered the difference to be statistically insignificant.

The looking-forward approach to aging is based on a new understanding of age. Classic chronological (retrospective) age indicators measure the number of years a person has lived since birth. People of the same age have lived for the same number of years. The other age indicator is prospective age, which is a forward-looking conception (Sanderson and Scherbov 2007) based on remaining years of life. The use of chronological age alone implicitly suggests that all other characteristics relevant to demographic aging do not change in time or space (Sanderson and Scherbov 2013, 673) and that people of the same age will behave the same across time and space (Sanderson and Scherbov 2007). However, this assumption is far from the reality, especially where life expectancy is increasing or where there are significant differences in mortality rate between populations. The number of remaining years of life is influenced by types of human behaviour (e.g. strategies related to savings, investments, education and healthcare) and by population characteristics (health, morbidity, cognitive ability etc.) (Sanderson and Scherbov 2007).

The main difference in analytical construction between the standard and prospective approaches is the way in which the old-age limit is set. Standard indicators use a fixed age threshold (usually 65 years), while prospective indicators use flexible ones since they are calculated as the age at which the population has a given remaining life expectancy. The prospective approach therefore works on the basis that as mortality rates improve so too does the definition of old age and that in every population or region the age at which a person is considered old may vary depending on the socioeconomic development, public healthcare advances or habits in that area (Sanderson and Scherbov 2008). Being able to account for these aspects is an important innovation that enables the researcher to obtain a far more objective view of the level and regional differences in demographic aging.

3 Data and methodology

The analysis in this article uses both standard and prospective characteristics of demographic aging to account for changes in life expectancy. The use of these two approaches means that both dimensions of age can be quantified, and therefore a more comprehensive view of aging is obtained (see e.g. Sanderson and Scherbov 2007).

The standard indicators were calculated on the basis of generally known relations. The first indicates the number of people aged 65 and over in the given population (Prop.65+). This chronological age is usually used as a fixed old-age threshold (e.g. Gavrilov and Heuveline 2003; European Commission 2012). It is a simple calculation that considers only the number of people aged 65 and over and the total number of individuals in the population in a given calendar year.

$$Prop.65+ = \frac{P_{65+}}{P} \cdot 100 \quad (1)$$

The second well-known aging indicator is the aging index (AI), which is the number of individuals aged 65 and over divided by the number of individuals under 20 (sometimes 15) years of age.

$$AI = \frac{P_{65+}}{P_{0-19}} \cdot 100 \quad (2)$$

The median age (MA) of a population is the age which demarcates the population into two equally sized groups (Sanderson and Scherbov 2007). Half the population is therefore younger than the median age and half is older (UN 2015). This is one of the most frequently used indicators for measuring demographic aging (Gavrilov and Heuvelin 2003).

The old-age dependency ratio (OADR) is used to analyse a number of aspects of population aging, from retirement and the public pension burden to the more amorphous concept of old-age dependency itself (Sanderson and Scherbov 2007, 48). The standard old-age dependency ratio is obtained by dividing the number of individuals aged 65+ by the number of individuals aged 20–64.

$$OADR = \frac{P_{65+}}{P_{20-64}} \cdot 100 \quad (3)$$

The standard indicators are calculated on the basis of fixed chronological age. Nonetheless, even if we were to alter this limit, we would not obtain a more objective view. Aging is affected by increases in life expectancy and a fall in mortality if it leads to an increase in the number of remaining years of life regardless of the fixed old-age threshold. A similar problem occurs when comparing regional populations with different mortality rates because individuals aged 65 will not have the same life expectancy, health, cognitive ability or other characteristics associated with the aging process. Sanderson and Scherbov (2005, 2008) therefore proposed a different way of determining aging that eliminates the effect of changes in life expectancy. This calculation is based on determining prospective age, which is the age attributed to a given population in a given year based on them having the same remaining life expectancy in the reference year. Sanderson and Scherbov (2008, 8) recommend that 15 years of remaining life expectancy should be used as the old-age threshold. Constant prospective age (*Constant Prospective Age, RLE15- age*; CPA RLE 15-) has also been used in this article to make the results easy to understand. It searches every population and every year to find the age that corresponds to a remaining life expectancy of 15 years (Sanderson and Scherbov 2013, 676).

The indicator for the standard proportion of individuals aged 65+ years is the *Proportion at Ages with Remaining Life Expectancies of 15 Years or Less* (Prop. RLE 15-).

$$Prop.RLE15- = \frac{P_{\chi_{RLE15-}}}{P} \cdot 100 \quad (4)$$

The prospective aging index *Prospective Aging Index* (PAI) is constructed in a similar way to the standard aging index:

$$PAI = \frac{P_{\chi_{RLE15-}}}{P_{0-19}} \cdot 100 \quad (5)$$

where $P_{\chi_{RLE15}}$ is the sum of persons in the age categories corresponding to a remaining life expectancy of 15 years or less and P_{0-19} is the sum of persons aged up to 19 years (inclusive).

The Prospective Old-Age Dependency Ratio (POADR) expresses the relationship between the number of persons with a remaining life expectancy of 15 years or less and the number of persons aged from 20 to the age at which remaining life expectancy is more than 15 years (Sanderson and Scherbov 2008, 11). The calculation is:

$$POADR = \frac{P_{\chi_{RLE15-}}}{P_{20-\chi_{RLE15-}}} \cdot 100 \quad (6)$$

where $P_{\chi_{RLE15-}}$ is the sum of persons at the age where remaining life expectancy is 15 years or less and $P_{20-\chi_{RLE>15}}$ is the sum of persons aged from 20 to the age at which remaining life expectancy is more than 15 years.

To obtain the prospective median age (PMA) we first have to calculate the traditional median age of the population observed. The relevant prospective age can then be found in the mortality tables. When comparing multiple populations, or development over time, a standard has to be selected because population mortality death rates differ (and therefore so do mortality tables). In our case the standard selected was the mean population from 2013 to 2015 in all the regions observed and the respective mortality tables calculated using the same method as for the NUTS2 regions. In the standard population and associated mortality table, the same life expectancy is then found as in the population observed and the age corresponding to the prospective median age sought. If *MA(t)* is the median age of the population observed in year *(t)*, then *e(x,t)* is life expectancy at age*(x)* and *e(MA,(t), t)* is life expectancy at median age*(MA)*. The prospective age then is the age at which the standard population (average of all NUTS2 regions) has the same remaining life expectancy as the population observed at median age *(e^{-1} (MA(t), t), standard)* (Sanderson and Scherbov 2015a).

The set of indicators is then statistically analysed using selected descriptive-statistics tools (weighted arithmetic mean, range of variation, coefficient of variation, standard deviation). A set of maps were then created showing the standard and prospective indicators and the spatial differences. To do this we used NUTS2 regions that had been categorised using quintiles. In other words, the set of regions being investigated was divided into five groups of approximately the same size according to the value of the demographic aging indicator. Each region was then represented in one of the groups (Quintile 1=youngest … Quintile 5=oldest), and this was done for both the standard and prospective indicators. So that differences in the status of each European region could then be observed from both angles, we calculated the differences in region membership based on the two quintiles. This means that if, for example, a region appeared in the first quintile when the standard measure was used and in the fourth quintile when the prospective measure was used, then the difference was calculated as -3.

The other aim of the article was to identify the main regions that are most and least affected by demographic aging. To enable us to do this we created separate typologies for the prospective and standard indicators. We used cluster analysis to categorise the set of NUTS2 regions into relatively homogenous subsets (clusters), where the aim was for clusters to contain regions with similar levels of demographic aging, and for the clusters to differ significantly from one another. The input data were the population-aging indicators (prospective and standard separately) and we used Ward's clustering method based on squared Euclidean distances.

The data source for the analysis was the 2013–2015 Eurostat data for each NUTS2 region in Europe.[2)] All indicators represent total population – males and females together. The regions of Turkey, and the non-European (overseas) areas of Portugal, Spain and France were removed from the data set. The concept of prospective age can also be enriched by other dimensions such as economic activity or health status, but data for all NUTS2 regions is often difficult to access.[3)]

4 Analysis of regional differences using standard and prospective indicators

Demographic aging is affected by many factors, such as previous population and socioeconomic development, public healthcare and family and migration policy. This along with policy effects can lead to marked differences both within and between countries and so having a detailed regional view of population aging is important. The prospective approach enables us to gain a much better understanding of the spatial differentiation in demographic aging, as it implicitly takes account of potential variation in age-based characteristics (e.g. health, morbidity and cognitive ability).

Considering remaining life expectancy as part of constant prospective age at the European NUTS2 level reveals relatively large value ranges (Fig. 1). The difference between the highest (Île de France) and lowest (Macedonia) constant prospective age in the period observed was almost 10 years (Tab. 1). The morbidity tables clearly show that those in the oldest age group (72 and over) with 15 years of remaining life are to be found in most regions of France, Spain, Switzerland, Italy, the Nordic countries and for example in the south of the United Kingdom. By contrast the lowest levels of constant prospective age can be seen in most of the Balkan countries, in regions of Hungary, Slovakia and Latvia and in northern Croatia, where it does not even reach 68 years. Given the large differences in mortality rates and other characteristics in the 65 and over population (e.g. health, economic activity, education and cognitive ability), the prospective approach allows for a better comparison of population aging among Europe's regions.

The descriptive statistics also indicate a higher degree of variability within the prospective characteristics than in the standard ones (Tab. 1). The main reason for this is that the standard indicators are derived from age structure only. While the prospective indicators are based on both, the age structure and the mortality tables, which reflect mortality characteristics.

In order to capture regional differences in the level of demographic aging and any differences in the regional pictures generated by standard and prospective indicators, both in graphic and statistical terms, the values of each characteristic were divided into quintiles and then any changes in quintile were observed in relation to whether standard or prospective indicators were used (Figs. 2-5).A quintile difference with a negative value in the third cartogram indicates that when the standard indicator was used the region was categorised as "younger" than was the case when the prospective indicator was used. By contrast a positive value means that when the standard indicator was used the region was classified as "older" in comparison to when the prospective indicator was applied.

When the aging index (AI) is used, the least favourable elderly-child population ratio can be found in north east Germany, northern Spain, northern and central Italy, northern Bulgaria, in several regions in Greece and in Latvia. The most favourable ratio can be found in the west, north west and south east of Poland, in central and eastern Slovakia and in the north east of Romania as well as in some regions of France, the Benelux countries, Norway, Ireland, the United Kingdom and Iceland. When differences in life expectancy have been eliminated using the prospective aging index (PAI), the situation deteriorates in the regions of south eastern Europe in particular, with the populations with the worst elderly-child ratios found in areas such as south west Croatia, most Hungarian regions and regions in eastern and southern Romania. It appears that when remaining life expectancy is taken into account, many regions of the former Eastern bloc 'age' the most. By contrast, the regions which become 'younger' are regions of Greece, France, Switzerland, the north east of the Iberian Peninsula, northern Italy, Corsica, Sardinia, Puglia and south west Sweden (see Fig. 2).

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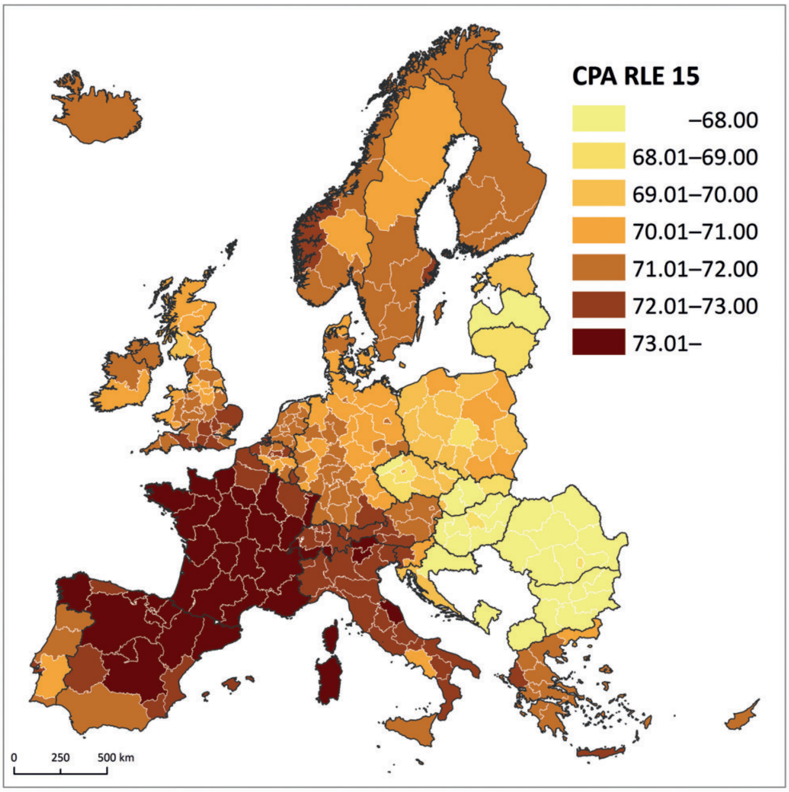
2) Data sources: table "demo_r_d2jan" in Eurostat database section Population and social conditions – Demography and migration – Population – Regional data and table"demo_r_mlifexp" in section Population and social conditions – Demography and migration – Population – Mortality - Regional data. Both available at [https://ec.europa.eu/eurostat/data/database];

3) For more details on the quality and availability of data, see the Discussion chapter.



Constant Prospective Age (CPA RLE 15)

Highest value

NUTS 2 Region	*years*
Île de France (FR)	75.2
Comunidad de Madrid (ES)	74.5
Rhône-Alpes (FR)	74.3
Midi-Pyrénées (ES)	74.3
Castilla y León (FR)	74.1

Lowest value

NUTS 2 Region	*years*
Macedonia (MK)	65.6
Severen tsentralen (BG)	65.9
Severozapaden (BG)	65.9
Severoiztochen (BG)	66.1
Yugoiztochen (BG)	66.3

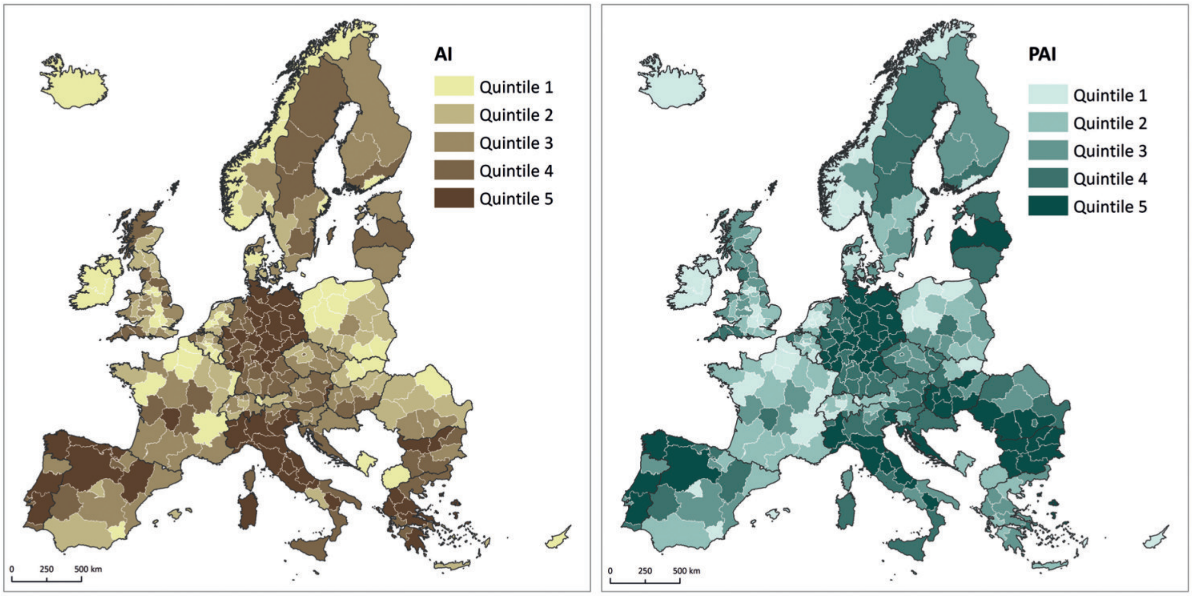
Fig. 1: Regional differences in constant prospective age (CPA RLE 15) and the five highest and lowest values in Europe, NUTS 2, mean for 2013–2015. Data source: Eurostat 2018.

Tab. 1: Descriptive statistics of standard and prospective indicators of demographic aging in Europe, NUTS 2 regions, mean for 2013–2015

Indicator	CPA RLE 15 (years)	AI (*)	PAI (*)	OADR (**)	POADR (**)	Prop. 65+ (%)	Prop. RLE 15- (%)	MA (years)	PMA (years)
Weigh. Arithmetic mean	71.3	89.7	55.1	31.2	14.5	18.6	11.4	42.1	41.6
Minimum	65.6	32.8	19.2	11.4	5.3	7.8	4.6	32.0	30.2
Maximum	75.2	179.6	125.8	49.3	31.7	27.9	22.2	50.6	54.9
Range of variation	9.6	146.8	106.6	37.8	26.4	20.1	17.7	18.6	24.7
Standard deviation	1.8	24.4	18.7	6.0	3.6	3.1	2.5	3.0	3.8
Coefficient of variation	2.5	27.2	33.9	19.1	24.6	16.5	22.0	7.2	9.1

Notes: CPA RLE 15 = constant prospective age, AI = aging index, PAI = prospective aging index, OADR = old-age dependency ratio, POADR = prospective old-age dependency ratio, Prop. 65+ = proportion aged 65 and over, Prop. RLE 15- = proportion with a remaining life expectancy of 15 years or less, MA = median age, PMA = prospective median age, (*) = per 100 persons aged 0–19 years, (**) = per 100 persons aged 20–64 years, weights = population size of the region (arithmetic mean of years 2013-2015), number of regions = 284. Data source: Eurostat 2018.

The greatest pressures exerted by the elderly on the productive section of society, expressed as the old-age dependency ratio (OADR), were identified in the regions of north east Germany, the west and north west of the Iberian Peninsula, southern and central France, northern and central Italy and most regions of Sweden and Greece (Fig. 3). The reverse situation was found mainly in Poland, Slovakia, Romania and – in western Europe – in Iceland, Ireland and southern Spain. However, when we take remaining life expectancy into account using the old-age dependency ratio then the situation changes, especially in regions of Bulgaria, Romania, Hungary, Croatia, Latvia and Lithuania. Given the distribution of the differences



Aging Index (AI)

Highest value		Lowest value	
NUTS 2 Region	*value*	*NUTS 2 Region*	*value*
Liguria (IT)	179.6	Inner London – East (UK)	32.8
Chemnitz (DE)	176.0	Flevoland (NL)	43.3
Sachsen-Anhalt (DE)	167.9	Southern and Eastern (IE)	45.0
Principado de Asturias (ES)	163.5	Border, M. and Western (IE)	46.7
Thüringen (DE)	154.9	Outer London – E and NE (UK)	47.8

Prospective Aging Index (PAI)

Highest value		Lowest value	
NUTS 2 Region	*value*	*NUTS 2 Region*	*value*
Chemnitz (DE)	125.8	Inner London – East (UK)	19.2
Severozapaden (BG)	125.1	Flevoland (NL)	22.4
Sachsen-Anhalt (DE)	122.5	Île de France (FR)	25.1
Severen tsentralen (BG)	121.0	Inner London – West (UK)	26.4
Liguria (IT)	113.0	Southern and Eastern (IE)	26.6

The values are per 100 people aged 0–19.

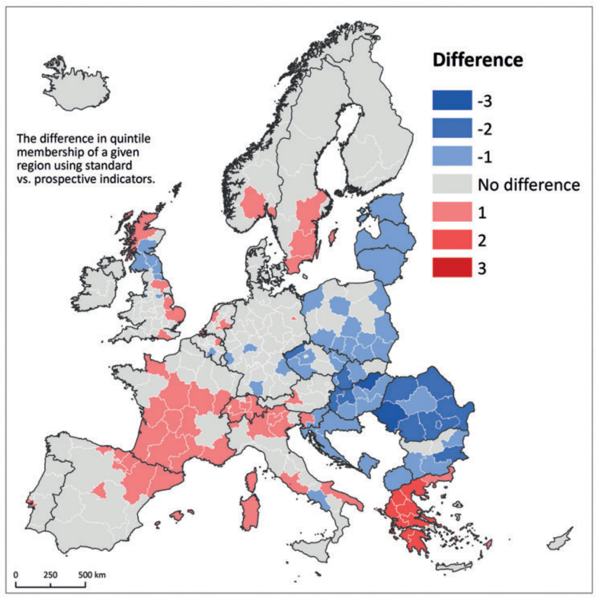
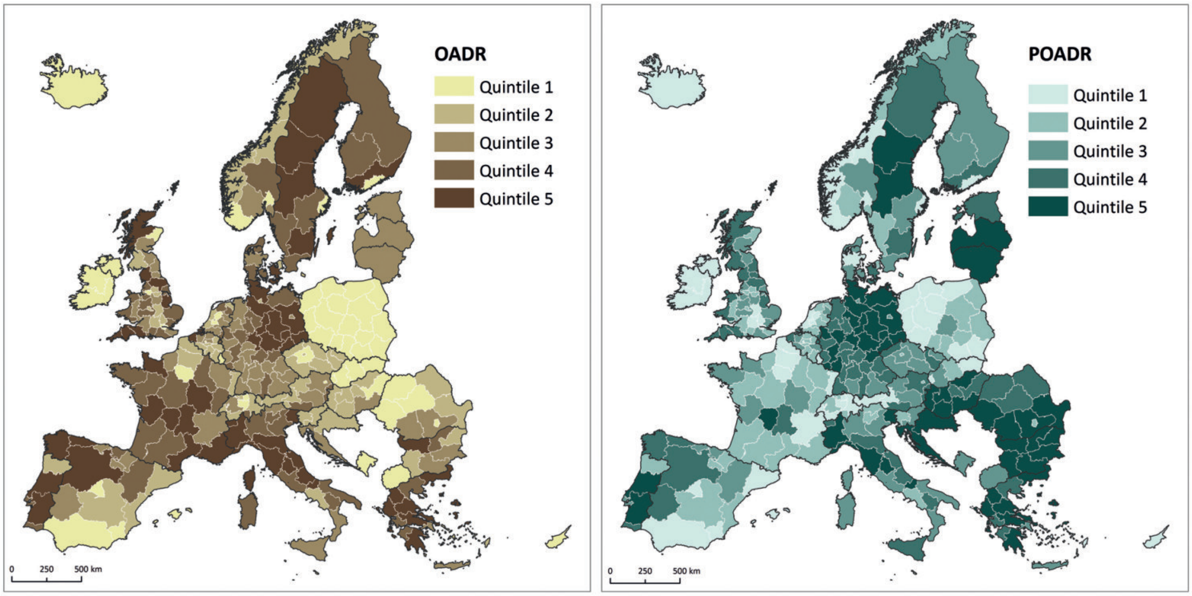


Fig. 2: Quintile distribution of the values of the aging index (AI), prospective aging index (PAI), differences and the five highest and lowest values in Europe, NUTS 2 regions, mean for 2013–2015. Notes: AI = aging index, PAI = prospective aging index, indicators are per 100 persons at given age. Data source: Eurostat 2018.

between the quintiles, it is possible – with a degree of generalization – to divide Europe into east and west once more. When looking at it from the prospective angle, a marked deterioration in the pressures on the productive section of society can be observed in most regions of Croatia, Bulgaria, Romania, Hungary, Latvia and Lithuania. Whereas in France especially, but also in many regions of the Benelux, Italy, northern Spain, Scandinavia and the United Kingdom, the POADR improves compared to when traditional measures are used. A similar situation can be seen in the proportion aged 65 and over (Prop. 65+) and the proportion with a remaining life of expectancy of 15 years or less (Prop. RLE15-) (Fig. 4).

One of the most frequently used measures of population aging – median age (MA) – also indicated similar spatial differences (Fig. 5). The highest values for median age were recorded in northeast Germany, in the west and north west of the Iberian Peninsula and in northern and central Italy. The youngest population according to median age was found in most regions of Poland, central and eastern



Old-Age Dependency Ratio (OADR)

Highest value		Lowest value	
NUTS 2 Region	*value*	*NUTS 2 Region*	*value*
Liguria (IT)	49.3	Inner London – East (UK)	11.4
Chemnitz (DE)	45.7	Inner London – West (UK)	16.0
Limousin (FR)	44.3	Flevoland (NL)	19.1
Ipeiros (EL)	44.2	Východné Slovensko (SK)	19,3
Cornwall and Isles of Scilly (UK)	42.9	Macedonia (MK)	19.5

Prospective Old-Age Dependency Ratio (POADR)

Highest value		Lowest value	
NUTS 2 Region	*value*	*NUTS 2 Region*	*value*
Severozapaden (BG)	31.7	Inner London – East (UK)	5.3
Severen tsentralen (BG)	28.1	Inner London – West (UK)	6.2
Chemnitz (DE)	25.5	Flevoland (NL)	7.3
Sachsen-Anhalt (DE)	23.9	Île de France (FR)	7.9
Alentejo (PT)	23.1	Outer London – W and NW (UK)	8.3

The values are per 100 people aged 20–64.

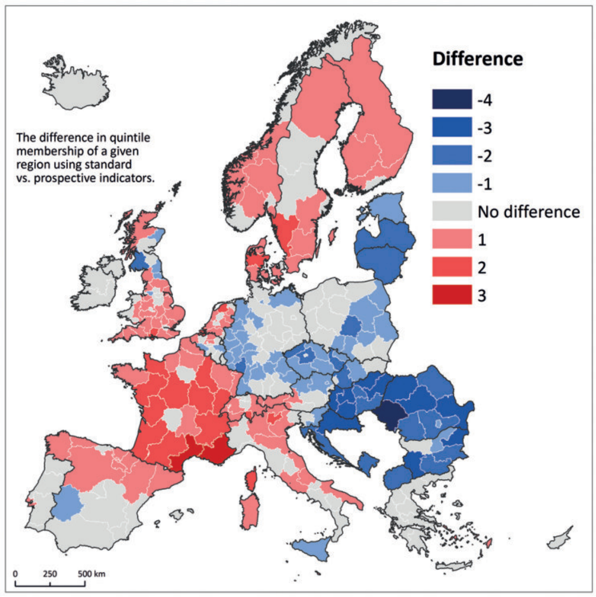
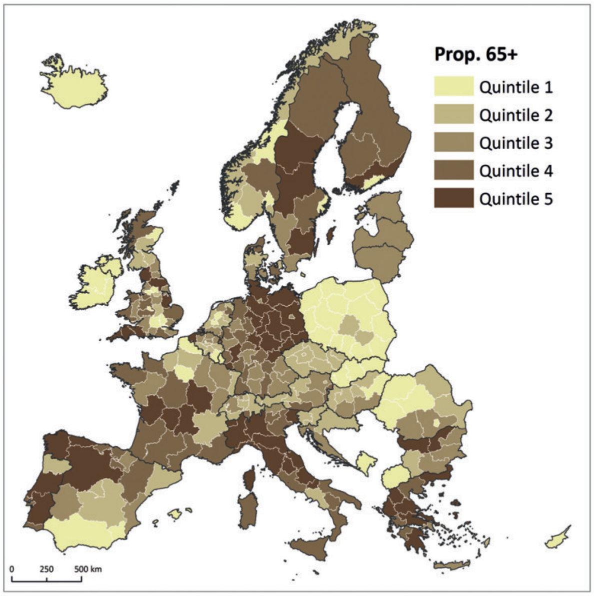
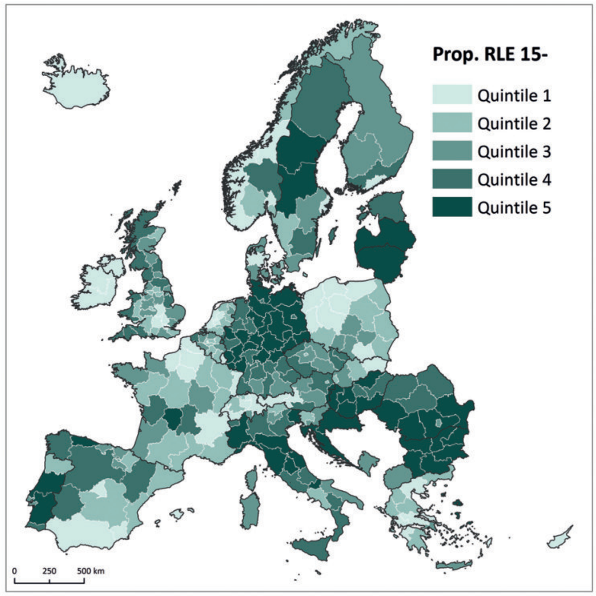


Fig. 3: Quintile distribution of old-age dependency ratio (OADR) and prospective old-age dependency ratio (POADR) values, differences and the five highest and lowest values in Europe, NUTS 2 regions, mean for 2013–2015. Note: OADR = old-age dependency ratio, POADR = prospective old-age dependency ratio, indicators per 100 persons in given age group. Data source: Eurostat 2018.

Slovakia and also northern Romania, Macedonia and Montenegro. In western Europe this was especially true of Ireland, Iceland and some regions of Norway, the United Kingdom and France. When prospective mean age (PMA) was used, the older regions, besides those mentioned above, were most regions in Bulgaria, Romania, Hungary, Latvia and Lithuania. Basically, the population was older in almost all regions in the former Eastern bloc (with the exception of the old East Germany) when prospective median age was used. The opposite tendency could be identified in south west France, north east Spain, the south and north east of Italy and to a lesser degree in the United Kingdom, Norway, Sweden, and Finland; however, the positive differences were less marked than previously.

Using the information obtained, we attempted to identify the main regions most and least affected by population aging. To do so we performed cluster analysis to create separate typologies for the





Proportion of the Population aged 65+ (Prop. 65+)

Highest value: *NUTS 2 Region*	*%*	Lowest value: *NUTS 2 Region*	*%*
Liguria (IT)	27.9	Inner London – East (UK)	7.8
Chemnitz (DE)	26.6	Inner London – West (UK)	11.0
Ipeiros (EL)	25.0	Flevoland (NL)	11.7
Friuli-Venezia Giulia (IT)	24.9	Východné Slovensko (SK)	12.3
Sachsen-Anhalt (DE)	24.8	Southern and Eastern (IE)	12.4

Proportion at Ages With Remaining Life Expectancy of 15 Years or Less (Prop. RLE 15-)

Highest value: *NUTS 2 Region*	*%*	Lowest value: *NUTS 2 Region*	*%*
Severozapaden (BG)	22.2	Inner London – East (UK)	4.6
Severen tsentralen (BG)	20.4	Inner London – West (UK)	5.3
Chemnitz (DE)	19.0	Flevoland (NL)	6.1
Sachsen-Anhalt (DE)	18.1	Île de France (FR)	6.5
Liguria (IT)	17.5	Outer London – W and NW (UK)	6.8

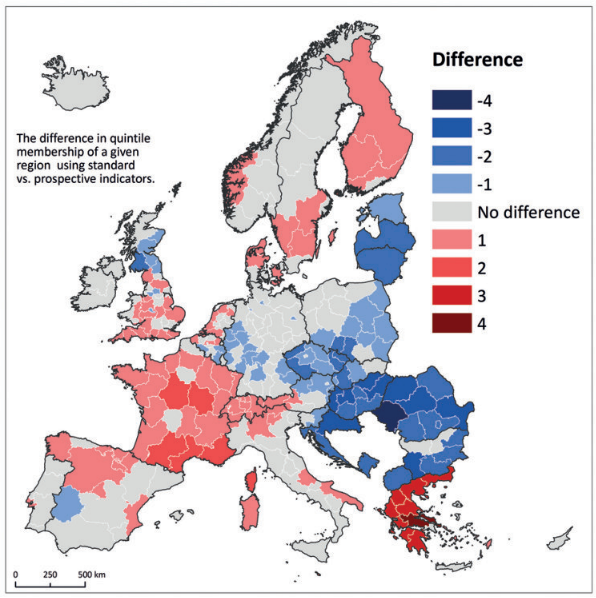
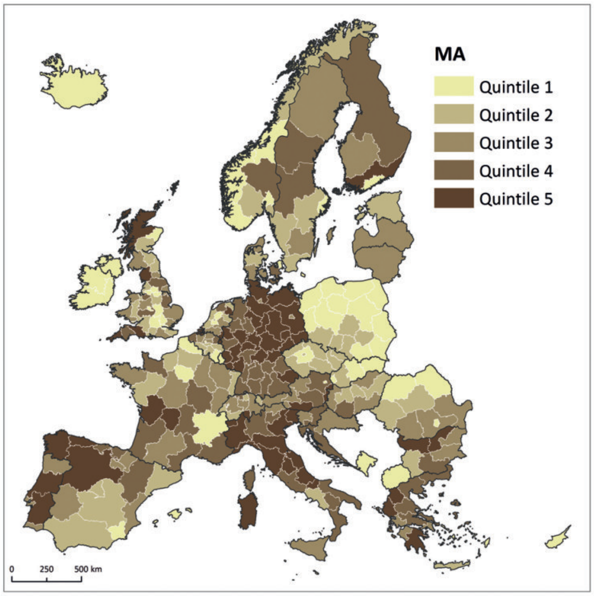
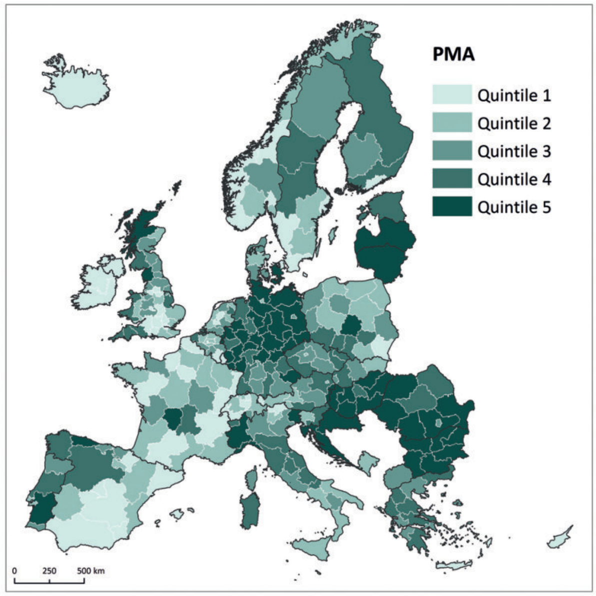


Fig. 4: Quintile distribution of values for proportion aged 65 and over (Prop. 65+) and for proportion at ages with a remaining life expectancy of 15 years or less (Prop. RLE15-), differences and the five highest and lowest values in Europe, NUTS 2 regions, mean for 2013–2015. Note: Prop. 65+ = proportion aged 65 and over, Prop. RLE 15- = proportion with remaining life expectancy of 15 years or less. Data source: Eurostat 2018.

prospective and standard indicators. Five clusters were identified – oldest, old, average, young and youngest (Tab. 2). The 'oldest' cluster contained 28 regions when standard demographic aging indicators were used, but only 13 of these remained in the cluster when prospective indicators were applied. The 'oldest' cluster contained the highest mean values for each indicator and this was the case for both the standard and prospective indicators. The regions appearing in this cluster regardless of type of indicator used were Bulgaria – Severozapaden, Severentsentralen; Germany – Brandenburg, Mecklenburg-Vorpommern, Saarland, Dresden, Chemnitz, Leipzig, Sachsen-Anhalt, Thüringen; Spain – Principado de Asturias; Italy – Liguria; and Portugal – Alentejo. When the standard indicators were applied the cluster expanded to include additional regions in Portugal, north west Spain, Germany and Italy as well as the regions of Ipeiros and Peloponnisos in southern and western Greece





Median Age (MA)

Highest value		Lowest value	
NUTS 2 Region	*years*	*NUTS 2 Region*	*years*
Chemnitz (DE)	50.6	Inner London – East (UK)	32.0
Sachsen-Anhalt (DE)	49.9	Inner London – West (UK)	34.2
Liguria (IT)	49.4	Outer London – E and NE (UK)	35.1
Brandenburg (DE)	49.3	Outer London – W and NW (UK)	35.4
Thüringen (DE)	49.1	Rég. de Bruxelles-Capitale (BE)	35.5

Prospective Median Age (PMA)

Highest value		Lowest value	
NUTS 2 Region	*years*	*NUTS 2 Region*	*years*
Severozapaden (BG)	54.9	Inner London – East (UK)	30.2
Severen tsentralen (BG)	52.2	Inner London – West (UK)	30.5
Sachsen-Anhalt (DE)	51.8	Outer London – W and NW (UK)	32.0
Chemnitz (DE)	51.7	Île de France (FR)	32.3
Mecklenburg-Vorpommern (DE)	50.4	Outer London – E and NE (UK)	32.9

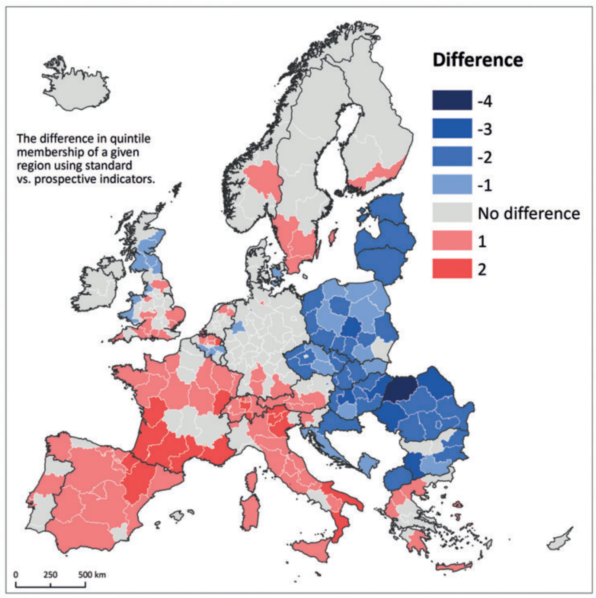


Fig. 5: Quintile distribution of median age (MA), prospective median age (PMA), differences and the five highest and lowest values in Europe, NUTS 2 regions, mean for 2013–2015. Note: MA = median age, PMA = prospective median age. Data source: Eurostat 2018.

(Fig. 6). Interestingly when prospective indicators were used the cluster changed substantially, with the two Greek regions ending up in the 'young' cluster, supporting the theory that there are two levels of aging – chronological and prospective (Sanderson and Scherbov 2005).

When standard indicators were applied, the 'old' cluster contained 88 regions – almost all the regions of Germany, Italy, Bulgaria and Greece that did not appear in the 'oldest' cluster, as well as south east Austria, south Hungary, central France, south Croatia, some regions in the United Kingdom, Sweden, Spain, Portugal, Latvia and the regions of Prov. West-Vlaanderen, Praha, Etelä-Suomi, Tessin, Limburg and Zeeland. When prospective indicators were used, it contained 64 regions, again mainly ones in Germany, Italy, Spain, Portugal, Romania, Croatia, Hungary, Sweden, Latvia and Lithuania. It is worth pointing out the marked dichotomy in the prospective analysis between the region of Limousin and the rest of France, which is a result of the largely rural character of the area and

Tab. 2: Typology of standard and prospective indicators of demographic aging in Europe – mean cluster values, NUTS 2, mean for 2013–2015

Order	Cluster	STANDARD INDICATOR TYPOLOGY AI (*)	OADR (**)	Prop. 65+ (%)	MA (years)	PROSPECTIVE INDICATOR TYPOLOGY PAI (*)	POADR (**)	Prop. RLE 15- (%)	PMA (years)
1	oldest	140.3	39.9	23.7	46.6	105.0	22.3	17.0	48.1
2	old	106.3	36.1	21.2	44.5	76.5	18.3	14.3	45.4
3	average	86.7	31.0	18.5	42.1	62.2	15.6	12.4	43.6
4	young	69.7	26.0	15.9	39.6	50.7	14.2	10.9	41.3
5	youngest	50.4	21.3	13.0	36.6	37.7	11.0	8.9	37.8

Note: AI = aging index, PAI = prospective aging index, OADR = old-age dependency ratio, POADR = prospective old-age dependency ratio, Prop. 65+ = proportion aged 65 and over, Prop. RLE 15- proportion with remaining life expectancy of 15 years or less, MA = median age, PMA = prospective median age, (*) = per 100 persons aged 0–19, (**) = per 100 persons aged 20–64. Data source: Eurostat 2018.

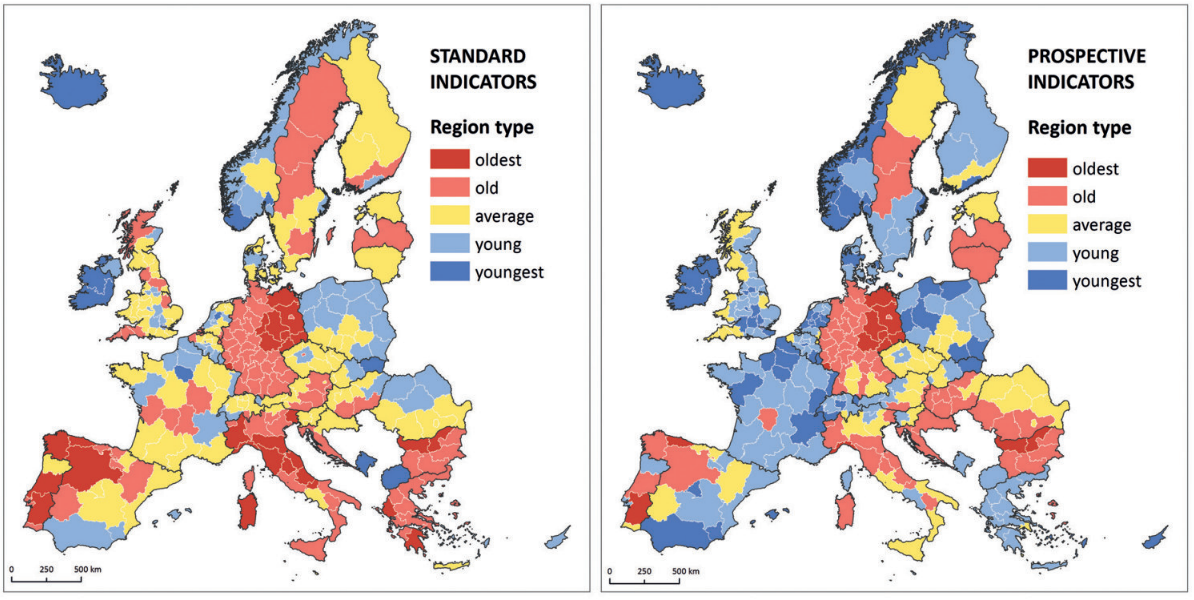


Fig. 6: Typologies of Europe's regions (NUTS2) using standard and prospective indicators of demographic aging, mean for 2013–2015. Data source: Eurostat 2018.

its economic situation. This has led to the younger population moving away, and is reflected in the age structure of this area.

At the other end of the spectrum, when standard indicators are used, the 'youngest' cluster contains 16 regions in Ireland, the United Kingdom and Norway as well as Východné Slovensko (SK), Montenegro, Macedonia, Région de Bruxelles-Capitale (BE), Île de France (FR), Iceland and Flevoland (NL). When prospective indicators are applied and remaining life expectancy is taken into account, the 'youngest' cluster expands to contain others regions in, for example, Norway, France, Poland and Denmark. The 'young' cluster contains more regions and includes ones from both the west and east. The remaining regions of Europe appear in the 'average' cluster, for example Czechia, excluding Praha and Střední Čechy.

These two typologies based on the standard and prospective indicators show marked within-country differences in terms of the progression of population aging (Fig. 6). In some cases, there is a marked difference depending on whether standard or prospective indicators are used. In particular, eastern regions appear younger when standard indicators are used. The cluster analysis based on standard indicators produced a larger number of old regions and fewer young regions than the typology based on prospective characteristics. This is because of the way the standard indicators are designed and the fact the age structure is shifting upwards. However, in both analyses the regions of southeast Germany and north Bulgaria as well as some regions in Italy, Portugal and Spain appear among the oldest, regardless of the type of indicator used. The largest difference can again be seen in the position of the Greek regions (and some French regions), which appear in the 'young' cluster when traditional characteristics are used and in the 'old' and 'oldest' clusters when prospective ones are applied, confirming the premise that using the age structure of a given population alone to assess demographic aging is not sufficient.

5 Discussion

Population aging is a multidimensional phenomenon which is one the most significant demographic challenge of European regions. In this article we employed a new prospective approach to analysing population ageing and contrasted it with the conventional chronological-aged based one. Given the marked regional differences in population change in Europe, we also attempted to apply these approaches to the level below the national one (NUTS2).

According to Kashnitsky et al. (2017), the spatial variation of the population aging (enumerated by total support ratio) between East-European regions and the rest of Europe narrows. However, the east-west gradient in Europe changes only slightly. This was confirmed by our results using selected classic aging indicators. For many crucial aspects relating to attitudes, behaviours (e.g. savings and investment strategies, the development of skills and abilities, consumer behaviour, the accumulation of tangible and human capital, etc.), social questions, such as the viability of public pension systems we need to know the potential number of remaining years of life not only how old people are (see e.g. Sanderson and Scherbov 2005, 2007, 2013). In combination with the traditional backward-looking age measure, we can obtain a much more complete picture of population ageing (Sanderson and Scherbov 2013).

Like previous research (e.g. Sanderson and Scherbov 2005, 2007, 2008; Spijker and MacInnes 2013; Spijker 2015), our study has shown that the use of both conventional and prospective methods can ultimately result in more moderate or even quite contradictory conclusions. This is partly the case with our regional analysis. Above all it is clear that, despite different demographic conditions, the level of population aging in regions with higher life expectancy values is not so high when measured using prospective indicators. By contrast in regions with worse mortality rates and less dynamic life expectancy, the process of aging may be more rapid. The shorter life expectancy and slower rate of increase mean that the local populations are older in the sense that they have shorter median remaining life spans. Understanding the links between life expectancy and population aging level is important if we are to determine future dynamics in aging. The use of this new perspective and approach to aging may help improve understanding within public discourse. Highlighting increased life expectancy and number of potential healthy years of life in the context of gradually altering pensionable age may be both politically and publicly more acceptable than suddenly increasing it by several years.

Despite the advances in analysing aging, constant prospective age remains an arbitrary boundary (Spijker 2015). The method has been further developed to ensure the end result better reflects the reality, depending on the research goals pursued. For example, in research involving healthcare costs, predictions based on age-related costs have been shown to substantially overestimate the costs (Bjørner and Arnberg 2012; Feldner 2012; Cutler et al. 2007; Miller 2001), and yet costs do raise sharply in the final years of life (e.g. Yang et al. 2003; Zweifel et al. 2004). Equally, in relation to state of health, there has been much criticism of the fact that remaining life expectancy is set at 15 years, yet it frequently includes individuals who consider themselves healthy (Spijker 2015). Miller (2001) and Spijker et al. (2014) constructed an alternative indicator, Time-to-Death, which is an indicator of acute health needs among the elderly population (see Spijker 2015). Using information on state of health (e.g. EHIS, EU-SILC findings), other indicators have been created that enable us to analyse aging and the burden it places on the productive population (see Spijker et al. 2014; Spijker 2015; Muszyńska and Rau 2012). In terms of practical use, one concern is access to input data, especially at the regional level.

There has also been a methodological shift in the prospective old-age dependency ratio. We need to be aware that it is not just life expectancy among the elderly that is increasing but also the extent to which they are economically active at an older age. We can assume that the proportion of older people who remain economically active will continue to rise. Spijker et al. (2014) and Spijker and MacInnes (2013) therefore proposed a further three indicators relating to POADR (Real Elderly Dependency Ratio, Elderly to GDP Ratio, Elderly to Tax Ratio), which should better reflect the burden exerted by the elderly population. They rely on data from the labour force survey (Real Elderly Dependency Ratio) and on GDP and tax revenue respectively. Again, researchers wishing to use these indicators at the regional level require access to the data.

Despite these limitations and the criticism of constant productive age, real progress has been made in the way age is perceived in analyses of aging, especially when compared with tools based on chronological (retrospective) age. Chronological age is problematic because it remains constant over time and so does not reflect changes taking place within populations and may even endanger the sustainability of the system if used to institute changes in key social areas (such as setting the level of retirement age). Thus far, there has been little use of prospective indicators in economic research. An analysis by Cuaresma et al. (2014, 56) provides clear empirical evidence of the superiority of measures based on prospective aging as a predictor of future economic growth at long horizons. While OADR, the conventional indicator, has been shown to be a robust determinant of economic growth for relatively short intervals only (Cuaresma et al. 2014). Based on their findings, Cuaresma et al. point out that, in policymaking targeting the negative impacts of aging on economic growth in Europe, the priority should be on monitoring prospective aging indicators (Cuaresma et al. 2014, 57). Some countries, especially the more developed economies in the world, have already begun moving away from the traditional view of age and towards prospective approaches. Several have opted for the explicit demographic indexation of pensions, and, according to the OECD (2017), the countries that have perhaps gone furthest are those that link increases in retirement age to average life expectancy. Criticism of the use of constant chronological age for setting retirement age, at 65 for instance, is widespread throughout the academic community; however, some researchers (e.g. Sanderson and Scherbov 2014) have raised the issue of fairness. They feel that the current retirement age reforms based on longevity fail to capture this. They have therefore come up with the concept of equitable normal pension age, which is based on a stable ratio between the potential number of person-years lived in retirement and the number of person-years lived at productive age (see Sanderson and Scherbov 2014). Their detailed analysis also highlights a number of problems with fixed retirement age, and the linear extension of that age by a specific constant value.

There are also certain limitations regarding regional analyses based on prospective aging and the available Eurostat database. It is the only source of comparable input data for constructing prospective indicators at the NUTS2 level. When we conducted our analysis, two aspects proved particularly problematic. The first is that the data are published as mortality tables for all populations at the NUTS2 level, but the upper age interval is open-ended (85+), and therefore not equal. That can affect the number of person-years and thereby mean life expectancy. The second limitation is migration which is also a factor at higher age levels.

The North–South migration flow within Europe includes people in their sixties and older (King et al. 2000; Innes 2008). Sixty-year-olds have longer remaining life expectancy and are generally healthier than in the past, and they often move to other regions or countries in retirement. The assumption is that migration is mainly undertaken by the relatively healthy elderly population; however, their health may subsequently change rapidly, and this may feed through into later increases in mortality. And of course we should not overlook the fact that less healthy individuals may also migrate in pursuit of better healthcare.

6 Conclusion

The consequences of demographic aging present a society-wide challenge. The measures adopted to deal with it largely rely on age-structure based analyses alone. However, it is relatively easy to design prospective indicators that can be used alongside standard indicators, which have been adapted to account for changes in life expectancy and that reflect these across space, making them better able to capture the reality of demographic aging at the regional level. The fact that these can be relatively easily interpreted by the general public is no less important.

Both the standard and prospective indicators clearly confirm the existence of marked spatial differences in demographic aging in Europe. The oldest regions are found mainly in Germany (especially in former East Germany), in the west and north west of the Iberian Peninsula, Italy, Bulgaria and Greece. The regional picture may at first glance appear to be almost the same regardless of whether standard or prospective characteristics are used. However, a closer inspection shows that unlike standard characteristics, the prospective ones reveal an advanced level of demographic aging in other regions of eastern Europe as well (e.g. in the south of Bulgaria, northern regions of Romania, in

Latvia and some parts of Hungary and Croatia). While these regions generally have a younger age structure, the high values of the prospective characteristics are generated by the fact that remaining life expectancy is lower than in western and northern Europe. The opposite situation can be observed in many regions of the former Western bloc. The standard indicators place these amongst the old or even very old regions, but the prospective indicators show that they have an average or even below-average level of population aging. A typical example is Greece, which appears in the oldest category when standard characteristics are used, but finds itself in the group of regions with a younger population when prospective indicators are used because of its higher remaining life expectancy.

Applying prospective characteristics at the NUTS2 level clearly improved our research on regional differences in population aging. On the one hand we were able to verify the existence of areas with an old population regardless of the method used to observe demographic aging and on the other hand we could identify other regions potentially at risk of demographic aging despite appearing to be relatively young when standard indicators are used. Of equal importance is the discovery, that when standard indicators are used old regions appear among those that have average or even young populations.

The traditional approaches rely on classic aging indicators that mainly point to an increasing proportion of elderly people and increased burden on the productive section of society, or on the parts of the social state relating to healthcare and the pension system. Where there are marked regional differences in mortality rates and lifespan this may lead to erroneous policy decisions. Equally the number of remaining years of life is important in decision-making on other aspects of social and health care (for instance, day care, demand for care beds, assistance with meals, transport services, etc).

When setting public sector policies, we need to recognise the importance not just of the pensionable age variable but also of the average length of time a pension is claimed, and this can be estimated using remaining life expectancy. Applying the prospective approach also allows one to model different pensionable ages. The added value of using prospective age characteristics is that they better illustrate biological and behavioural aging (Sanderson and Scherbov 2010). We believe that incorporating remaining life expectancy into the quantification of demographic aging is also important in regional analyses and allows for a more objective comparison over time as well as across different territories.

Acknowledgement

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References

Avramov, D. and Maskova, M. (2003): Active ageing in Europe. Strasbourg

Bjørner, T. B. and Arnberg, S. (2012): Terminal costs, improved life expectancy and future public health expenditure. In: International Journal of Health Care Finance and Economics 12 (2), 129–143. https://doi.org/10.1007/s10754-012-9106-1

Cuaresma, J. C.; Lábaj, M. and Pružinský, P. (2014): Prospective ageing and economic growth in Europe. In: The Journal of the Economics of Ageing 3, 50–57. https://doi.org/10.1016/j.jeoa.2014.05.003

Cutler, D. M.; Liebman, J. B.; Shepard, M. and Smyth, S. (2007): An expanded model of health and retirement. Cambridge, MA. http://www.nber.org/programs/ag/rrc/NB07-15%20Cutler%2C%20LIebman%20FINAL.pdf

d´Albis, H. and Collard, F. (2013): Age groups and the measure of population aging. In: Demographic Research 29, 617–640. https://doi.org/10.2307/2287035

Długosz, Z. (2011): Population ageing in Europe. The 2nd International Geography Symposium GEOMED 2010. In: Procedia Social and Behavioral Sciences 19, 47–55. https://doi.org/10.1016/j.sbspro.2011.05.106

European Commission (2012):The 2012 ageing report: economic and budgetary projections for the 27 EU member states (2010-2060). European Economy 2/2012. European Union. https://doi.org/10.2765/19991

– (2015): The 2015 ageing report. Economic and budgetary projections for the 28 EU member states (2013-2060). European Economy 3/2015. Economic and Financial Affairs. Luxembourg. https://doi.org/10.2765/76255

Feldner, S. (2012): Health care expenditures and the aging population. In: Bundesgesundheitsblatt Gesundheitsforschung-Gesundheitsschutz 55 (5), 614–621. https://doi.org/10.1007/s00103-012-1469-4

Fuchs, V. R. (1984): Though much is taken - reflections in aging, health, and medical care. Milbank Memorial Fund Quarterly - Health and Society 62, 143–166. https://doi.org/10.2307/3349821

GAVRILOV, L. A. and HEUVELINE, P. 2003. Aging of population. In: DEMENY, P. and MCNICOLL, G. (eds.): The encyclopedia of population. New York, 32–37.

HERSCH, L. (1944): De la démographie actuelle à la démographie potentielle. Melange des Études Economiques Offertes à William Rappard. Geneva.

INNES, A. (2008): Growing older in Malta: experiences of British retirees. In: International Journal of Ageing and Later Life 3 (2), 7–42. https://doi.org/10.3384/ijal.1652-8670.08327

KASHNITSKY, I.; DE BEER, J. and VAN WISSEN L. (2017): Decomposition of regional convergence in population aging across Europe. In: Genus 73 (2). https://doi.org/10.1186/s41118-017-0018-2

KING, R.; WARNES, T. and WILLIAMS, A. (2000): Sunset lives: British retirement migration to the Mediterranean. Oxford.

LUTZ, W. (2009): The demography of future global population aging: indicators, uncertainty, and educational composition. In: Population and Development Review 35 (2), 357–365. https://doi.org/10.1111/j.1728-4457.2009.00282.x

LUTZ, W.; SANDERSON, W. and SCHERBOV, S. (2008): The coming acceleration of global population ageing. In: Nature 451, 716–719. https://doi.org/10.1038/nature06516

MESLÉ, F. and VALLIN, J. (2002): Mortality in Europe: the divergence between east and west. In: Population 57, 157–197. https://doi.org/10.3917/pope.201.0157

MILLER, T. (2001): Increasing longevity and medicare expenditures. In: Demography 38 (2) 215–226. https://doi.org/10.1353/dem.2001.0018

MUSZYŃSKA, M. M. and RAU, R. (2012): The old-age healthy dependency ratio in Europe. In: Journal of population ageing 5 (3), 151–162. https://doi.org/10.1007/s12062-012-9068-6

OECD (2017): Pensions at a glance 2017: OECD and G20 Indicators. Paris, https://doi.org/10.1787/pension_glance-2017-en

RIFFE, T. (2015): The force of mortality by life lived is force of increment life left in stationary populations. In: Demographic Research 32, 827–834. https://doi.org/10.4054/DemRes.2015.32.29

RYDER, N. B. (1975): Notes on stationary populations. In: Population Index 41, 3–28. https://doi.org/10.2307/2734140

SANDERSON, W. C. and SCHERBOV, S. (2005): Average remaining lifetimes can increase as human populations age. In: Nature 435, 811–813. https://doi.org/10.1038/nature03593

– (2007): A new perspective on population aging. In: Demographic Research 16, 27–58. https://doi.org/10.4054/DemRes.2007.16.2

– (2008): Rethinking age and aging. In: Population Bulletin 63 (4), 3–16.

– (2010): Remeasuring aging. In: Science 329 (5997), 1287–1288. https://doi.org/10.1126/science.1193647

– (2013): The characteristics approach to the measurement of population aging. In: Population and Development 39 (4), 673–685. http://doi.org/10.1111/j.1728-4457.2013.00633.x

– (2014): An easily understood and intergenerationally equitable normal pension age. Interim Report IR-14-020. Laxenburg.

– (2015a): Are we overly dependent on conventional dependency ratio? In: Population and Development Review 41 (4), 687–708. http://doi.org/10.1111/j.1728-4457.2015.00091.x

– (2015b): Faster increases in human life expectancy could lead to slower population aging. In: PLoS ONE 10 (4): e0121922. https://doi.org/10.1371/journal.pone.0121922

– (2016): New approaches to the conceptualization and measurement of age and aging. In: Journal of Aging and Health 28 (7), 1159–1177. http://doi.org/10.1177/0898264316656517

SHOVEN, J. B. (2007): New age thinking: alternative ways of measuring age, their relationship to labor force participation, government policies and GDP. NBER Working Paper. Cambridge, MA. https://doi.org/10.3386/w13476

– (2008): Adjusting government policies for age inflation. NBER Working Paper. Cambridge, MA. https://doi.org/10.3386/w14231

SHOVEN, J. B. and GODA, G. S. (2010): Adjusting government policies for age inflation. In: Shoven, J. B. (ed.): Demography and the economy. Chicago, 143–162. https://doi.org/10.7208/chicago/9780226754758.003.0005

SIEGEL, J. (1993): Ageneration of change: a profile of America's older population. New York.

SIEGEL, J. C. and DAVIDSON, M. (1984): Demographic and socioeconomic aspects of aging in the United States. Current Population Reports 138, Series P-23. Washington DC.

SPIJKER, J. (2015): Alternative indicators of population ageing: an inventory. Working Papers 4/2015, Vienna Institute of Demography. Vienna.

SPIJKER, J. and MACINNES, J. (2013): Population ageing: the time bomb that isn't? In: BMJ 2013, 347. https://doi.org/10.1136/bmj.f6598

SPIJKER, J.; RIFFE, T. L. M. and MACINNES, J. (2014): Incorporating time-to-death (TTD) in health-based population ageing measurements. Presented at the New Measuremes of Age and Ageing, Vienna 3-5 December. https://www.oeaw.ac.at/fileadmin/subsites/Institute/VID/PDF/p1-Spijker.pdf

ŠPROCHA, B.; ŠÍDLO, L. and BURCIN, B. (2015): Úroveň úmrtnosti na Slovensku a v Česku v európskom pohľade [Mortality levels in Slovakia and Czechia in European comparative perspective]. In: Geografický časopis 67 (1), 25–43.

UN (2001): World population ageing. Departmet of Economic and Social Affairs Population Division. New York.
– 2015): World population ageing. Departmet of Economic and Social Affairs Population Division. New York.
Vallin, J. and Meslé, F. (2004): Convergence and divergences in mortality. A new approach to health transition. In: Demographic Research. Special Collection 2, 11–44. https://doi.org/10.4054/DemRes.2004.S2.2
Yang, Z.; Norton, E. C. and Stearns, S. C. (2003): Longevity and health care expenditures: the real reasons older people spend more. In: The Journals of Gerontology: Series B, 58 (1), S2–S10. https://doi.org/10.1093/geronb/58.1.S2
Zweifel, P.; Felder, S. and Meier, M. (1999): Ageing of population and health care expenditure: a red herring? In: Health Economics 8 (6), 485–496. https://doi.org/10.1002/(SICI)1099-1050(199909)8:6%3C485::AID-HEC461%3E3.0.CO;2-4

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