Urbanization and regional difference in ageing in Europe

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1. Introduction

Human populations experience Demographic Transition at varying timing and pace (Lee, 2003; Reher, 2004). While booming population growth and persisting higher levels of fertility is still the major issue in the least developed countries (Bloom, 2011), developed countries are most worried about the rapid ageing of the population (Lutz *et al.*, 2008; Bloom *et al.*, 2015) and the societal and economic challenges it poses for the future generations (Lloyd-Sherlock, 2000; Skirbekk, 2008; Christensen *et al.*, 2009). As the demographic dividend, the most profitable period of demographic modernization, when the burden on the working-age population is the smallest, is left behind in most of the developed countries (Van Der Gaag and De Beer, 2015), the ways to deal with population ageing gradually become the central topic of demographic debate (Van Nimwegen, 2013).

Even though all European countries experience population ageing, there are relative differences in the speed of the process across countries and regions (De Beer *et al.*, 2012; Rees *et al.*, 2012; Kashnitsky *et al.*, 2017). In the context of rapidly ageing population (Giannakouris, 2008), migration becomes an increasingly important factor of population change (Findlay and Wahba, 2013); David Coleman (2006) goes as far as proposing the concept of the Third Demographic Transition, in which migration plays the key role as a factor of population replacement. While more public attention is fixed upon international migration (Van Wissen, 2001; Czaika and Haas, 2014), internal migration is crucial in determining sub-national population structures (Rees *et al.*, 2013, 2017). And the key distinction in the relative speed of population ageing at sub-national level is between urban and rural areas, which is in turn largely driven by migration, mostly internal (De Beer *et al.*, 2012). Ageing and urbanization are seen as the two main demographic transitions of the developed populations (Beard and Petitot, 2010).

This paper examines differences in population ageing across NUTS-2-regions. Most research on urban-rural differences focuses on the local level, e.g. NUTS-3-regions (Sabater *et al.*, 2017; Gutiérrez Posada *et al.*, 2018). However, at the NUTS-2 level much more internationally comparable statistics are available. Moreover, the NUTS-2-level is the most important geographic level in terms of data informed policy decisions (De Beer *et al.*, 2012, 2014; Capello and Lenzi, 2013; European Commission, 2014). Therefore this paper examines urban-rural differences across the 261 NUTS-2 regions in EU-27 over the period 2003–2013 for which a harmonized dataset is prepared[1] (De Beer *et al.*, 2012, 2014).

Once we establish the concept of urbanization at NUTS-2 level, we explore whether urban-rural differences are contributing towards convergence or divergence in population ageing. The process of urbanization is likely to contribute to a divergent pattern of ageing: Urbanized regions tend to attract population at working ages, while rural regions are left with a higher proportion of people out of the labor market (Smailes *et al.*, 2014). On the other hand, there is an extensive evidence of urban health and longevity advantage (Beard and Petitot, 2010; Kibele, 2014; Chen *et al.*, 2017; Naito *et al.*, 2017). This urban health bonus coupled with lower fertility in the most urbanized areas (Kulu *et al.*, 2009; Vobecká and Piguet, 2011; Van Nimwegen, 2013) are likely to contribute to faster ageing in urban areas offsetting the direct effect of urbanization (Zeng and Vaupel, 1989). Even though there are multiple studies that document increasing disproportions in local population structures (Chen *et al.*, 2017; Faggian *et al.*, 2017; Sabater *et al.*, 2017; Gutiérrez Posada *et al.*, 2018), it is rather unclear whether a similar pattern can be found at the NUTS-2 level.

There are large demographic differences between Eastern, Southern, and Western Europe that might also manifest themselves in the process of urbanization. For example, Shucksmith *et al.* (2009) found that the urban-rural difference in the quality of life is much smaller in Western Europe compared to Eastern Europe. Similarly, Crespo Cuaresma *et al.* (2014) uncovered a large heterogeneity between Eastern Europe regions. Even though on average they are catching-up, the gap between the biggest urban regions and the periphery is widening within the countries. Multiple studies have revealed a widening gap between the deprived peripheral regions and the better-off urban areas in the countries of Southern Europe after the financial crisis of 2008-2009 (Salvati, 2016; Salvati and Carlucci, 2017). Thus our paper examines the differential effect of the urban-rural divide on convergence or divergence in ageing in Western, Southern and Eastern Europe.

[1] All the regions included in the analysis are available in the reference map in Appendix 1. The analyzed countries do not include Croatia, which is a current state of European Union but it joined only in 2013. United Kingdom, which exited European Union in 2020, is included. Here and throughout the paper the references to groups of regions, e.g. Eastern Europe, means a subset from the analyzed EU-27 countries.

2. Is there urbanization at the NUTS-2 regional level?

The official Eurostat urban-rural classification exists only at the NUTS-3 level (Eurostat, 2017); such a classification requires quite a granular delimitation of urban areas, which is only possible at low enough levels of spatial disaggregation. However, most statistics comparable at the pan-European level are aggregated at the NUTS-2 level, which is the prime level of regional analysis within the EU. Also, the Regional Cohesion policy programs operate at the NUTS-2 level (Leonardi, 2006). NUTS-2 regions are rather large: on average, a NUTS-2 region has the size of 19.7K sq. km and the population of 1.87M – that is comparable to a small country like Slovenia (European Commission, 2014; Kashnitsky and Mkrtchyan, 2014). And almost every NUTS-2 region includes both urban and rural population, which makes it difficult to classify the regions binary into urban or rural. The challenging classification task was solved within the NEUJOBS project (De Beer *et al.*, 2012, 2014). To proxy urban-rural differences, NUTS-2 regions were classified into three categories: Predominantly rural, Intermediate, and Predominantly urban. This classification was designed in such a way to keep the population figures of the three categories as close as possible to that of the official Eurostat NUTS-3 level classification. In this paper we use a simplified version of the NEUJOBS classification (Figure 1A).

On average, European regions aged a bit over the study period, 2003–2013 (Figures 1B, 1C) – the mean share of working age population (15–64) decreased by almost 1 percentage point, from 66.85 to 65.94 percent. At the same time inequality in regional population age structures increased – standard deviation of the share of working age population rose from 2.26 to 2.50 percent, and the coefficient of variance rose accordingly from 0.034 to 0.038. This large scale glance suggests that together with the dominant mode population ageing there was divergence in population age structures, at least as measured by these two variance based metrics. The question we want to tackle is whether this divergence could be explained to some extent by differential population age structure developments in urban and rural regions. Yet, first we need to figure out if urbanization is still happening in Europe.

There is evidence of both urbanization and counter-urbanization going on in modern Europe at the local level (Kabisch and Haase, 2011). If anything, regional paths of economic (Ballas *et al.*, 2017) and demographic (Wolff and Wiechmann, 2017; Gurrutxaga, 2019) development become rather more heterogeneous; Danko and Hanink (2018) found similar results for the counties of the United States. The reasonable question arises: do European regions still experience urbanization when we look at the urban-rural differences at the NUTS-2 level? To address this question, we calculated total net age-specific migration rates for all NUTS-2 regions using the demographic balance approach (Kashnitsky *et al.*, 2017). With such an approach,

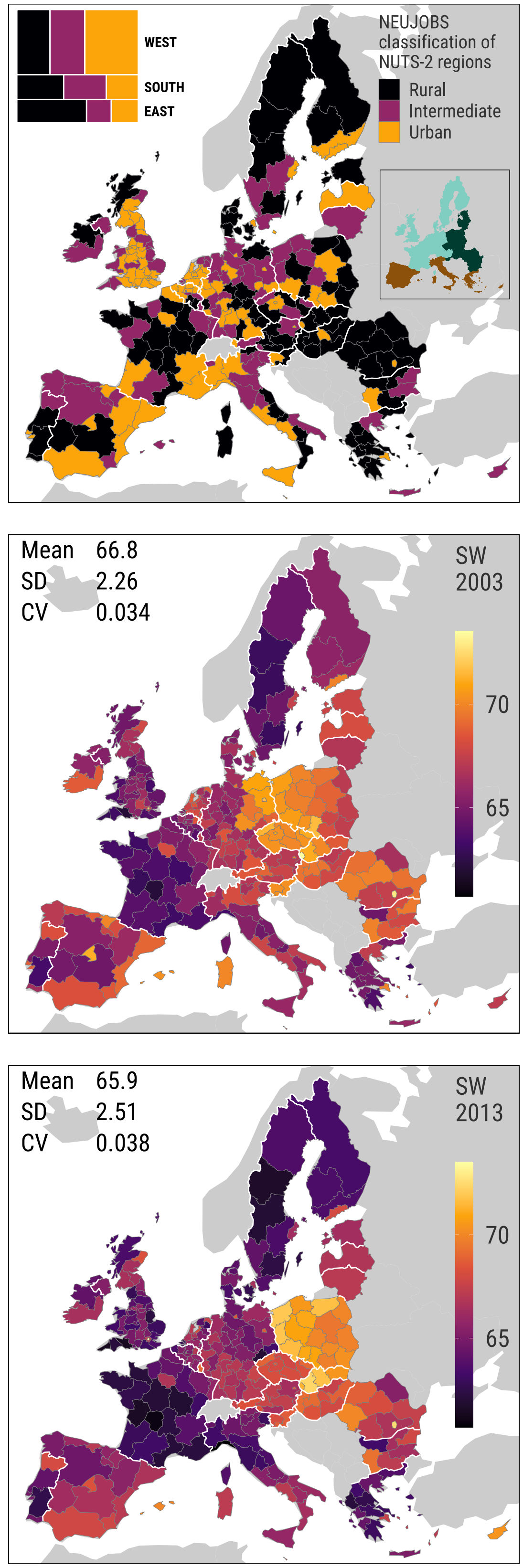

Fig. 1. Reference maps of the EU-27 NUTS-2 regions: A – NEUJOBS urban-rural classification, inset map shows the division of European countries into Western, Southern, and Eastern parts, mosaic plot in the top-left corner gives the relative frequencies of the regions across the three parts of Europe and urban/intermediate/rural classification; B, C – share of working age population in 2003 and 2013. See Appendix 1 for the reference map with all the regions labelled.

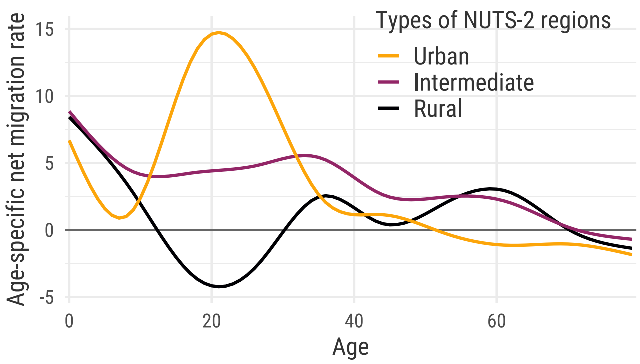

Fig. 2. Age-specific total net migration rates by urban-rural types of NUTS-2 regions, pulled single year data for the period 2003-2012. Note: the lines are GAM smoothing. Source: own calculations based on demographic balance; migration change includes both internal and international migration.

we capture age-specific change in population size due to total migration not distinguishing between regional, national, European, or outer-EU international migration flows. Then these rates were smoothed separately for each of the three NEUJOBS categories of regions: Predominantly rural, Intermediate, and Predominantly urban (Figure 2).

The age pattern looks exactly as we would expect to see in the presence of ongoing urbanization. The process of urbanization implies that population migrates from less urbanized territories to urban agglomerations. Migration always has a characteristic age profile, with higher intensities at young adult ages (Pittenger, 1974; Rogers *et al.*, 2002). This is precisely what we see in Figure 2 – it clearly shows that Predominantly urban regions receive much more in-migration at young adult ages compared to Intermediate and Predominantly rural regions. Rural regions loose population at young adult ages; these people are most likely to migrate to more urbanized areas, which are able to offer them better educational and employment opportunities. In contrast young families with children and older adults tend to move from urban to rural and intermediate regions. Note that the three lines do not balance off at zero net migration, which means that on top of migration between the regions Europe sees quite a substantial inflow of international migration. To sum up, if we can define urbanization at such a level of aggregation as NUTS-2, there was an ongoing urbanization in 2003-2012.

One question is whether the net migration age profiles change over time. In Appendix 2, Figure 8, we check these profiles in the first (2003–2007) and the second (2008–2012) halves of the study period. In contrast with the analysis for the US (Cooke, 2011, 2013), we see no major reduction of net age-specific migration rates; it's only prominent in Southern Europe, but the reason there is likely the economic crisis of 2008–2009 coupled with the extremely high in-migration rate just before it.

To account for the possible differences between Eastern, Southern and Western Europe, we also did the similar smoothing separately for each of the three parts of Europe (Figure 3). Following the logic of our previous research (Kashnitsky *et al.*, 2020), we divide European NUTS-2 regions not in four parts – as is done by the official (EuroVoc, 2017) classification of Eurostat – but in three parts: Eastern, Southern, and Western. We chose not to distinguish Northern Europe as a separate part because of its relatively small size (just 22 NUTS-2 regions) and considerable inner heterogeneity: the Nordic regions were merged with Western Europe, the Baltic regions were classified as Eastern Europe with which they have much more in common in terms of the analyzed variables. See the small sub-plot map in Figure 1A showing the division of the NUTS-2 regions across the three parts of Europe.

All the three parts of Europe experience faster population growth through migration in the young adult ages in the Predominantly urban regions, which means urbanization at the level of NUTS-2. Though, there are some differences between the three parts of Europe in the way they urbanized. Regions of Southern Europe experienced highest net migration rates within the study period: even the Predominantly rural regions saw population growth through migration, though much more moderate than that of the Predominantly urban and Intermediate regions. This is due to relatively high international migration. Another feature of South-European regions is that Intermediate regions are closer to Predominantly urban regions in terms of the age-specific migration profile (based on this we simplified the classification to just urban-rural, see the Section 3.2. The main difference between Eastern and Western Europe is in the sub-urbanization that is evident for the latter – net migratory surplus in rural regions at the mature adult ages – and nonexistent for the former. Despite some notable differences, all the three parts of Europe clearly experienced urbanization at NUTS-2 level during the study period, with urbanization being defined as relative population change due to migration. That brings us back to the question whether urbanization contributed to convergence or divergence in population structures.

3. Methods and data

3.1. Methods. In this paper we focus on the share the of working-age population as a summary measure of the population age structure. The working-age population is defined conventionally as the proportion of population aged 15–64 in the total population. The reason for choosing this indicator is that it is expected to have a positive relationship with the economic growth potential of regions (Van Der Gaag and De Beer, 2015).

To compare urban-rural differences in the share of the working-age population we calculate empirical cumulative densities and plot the distributions of corresponding groups of regions arranged in ascending order. This distributional approach to convergence analysis has several advantages. It allows to distinguish different causes of convergence. For instance, convergence can be due to smaller differences

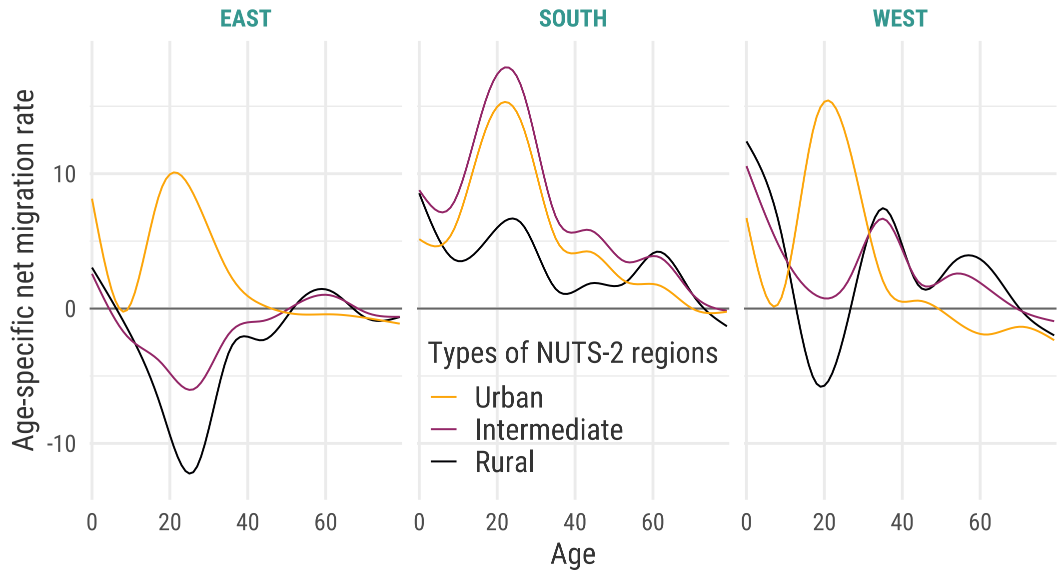

Fig. 3. Age-specific migration rates by urban-rural types of NUTS-2 regions and parts of Europe, pulled single year data for the period 2003-2012. Note: the lines are GAM smoothing. Source: own calculations based on demographic balance; migration change includes both internal and international migration.

across clusters of regions or smaller differences within clusters of regions, and cumulative distributions show both at the same time. Changes in the distance between separate distributions show whether there is convergence or divergence between clusters. This can be seen clearly from changes in the difference in the median values. Changes in the slope of the distributions shows whether there is convergence or divergence within a group of regions: the steeper the slope, the smaller is the variation of values in the distribution. Hence, an increase in the slope indicates convergence within the group of regions. Next, the approach helps to distinguish the effects of changes that occur in the upper and lower parts of the distribution. This is important since there is a conceptual distinction between convergence occurring due to the catching-up of the lagging regions or a faster decrease in the upper part of the distribution. Finally, when the profiles of the cumulative density distributions for two groups of regions become more similar over time, this can also indicate a specific type of distributional convergence, otherwise not captured by summary measures.

Empirical cumulative densities provide a powerful visualization framework to picture convergence. However, in order to assess the magnitude of changes we need to calculate metrics based on the distributions. For this purpose we use a logistic-type model in which we allow the slope parameter to vary between the lower and upper parts of the distribution, i.e. above and below the median value:

$$f(x) = \delta(x \geq m)\frac{e^{a(x-m)}}{1+e^{a(x-m)}} + \delta(x < m)\frac{e^{b(x-m)}}{1+e^{b(x-m)}}$$

where $f(x)$ is the cumulative density function, x is the share of the working-age population, m is the median value, δx is the indicator function; a, b, and m are the parameters to be estimated by non-linear least squares.

A greater estimated value of the a and b parameters indicates a steeper curve of the cumulative density. Hence, an increase in these parameter values over time means convergence, a decrease means divergence. Furthermore, if a increases there is convergence above the median, if b increases there is convergence below the median. A change in the median value, parameter m, implies a shift of the whole distribution. If, for example, a and b do not change and m increases, that means that the whole distribution is shifted uniformly toward higher values of x, but neither convergence, nor divergence is observed.

3.2. Data. We analyze population age structures of the 261 NUTS-2 regions of EU-27 using a harmonized dataset for the years 2003–2012 (Kashnitsky *et al.*, 2017). The overseas territories of France, Spain and Portugal are excluded from the dataset. The data come from Eurostat (Eurostat, 2015a). We use the 2010 definition of NUTS regions (Eurostat, 2015b) and the a modified version of EuroVoc (2017) official classification of parts of Europe, in which we split Northern European regions between Western (Nordic countries) and Eastern (Baltic countries) Europe. The NEUJOBS urban-rural classification of NUTS-2 regions is used (De Beer *et al.*, 2012, 2014). We simplified it by eliminating the intermediate category: based of the profile of age-specific net migration rates, in Southern Europe intermediate regions were classified as urban, and in Eastern and Western Europe – as rural.

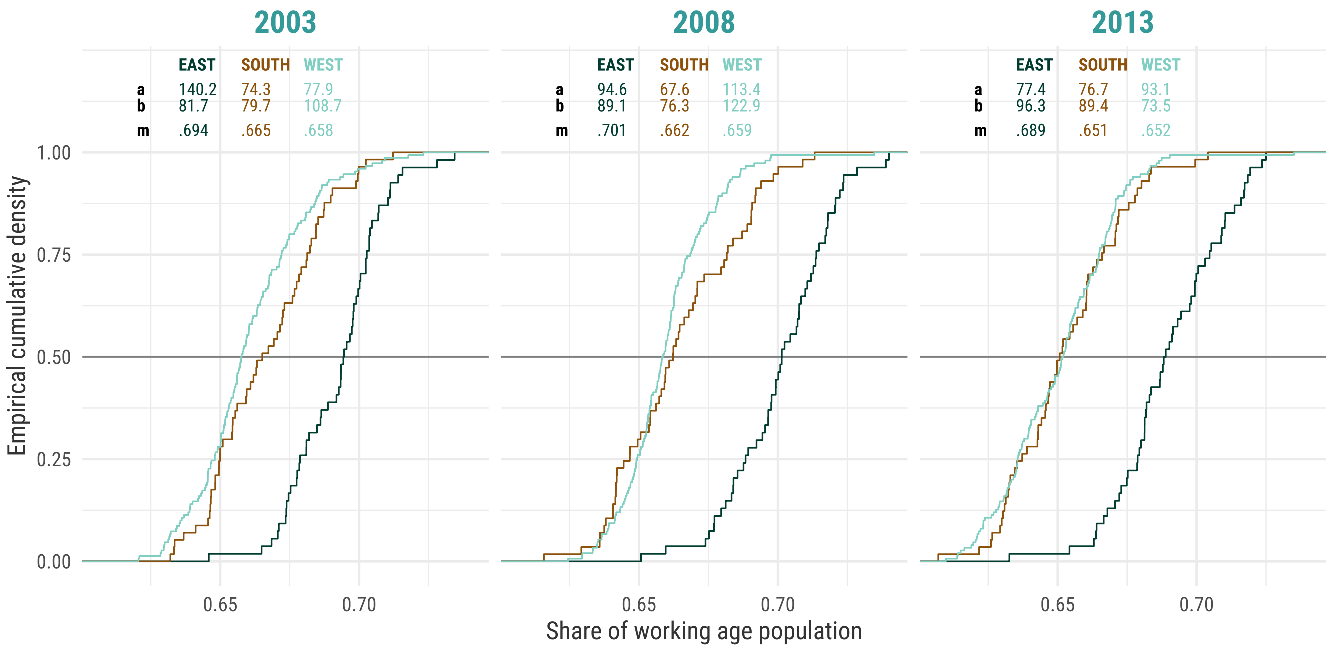

Fig. 4. Empirical cumulative densities of the share of working age population variable for the three parts Europe at the beginning, the middle, and the end of the study period.

4. Results

4.1. Convergence or divergence in population structures?.

To address the main question of the paper – whether urbanization contributes to divergence (our main hypothesis) or convergence in population age structures – we first want to figure out what were the baseline dynamics of the relative regional differences in population structures within the study period.

A glance at the empirical cumulative densities of the share of the working age population for the three parts of Europe (Figure 4) tells the story of the ending phase of the demographic dividend in Eastern Europe (Van Der Gaag and De Beer, 2015; Kashnitsky *et al.*, 2020). The median values for this group of regions are much higher throughout the study period. In the first half, 2003–2008, Eastern Europe shows distinct diverging development from the rest of Europe – its distribution line moves further apart from the two other lines, m increases from 0.694 to 0.701 while it decreases slightly in Southern and Western parts. In this period Eastern Europe still benefited from the main phase of demographic dividend. Though in the second part, 2008–2013, the gap between East and the rest of Europe started to decrease indicating the end of demographic dividend and the start of rapid catching-down convergence, m decreased by 0.012 in Eastern, 0.011 in Southern and only 0.007 in Western Europe. The differences between Southern and Western Europe, that were driven entirely by the regions in the upper part of the distributions, virtually disappeared – South caught up with West, the forerunner of demographic transition. This may reflect the fact that there were only a handful of regions in Southern Europe that managed to keep a relatively high share of working age population. Population ageing was especially fast in the upper part of the distribution of Eastern regions, which is most likely caused by the rapid outflow of working age migrants from Eastern to Western Europe that came more from the urbanized areas (Okólski and Salt, 2014).

The differences between Eastern, Southern and Western Europe first increased a bit due to the divergent development of Eastern Europe, but then decreased a lot by the end of the study period. In fact the differences the in cumulative density distributions disappeared completely in the case of Southern and Western Europe. Analyzing the slopes of the empirical cumulative densities, we notice that they became much more similar towards the end of the study period, in every part of Europe the distribution of regions became alike. Though, the distributions themselves became plainer, meaning that the overall variance in the share of the working age population has increased indicating divergence within the three parts of Europe. In other words, regions in every part of Europe became more heterogeneous by the end of the study period. This effect is most clearly visible in Western Europe, which was characterized by a squeezed lower tail of the distribution in 2003. By 2013 the lower half of the distribution became much plainer and wider, which reflects the fact that there are some regions in Western Europe that age at an accelerated pace. Most likely, these are the regions of rural periphery (Kashnitsky and Schöley, 2018). This raises the question whether the divergence can be attributed to the effects of urbanization.

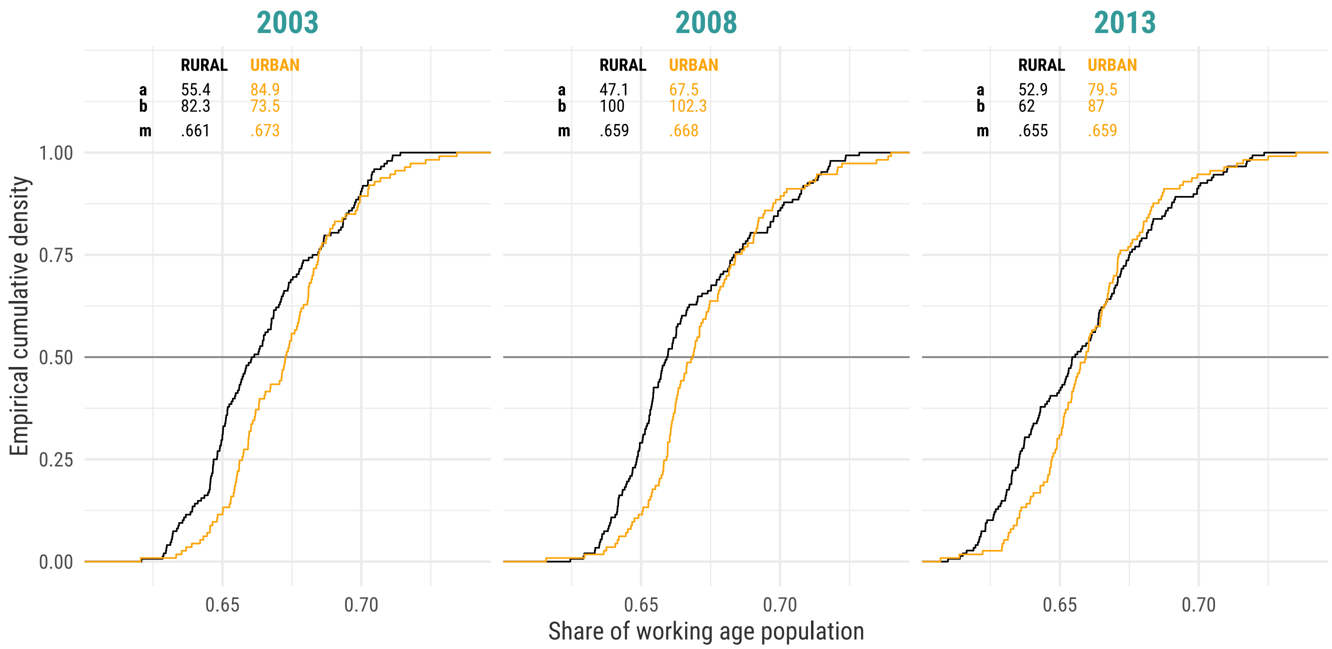

Fig. 5. Empirical cumulative densities of the share of working age population variable for the two urban-rural categories of regions at the beginning, the middle, and the end of the study period.

4.2. The contribution of urbanization. Figure 5 compares the empirical cumulative densities of Predominantly Rural and Predominantly Urban regions at the beginning, the middle, and the end of the study period. At first glance, they look surprisingly alike, and there seems to be very little change between the lines over time. This is an artifact driven by the systematic differences in the timing of Demographic Transition between the three parts of Europe (Kashnitsky *et al.*, 2020). As in the case of the analysis of convergence in ageing for all European NUTS-2 regions above (Figure 4), the differences between Eastern, Southern and Western Europe are masking the differences that exist between the urbanized and less urbanized regions.

When similar empirical cumulative densities are calculated for each part of Europe separately, the picture becomes much more informative (Figure 6). The dynamics of the distributions suggest that in every part of Europe differences between urban and rural regions decreased over time – the cumulative distribution lines for urban and rural regions come closer to each other over time in every part of Europe. This means that the process of urbanization, that, as we saw in the second part of this paper, was occurring in Europe at NUTS-2 level over the study period, contributed to convergence of regions in population structures rather than the expected divergence.

In Eastern regions, the distributions of urban and rural regions have become very similar, indicating convergence across urban and rural regions. Not only the shapes of the distributions became more similar, but also the difference in the median values reduced strongly in the second part of the study period from 0.012 to 0.006. At the same time within the urban and rural groups of regions variation has increased in the regions with relatively high shares of working age population – the slopes above the median have become plainer: the value of the a parameter for rural regions declined from 173.5 to 81.8, and for urban regions from 130.8 to 94.1.

In Southern Europe, urban regions aged fastest reducing the gap with rural regions: the values of m for urban regions decreased from 0.677 to 0.657. As a result the urban-rural difference in m decreased from 0.027 to 0.014. The Southern regions saw the biggest increase in variation within urban and rural groups of regions, which may reflect the uneven effect of economic crisis that hit this part of Europe hardest. The a parameter for rural regions declined from 152 to 90.2, and for urban regions from 139.2 to 84.4; the b parameter for rural regions decreased from 207.8 to 103.5, and for urban regions from 85.1 to 79.7.

Western regions saw a rapid convergence in the first part of the period, and then divergence in the second part. The a parameter for rural regions increased from 89.7 to 125.6 in the first period and declined to 65 in the second period, for urban regions there was an increase from 72.6 to 106.4 followed by a decrease to 100.4; the b parameter for rural regions increased from 108 to 128.2 followed by a decrease to 94, and for urban regions an increase from 116.4 to 164.6 was followed by a decrease to 110.3. The difference in the medians did not change in the first sub-period, but increased in the second sub-period, even though both urban and rural regions saw graying of the first baby boomers; the

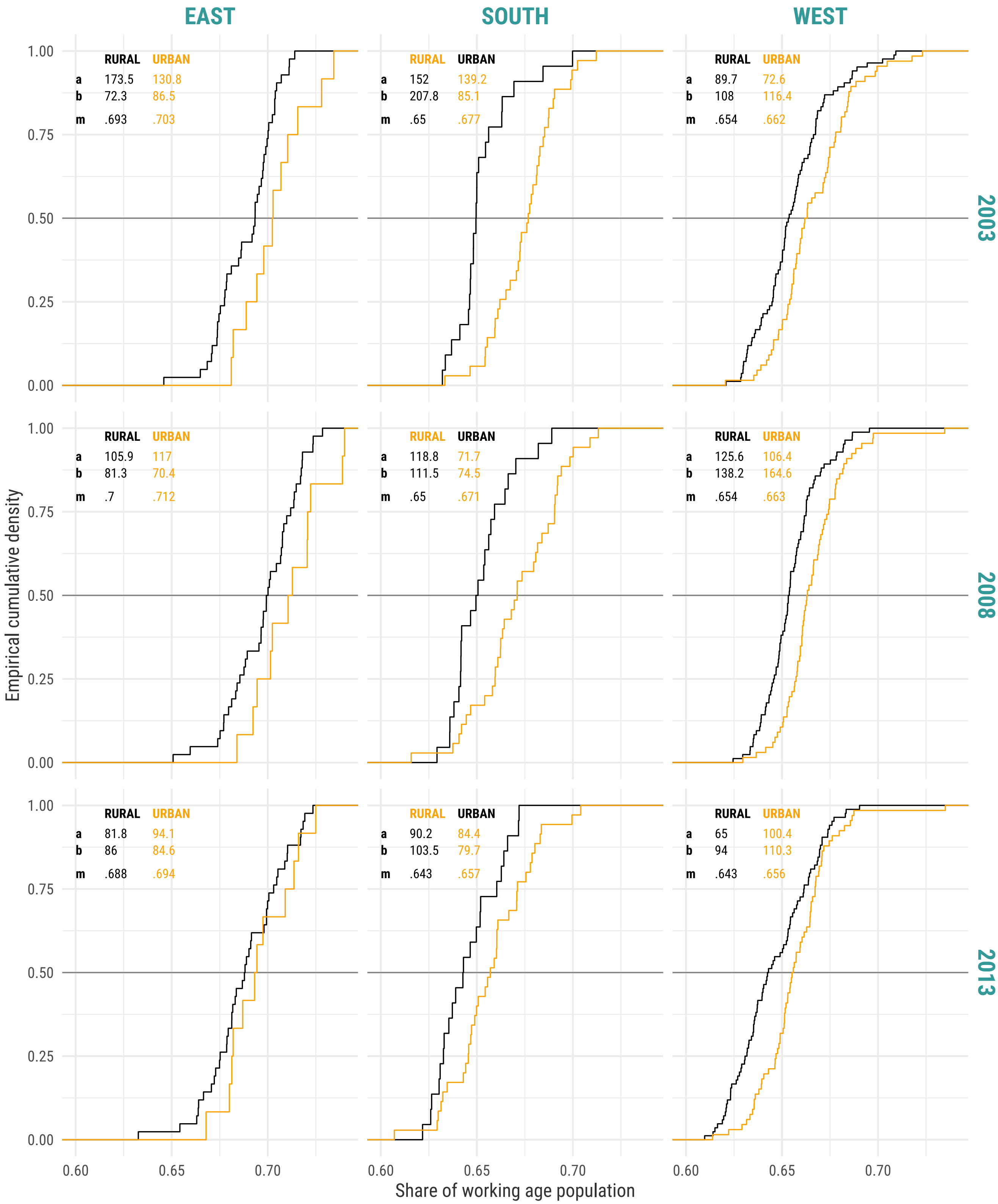

Fig. 6. Empirical cumulative densities of the share of working age population variable for the three parts Europe and the two urban-rural categories of regions at the beginning, the middle, and the end of the study period.

urban-rural difference in m increased from 0.008 to 0.013. This reflects the uneven effect of the ageing of the baby boom generation across Western regions – it hit rural regions more than urban regions and the lower half of the urban regions distribution more than the upper half. In fact, only the second part of the study period in Western regions shows us a picture close to the one that we expected, when faster ageing in rural regions increases the gap in population age structures between urban and rural regions and increases the heterogeneity within both groups of regions.

The distributions for South and West, that at the first inquiry (Figure 4) became almost identical towards the end of the study period, no longer look so once we distinguish between urban and rural regions (Figure 6). In Southern regions the main urban-rural differences occur in the upper half of the distribution indicating that there is a certain number of urban regions that are more successful in preserving a younger population structure. In contrast, in Western regions the upper half of the rural distribution do not differ a lot from the urban regions. This may be the result of less contrast in the urban-rural continuum in the densely populated parts of Western Europe prosperous rural regions do not age much faster than urban regions.

The overall contribution of urban-rural differences to regional differences in population ageing is clearly visible in the changes of the median values. Both in Eastern and Southern Europe this difference reduced significantly during the study period indicating convergence across urban and rural regions in population ageing in contrast to the overall divergence of population age structures. Western Europe saw a slight increase of the difference between the medians, which was to some extent compensated by the reduced difference at the upper half of the distribution. In general, we saw a decrease in the estimated values of a and b parameters, which means that within urban and rural groups of regions there was divergence in population age structures. In all three parts of Europe the fastest divergence occurred in the upper half of the distributions. This means that, in the context of rapidly ageing Europe, there are some regions that are more successful in keeping a relatively high proportion of population at working ages.

5. Discussion

Our results show that overall NUTS-2 regions in Europe become less similar in population age structures, though the differences between part of regions diminish over time. Similarly, yet contrary to our aspirations, continuing urbanization does not lead to divergence in population age structures – increasing disparities between urban and rural regions. Instead, both categories of regions become more unequal. Towards the end of the study period we observe that the upper part of the rural distribution, regions with the highest share of working age population, become less different from the corresponding upper part of the urban regions distribution. This development is less prominent in the lower part of the distributions – rural regions with the lowest share of working age population form particularly disadvantaged clusters. This suggests that the urban-rural classification becomes less informative. This finding goes in line with other published papers (Kabisch and Haase, 2011; Pagliacci, 2017; Wolff and Wiechmann, 2017; Danko and Hanink, 2018).

One limitation of our study is a rather crude conventional approach to the definition of ageing based on the fixed age boundaries of the working age population. With the increasingly flexible later-life working arrangements, the cutting edge of 65 years of age is progressively becoming less descriptive of the real productivity of population (Vaupel and Loichinger, 2006; Lee *et al.*, 2014). Ideally, one would want to have estimates for population consumption and production age curves at regional level, similar to the National Transfer Accounts estimated for countries (Kupiszewski, 2013; Vargha *et al.*, 2017; Kluge *et al.*, 2019). Unfortunately, these estimates are not yet available at regional level where we focus to study urban/rural differences.

One possible refinement of the presented results may include a more nuanced approach to the definition of age boundaries for elderly population (Sanderson and Scherbov, 2010; Spijker and MacInnes, 2013; Kjærgaard and Canudas-Romo, 2017; Loichinger *et al.*, 2017). The other arbitrary conventional working age boundary of 15 years is also changing its meaning with the persistent growth of educational attainment (Kc *et al.*, 2010; Harper, 2014) and prolonging transitions to adulthood (Billari and Liefbroer, 2010; Bongaarts *et al.*, 2017). Thus, conventional age cut-offs become less and less valuable in defining the transition to working age category. This is especially important with a tremendous diversification of lifestyles and generally much increased variability in the pathways to adulthood (Buchmann and Kriesi, 2011; Damaske and Frech, 2016). In fact, the more variable is the age of becoming adulthood, the less informative any fixed cut-off point becomes. To address this limitation of our study, we checked how sensitive are the regional differences in the share of working age population to shifting the lower age boundary from the conventional 15 years to 20 years, and the upper boundary – from 65 years to 70 years (see Appendix 3).

Another possible way to develop the present study would be to focus on other relevant dimensions of regional inequality that may contribute to convergence or divergence in population age structures and may interplay with urban-rural differences, e.g. ethnic (Franklin, 2014), socio-economic (Tselios, 2014) and educational (Striessnig and Lutz, 2013; Goujon *et al.*, 2016) structures of the population.

The evident difficulty of the research on urban-rural differences in population structures lies in the urban-rural classification itself. In this paper we rely on the classification developed in the NEUJOBS project (De Beer *et al.*, 2012, 2014). Apart from the aggregation difficulties that were discussed and solved in this approach, there are challenges posed by the constantly evolving urban-rural continuum. For instance, many regions of Europe still experience urban sprawl (Morollón *et al.*, 2016, 2017; Salvati and Carlucci, 2016). There were multiple attempts to develop a more nuanced approach to urban-rural classification (Champion, 2009; Pagliacci, 2017). Some studies show that the areal changes of urban-rural boundaries cast quite some effect on the urban-rural differences in demographic development (Chen *et al.*, 2017). The increasing difficulty of the urban-rural boundary delimitation even motivated Caffyn and Dahlström (2005) to call for a new interdependence approach in urban-rural research as opposed to the conventional approach that is focused on differences.

6. Conclusions

Our paper examines whether urbanization has contributed to divergence in population ageing across urban and rural NUTS-2 regions. We first show that at the NUTS-2 level the age profiles of net migration indicate that there has been ongoing urbanization. Young adults tend to move from rural to urban regions. However, our results show that this has not resulted in an increase in the difference in population age structures between urban and rural regions. The effect of net migration is rather small and is overbalanced by the overall divergence in the regional the share of working age population distributions. We found support for previous studies that show that urban areas are becoming more and more heterogeneous (Kabisch and Haase, 2011; Wolff and Wiechmann, 2017). It is important to distinguish urban regions that tend to form successful clusters, in terms of preserving favorable population age structure, from less prosperous ones (Sabater *et al.*, 2017). This effect is especially evident in Southern Europe after the recent economic recession (Salvati, 2016; Salvati and Carlucci, 2017). Regional population age structures become more unequal both in urban and rural groups of regions, and the binary urban-rural classification is becoming less and less useful in distinguishing macro patterns in regional population age structure dynamics.

7. References

Ballas D, Dorling D, Hennig B. 2017. Analysing the regional geography of poverty, austerity and inequality in Europe: A human cartographic perspective. *Regional Studies* **51**: 174–185 DOI: 10/ggnmpg

Beard JR, Petitot C. 2010. Ageing and Urbanization: Can Cities be Designed to Foster Active Ageing? *Public Health Reviews* **32**: 427–450 DOI: 10/ggnfgw

Billari FC, Liefbroer AC. 2010. Towards a new pattern of transition to adulthood? *Advances in Life Course Research* **15**: 59–75 DOI: 10/cxkgfg

Bloom DE. 2011. 7 Billion and Counting. *Science* **333**: 562–569 DOI: 10/d6h9c9

Bloom DE, Chatterji S, Kowal P, Lloyd-Sherlock P, McKee M, Rechel B, Rosenberg L, Smith JP. 2015. Macroeconomic implications of population ageing and selected policy responses. *The Lancet* **385**: 649–657 DOI: 10/f25v3m

Bongaarts J, Mensch BS, Blanc AK. 2017. Trends in the age at reproductive transitions in the developing world: The role of education. *Population Studies* **0**: 1–16 DOI: 10/ggnfh9

Buchmann MC, Kriesi I. 2011. Transition to Adulthood in Europe. *Annual Review of Sociology* **37**: 481–503 DOI: 10/crbdjz

Caffyn A, Dahlström M. 2005. Urban–rural interdependencies: Joining up policy in practice. *Regional Studies* **39**: 283–296 DOI: 10/fns9k2

Capello R, Lenzi C. 2013. Territorial Patterns of Innovation and Economic Growth in European Regions. *Growth and Change* **44**: 195–227 DOI: 10/f4xqd7

Champion T. 2009. Urban–Rural Differences in Commuting in England: A Challenge to the Rural Sustainability Agenda? *Planning Practice & Research* **24**: 161–183 DOI: 10/brwjwx

Chen Q, Dietzenbacher E, Los B. 2017. The effects of ageing and urbanisation on China's future rural and urban populations. *Asian Population Studies* **13**: 172–197 DOI: 10/ggnfjb

Christensen K, Doblhammer G, Rau R, Vaupel JW. 2009. Ageing populations: The challenges ahead. *The Lancet* **374**: 1196–1208 DOI: 10/b463sd

Coleman D. 2006. Immigration and Ethnic Change in Low-Fertility Countries: A Third Demographic Transition. *Population and Development Review* **32**: 401–446 DOI: 10/dhp669

Cooke TJ. 2011. It is not Just the Economy: Declining Migration and the Rise of Secular Rootedness. *Population, Space and Place* **17**: 193–203 DOI: 10/bqjz6b

Cooke TJ. 2013. Internal Migration in Decline. *The Professional Geographer* **65**: 664–675 DOI: 10/ggnphh

Crespo Cuaresma J, Doppelhofer G, Feldkircher M. 2014. The Determinants of Economic Growth in European Regions. *Regional Studies* **48**: 44–67 DOI: 10/gfgwbb

Czaika M, Haas H de. 2014. The Globalization of Migration: Has the World Become More Migratory? *International Migration Review* **48**: 283–323 DOI: 10/gdnfpd

Damaske S, Frech A. 2016. Women's Work Pathways Across the Life Course. *Demography* **53**: 365–391 DOI: 10/f8hnnd

Danko JJ, Hanink DM. 2018. Beyond the obvious: A comparison of some demographic changes across selected shrinking and growing cities in the United States from 1990 to 2010. *Population, Space and Place* **24**: e2136 DOI: 10/gd4g3d

De Beer J, Van Der Erf R, Huisman C. 2012. The growth of the working age population: Differences between rural and urban regions across Europe. D 8.1. NIDI, The Hague. Available at: http://bit.ly/debeer2012

De Beer J, Van Der Gaag N, Van Der Erf R. 2014. New classification of urban and rural NUTS 2 regions in Europe. *NIDI Working Papers* **2014/3** Available at: http://www.nidi.nl/shared/content/output/papers/nidi-wp-2014-03.pdf

European Commission. 2014. *Eurostat regional yearbook 2014*. Publications Office of the European Union: Luxembourg. Available at: http://doi.org/10.2785/54659

Eurostat. 2015a. Population on 1 January by age, sex and NUTS 2 region Available at: http://bit.ly/eurostat2015n2agesex [Accessed 4 March 2015]

Eurostat. 2015b. History of NUTS Available at: http://ec.europa.eu/eurostat/web/nuts/history [Accessed 21 September 2015]

Eurostat. 2017. Urban-rural typology. *Statistics Explained* Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Urban-rural_typology

EuroVoc. 2017. Subregions of Europe Available at: http://eurovoc.europa.eu/100277

Faggian A, Rajbhandari I, Dotzel KR. 2017. The interregional migration of human capital and its regional consequences: A review. *Regional Studies* **51**: 128–143 DOI: 10/gfc4pz

Findlay AM, Wahba J. 2013. Migration and Demographic Change. *Population, Space and Place* **19**: 651–656 DOI: 10/ggnfg4

Franklin RS. 2014. An Examination of the Geography of Population Composition and Change in the United States, 2000–2010: Insights from Geographical Indices and a Shift–Share Analysis. *Population, Space and Place* **20**: 18–36 DOI: 10/f5nhdn

Giannakouris K. 2008. Ageing characterises the demographic perspectives of the European societies. *Statistics in focus* **72**: 2008 Available at: http://ec.europa.eu/eurostat/documents/3433488/5583040/KS-SF-08-072-EN.PDF/1c8f668a-d1d9-42cb-80b1-eaf3dfc1b7df

Goujon A, K.C. S, Speringer M, Barakat B, Potancoková M, Eder J, Striessnig E, Bauer R, Lutz W. 2016. A harmonized dataset on global educational attainment between 1970 and 2060 – an analytical window into recent trends and future prospects in human capital development. *Journal of Demographic Economics* **82**: 315–363 DOI: 10/f9gb4c

Gurrutxaga M. 2019. Incorporating the life-course approach into shrinking cities assessment: The uneven geographies of urban population decline. *European Planning Studies* **0**: 1–17 DOI: 10/ggnmpj

Gutiérrez Posada D, Rubiera Morollón F, Viñuela A. 2018. Ageing Places in an Ageing Country: The Local Dynamics of the Elderly Population in Spain. *Tijdschrift voor economische en sociale geografie* **109**: 332–349 DOI: 10/gdqgsf

Harper S. 2014. Economic and social implications of aging societies. *Science* **346**: 587–591 DOI: 10/f6mw6g

Kabisch N, Haase D. 2011. Diversifying European agglomerations: Evidence of urban population trends for the 21st century. *Population, Space and Place* **17**: 236–253 DOI: 10/cz3qz2

Kashnitsky I, Mkrtchyan N. 2014. Russian periphery is dying in movement: A cohort assessment of Russian internal youth migration based on Census data. *NIDI Working Papers* **2014/14** DOI: 10/ggnfj9

Kashnitsky I, Schöley J. 2018. Regional population structures at a glance. *The Lancet* **392**: 209–210 DOI: 10/dfnv

Kashnitsky I, De Beer J, Van Wissen L. 2017. Decomposition of regional convergence in population aging across Europe. *Genus* **73**: 2 DOI: 10/gdq9ws

Kashnitsky I, De Beer J, Van Wissen L. 2020. Economic Convergence In Ageing Europe. *Tijdschrift voor economische en sociale geografie* **111**: 28–44 DOI: 10/ggnfjh

Kc S, Barakat B, Goujon A, Skirbekk V, Lutz W. 2010. Projection of populations by level of educational attainment, age, and sex for 120 countries for 2005-2050. *Demographic Research* **22**: 383–472 DOI: 10/cgr9ct

Kibele EUB. 2014. Individual- and area-level effects on mortality risk in Germany, both East and West, among male Germans aged 65+. *International Journal of Public Health* **59**: 439–448 DOI: 10/f54prf

Kjærgaard S, Canudas-Romo V. 2017. Potential support ratios: Cohort versus period perspectives. *Population Studies* **71**: 171–186 DOI: 10/gctr2z

Kluge FA, Goldstein JR, Vogt TC. 2019. Transfers in an aging European Union. *The Journal of the Economics of Ageing* **13**: 45–54 DOI: 10/ggnfjj

Kulu H, Boyle PJ, Andersson G. 2009. High Suburban Fertility: Evidence from Four Northern European Countries. *Demographic Research* **21**: 915–944 DOI: 10/d3zsz8

Kupiszewski M (ed.). 2013. *International Migration and the Future of Populations and Labour in Europe*. Springer Netherlands. DOI: 10.1007/978-90-481-8948-9

Lee R. 2003. The Demographic Transition: Three Centuries of Fundamental Change. *Journal of Economic Perspectives* **17**: 167–190 DOI: 10/dgx83v

Lee R, Mason A, Lee R, Mason A, Amporfu E, An C-B, Bixby LR, Bravo J, Bucheli M, Chen Q, et al. 2014. Is low fertility really a problem? Population aging, dependency, and consumption. *Science* **346**: 229–234 DOI: 10/f6jjdb

Leonardi R. 2006. Cohesion in the European Union. *Regional Studies* **40**: 155–166 DOI: 10/dbr59p

Lloyd-Sherlock P. 2000. Population ageing in developed and developing regions: Implications for health policy. *Social Science & Medicine* **51**: 887–895 DOI: 10/fq6wrj

Loichinger E, Hammer B, Prskawetz A, Freiberger M, Sambt J. 2017. Quantifying Economic Dependency. *European Journal of Population* **33**: 351–380 DOI: 10/gbmppr

Lutz W, Sanderson W, Scherbov S. 2008. The coming acceleration of global population ageing. *Nature* **451**: 716–719 DOI: 10/c3hv48

Morollón FR, Marroquin VMG, Rivero JLP. 2016. Urban sprawl in Spain: Differences among cities and causes. *European Planning Studies* **24**: 207–226 DOI: 10/gfpnf8

Morollón FR, Marroquín VMG, Rivero JLP. 2017. Urban sprawl in Madrid? *Letters in Spatial and Resource Sciences* **10**: 205–214 DOI: 10/ggnfjc

Naito T, Ikazaki D, Omori T. 2017. Precautionary public health, ageing and urban agglomeration. *Asia-Pacific Journal of Regional Science* **1**: 655–669 DOI: 10/ggnfjd

Okólski M, Salt J. 2014. Polish Emigration to the UK after 2004; Why Did So Many Come? *Central and Eastern European Migration Review* **3**: 11–37 Available at: http://www.ceeol.com/aspx/getdocument.aspx?logid=5&id=b0b651a7e605474fa9c6618339f7133c

Pagliacci F. 2017. Measuring EU Urban-Rural Continuum Through Fuzzy Logic. *Tijdschrift voor economische en sociale geografie* **108**: 157–174 DOI: 10/f92xj4

Pittenger DB. 1974. A Typology of Age-Specific Net Migration Rate Distributions. *Journal of the American Institute of Planners* **40**: 278–283 DOI: 10/bn98bw

Rees P, Bell M, Kupiszewski M, Kupiszewska D, Ueffing P, Bernard A, Charles-Edwards E, Stillwell J. 2017. The Impact of Internal Migration on Population Redistribution: An International Comparison. *Population, Space and Place* **23**: e2036 DOI: 10/ggnfjf

Rees P, Van Der Gaag N, De Beer J, Heins F. 2012. European Regional Populations: Current Trends, Future Pathways, and Policy Options. *European Journal of Population / Revue européenne de Démographie* **28**: 385–416 DOI: 10/f4fdnd

Rees P, Zuo C, Wohland P, Jagger C, Norman P, Boden P, Jasinska M. 2013. The Implications of Ageing and Migration for the Future Population, Health, Labour Force and Households of Northern England. *Applied Spatial Analysis and Policy* **6**: 93–122 DOI: 10/ggnfg8

Reher DS. 2004. The demographic transition revisited as a global process. *Population, Space and Place* **10**: 19–41 DOI: 10/b945kv

Rogers A, Raymer J, Willekens F. 2002. Capturing the age and spatial structures of migration. *Environment and Planning A* **34**: 341–359 DOI: 10/fk4brh

Sabater A, Graham E, Finney N. 2017. The spatialities of ageing: Evidencing increasing spatial polarisation between older and younger adults in England and Wales. *Demographic Research* **36**: 731–744 DOI: 10/f9zbnh

Salvati L. 2016. The Dark Side of the Crisis: Disparities in per Capita income (2000–12) and the Urban-Rural Gradient in Greece. *Tijdschrift voor economische en sociale geografie* **107**: 628–641 DOI: 10/f9p5jp

Salvati L, Carlucci M. 2016. Patterns of Sprawl: The Socioeconomic and Territorial Profile of Dispersed Urban Areas in Italy. *Regional Studies* **50**: 1346–1359 DOI: 10/ggnfh3

Salvati L, Carlucci M. 2017. Urban growth, population, and recession: Unveiling multiple spatial patterns of demographic indicators in a Mediterranean City. *Population, Space and Place* **23**: e2079 DOI: 10/gckcmg

Sanderson W, Scherbov S. 2010. Remeasuring Aging. *Science* **329**: 1287–1288 DOI: 10/bbxfg6

Shucksmith M, Cameron S, Merridew T, Pichler F. 2009. Urban–Rural Differences in Quality of Life across the European Union. *Regional Studies* **43**: 1275–1289 DOI: 10/d6s3b6

Skirbekk V. 2008. Age and productivity potential: A new approach based on ability levels and industry-wide task demand. *Population and Development Review* **34**: 191–207 Available at: https://www.jstor.org/stable/25434764

Smailes P, Griffin T, Argent N. 2014. Demographic Change, Differential Ageing, and Public Policy in Rural and Regional Australia: A ThreeState Case Study. *Geographical Research* **52**: 229–249 DOI: 10/ggnfhj

Spijker J, MacInnes J. 2013. Population ageing: The timebomb that isn't? *BMJ* **347**: f6598 DOI: 10/ggnfg7

Striessnig E, Lutz W. 2013. Can below-replacement fertility be desirable? *Empirica* **40**: 409–425 DOI: 10/ggnfg9

Tselios V. 2014. Urbanization and Socioeconomic Status in the European Regions: The Role of Population Ageing and Capital City Regions. *European Planning Studies* **22**: 1879–1901 DOI: 10/ggnfhk

Van Der Gaag N, De Beer J. 2015. From Demographic Dividend to Demographic Burden: The Impact of Population Ageing on Economic Growth in Europe: From Demographic Dividend to Demographic Burden. *Tijdschrift voor economische en sociale geografie* **106**: 94–109 DOI: 10/ggnfht

Van Nimwegen N. 2013. Population change in Europe: Turning challenges into opportunities. *Genus* **69**: 103–125 DOI: 10/ggnfhc

Van Wissen L. 2001. James P. Smith and Barry Edmonston (eds.) The Immigration Debate: Studies on the Economic, Demographic and Fiscal Effects of Immigration. *European Journal of Population / Revue européenne de Démographie* **17**: 203–205 DOI: 10/btg3r7

Vargha L, Gál RI, Crosby-Nagy MO. 2017. Household production and consumption over the life cycle: National Time Transfer Accounts in 14 European countries. *Demographic Research* **36**: 905–944 DOI: 10/f9w8sx

Vaupel JW, Loichinger E. 2006. Redistributing Work in Aging Europe. *Science* **312**: 1911–1913 DOI: 10/b6b5mc

Vobecká J, Piguet V. 2011. Fertility, Natural Growth, and Migration in the Czech Republic: An Urban–Suburban–Rural Gradient Analysis of LongTerm Trends and Recent Reversals. *Population, Space and Place* **18**: 225–240 DOI: 10/b74txt

Wolff M, Wiechmann T. 2017. Urban growth and decline: Europe's shrinking cities in a comparative perspective 1990–2010: *European Urban and Regional Studies* DOI: 10/ggbdvb

Zeng Y, Vaupel JW. 1989. The Impact of Urbanization and Delayed Childbearing on Population Growth and Aging in China. *Population and Development Review* **15**: 425–445 DOI: 10/frxg2d

8. Appendix 1

Figure 7 provides a reference to help the reader navigate across the vast number of NUTS-2 regions in Europe. Please find the complete list of regions at Eurostat website, the page devoted to history of NUTS (Eurostat, 2015b). The NUTS version used in in this paper is 2010. Eurostat also provides a detailed explanation of the urban-rural typolofy at NUTS-3 level (Eurostat, 2017).

9. Appendix 2

Figure 8 is a sensitivity check for the possible leveling off of urbanization driving migration. As we see, only in Southern Europe the intensity of positive migration reduced slightly in the second part of the study period. Though, this effect is likely driven by the economic crisis of 2008-2009 and might be rather a temporaty shock than a more permanent change.

10. Appendix 3

Defining working age population using conventional age boundaries of ages 15 and 65 is gradually becoming less and less valuable way to proxy the economically active part of the population. Thus, in Figure 9 we do a sensitivity check comparing three more definitions of working age population against the conventional definition. We test all four combinations of the lower age boundary 15 or 20 and the upper age boundary of 65 or 70. Since the resulting working age groups differ in the number of single ages they contain – 45, 50, or 55 years of age – we perform z-standardization of the four differently defined proportions of the working age population. Then we plot alternative definitions (Y-axis, in different colors) against the conventional one (X-axis) and report the Pearson product-moment correlation statistics. All the correlations are very tight, which suggests that there should be no major difference in the results of the current study due to the choice of an alternative definition of the working age population. Due to the present waves in population age structures, shifting the definition of working age population may slightly offset the timing of demographic transition but not reverse the relative regional differences.

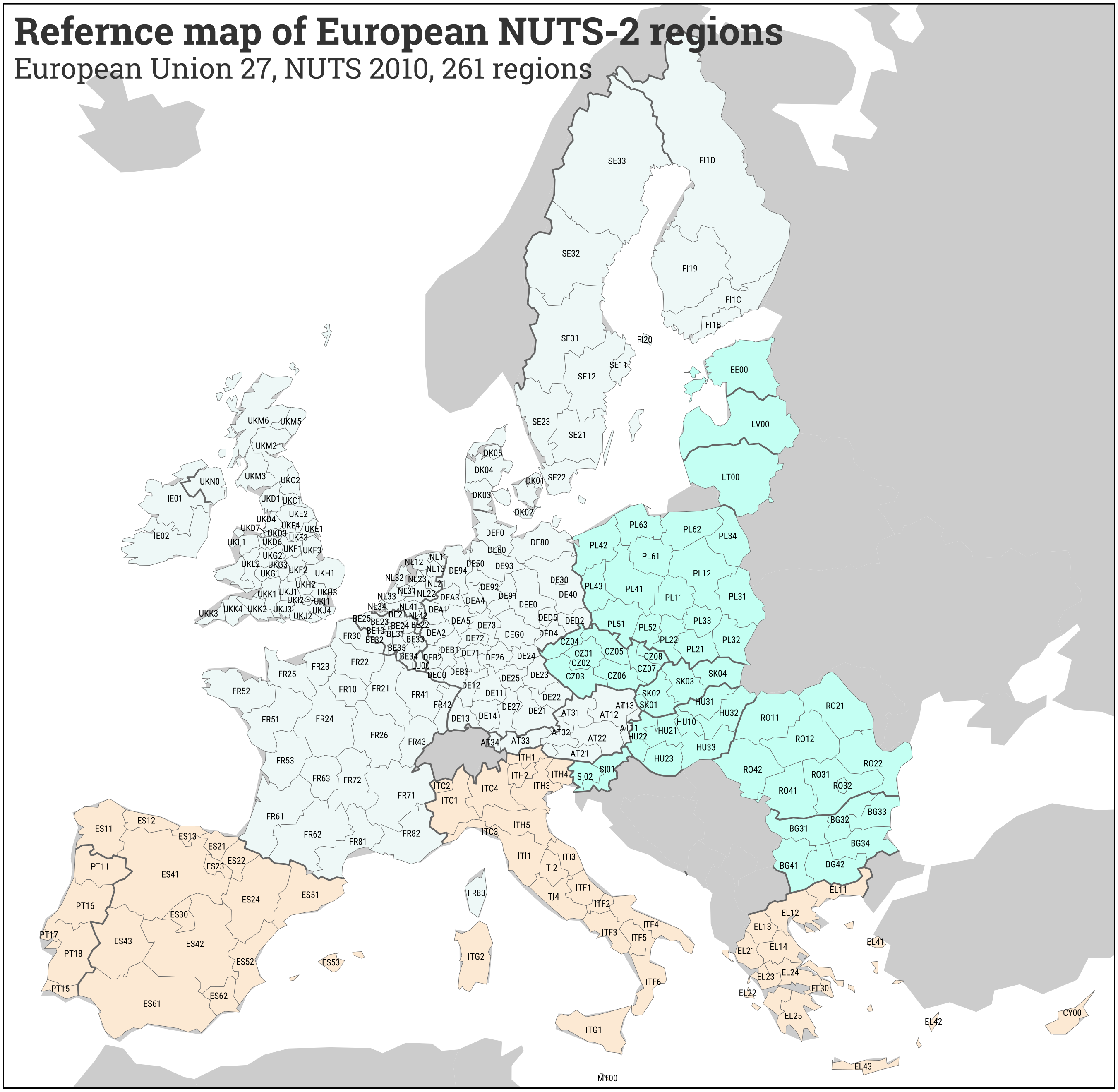

Fig. 7. Reference map of the EU-27 NUTS-2 regions.

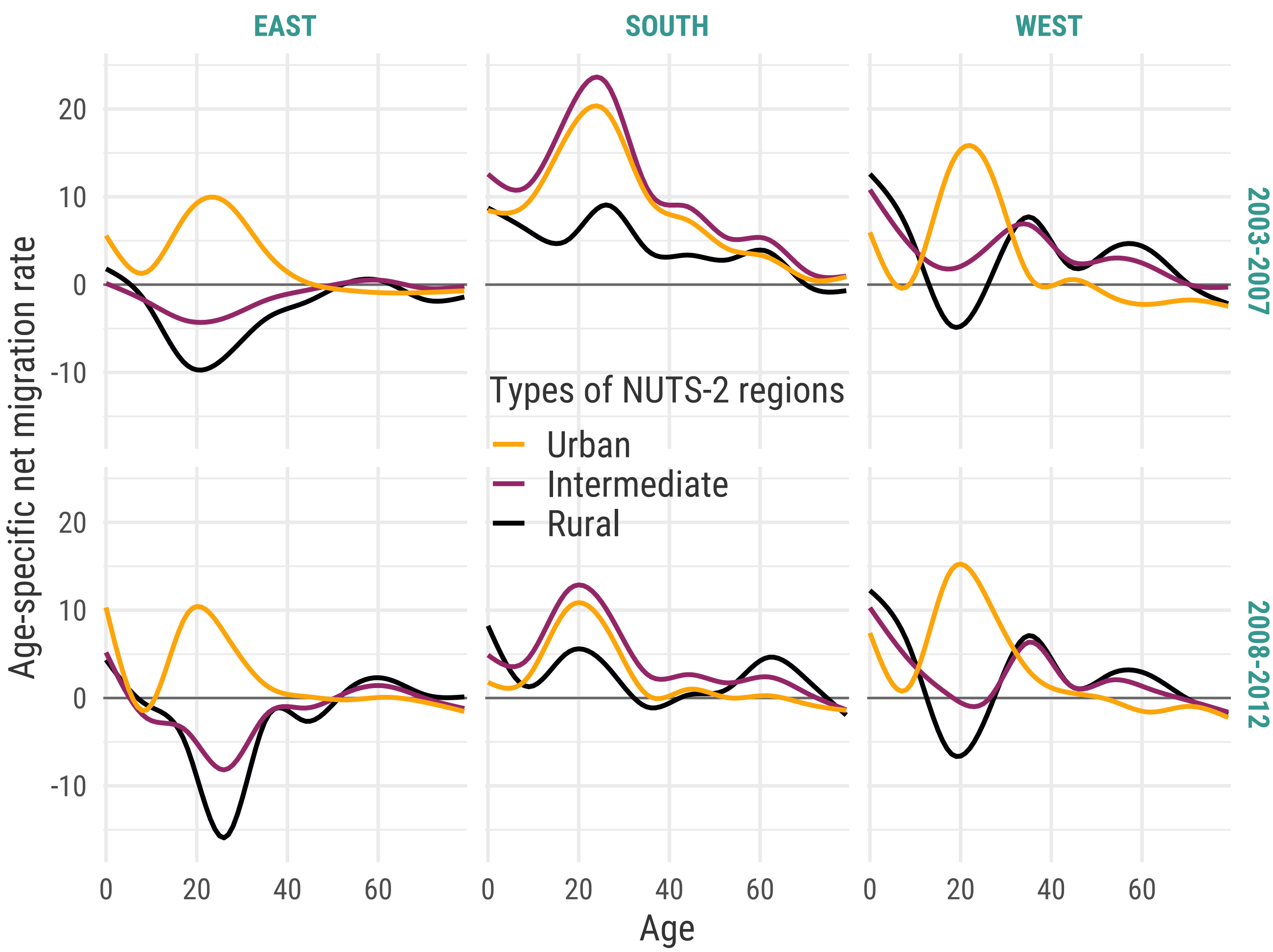

Fig. 8. Age-specific total net migration rates by urban-rural types of NUTS-2 regions, pulled single year data for two subperiods, 2003-2007 and 2008-2012, of the main study period, 2003-2012. Note: the lines are GAM smoothing. Source: own calculations based on demographic balance; migration change includes both internal and international migration.

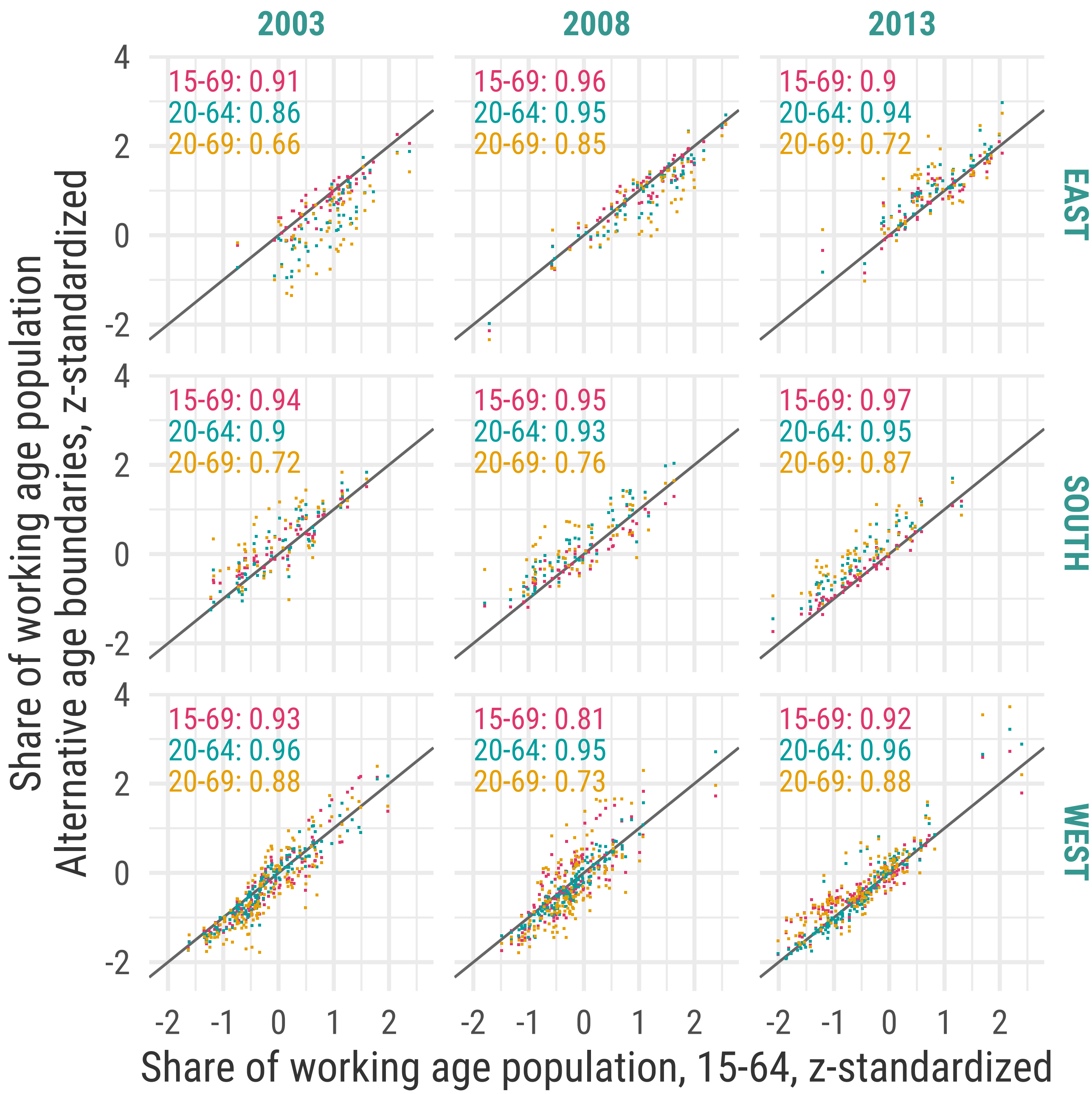

Fig. 9. Equality-line plot for the z-standardized shares of working age population calculated using conventional (X-axis) age boundaries of 15 and 65 years of age and three alternative definitions (Y-axis, in different colors) – age boundaries of 15 and 70, 20 and 65, and 20 and 70 years of age.