European Commission

THE DEMOGRAPHIC LANDSCAPE OF EU TERRITORIES

CHALLENGES AND OPPORTUNITIES IN DIVERSELY AGEING REGIONS

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Joint Research Centre

Demographic landscape of EU territories: challenges and opportunities in diversely ageing regions

Abstract
This report aims at detailing the territorial diversities of ageing across the EU, understanding the main drivers behind such differences and exploring their relations with data on access to services and amenities, regional economic performance, political attitudes and behaviours.

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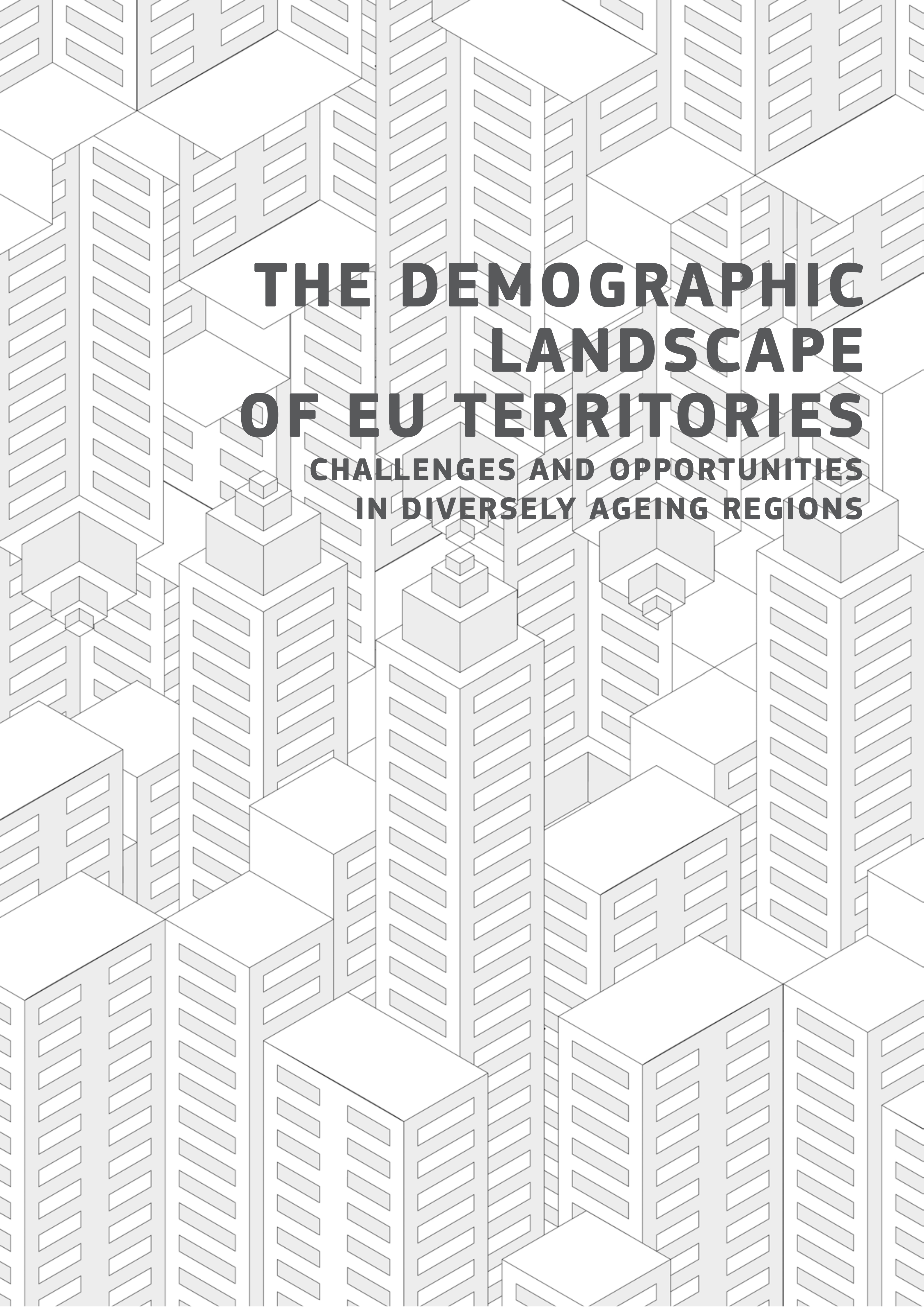

THE DEMOGRAPHIC LANDSCAPE OF EU TERRITORIES

CHALLENGES AND OPPORTUNITIES IN DIVERSELY AGEING REGIONS

CONTENTS

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FOREWORD

Dubravka Šuica
Vice President

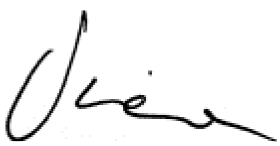
This Report on the Demographic Landscape of EU Territories is a welcome addition to our body of research because it equips us with much needed objective and evidence-based support for our work within the new Commission portfolio of Demography and Democracy. We published our Report on the Impact of Demographic Change in June 2020 and we are now putting in motion many of the follow up initiatives to this initial stocktaking exercise. These include the Green Paper on Ageing, the Long Term Vision for Rural Areas and the EU Strategy on the Rights of the Child, all of which will be adopted during the first half of 2021. This Landscape is an innovative study, which explores through time the changes in age structure at different geographical levels across the EU. It will provide a scientific basis to all our initiatives. Most importantly, it will feed directly into our reflection on identifying the topics we must address through the broad lens of demographic resilience.

The publication of this study occurs in truly exceptional circumstances. Within just a few short months, the COVID-19 pandemic has radically changed the way we live, the way we interact with one another, the way we work and the way we organise our lives. The main priority of the European Commission during 2020 was to deal head-on with the health crisis. As we move beyond crisis management, demographic knowledge and policies will be instrumental in supporting the recovery of our hard hit economy and will contribute to nurturing the Union back to health. While the virus has not had an explicit impact on demography as such, the opposite is not true as demography did have a genuine impact on the virus. Demographic patterns, like our ageing population or the changing composition of our households are not neutral factors in the propagation of the virus or in the recovery process; this report is particularly relevant in this regard.

This research demonstrates how changes in the age structure of territories can shape political attitudes and electoral behaviour. This goes right to the heart of our democratic life, as we also pursue work on developing a democracy that is fit for the future. It provides insight on how geographical patterns of ageing are associated with depopulation, in a manner that affects urban areas just as much as rural ones. In its approach to the challenges and opportunities in diversely ageing regions, this report offers quantitative information in support of active ageing, which is a key issue for the debate we will launch with our Green Paper. The information it provides about differences in population distribution and where people live is vital for effective policy-making.

The case studies and territorial analyses highlight the interaction between demographic change and the particular needs of a given village, town or region. Again, this has implications for our policy-making as we seek to minimise, curtail or where possible, counter the harmful effects of the demographic change the EU is undergoing. Indeed in some cases we will even try to turn those changes to our advantage: for instance we have seen that COVID-19 has highlighted the advantages of living in less-crowded, rural areas. The policies we want to pursue at an EU level must be responsive to local needs and demands in ways that are fair and balanced for all regions, especially for their economies, their productivity, social cohesion and democracy.

Together with the green and digital transitions, demographic change is the third transformation shaping the future of Europe. To many this may be a less visible revolution, but this study provides the insights and tools necessary for us to better understand what is going on and to tailor our policies to the new realities on the ground. It helps us to capture the diversity of regional dynamics, which we will use to better target our initiatives in response to the new demographic challenges we are all facing.



Mariya Gabriel
Commissioner

Demographic change is one of the main processes shaping the future of Europe. As reflected in the mandate for the European Commission, demography is not only relevant for economic growth or the sustainability of the EU fiscal systems but also for the functioning of our democracies.

Europe is not ageing uniformly across its territories. In particular, the mobility of young people in search for job opportunities and for education is profoundly shaping the demographic structure of the EU. Younger generations are extremely mobile and their residential preferences, which might change over their life course, influence the need for services and opportunities in both the regions of origin and destination.

While some regions and Member States are thriving thanks to the inflow of younger generations, other regions are lagging behind with an increasing number of young people forced to leave due to lack of opportunities. It is important to understand how ageing in some parts of Europe is driven by large outflows of young people and to address the widening gaps between Eastern and Western, North and South of Europe.

Effective policies targeting youth need solid evidence. The report on the *Demographic Landscape of EU Territories* is a welcome contribution to fostering such effective policies, by drawing on the demographic expertise recently established at the Commission's Joint Research Centre.

The report goes beyond the simple representation of population data by examining the implications of age composition on regional economic growth, accessibility to services, political attitudes and behaviour. It expands on traditional demographic analyses at country level with unique data and forecasts at a high spatial resolution. These analyses provide first important insights into the territorial differences of demographic change across Europe at the local level, where the needs of EU citizens are most concrete.

Digitalisation is already reshaping our way of working, commuting and learning. The COVID-19 pandemic has radically changed our relationships with the places where we live, study and work. We need to ensure that digitalisation and the benefits it brings to our societies will also contribute to addressing a deepening divide between generations and between regions with diverging demographic characteristics.

To counteract both economic and demographic declines in specific regions, we need to exploit better interlinkages between education, research and innovation under a European Innovation Area, and encourage public support for companies, start-ups, SMEs to adopt new technologies and innovations, in particular in regions lagging behind.

EXECUTIVE SUMMARY

Anne Goujon, Fabrizio Natale, and Guido Tintori

This report aims to examine the territorial diversity of ageing across the EU, to understand the main drivers behind these differences, and to explore their relationships with access to services and amenities, regional economic performance, and political attitudes and behaviours.

Ageing has many faces. Without doubt the prolonging of life expectancy represents a major achievement of progress and economic development. However, it has also changed the age structure of several countries towards larger proportions of the elderly in the population, thus posing new societal challenges. From an economic point of view, the increase in individuals traditionally considered unproductive (over 65 years of age) is affecting economic growth in the EU and the sustainability of its welfare systems. An elderly population requires more health care and resources. The life and future of our democracy is deeply connected to changes in the structure of the population, in that values, attitudes, and salience of key issues – such as European integration, climate change, and globalisation – vary with age and find their definition through negotiations between generations. Even external shocks impact age groups in the society differently, as is the case with the COVID-19 pandemic. Since the elderly have been exposed to the direst consequences in terms of morbidity and mortality, the measures adopted to protect their specific vulnerability entailed psychological and socio-economic externalities that are likely to have long lasting consequences for all age groups, including school-age children missing out on crucial steps in their educational development, and rising youth unemployment.

Therefore, studying the process of ageing involves considering its many sides and ramifications. To begin with, while ageing shows some common traits across all EU Member States, there are strong **territorial differences** and imbalances. All things considered, the share of elderly in the EU at the aggregate level of Member States is increasing due to the low fertility and low mortality rates. This has translated into an increase in life expectancy for individuals in the EU where about 84% of new-borns in 2020 are expected reach the age of 65 years in the future as opposed to 55% in sub-Saharan Africa, 69% in South Asia and 74% in the World (United Nations, 2019). In addition, there are signs of convergence at macro-regional level, with Eastern Europe catching up with Southern and Western Europe, which are characterised by high proportions of elderly and low proportions of working age population. However, when looking at EU territorial data more granularly, it can be seen that some areas are becoming younger while at the same time others are ageing and depopulating, foremost because of the outward mobility of young people. Such divergences in the demographic composition of EU territories are bound to generate different, often conflicting, place-based policy needs as well as polarisation vis-à-vis highly contested issues such as globalisation, immigration, climate change, and response to COVID-19.

Against this background, this report firstly empirically analyses the territorial features of the EU demographic transition and its drivers, then looks at the effects of current demographic change on the labour market and regional economies, access to services, political attitudes, and electoral outcomes. Some sections of the report specifically focus on gender.

This study is innovative because it explores changes in age structure at various geographical levels through time, from highly detailed data at grid level to municipalities and regions (NUTS3). The demographic analyses rely on historical data and projections from EUROSTAT statistics at regional level and a unique set of projections for the EU population by age between 2015 and 2050 at a resolution of 1 km. The analyses classify territories by three classes of the urban-rural regional typology and regions by degree of urbanisation, and consider mountain areas, population density, and distance from city centres. Furthermore, they examine cohort turnover and net migration as main drivers of the territorial trends observed. The detailed data will be available in the Atlas of Demography, developed at the JRC.

In particular, analyses of the **geographical patterns of ageing** (Chapter 2) show that the increase in the share of the elderly is more clearly associated with depopulation than with the urban-rural typology. Population decline is the factor that increases ageing in territories, and this is independent of whether or not it is a rural or mountain area, a town, or a city. Consequently, the pace of ageing and demographic decline in urban areas will tend to converge to that in intermediate and rural areas in the future. This is also confirmed when using the Eurostat population projections at NUTS3 level released in January 2021.

Differences in the distribution of the population by age emerge as a function of the distance from city centres and population density. In fact, the overall picture for the EU is that the elderly population tends to be concentrated far from city centres and in areas with lower population density. In contrast, children and adolescents are concentrated in suburban areas and in intermediate density areas. This distribution may be conducive to residential segregation between age groups, particularly in the case of the elderly and the young (20-24 years).

There are two main **demographic drivers** (Chapter 3) that explain differences in age structure at the territorial level in the EU working-age population: cohort turnover (whether individuals entering working age replace those reaching retirement age); and net migration (whether immigration is compensating for emigration) considering all types of migration lumped together (internal and international). In this respect, several regions in the EU (at NUTS3 level) are experiencing an increase rather than a decrease in their working age population, thanks to both a positive cohort turnover of the resident population and to the fact that more young people are arriving than leaving.

All in all, the vast majority of EU regions at NUTS3 level (87%) record a positive migration balance. Furthermore, net migration in the period 2015-19 offsets the deficit caused by cohort turnover in 28% of regions. This study looked into the cases of Italy and Sweden in more detail to unveil the underlying territorial specificities that are not visible at an aggregate level. In this respect, the two case studies show that international migrants compensated the negative cohort turnover of natives, but the effect was more pronounced in urban areas.

Another general trend emerges from the further breakdown of net migration by individual age groups, which reveals distinct age patterns among those who are mobile, linked to the processes of urbanisation and counter urbanisation. Europeans approaching the age of retirement exhibit a high propensity to move from urban to rural areas. In contrast, younger cohorts mainly move from rural (and intermediate) regions to urban areas.

One main challenge faced by ageing territories concerns **access to local services** in cities (Chapter 4). Dealing with an ageing society, cities may be confronted with the issue of adapting their infrastructures while guaranteeing their affordability. A quantitative understanding of the actual needs of cities in terms of accessibility to general services (e.g., health, education) and specific amenities (e.g., parks, food shops) for citizens over 65 years of age is essential in defining the right targets in policy, planning and prioritising interventions to improve conditions for elderly living in cities. Such quantitative information can also be used to evaluate the walking accessibility to local services aimed at supplying essential needs (e.g., healthcare centres, green areas, daily shopping) supporting active ageing.

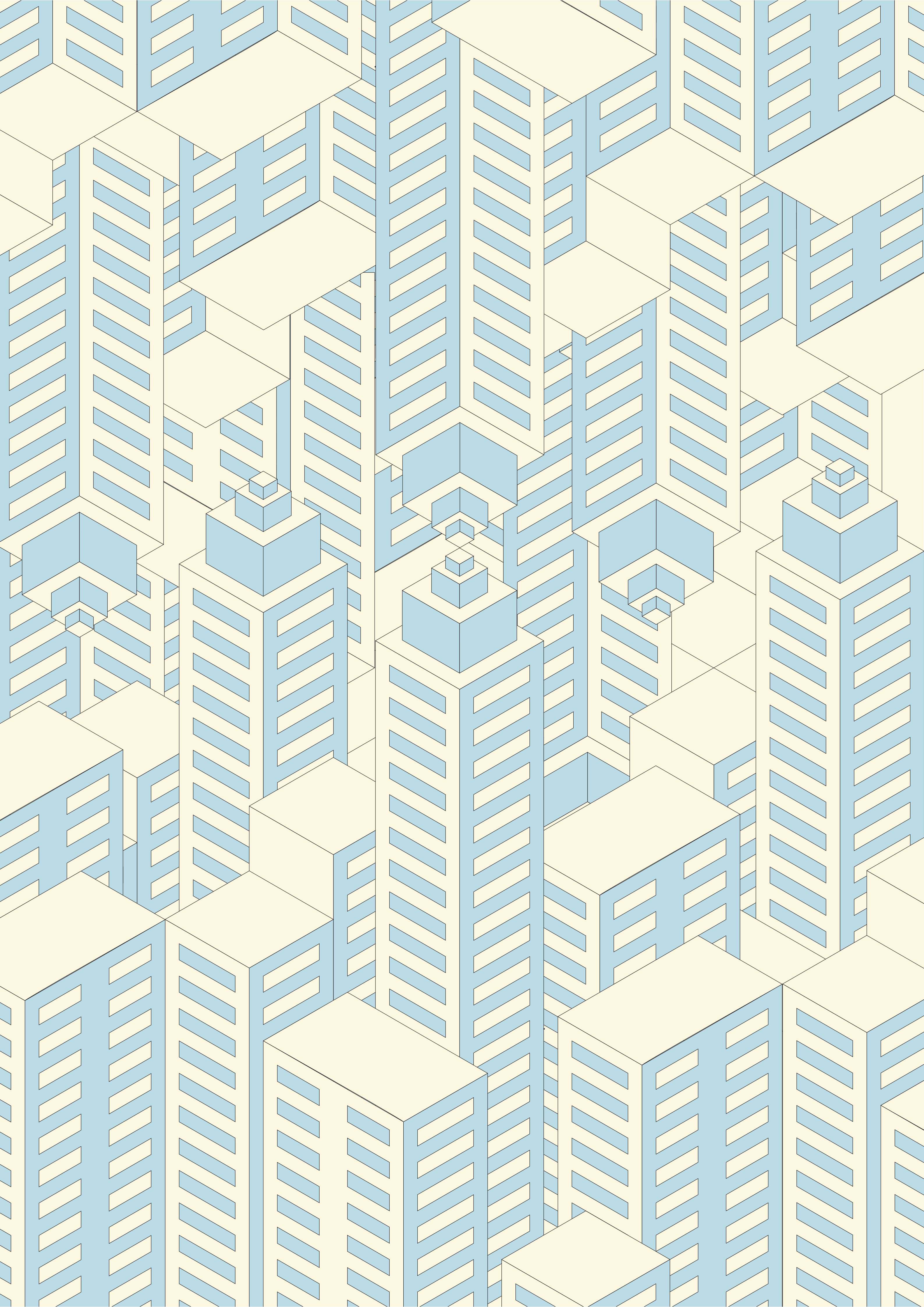
As expected, compared to rural areas, cities, towns, and suburbs provide better accessibility to generic services and amenities for all age groups. This is especially true for mostly uninhabited and dispersed rural areas where people (including the elderly) must travel considerably longer distances to reach any facility. In addition, the elderly in rural areas live slightly further away from services than the rest of the population in rural areas, while in urban areas the opposite is the case.

Changes in age structure in territories are related to **macro-economic performance** (Chapter 5) in terms of both GDP per capita and labour productivity per capita. As already documented in studies at country and micro level, this regional level analysis confirms that GDP per capita and labour productivity peak in association with high proportions of middle-aged population (35-54 years). However, the findings also highlight the fundamental role played by the degree of urbanisation, depopulation, and net migration. In fact, while at a higher degree of urbanisation, the younger age groups (15-34 years) have positive effects on macroeconomic outputs, rural and depopulating regions experience low values of economic performance irrespectively of the demographic structure and the presence of a large proportion of the population being young. Other key factors (such as economic diversity and total fertility rate at regional level) play an essential role in the economic development of a region and contribute to potentially mitigating the economic consequences of an ageing population in the short-term.

Not limited to the economic domain, changes in age structure of territories shape both **political attitudes and electoral behaviours** (Chapter 6). Survey data from Eurobarometer show that age divides appear when it comes to both the salience of and attitudes towards different key political issues, whereas rural-urban divides are rarely observed. Age-based and place-based differences emerge in political interest and participation. Responders to the surveys self-described themselves as being in urban and older cohorts with higher levels of interest in politics compared to the other respondents. Data on political behaviour align with this as turnout tends to increase with age and is higher in predominantly urban NUTS3 regions, compared to both intermediate and rural regions. Spatially detailed election data at NUTS3 level show that political divides depending on both age and place of residence emerge when analysing votes for political parties along two dimensions, namely their stances regarding the EU and immigration. These territorial analyses underline the fundamental role of the interaction between demographic change and place specificities, contributing to the longstanding debate on the role of places and compositional characteristics in shaping political behaviour.

In conclusion, the findings presented in this report bring a series of **policy implications** to bear. The chapters of this report reveal the added value of looking at ageing in the EU, and its impact on urban and rural areas in the context of other coexistent territorial characteristics and processes such as depopulation, remoteness, accessibility to services, political participation, economic developments, and opportunities. The scenarios projected by the report show that the future of ageing in EU territories will not be a predetermined and uniform outcome of the demographic convergence recorded at national and macro-regional scales. Ultimately, selective age at migration following the various stages of the life course will shape significant territorial differences. Deepening differences in demographic structures are already becoming apparent at different geographical scales. Not only may they worsen economic inequalities and imbalances, they may also result in deep rooted polarisations towards the EU, immigration, and the meaning of democracy.

Policy actions have a limited ability to affect demographic trends, and need time. Yet, policies can intervene to ensure that the effects of the demographic change the EU is undergoing do not have critical repercussions on its economies, productivity, social cohesion, and democratic life. The findings of this report emphasise the key role that scientifically robust knowledge concerning the demographic specificities of territories may play in support of both EU regional policies and cohesion policies. The insights and tools provided by this study can inform the adoption of tailored local measures, for instance, regarding the availability of public services for the less mobile aged population in remote and in areas with lower population density, the changing demographic landscape of cities losing population or sprawling over surrounding rural territories. Understanding how and why regional needs triggered by ageing significantly differ between territories is essential to ensure that EU policies reflect the reality on the ground, and are responsive to local demands in ways that are fair and balanced for all regions and territories.



1. INTRODUCTION

Anne Goujon

As a result of socio-economic progress and significant medical advances in the 20th century, the life expectancy of each subsequent generation has been longer than the preceding one. This process has translated into substantial increases in life expectancy at birth, from 32 years in 1900 (Riley, 2005) to 73 years in 2020 (United Nations, 2019). In combination with significant declines in the number of children born per woman, from 5.0 children in 1950 to 2.4 children in 2020 (United Nations, 2019), this has led to changes in the age structure of most societies. Consequently, the ratio of the elderly to the total population has increased globally from 5% in 1950 to 9% in 2020 (United Nations, 2019). The natural process of ageing has turned into a challenge in high-income countries where both mortality and fertility reductions have been most significant. This is the case in Europe where the share of the elderly population (65 years of age and over) among the Member States has increased from 9% in 1950 to 21% in 2020, and the share of the 80-year-olds from 1% to 6% in the same period. Another way to look at the change in the age structure is to consider that since the turn of the 21st century, there have been more people in the elderly age group than under the age of 15 years and the proportion of under 15 in the total population has declined from 26% in 1950 to 15% in 2020.

There are many socio-economic and health challenges associated with the changes in the age structure of the EU population.[1] The literature, particularly the economic, moves in two opposing directions. Some authors highlight the opportunities associated with an ageing population. Bloom *et al.* (2015) point out the human capital investments and productivity increases that ensue from a decline in fertility, allowing more women to enter the labour force and more investment in education (see Loichinger and Marois, 2018). Moreover, they emphasize that with longer life expectancy and greater expected length of retirement, the population in ageing societies would have higher rates of savings. However, many others are pessimistic (Teulings and Baldwin, 2014; Börsch-Supan, 2003) about the consequences of ageing and highlight the substantial productivity boost that would be required to compensate for the declining support ratio. All projections – whether from Eurostat, the United Nations, or IIASA[2] – point to further increases in life expectancy, absolute and proportion of the elderly population in Europe.

Although the death toll associated with the on-going COVID-19 pandemic has been substantial (2.1 million in total worldwide by January 24, 2021 and 450,000 in the European Union[3]), it is unlikely to continue and change the aforementioned trend significantly (for instance, see the analysis of the United States in Goldstein and Lee (2020)). On the other hand, the pandemic has not been affecting all regions and territories equally as it depends on specific contamination clusters as in Mulhouse (France) or Codogno (Italy) but more importantly it follows the urban/rural gradient (Goujon *et al.*, 2020, see also data on excess mortality by ESTAT and The Economist).

The territorial aspect of the health crisis is an epiphenomenon of the territorial specificity of ageing. While the latter is often mentioned, particularly in the public debate in the context of depopulation in rural and remote areas, it is more difficult to quantify due to lack of data, for which the research developed in this report is useful. Life spans can vary significantly with populations in the more deprived territories having lower life expectancies than the national average as, for instance, has been shown in the United Kingdom (Evandrou *et al.*, 2015). One of the challenges is that ageing is impacting territories unequally.

The literature has shown the existence of multiple realities at the local level that are dynamic in time and over the life course. Generally, since the Second World War, rural areas have been losing population to urban places. However, some suburban areas have seen reverse direction movements towards rural areas since the 1970s, and particularly involving the selected group of the retired and high-income population. This affected some European peripheries (Davoudi, Wishardt & Strange, 2010) which lost population. Some cities whose populations are growing tend to be more intergenerational, meaning that they host all ages – children and adolescents, working age population, and elderly – in a balanced way, or in a way that is representative of the situation at a more aggregated level, e.g., at national level. This does not mean that there are no challenges associated with it, with particular problems accessing services and infrastructure. There are also cities, particularly large ones, which have lower proportions of elderly people because, on the one hand, they attract the young generations (students and working age), and on the other hand, for varied reasons,

1 For instance see the European Commission Report on "The Impact of Demographic Change", https://ec.europa.eu/info/sites/info/files/demography_report_2020_n.pdf, and the Science for Policy Report on "Health care and long-term care workforce: Demographic challenges and potential contribution of migration and digital technology" forthcoming here: https://publications.jrc.ec.europa.eu/repository/handle/JRC121698.

2 International Institute for Applied Systems Analysis. www.iiasa.ac.at

3 Source: https://ourworldindata.org/coronavirus#deaths-due-to-covid-19 (accessed on 14/12/2020).

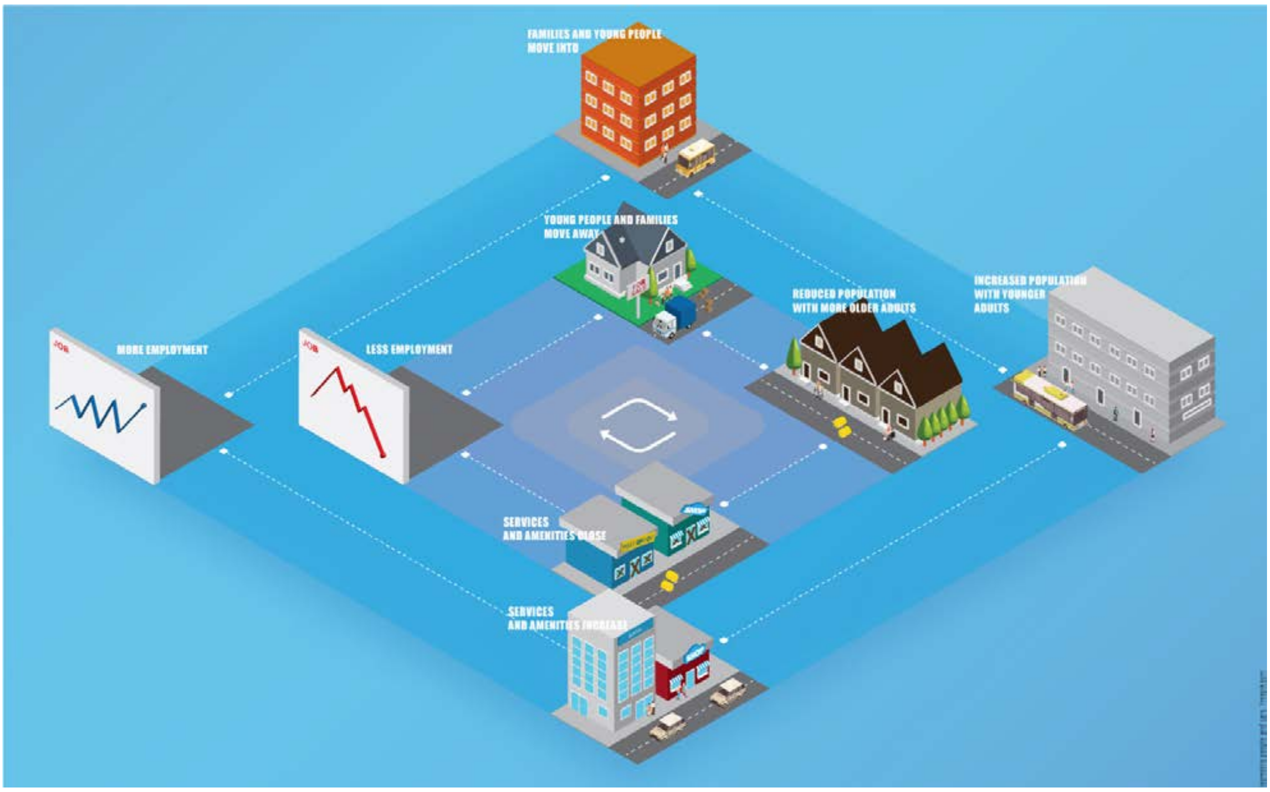
they tend to push the elderly population away. The same can be true of other settlement categories such as intermediate places or rural areas. In the latter, some rural areas are intergenerational while others have lost younger generations attracted by the cities, leaving the elderly behind to become a majority.

The following infographic highlights some of the mobilities that can reshape the age composition of territories in EU member states.

Although the topic is under-researched, several strands in the literature explore the issue of age distributions (more or less) incorporating geography:

- *Segregation studies* typically look at age segregation from two different angles. The first most common thread of analysis investigates the age-structure of the social networks of the elderly (Uhlenberg and De Jong Gierveld, 2004; Sun & Schafer, 2019[4]), finding mostly high-level integration in multi-generational kin networks and marginal integration in non-kin networks that extend to different age cohorts. Other studies have seldom examined whether areas/neighbourhoods/territories are age-segregated, mostly across Europe but also in the United States. These studies tend to find increased spatial segregation between youth and elderly across time. For example, it is the case in a study of neighbourhoods in England and Wales between 1991 and 2011 (Sabater, Graham and Finney, 2017), and West German cities (Franz and Vaskovics, 1982). Winkler (2013) used a dissimilarity index and found moderate segregation levels of older adults and younger adults at the micro-level in the United States. As pointed out by Uhlenberg (2000), some localities are intentionally age-segregated such as retirement homes or university campuses.
- *Spatial aspects of ageing studies* concentrate on the geographical aspects of ageing, and also link spatial variability to potential determinants, such as variability in socio-economic development, with the logic that economically thriving places will attract the active young population, leaving the inactive mostly elderly population behind (Davies and James, 2016). This type of research is prominent in China (for instance, see the list of references in Wang *et al.* (2016)). Other research – mainly of a gerontological nature – focuses on the availability of adequate social and health care for the elderly at residential level (Andrews and Phillips, 2005).
- *Quality of ageing studies analyse* the characteristics of ageing (Davies and James, 2016) and life satisfaction at various spatial levels. While not considering age, it has been shown that the gradient of life satisfaction for the population does not necessarily follow the density gradient but is linked to the level of development (Van Hoof *et al.*, 2018; Sørensen, 2014). A few surveys

INFOGRAPHIC



4 Making use of the Survey of Health, Ageing and Retirement in Europe (SHARE) dataset, whose 6th wave contains information on the age of the network of elderly.

have found that urban centres seem to be favoured by the elderly over rural territories, as for example in China (Ng, Tey and Asadullah, 2017). An analysis in Southern Europe based on Survey of Health, Ageing and Retirement in Europe (SHARE) data – covering a representative sample of the population aged 50 years and more – shows that living in rural areas is associated with better quality of life (Cantarero-Prieto, Pascual-Sáez and Blázquez-Fernández, 2018)[5].

- *Dynamic spatial analyses of migration/mobility and ageing* concentrate on international migration and internal mobility as the main underlying force of age-related structural change at the local level in Europe rather than natural increase (births and deaths), which are considered not to be as influential because they are presumed less differentiated across territories. These flows determine the various historical phases of urbanisation in Europe as sketched by Van den Berg *et al*. (1982) according to four sequential stages: urbanisation (core cities gaining population, mostly young), suburbanisation, deurbanisation (both cities and suburbs losing population), and reurbanisation. While all of the stages are visible across Europe, they do not happen at the same time nor with the same magnitude. Furthermore, international and internal migration flows do not always go in the same direction (Bayona-i-Carrasco and Gil-Alonso, 2011). These stages influence ageing of local urban and rural areas since migration is typically age-selective and concerns younger segments of the population who are attracted to dynamic social, cultural, and economic city cores, "triggering a self-reinforcing process towards polarization", including in terms of age (Gregory and Patuelli, 2015, p. 1193). The second pattern is that of suburbanisation (Swiaczny, Graze and Schlömer, 2008) with the outward growth of agglomerations around city cores, which can involve several phases of ageing/rejuvenation in urban cores and suburbs. Other patterns exist that are linked to the elderly population retiring to regions with many natural and cultural amenities. This is typical of the United States but also in Europe, for instance in Southern EU cities like Alicante in Spain, particularly in the 1990s.

Another strand of research analyses whether the widespread phenomenon of urbanisation has led to convergence or divergence of ageing at the regional level. Rather than showing the divergence of urban and rural regions, these studies (Kashnitsky, de Beer and van Wissen, 2020) tend to highlight the increased disparities existing within urban regions and rural ones (at NUTS2 level), whether or not they were able to attract and retain population. They also show that young cohorts in many cities drive a parallel process of suburbanisation and reurbanisation (Kabish and Haase, 2011). The territorial approach in this report is able to examine the phenomenon at a more detailed spatial level.

Other strands of research focus on the impacts and consequences of ageing at the spatial level, which could be critical. One of the challenges is the *accessibility and availability of services*, that is, matching the presence of elderly people at local level with the infrastructure required in terms of housing, transport, health facilities, shopping, and other essential services. This is also linked to the sustainability of the infrastructure and services that would require continuous flows of population, hence maintaining the attractiveness of those territories by appropriate planning. Such planning should also rely on the crucial understanding that there is another side of ageing with the elderly contributing to society through economic activity, volunteering, and informal care provision, for instance, for their grandchildren (Evandrou *et al*., 2015).

Another concern is related to social cohesion that is fostered by positive relationships between the various members of a community, including along the intergenerational dimension. The consolidation of homogenous territorial pockets by age can have repercussions at the political level as seen in several elections showing polarization of the elderly votes, e.g., in the case of the American presidential election of 2016 (Pew research Center, 2018) or the 2016 Brexit referendum in Britain (Alabrese *et al*., 2019). A rupture of the contract between generations would be damaging to the concept of intergenerational justice that drives many of the transformations that are regarded as essential for the environment, the fight against climate change, resource depletion, and the establishment of a fair welfare system in the future (Vanderbeck and Worth, 2015).

A third challenge is the impact of ageing on regional economic growth, for which the evidence is mixed as seems to be the literature on the impact of ageing on economic growth at national level. Gáková and Dijkstra (2010) found a trend towards balanced economic growth between urban and rural EU regions in a study of the period 2000-07 (van de Gaag and De Beer, 2015). In a case study of Italian provinces, Gabriele, Tundis, and Zaninotto (2018) found a negative relationship between productivity and the share of elderly workers in the labour force. Daniele, Honiden, and Lembcke (2018) also point out the different pathways through which gaps in the growth of productivity between more and less ageing regions could increase by impacting fiscal transfers, wage growth, job creation, new company start-ups, etc.

The research in this report builds upon most of the above-mentioned research strands and contributes to advancing the state of the art thanks to the use of a unique dataset of population age structure at grid-cell level (the LUISA - and Use-based Integrated Sustainability Assessment - modelling platform[6]). Chapter 2 exploits the LUISA platform to analyse the patterns of ageing

5 For an attempt to systematise the field of geography of ageing, see also Skinner, Cloutier and Andrews (2015).

6 https://ec.europa.eu/jrc/en/luisa (accessed on 27/11/2020)

throughout EU territories in relation to place of residence (urban, intermediate, and rural) and the various realities they encompassed in 2011. Then Chapter 3 explores how territorial differences may derive from net migration rather than cohort turnover. After this, Chapter 4 looks at the implications of needs and accessibility to services and amenities. Chapter 5 focuses on the association between ageing and economic growth, and lastly, chapter 6 considers the impact of different age distributions on attitudes and political behaviour.

2. GEOGRAPHICAL PATTERNS OF AGEING IN EU TERRITORIES

Chris Jacobs-Crisioni, Claudio Bosco, Carolina Perpiña Castillo, Jean-Philippe Aurambout, Paola Proietti, Filipe Batista e Silva, and Fabrizio Natale

Key findings

- To assess ageing and its implications in the EU, the analysis needs not only be framed in relation to the standard categories of urban, rural, or mountain areas, but also in the context of other territorial characteristics and processes such as depopulation, remoteness, accessibility to services, and lack of economic opportunities.
- Ageing is not a predetermined and uniform outcome of the demographic convergence experienced at national and macro-regional scales. When it is considered at a more local level, ageing appears to be profoundly influenced by household composition, internal migrations linked to age specific residential preferences, and attractiveness of places for each phase during a life course.

2.1 INTRODUCTION

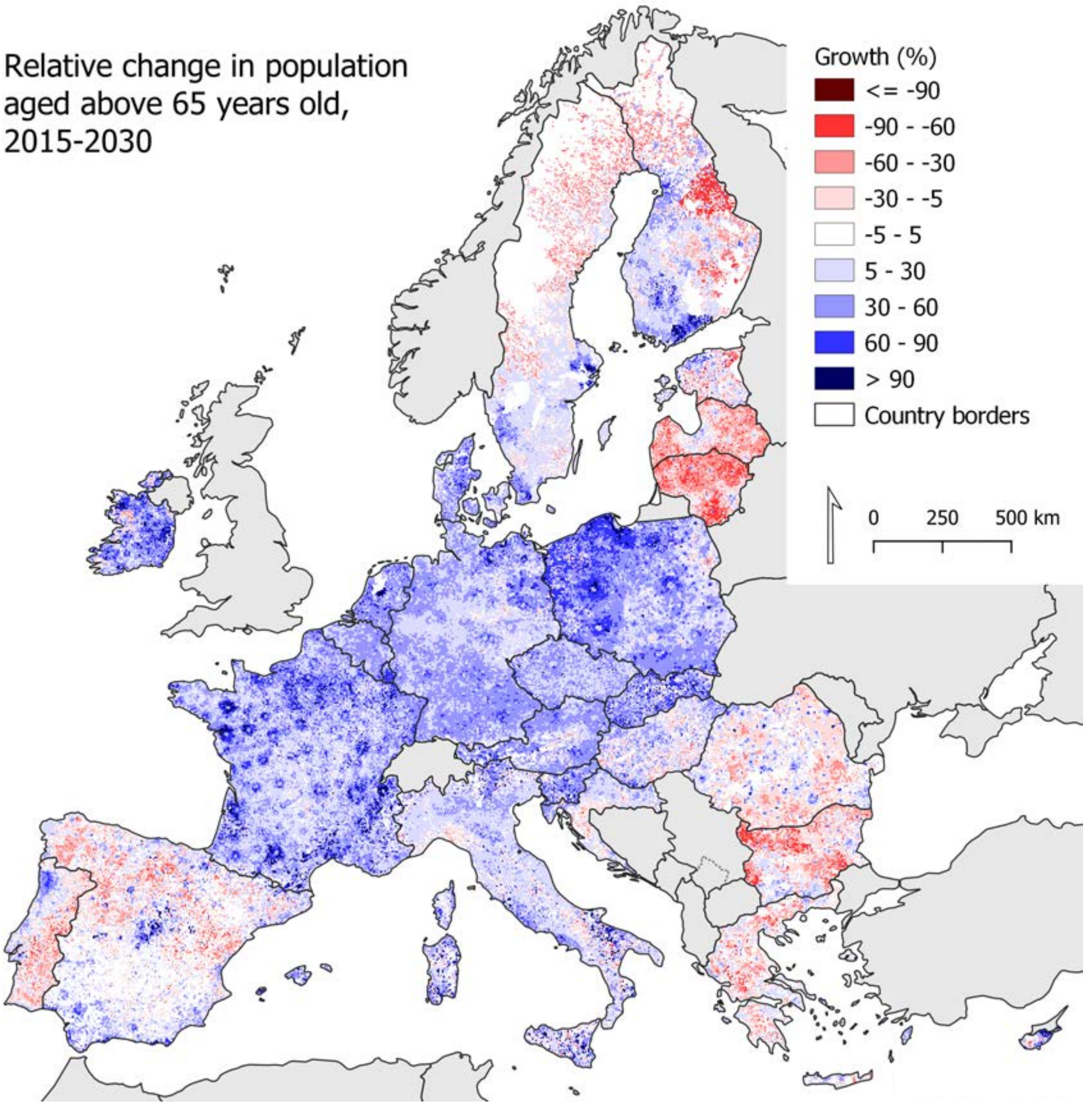
In this chapter, we provide an overview of ageing across EU regions by using a combination of historical data from EUROSTAT statistics, downscaled at a resolution of 1km, and a unique set of projections of the EU population by age between 2015 and 2050 produced by the JRC LUISA modelling platform.[7] The overview of territorial disparities across the EU in this chapter also serves as an empirical introduction for the subsequent chapters in the report, which look more in detail at the drivers and impacts associated with these patterns. Figure 1 exemplifies the data at high spatial resolution used for most of the analyses contained in this chapter. The map shows the expected relative change of the share of elderly (population above 65 years) between 2015 and 2030.

From the map (Figure 1) it is possible to recognise that within a generalised process of ageing there are not only strong differences between Member States but also within Member States, and between urban centres and areas outside of city centres. For example, several large cities such as Paris, Berlin, Madrid, and Warsaw are characterised by concentric patterns of ageing with a higher increase in the share of elderly in the outskirts of the city compared to the city centre.

These aspects do not necessarily emerge in aggregated data for NUTS2 and NUTS3 regions. The data at fine spatial resolution produced for this study was used to explore differences in age structure in the EU population, zooming in at the level of Local Administrative Units (LAU) (section 2.2), and how they might evolve. Section 2.3 looks at the interaction between population decline and ageing, while section 2.4 studies how ageing evolves in the several EU macro-regions. Furthermore, by making use of data at the even more granular level of 1km grid cells, the age distributions as a function of population density and distance from city centres was examined independently from the reference to administrative boundaries (sections 2.5 and 2.6) and how this is affecting segregation by age (section 2.7). Finally, in the last section these analyses are complemented by considering the classification of LAU based on their location in mountain areas (section 2.8).

7 The findings presented in this chapter rely on two datasets. The data for 2011 consists of a downscaling at high spatial resolution of population statistics by age and gender from the 2011 censuses. The downscaled data maintain consistency with the overall population size of the ENACT night-time population grid map. The projected data for the period 2012-2050 are derived from LUISA and Eurostat's EUROPOP 2013 demographic projections at NUTS3 level. These projections at high spatial resolution are influenced by the demographic scenarios adopted in the reference data at NUTS3 level and assume a future prolongation of the spatial distribution patterns by age observed in the past. More detail on the assumptions and the methodology to produce the data used in this chapter are given in Appendix 1. At first glance, the findings presented in this chapter hold when using the Eurostat population projections at NUTS level 3 corresponding to EUROPOP2019, released in January 2021, see here: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_19rp3 (accessed 25/01/2021).

FIGURE 1. Projected relative change in population aged over 65 years old per 5-km grid cells, 2015-2030



2.2 AGEING AND URBAN-RURAL TYPOLOGY

In order to find out if and where ageing is affecting rural and urban areas in Europe differently, the share of elderly (population 65 years old and over) in 2020 for around 98,000 LAU (Local Administrative Units[8]) in the EU was estimated by grouping them in the three classes of the urban-rural regional typology, namely, cities, towns, and rural areas. The graph in Figure 2 shows that the average share of elderly in rural areas is 2 percentage points (pp) greater than in towns and 3 pp greater than in cities.[9] Furthermore, these descriptive analyses were confirmed by a regression model which tests for differences based on the three classes of the urban-rural regional typology, including after controlling for differences in ageing across Member States, a generalised trend for the increase in the share of elderly in time, and the population size of the areas (see Table A1.1 in Appendix 1). The coefficients of the regression model through the period 2011-2050 indicate that the share of elderly in a rural LAU is likely to be 4.2 pp higher than in cities. In addition, a positive coefficient for the time variable shows that the trend in ageing would increase while a negative coefficient for population size indicates that large municipalities would not be as affected by ageing as small ones would.

To appreciate differences that exist between Member States, Figure 3 presents a comparison of the median values of the share of the elderly in cities.[10] The more a

8 Using the 2016 version.

9 As a robustness check although not shown here for the sake of brevity, it is confirmed that similar gaps between the three classes of urbanisation, which are emerging from our analyses at LAU level and using estimated data, are also present when calculating the share of elderly at the higher level of aggregation of NUTS3 regions and referring to historical data and official statistics from EUROSTAT for the period 2014-2019.

10 Towns are disregarded in Figure 3.

FIGURE 2. Share of elderly by three classes of the urban-rural regional typology
Note: The values are medians with 95% Confidence Interval (CI) across approximately 98,000 LAU in the EU grouped according to the urban-rural regional typology and refer to estimated data for 2020.

Member State is above the diagonal, the larger the gap in the share of elderly between rural areas and cities. This is especially true for Spain and Portugal, which show a substantially greater value of the share of elderly in rural areas. On the contrary, the median proportions of elderly are remarkably similar across place of residence in many other Member States, such as in Germany, and higher in cities in the case of Poland, Slovenia, Slovakia, and Malta.

In addition to exploring the gap in 2020, Figure 4 considers the results of the demographic simulation until 2050 alongside the data from the 2011 Census. In this case, whether the gap between areas grouped by the three classes of the urban-rural regional typology is expected to expand in the future, or if there will be convergence between areas within the general ageing process for the EU, is visualized. The graph in Figure 4 indicates that the share of elderly would be increasing in all areas. The maximum values are reached in rural areas where the share would increase from 19% in 2011 to 30% in 2050, in contrast to an increase from 17% to 29% in towns, and from 15% to 27% in cities. From the graph, it is clear that the gap between cities and in particular towns in respect of rural areas would be narrowing. In other words, cities and towns would be quickly catching up with the higher level of ageing in rural areas, within a general process of ageing that is common to the three groups of degree of urbanisation.

Furthermore, these descriptive results are confirmed by statistical tests that not only compare differences between the median values, but also consider the entire distribution of the share of elderly for the three groups across time (see Figure A1.2 in Appendix 1).

The fact that the gap between rural and urban areas is not expected to expand in the future becomes evident when the evolution by individual EU Member State is examined. Figure 5 shows the difference in the median values for the proportion of the elderly in 2015 and 2050 for each EU Member State. Values above the horizontal line in this figure indicate that rural areas have a higher average proportion of the elderly than cities, while the two symbols indicate the situation for each Member State in 2020 and 2050.

For a few Member States like Germany and Denmark, the difference between rural areas and cities would increase between 2020 and 2050, while for many other Member States the gap would get smaller or even reverse, with cities having a higher proportion of the elderly compared to rural areas.

Overall, these findings indicate that while there are clear differences in the current level of ageing between rural areas and cities in most Member States, in the future these differences would not be expanding. The fact that for most Member States, by 2050, the gap is expected to narrow in favour of cities triggers the question of what other factors beyond the urban-rural regional typology may shed light on ageing. This, we explore in the next section.

FIGURE 3. Share of elderly in rural areas vs. cities by EU Member State in 2020
Note: The values are medians across approximately 98,000 LAU in the EU grouped by Member States. Colours represent the difference in proportions between cities and rural areas

FIGURE 4. Evolution of the share of the elderly by three classes of the urban-rural regional typology until 2050
Note: The values are medians across approximately 98,000 LAU in the EU grouped according to the urban-rural regional typology.

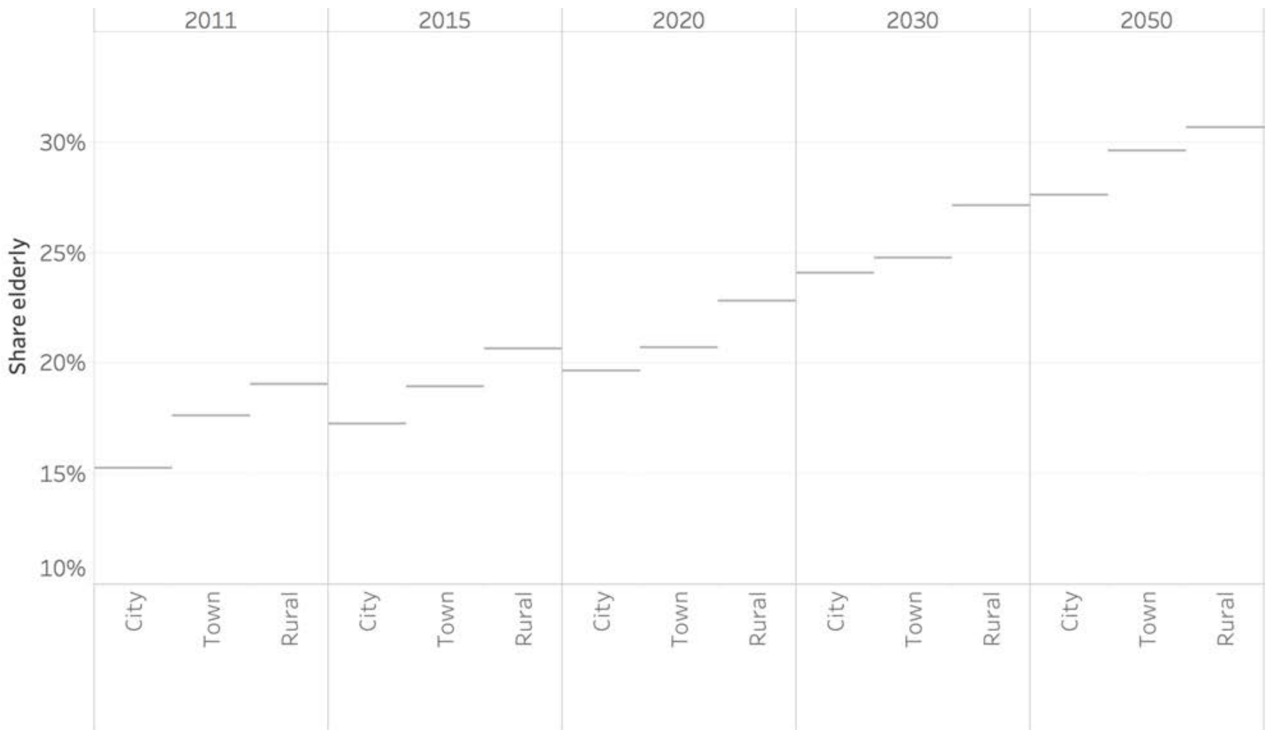
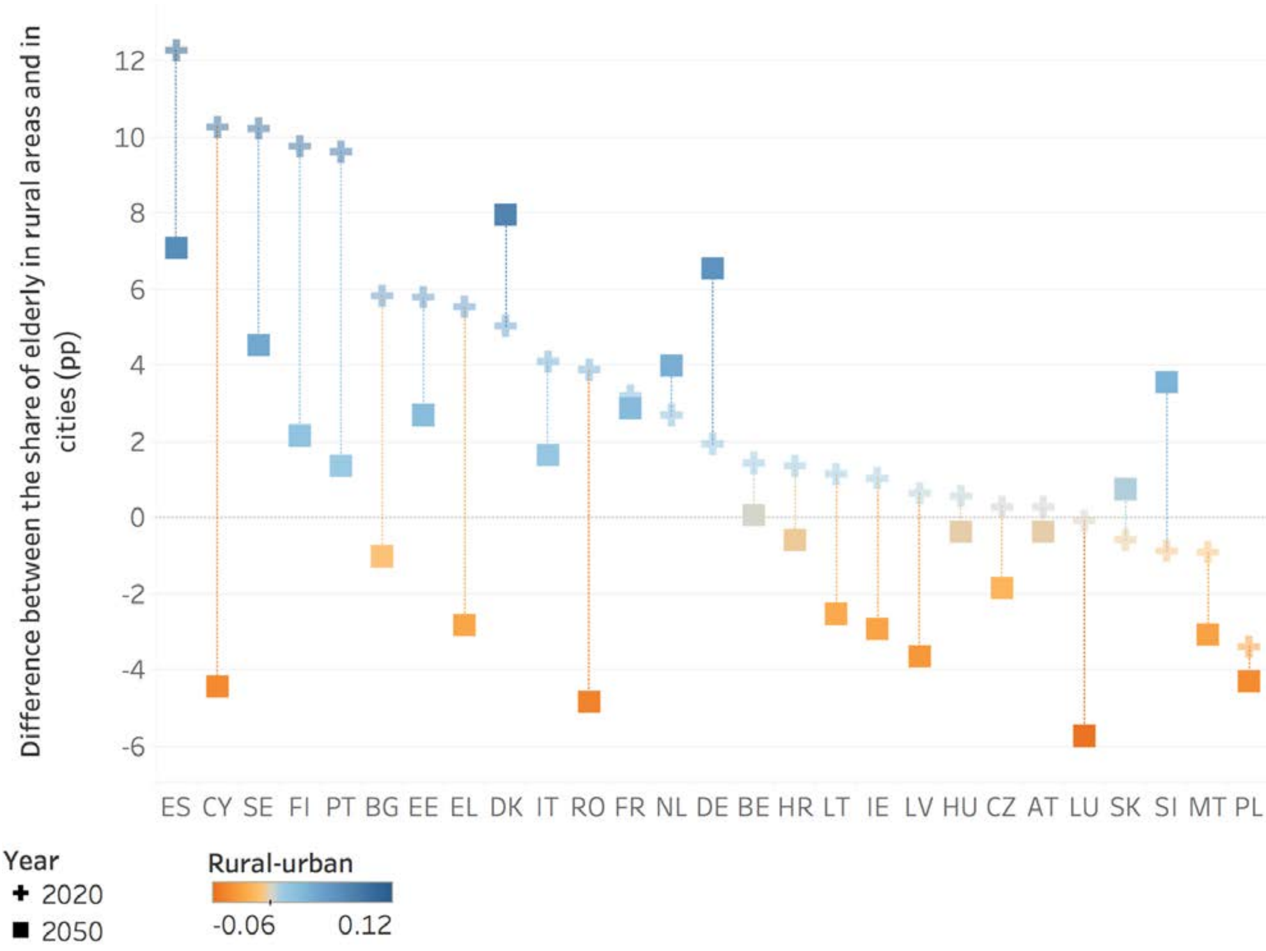


FIGURE 5. Difference in the share of the elderly between rural areas and cities by Member State in 2015 and 2050



2.3 INTERACTION BETWEEN POPULATION DECLINE AND AGEING

Many territories within EU Member States have experienced and are still experiencing depopulation caused by negative natural population change (more deaths than births), negative net migration (more emigrants than immigrants), or both. At the same time, many of these territories are also facing a population ageing process caused by a declining birth rate and rising life expectancy. A strong connection exists between depopulation and population ageing processes (Reynaud and Miccoli, 2018) and ageing may be both the result and the driver of a process of depopulation. Independently from the direction of the causal relationship, the presence of this association between these two demographic processes may underline a trend of demographic decline, which can impact economic growth, attitudes, and political behaviour as described in more detail in the following chapters.

Figure 6 shows the change in the proportion of elderly in LAU compared with the level in 2011, grouped into those experiencing a decrease or an increase in overall population in each period. The figure shows that areas in both groups would experience an increase in the proportion of elderly, but this increase would be less pronounced in areas where the population is increasing. This effect becomes increasingly evident nearer 2050. Urban and rural contexts differ in their linkage between depopulation and ageing. Figure 7 shows the relationship between the relative changes in the proportion of elderly and in the overall size of the population for different years compared to the 2011 baseline. Each dot represents an EU NUTS3 region.[11] The lines in the figure separately indicate the linear trends in the association between the two variables by regions grouped by the three classes of the urban-rural regional typology. In general, the association between the two variables is negative, indicating that areas with lower values of population change are experiencing higher increases in the proportion of the elderly. Up until 2020 these negative trends are not particularly differentiated by the urban-rural regional typology. However, by 2030 and 2050 the negative association would strengthen and at the same time diverge between the three classes. In particular, and somehow contrary to what might be expected, the

11 In this case, we define areas at the higher level of aggregation of NUTS3 regions so that the relation between the two variables can be appreciated better. The linear trend is confirmed by regressions calculated at the level of LAU.

negative association would become more pronounced in urban regions rather than in rural and intermediate regions. The association between ageing and depopulation is often depicted as a process of demographic decline, which is affecting typically remote and rural regions. Here it is shown that while the two processes are clearly linked,

FIGURE 6. Median change in the share of elderly for LAU experiencing population decline and LAU experiencing population increase
Note:The changes in the share of elderly and in overall population are calculated for 2011.

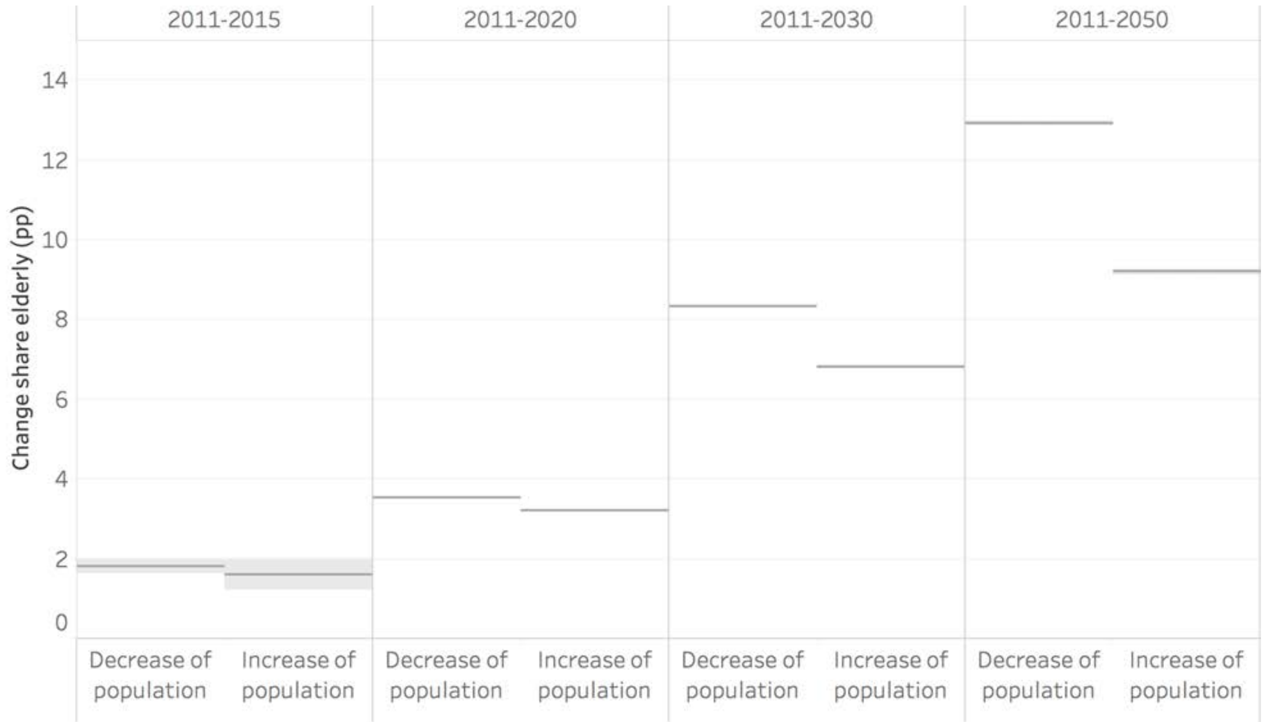
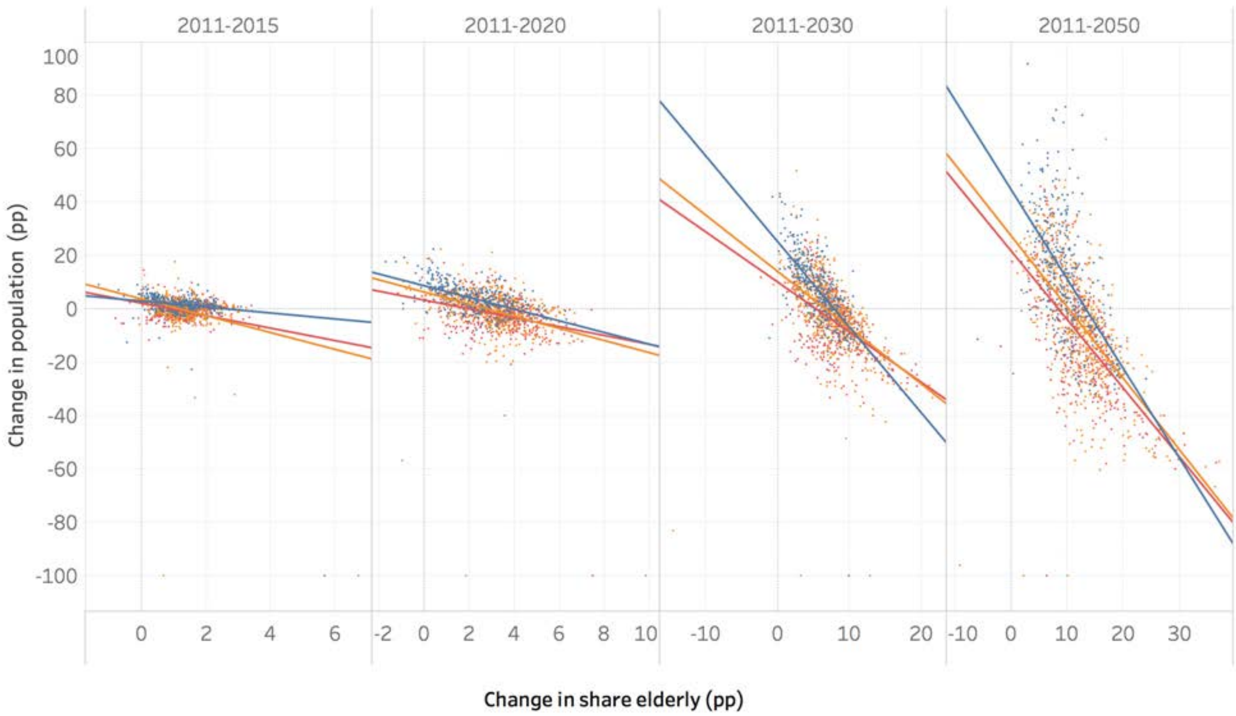


FIGURE 7. Evolution through time of the association between ageing and population change by urban-rural regional typology



urban regions would be affected by this demographic decline even more than intermediate and rural regions.[12]

2.4 DEMOGRAPHIC TRENDS AT MACRO-REGIONAL LEVEL

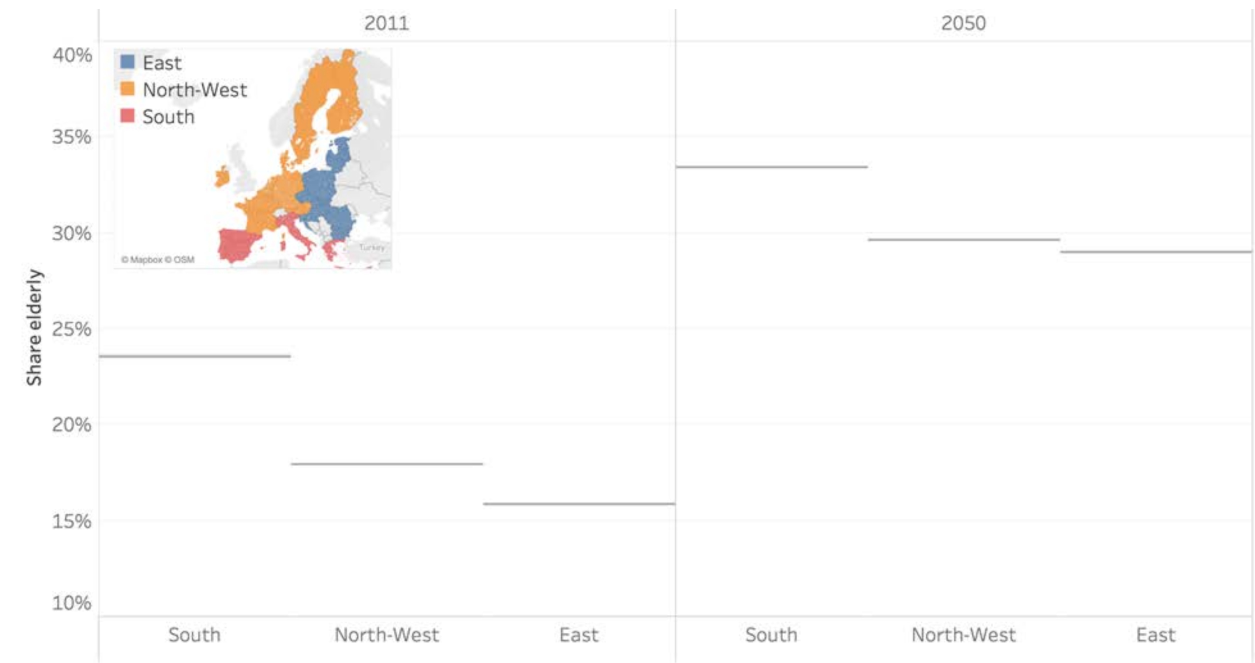
Besides the clear association between ageing and depopulation, ageing at the local level may be influenced by more general demographic trends taking place at the higher geographical level of countries and macro-regions of the EU (Kashnitsky, de Beer and van Wissen, 2017). To help appreciate the effect of these macro-regional trends, Figure 8 shows the median values of the share of elderly across LAU by grouping them into three main macro-regions, namely Southern, North-western, and Eastern Europe.[13] The figure reveals that ageing in 2011 was more pronounced in the South of Europe. Over time, most of the LAU in North-Western and Eastern Europe are expected to converge towards the higher level of ageing experienced by the LAU in South Europe. This is in line with the results of Kashnitsky, de Beer and van Wissen (2020) obtained by analysing NUTS2 level data from 2003 to 2013. They conclude that the differences between the three macro-regions have diminished, but at the same time, regions in Europe have become less similar in age structures in their territories through time.

These descriptive results are also confirmed by statistical tests, which compare the entire distributions of values at LAU level (see Figure A1.2 in Appendix 1). The analysis indicates that the convergence between macro-regions is not only happening for LAU with intermediate levels of ageing, but also for LAU at both ends of the distributions, with very low or very high proportions of the elderly.

2.5 AGEING AND DISTANCE TO FUNCTIONAL AREAS

Several studies observed how young adults in Europe tend to move from rural to urban regions, but their findings also show that, at NUTS2 level, this has not resulted in a general increase in the difference in population age structures between urban and rural regions (Kashnitsky, de Beer and van Wissen, 2020). The highly detailed data produced in our simulations allow patterns of aging to be explored independently from the classification by degree of urbanisation. Therefore, the study presented here also looks at how the proportions of elderly and other age groups are changing in each 1 km² cell along continuous gradients of population density and distance[14] from the closest functional urban areas. The relationship between on the one hand distance and on the other hand the shares of elderly and of children

FIGURE 8. Median share of elderly across LAU grouped by macro-regions



12 Part of this result may be due to the convergence assumptions underlying the population projections.

13 The grouping of Member States in macro-regions is based on the EUROVOC (multilingual thesaurus maintained by the Publications Office of the European Union) classification (Central and Eastern Europe, Northern Europe, Southern Europe, and Western Europe) with an additional merging of Member States in Northern and Western) and is justified by the fact that Member States in Northern and Western Europe have very similar demographic trajectories.

14 Euclidean distance calculated for each cell compared to the centroid of the closest Functional Urban Area (consisting of cities over 50,000 inhabitants and their commuting zone) in the same country.

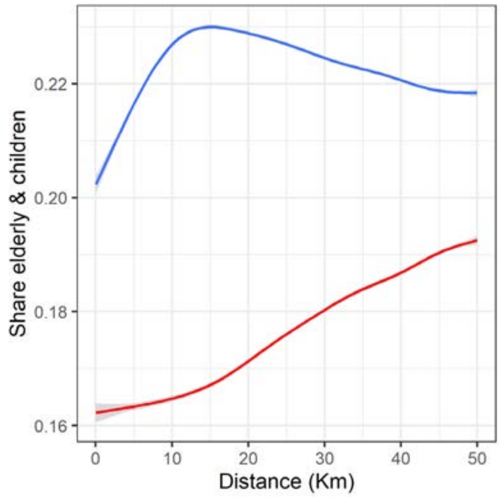
and adolescents (individuals under 20 years of age) is estimated by applying a generalised additive model[15] using individual grid cells values as observations of the proportion of elderly, and children and adolescents in 2011.

The graph in Figure 9 shows that the proportion of elderly in Europe increases systematically with distance from the city centre, while the share of children and adolescents increases within 10 kilometres from functional area centres, and then slightly decreases at longer distances.

Differences exist across Member States within this general pattern at EU level. Figure 10 reports the evidence of some of these national differences. While Sweden follows the EU pattern with a general increase of the proportion of the elderly with distance from the city centre, Italy is characterised by a high share of elderly close to city centres. Germany shows a more uniform effect of the distance on the proportion of the elderly, and Portugal a mixed pattern, but generally an increasing share of elderly moving away from the city centre.

A similar difference between Member States also exists for the share of children and adolescents. For example, Germany does not show the peak that characterizes the pattern of Italy, Sweden, and Europe as a whole, but it shows an almost continuous increase of the share of children and adolescents with distance from the city centre. On the contrary, Portugal shows a general decrease in the share of children and adolescents with distance, but it is also associated with an irregular trend in a radius of around 20 kilometres from city centres. Additional information is available in Appendix 1 (Figure A1.3).

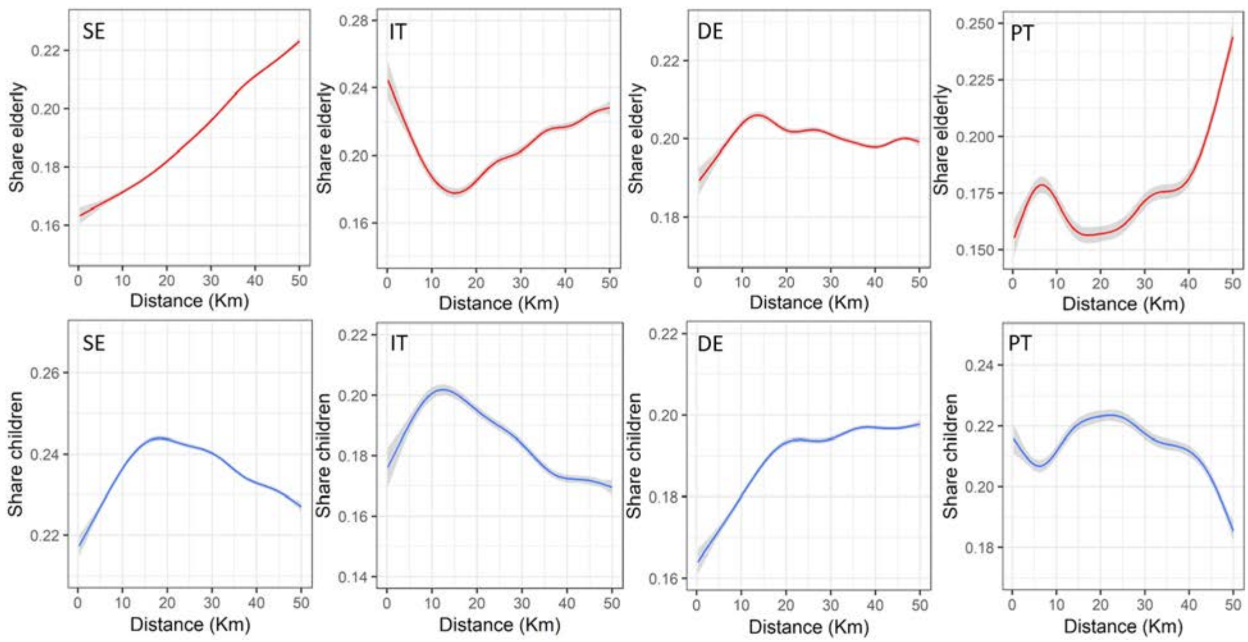
FIGURE 9. Changes in the proportion of the elderly (in red) and of children and adolescents (in blue) with distance from the centre of functional areas in Europe, 2011



2.6 AGEING AND POPULATION DENSITY

Distance to functional areas and population density are linked. Here, the proportion of elderly and children and adolescents in 2011 in 1km cells is analysed in order

FIGURE 10. Changes in the proportion of the elderly (in red) and of children and adolescents (in blue), with distance from the centre of functional area, in Italy (IT), Germany (DE), Portugal (PT), and Sweden (SE) in 2011



15 A generalised additive model (GAM) is a generalized linear model in which the relationship between individual predictors (distance and population density) and the dependent variable (proportion of the elderly, and children and adolescents) follows smooth patterns that may be linear or nonlinear.

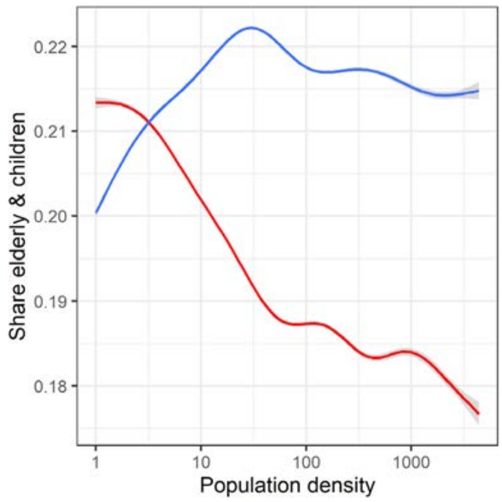
to highlight how ageing changes as a function of the population density of each cell. As with the analyses by distance from city centres, in this case we estimate a series of GAM (Generalised Additive Model) models, from which continuous and smoothed functions of the share of the two population groups in relation to population density can be derived, considering the entire EU, and each Member State separately.

Figure 11 shows that the proportion of the elderly in the entire EU decreases rapidly with increasing population density, passing from a mean proportion of the elderly of more than 21% per one square kilometre to less than 18% when the density reaches 5,000 inhabitants per square kilometre.

The proportion of children and adolescents recorded has the opposite trend, increasing up to a population density of around 40 inhabitants per square kilometre and slightly decreasing for higher densities.
This general pattern for the entire EU hides marked differences across Member States. Figure 12 highlights how in Spain, Portugal, and Romania a consistent reduction in the proportion of the elderly is associated with increasing population density. Within this common trend, Romania is characterised by a constant proportion of the elderly up to a density of approximately 100 inhabitants per square kilometre, and rapidly decreasing after that. On the contrary, the effect of population density on ageing in Germany is rather uniform.

Member States are also dissimilar for the proportion of children and adolescents. For example, Portugal and Spain present a similar pattern that differs from the trend at EU level. Romania and Germany show a trend more in line with the EU one, but marked by relevant local differences. Additional information is available in Appendix 1 (Figure A1.4).

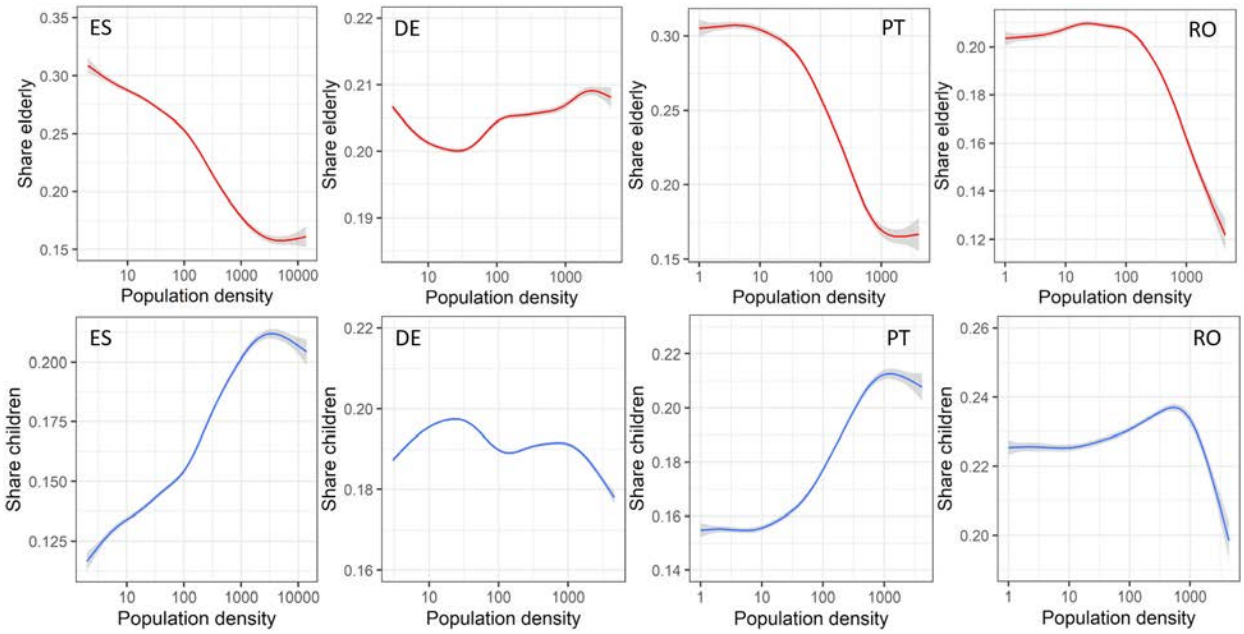
FIGURE 11. Changes in the proportion of the elderly (in red) and of children and adolescents (in blue) with increase of population density in Europe, 2011



2.7 AGE SEGREGATION IN NUTS3 REGIONS

One of the implications emerging from the spatial sorting by age, as described above, is that different age groups may cluster in specific neighbourhoods within the administrative boundaries of each region or LAU.

FIGURE 12. Changes in the proportion of the elderly (in red) and of children and adolescents (in blue) with increase in population density in Germany (DE), Portugal (PT), Romania (RO), and Spain (ES), 2011



The clustering of age groups can be measured by using indexes typically used to study ethnic segregation (Massey and Denton, 1988). These indexes measure the degree of distinction between groups living apart. The fact that some places within a region are disproportionally inhabited by people of a certain age may have impacts on social cohesion and political behaviour, and on the local demand for social services (Boterman, 2020; Sabater, Graham and Finney, 2017) as described more in detail in Chapter 5 and 6. One of the simplest measures of segregation is represented by the dissimilarity index (Duncan and Duncan, 1955) which considers the variations in the proportions of two age groups across geographical sub-units within an area.

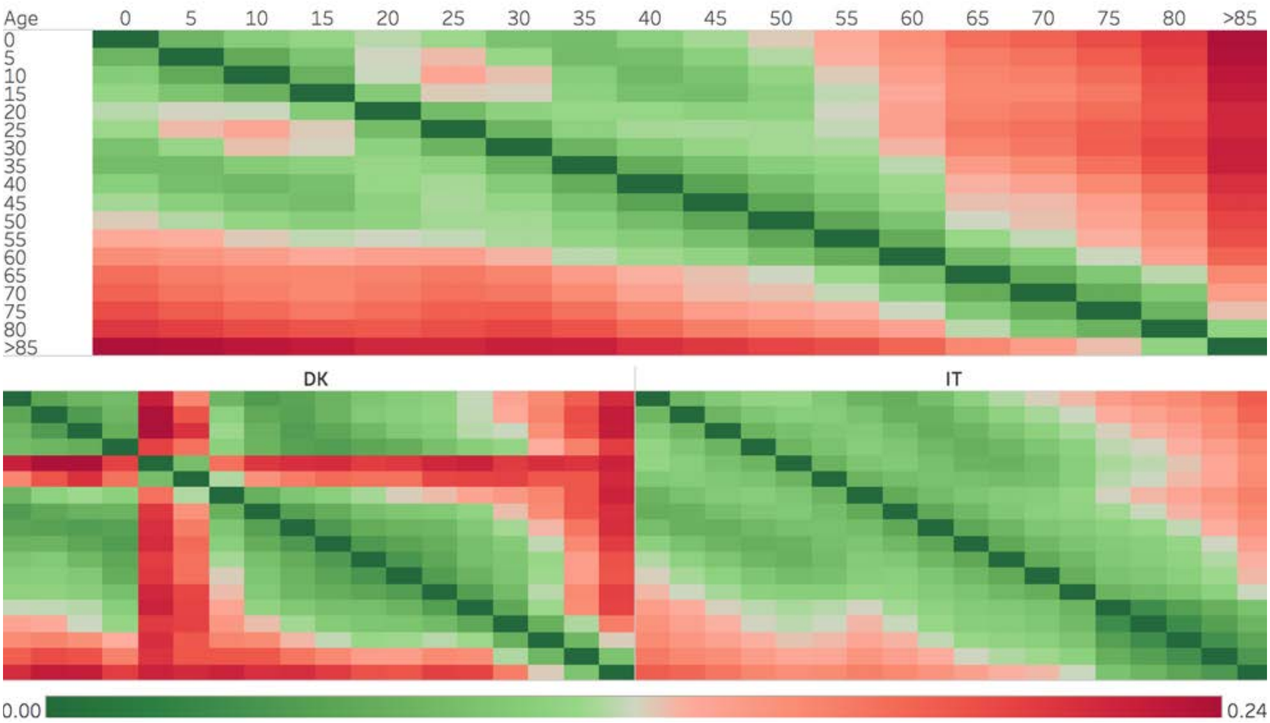
Figure 13 shows the results of the calculation of these dissimilarity indexes for the EU for all combination of ages based on the proportions of population by age in sub-units of 1km in 2011. The values represent the average values across all NUTS3 regions. A high value of the index indicates that the two age groups considered tend to be unequally distributed and are clustered in distinct geographical sub-units within the region. The value of the index is independent from the overall proportions of each group at NUTS3 level. So for example this allows NUTS3 regions with high and low proportions of elderly to be compared and the index to be exclusively used to reflect the variation in the local distribution of the population. The general picture emerging from Figure 13 is that the elderly population in particular, tends to be segregated and lives in isolation from all other younger age groups. The segregation of the elderly is increasing with age, reaching its maximum for ages 85 years and above. As expected, children and adolescents tend to have low segregation values in respect to the age groups between 35 and 49 years because they live in the same household. Along these lines, the decreasing segregation between ages 0 and 15 years compared to the ages 35 and 49 is an expression of the typical household composition and timing of having children.

Another group that is highly clustered is represented by young adults 20-29 years of age, compared to children and adolescents, and to adults aged 40-59 years. The high segregation in these age combinations can be explained by the low probability of having children at this age and by the tendency to leave the residence of the family of origin and move to places where affordable housing or university accommodation is available.[16]

The lower part of the figure shows some interesting variations across Member States. For example, it is possible to recognise that the residential segregation of youth (aged 20-29 years) compared to all other age groups is more pronounced in Denmark compared to Italy. This may indicate a delay in leaving the parental home in Italy and/or a higher residential clustering of students in Denmark. In the case of the combination of young

FIGURE 13. Median values of the dissimilarity indexes for combinations of age groups and across NUTS3 regions in the EU (top chart) and in Denmark and Italy (lower charts)

Note: A high value of the index indicates that the two age groups within NUTS3 regions considered tend to live apart.



16 There are also accounting issues: in some countries, the census records students in their student housing, in others in their parental home.

parents (35-39 years old) and children aged 0-4 years, the segregation value for Italy is slightly higher than in Denmark, and this may indicate a delay in childbearing and family formation for Italy.

These variations in segregation by age offer a complementary perspective to the analysis of ageing at territorial level. In particular, they show how the territorial demographic structure is also determined by the household composition and socio-cultural norms prolonging or anticipating life course events such as childbearing, leaving home to study, family formation, and co-residence with the elderly.

2.8 AGEING IN MOUNTAIN AREAS

Mountains are of vital importance to the EU's population. They are a reservoir of natural resources, landscape amenities and biodiversity, and they might play a special role in the transition to a green and sustainable Europe. However, mountain regions are traditionally characterised by limited access to services, overexposition to natural hazards, remoteness, and low-population density, together with the impact of slope and altitude, which decrease the productivity of agriculture and increase transport costs. Agricultural land abandonment in EU mountains and remote areas is also a current problem (Lasanta *et al.*, 2016; Perpiña Castillo *et al.*, 2018, Perpiña Castillo *et al.*, 2020), along with depopulation of some areas ("rural exodus"), low incomes and productivity, and low deployment of innovative services. Finally, evidence suggests that the combination of geographical isolation and ageing in these areas may exacerbate the individual perceptions of loneliness (Sagan and Miller, 2017; Victor and Pikhartova, 2020).

The policy debate focuses on the need to foster a balanced and sustainable territorial development in rural, mountain, and remote areas (European Parliament, 2018) and turning challenges into opportunities. Opportunities are offered by initiatives to restore biodiversity, promotion of healthy and active ageing lifestyles, and digital inclusion, in order to facilitate the delivery of essential services. Policies aimed at increasing the share of working age population might incentivise the creation of silver enterprises (e.g., small and medium-sized enterprises) to target the needs of the older population, but also to counteract land abandonment and implement new farming or agricultural activities (Corrado, Dematteis and Di Gioia, 2014). Other initiatives aimed at increasing the working age population in mountain areas might involve the creation of permanent spaces of cultural creativity (Viazzo and Zanini, 2014), and of employment opportunities related to sustainable tourism (Batista *et al*, 2020). Finally, strategies to limit the shrinkage of the resident population in mountain areas might consider the possibility of hosting small communities of migrants as well as asylum seekers and refugees (Perlik and Membretti, 2018) which would contribute to keeping local services open (Proietti and Veneri, 2019).

Ageing is at the heart of the challenges facing mountain areas. To analyse the ageing of population living in mountain areas,[17] the projected trends to 2050 for three age groups were examined: children (under 15 years of age), elderly (over 65 years) and working age population (between 15 and 64). At EU level, the working age population is expected to decline, with a loss of more than 7.4 million people (9.1 pp) between 2015 and 2050. In contrast, the elderly population is expected to increase by 7.9 million (about 9.9 pp). The population of children (aged 15 years and below) is projected to remain rather stable with a small negative trend (0.5 million, equal to a contraction of about 0.7 pp) over the same period.

The trend of ageing varies in intensity -from EU Member State to EU Member State (see Appendix 1, Figure A1.5). Greece, Cyprus, Sweden and Portugal would have the highest proportions of elderly population in mountainous areas in the EU, well-above the EU average (20%). On the other hand, France, Finland and Poland would register the highest proportions of children in mountainous areas. Finally, Slovakia, Poland, and Romania are the Member States in which the working population in mountainous areas is expected to be above the EU average (65%). Between 2015 and 2050, the elderly population is projected to increase in all EU Member States except in Cyprus. In particular, the population above 65 years old in Slovakia is expected to almost double in its mountain areas. Lastly, Poland, Slovenia, Austria, and Spain would see their elderly mountainous area population increase by more than 60%.

Figure 14 further zooms in on the municipalities in mountain areas, which number almost 26,000 (26% of the total).[18] The data is clustered in three classes based on the change by age groups, namely: population decline (< -10%), quite stable population (between -10% and +10%), and population growth (>+10%). The general pattern for the elderly population group indicates that ageing would affect most of the municipalities (63%) with an average increase of more than 57%. A decrease in the share of elderly is only expected in a

17 In the current analysis, mountain areas are characterised spatially using the category of "Totally mountain areas" from the Less-Favoured Areas (LFA) classification map. This definition is used to select EU municipalities (local level) within the mountain areas delineation. According to this definition, almost 26,000 municipalities are mountain. Some Member States (Belgium, Denmark, Estonia, Ireland, Latvia, Lithuania, Luxembourg, Malta and the Netherlands) are excluded from the analysis since they have no mountain areas according to this definition.

18 The number and size of LAU in mountain areas greatly differ across Member States from more than 7,000 municipalities in France to less than 100 municipalities in Hungary and Croatia.

few geographical areas, mainly in the northern half of the Iberian Peninsula, south-eastern part of France, Greece, Finland, Sweden, and in areas surrounding the Balkan Mountains. Population decline would also affect the other two age groups (children and working age population), especially in northern Portugal, Croatia, Greece, the South of peninsular Italy and Sardinia, the borderlands between Slovenia and Austria, most of the municipalities in Slovakia as well as the southern part of the Carpathians in Romania, thein western part of the Balkans and the Rhodopes mountains in Bulgaria.

To understand whether the tendency for ageing is particularly pronounced in mountain areas, Figure 15 presents the median values of the proportion of the elderly across municipalities in mountain and non-mountain areas (labelled as other) through the period 2011-2050. The comparison between these two groups of municipalities reveals that mountain areas on average host higher proportions of the elderly and that this share is expected to increase from 21% in 2011 to 30% in 2050. However, especially after 2030, the gap between the mountain and non-mountain areas would shrink, meaning that the age of people in mountain areas are not expected to increase faster than the other areas.

This trend at EU level is confirmed by the data at Member State level shown in Figure 16, which indicates

FIGURE 14. Population change in EU mountain areas by age groups between 2015 and 2050 at local level measured in percentage change

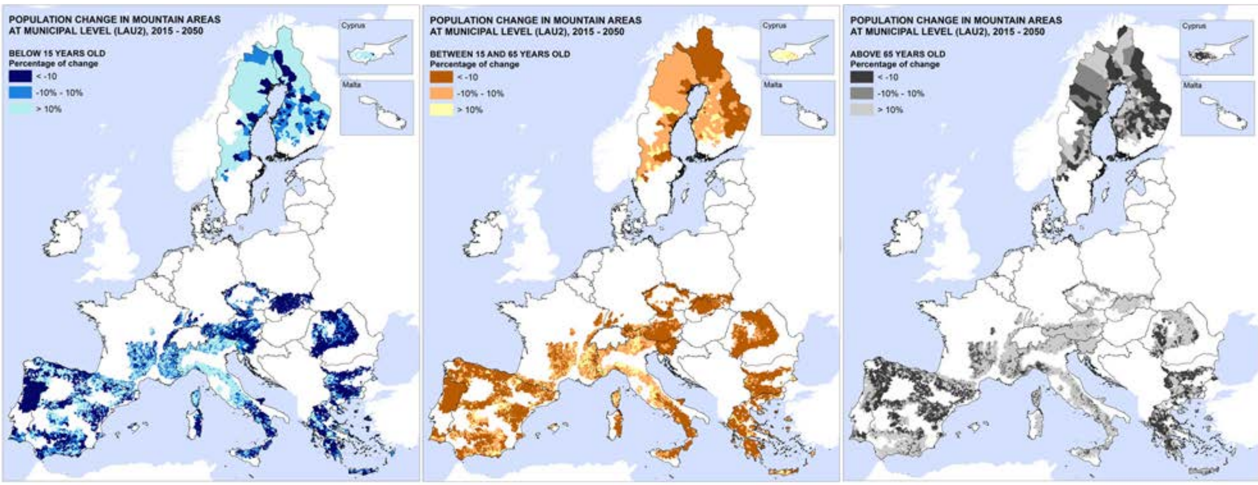
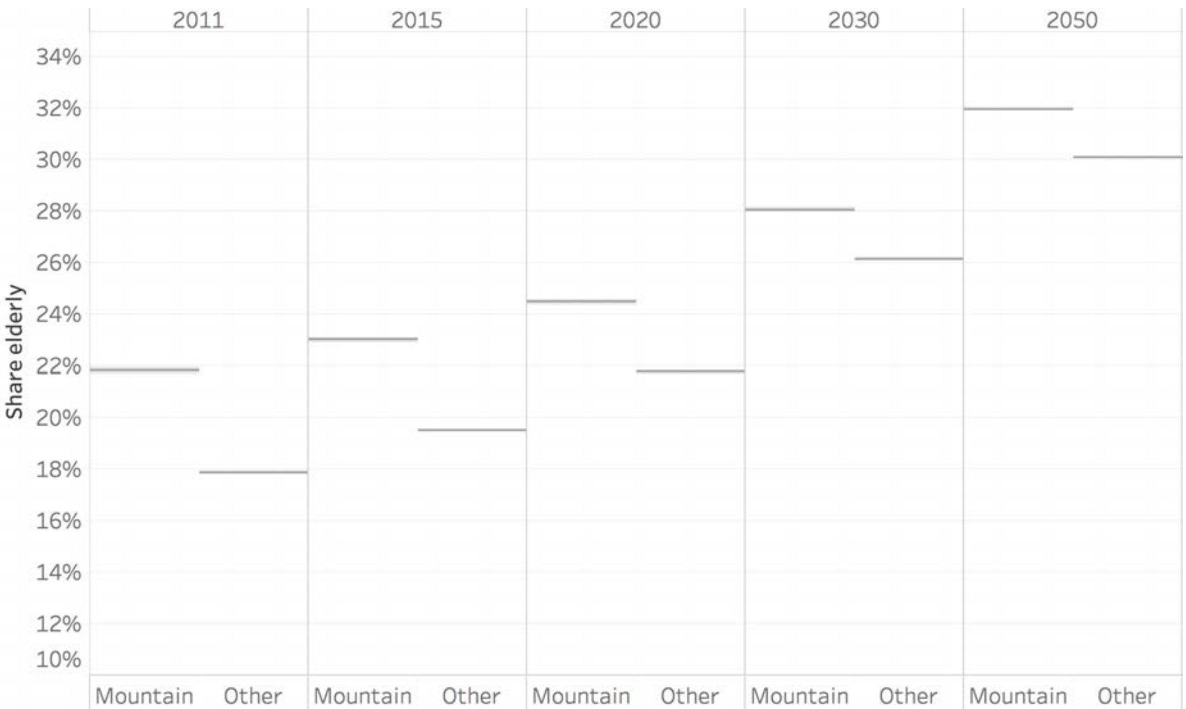


FIGURE 15. Evolution of the median share of the elderly in mountain and other areas until 2050
Note: The values are medians across approximately 98,000 LAU in EU divided into the two groups.



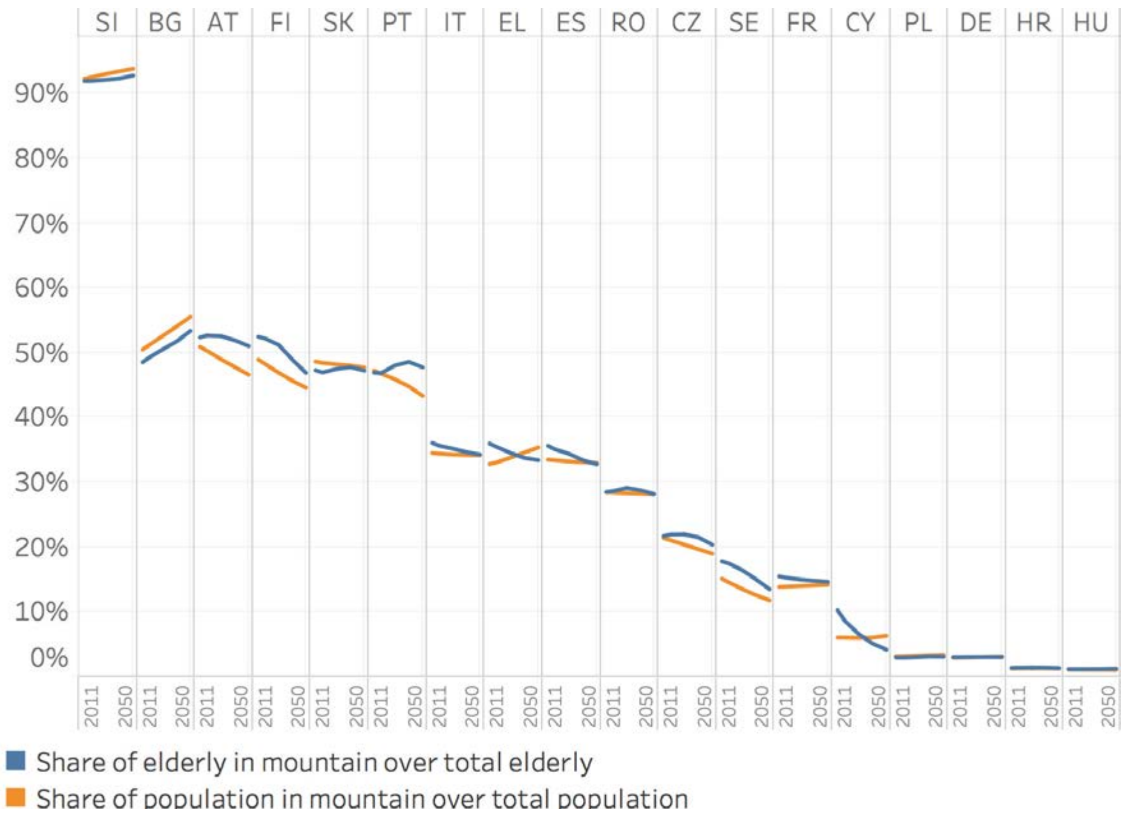
the proportion of the elderly living in mountain areas compared to the total of elderly, and the proportion of total population in mountain areas compared to the total population. For the mountain areas in most Member States, with the exception of Slovenia and Bulgaria, both the proportion of the elderly and the total population are expected to decrease. Only in the case of Portugal, the proportion of the elderly in mountain areas is increasing while the population in mountain areas is in decline. In all other cases, the number of elderly in mountain areas is expected to diminish at a faster rate than the decrease in the overall population in those mountain areas; or at least decreasing at the same pace.

2.9 CONCLUSIONS

The main contribution made by this chapter is in showing how future trends of ageing in EU territories would be shaped by the following five main processes, taking place at different spatial scales.

- At the macro-regional level, the different parts of Europe are converging in the distribution of the elderly across their territories. In particular, eastern EU Member States are catching up with southern EU Member States in the rate of ageing.
- At LAU level, rather than being linked to the urban-rural regional typology (rural areas, towns and cities), the increase in the share of the elderly is more clearly associated with the process of depopulation whereby territories experiencing a decline in population are also those that are ageing faster.
- In the case of mountain areas, the population is expected to remain relatively stable until 2050. In most EU Member States, mountain areas are not ageing faster compared to non-mountain areas except in Slovakia, Portugal, Spain, and Poland. The working age population (15-64 years) in mountain areas would experience a decline of more than 7 million people, about half a million children (below 15 years), and an increase of 7.9 million in the elderly between 2015 and 2050.
- At the more detailed geographical level of 1km cells, there are clear differences in the distribution of population by age as a function of distance from city centres and population density. At the scale of variations across Member States, the overall picture for the EU is that the elderly tend to concentrate far from city centres and in areas with lower population density, while children are concentrated in areas outside of city centres and at intermediate density places.
- A result of these differences in population distributions by age is that besides the increase of the overall proportion of the elderly, territories are also experiencing a clustering and segregation of age groups in specific areas within their administrative boundaries. This phenomenon of age segregation is particularly evident for the elderly and the young between 20 and 24 years of age.

FIGURE 16. Share of total population (orange) and of the elderly (blue) living in mountain areas by Member States between 2015 and 2050



3. DEMOGRAPHIC CHANGES IN LABOUR FORCE SUPPLY: COHORT TURNOVER VERSUS NET MIGRATION EFFECTS

Daniela Ghio, Fabrizio Natale, and Anne Goujon

Key findings

- Although ageing is a common trend across the European Union, in the period 2015-19 28% of regions (24% of population) benefitted from net migration (including all types of migration) to compensate for the demographic deficit in working age population that exists due to cohort turnover.
- Two case studies for Italy and Sweden show that international migrants (not distinguishing between EU intra-migrants and third country nationals) compensate the negative cohort effect of natives. However, this effect is more pronounced in urban areas, where it is also not as needed thanks to the younger age composition of natives.
- The breakdown of net migration by age reveals distinct age patterns in the processes of urbanisation and counter urbanisation: when approaching the age of retirement, older cohorts living in the EU exhibit a high propensity to move from urban to rural regions. In contrast, younger cohorts mainly move from rural (and intermediate) regions towards urban regions.
- These internal migration trends between rural and urban regions, differentiated by age, follow life course events and in part explain the differences in patterns of ageing across EU territories.

3.1 INTRODUCTION

Population ageing in Member States of the European Union has direct impacts on labour force participation, on economic growth, and on the sustainability of social security systems. Because EU Member States significantly differ in their age structure, social care (Esping-Andersen, 1999; Ferrera, 1996), labour markets (Mingione, 2002), and welfare systems (Saraceno, 2000; Kalmijn and Saraceno, 2008), countries have responded differently to the challenges presented by ageing. The main concern is centred on how to provide for the growing proportion of retirees, while depending on a declining proportion in the active labour force (Lutz *et al.*, 2019). In many cases, governments have implemented reforms to gradually postpone the retirement age (Milligan and Wise, 2012). In other cases, countries have introduced policies with the aim of improving flexibility and incentivising the participation of women in the labour force (Zamarro, Meijer and Fernandes, 2008). The policy debate has also focused on the role of international migration that could have rejuvenating effects, considering that migrants are usually young when they arrive in EU Member States, and have more children compared to native populations (Coleman, 1995). Particularly in *traditionally labour importing countries*, migration appears as an alternative to revitalise the economy and mitigate labour shortages. However, national aggregates hide what plays out at a more local territorial level in terms of ageing and migration, and their consequences on the age structure.

This section focuses on the demographic components of change in the working age population across EU regions. Differences in the size of the active population are linked to the structure of local populations and migration flows that may significantly differ according to age, and between rural and urban areas. This basis is used in the analysis to break down the changes in the working age population, distinguishing between cohort turnover and net migration effects, in order to investigate demographic dynamics of labour force supply at national and NUTS3 levels. Specifically, this chapter seeks to answer the following questions:

- To what extent do cohort turnover and migration flows shape the evolution of the working age population at local level?
- In what ways does the incidence of the two components depend on territorial and demographic patterns?

Using Eurostat datasets at NUTS3 level, the analysis measures the changes in working age population with respect to spatial demographic patterns. Heterogeneity is examined across NUTS3 regions[19] and within each Member State by considering rural and urban place of residence. The contribution of this section to policy debate is twofold. First, it provides a detailed mapping of regions where the working age population is declining rapidly. Secondly, it provides an assessment of the contribution of the migration balance in mitigating the effects of cohort turnover on the changes in the working age population at territorial level.

3.2 METHODS AND DATA

The approach proposed by de Beer, van der Erf, and Huisman (2011) is adopted here. Based on the conventional demographic classification of working age population as 15-64 classes,[20] the cohort turnover is defined as the difference between the entry cohort (15-19 age group) and the exit cohort (65-69 age group). Using Eurostat data collected at NUTS3 resolution, the working age population in 2015 was compared with that recorded in 2019. The demographic changes are disaggregated by components as follows:

- cohort turnover, which consists of the population difference (in absolute value) between the entry cohort (15-19 age group) and the exit cohort (65-69 age group) in 2019 (A);
- mortality, corresponding to the age-specific number of deaths by 5-year age groups (15-64 years) reported during the period 2015-18; for 2019, numbers of deaths are estimated as the mean values of the two latest periods (2017 and 2018) (B); net migration, which derives from the population variations between the two periods of observation (2015 and 2019), net of the cohort turnover and mortality (C).

From a demographic point of view, the use of net migration presents limitations as it does not distinguish between immigration and emigration (Box 1). In addition, when obtained from a residual method (A-B), net migration may suffer statistical biases.[21] *From an economic perspective,* the method used presents the constraint that workers in the entry and exit cohorts are *implicitly assumed* to be perfectly interchangeable. The literature has demonstrated that the degree of interchangeability between cohorts is negatively correlated with the age interval between them (Morin, 2015), concluding that interchangeability is feasible under certain conditions, such as when age ranges are narrow between entry and exit cohorts. Moreover, when older workers might occupy high-skilled positions, replacement with young entry workers would require an extended period of adjustment.

BOX 1 I have never met a net migrant!

Several migration analysts have explained the limitations and expressed concerns about the use of net migration. For instance, Rogers (1990) significantly entitled his paper *Requiem for the Net Migrant* to show the problem of using a non-existent person such as a net migrant. Furthermore, Termote (1993) classifies net migration as a *pure abstraction.* Despite all of its limitations, net migration remains the default indicator at global level because it maximises the application of the limited official statistics available and – at the same time - accounts for the specific spatial distribution of populations. However, net migration as the balance resulting from the migratory exchange between the targeted population and the rest of geographical population systems cannot distinguish between distinct types of migratory movements, neither regional (from the region towards the same national area) nor international flows (across borders).

19 Hereafter, regions.

20 Here working age population identifies the potential supply of labour force. The range 15-64 is preferred to the alternative 20-64 for making the analysis comparable at international level and consistent with de Beer, van der Erf, and Huisman (2011).

21 This case is described in the EMN Glossary (https://ec.europa.eu/home-affairs/what-we-do/networks/european_migration_network/glossary_search/net-migration_en). "Since many countries either do not have accurate figures on immigration and emigration or have no figures at all, net migration is frequently estimated as the difference between total population change and natural increase between two dates (in Eurostat's database it is then called corrected net migration). The statistics on net migration are therefore affected by any statistical inaccuracies in any of the components used for their derivation".

Nevertheless, the decomposition method is built upon a widely recognised approach differentiating between period and cohort effects, which makes it relevant to detect declines in the size of entry cohorts compared to exit cohorts that can generate substantial shifts in the relative sizes of active/inactive populations (Keiding, 2011).

3.3 NET MIGRATION AND COHORT TURNOVER IN EU REGIONS

Through the period 2015-19, 22.9 million of EU young people entered the working age population, whereas 26.6 million people left it after becoming 65 year and older: this means that around 3.8 million potential workers were not replaced.[22]

Within this generalised trend for the EU, around 64% of EU regions experienced a decrease in their working age population. On the contrary, the remaining EU regions (422 out of 1,170 NUTS3 regions) report a positive change of their working age population. Among these, a small percentage (8%) combines a surplus in cohort turnover with a positive net migration balance. In general, the migration balance is positive in most EU regions (87%). In 324 EU regions (28% of regions and 24% of total EU population), net migration counterbalances the deficit due to a negative cohort turnover and contributes to an increase of the working age population. Cohort turnover in the remaining regions dominates, which has led to the shrinking of the labour force supply.

Figure 17 shows the relative effects of cohort turnover and net migration on the working age population for each region during the period 2015-19.

The first quadrant (Figure 17, top left) displays NUTS3 populations with a positive cohort turnover effect (the entry cohort is larger than the exit cohort) and a negative net migration balance (more out-flows than in-flows). In this quadrant are 46 regions (only 4% of the total EU territories and 7% of the 2019 EU population), mostly located in France (24 regions). Among these, there are five regions where the relative change in the size of working age population is positive (blue points), namely: Seine-et-Marne, Hauts-de-Seine, Val-d'Oise, and the Départements d'Outre Mer, French Guyane, and Mayotte. The other regions report a negative change (red points). Only three NUTS3 territorial units in this quadrant are in Italy; for example, Naples (ITF33), which is in one of the three most populous metropolitan areas in Italy (with Milan and Rome), has experienced a decrease of its working age population (-29,700) in 2019 compared to 2015. This is the result of a positive cohort turnover (approximately 17,200 additional young potential workers entering the working age population, a total of 184,700 in the 15-19 entry cohorts, against a total of 167,500 in the 65-69 exit cohorts), and, when accounting for deaths, a negative migration balance, losing approximately 11,600 *potential workers* because of migration during the period 2015-19.

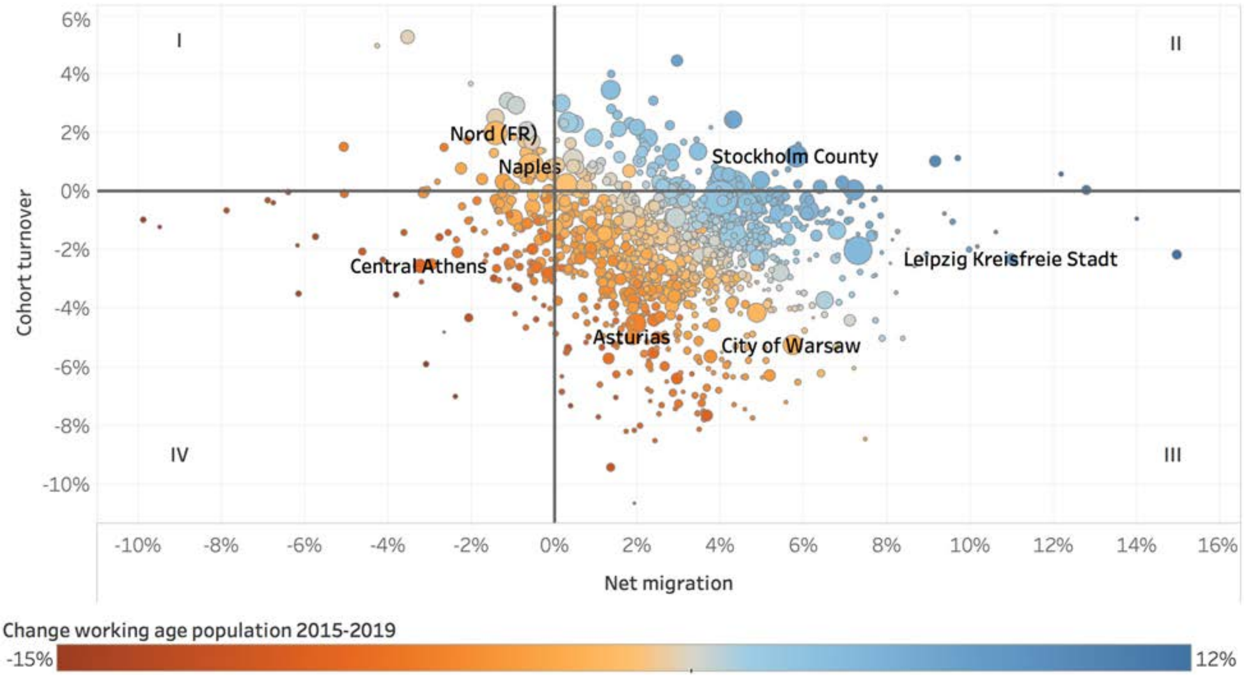
NUTS3 territorial units, where both components are positive, are visualized in the second quadrant (Figure 17, top right). They describe dynamics in approximately 10% of the EU territories and 16% of the 2019 EU population, mainly distributed as follows: the Netherlands (20 regions), Belgium (16 regions), Spain (15 regions), and Germany (11 regions). Among the three Swedish regions, Stockholm (*Stockholms län*) records the largest increase, where the working age population benefits from positive generation and migration effects (18,600 and 89,300 respectively). Regions where the relative change in the size of working age population is positive (blue dots), are mainly located in the North-Western regions (in Ireland, the Netherlands, Belgium, and Germany) and Spain. This group (per se) represents 8% of EU regions.

In contrast to the first, the third quadrant (Figure 17, bottom right) displays regions with negative cohort turnover effects alongside with positive net migration effects. This is the largest group (77%) of EU territorial units and 70% of the 2019 EU population, and has the following composition: Germany (390 regions); Italy (93 regions), Poland (70 regions), and France (54 regions). For example, among Polish regions, in the capital area (*Miasto Warszawa*), migration is insufficient to compensate for negative cohort effects between entry cohorts (63,200 in the 15-19 age group) and exit cohorts (123,000 in the 65-69 age group). The share of regions, where the relative changes in population size are positive (blue dots), meaning that during the period 2015-19 ageing effects (the deficit generated by the replacement between the new entry cohorts and the cohorts reaching retirement age) are counterbalanced by net migration effects, is around 28% of the total in EU regions. They are mainly located in Germany (219 regions), Austria and Sweden (16 regions in each Member State), Belgium (13 regions), Italy, Spain, and the Netherlands (9 regions in each Member State).

Finally, the fourth quadrant (Figure 17, bottom left) shows the regions where both cohort turnover and net migration balance are negative. These regions (101, corresponding to 9% of EU territorial units and 7% of the 2019 EU population) are distributed across Member States, such as Romania (22 regions), Greece (15 regions), Croatia (14 regions) and Italy (12 regions). In Greece for example Athens' 15-64 working age population declines from 641,400 in 2015 to 591,000 in 2019 (NUTS3 territorial unit of Kentrikos Tomeas Athinon); when disaggregated, both components, migration and turnover cohort effects, are negative. Accounting for the relative changes in working age population, we group 518

22 The attribute of potential refers to workers derived from the demographic perspective of analysis. Indeed, this does not necessarily correspond to either the real employment status of people or the economic market conditions.

FIGURE 17. Cohort turnover and migration changes across EU regions, 2015-2019
Note: change in the working age population during the period 2015-2019 is presented as a proportion (percentage) of the population residing in the NUTS3 territorial unit in 2015. The relative size of changes is reflected in the colour gradient (negative changes are in red, positive changes in blue), and the size of the NUTS3 region in the size of the dot.



regions where migration effects are too small to compensate for the reduction due to cohort effects (red points). This is for instance the case of 171 German, 84 Italian, 66 Polish and 48 French regions. Only 41 EU regions have a positive cohort effect (the entry cohort is larger than the exit cohort), but still lose working age population due to the migration effect. Details of results observed in Figure 17 are shown by sub-region in the map below (Figure 18). It shows the geographical distribution of relative changes in the working age population across the EU regions driven by cohort turnover and migration effects. As mentioned, most EU regions have experienced a decline in their working age population due to a deficit in cohort turnover, despite a positive net migration. But the many other patterns are visible with clear differences across Member States and within Member States.

3.4 NET MIGRATION AND COHORT TURNOVER BY MEMBER STATES

This section provides insights into the changes in working age populations at national levels by aggregating values recorded at NUTS3 levels.[23] Over the period 2015-19, 11 EU Member States (Figure 19) saw a positive change in the size of their working age population. Cyprus, Luxembourg, Denmark, Ireland, and the Netherlands benefit from positive effects in both cohort turnover and net-migration. In the other Member States (Malta, Belgium, Spain, Austria, Sweden, and Germany), the relative increase in the size of their working age population is on average due to the contribution of migration. For example, in Germany the net migration balance is approximately 1.7 million (median across regions: 4.1% of the working age population in 2015) and counters the cohort turnover effects of - 1 million (median across regions: -2.1% of the working age population). During the period 2015-19, the size of the working age population decreased in: Estonia, Slovenia, Finland, Latvia, Slovakia, Lithuania, Portugal, Croatia, Czechia, Greece, Hungary, Bulgaria, France, Italy, Romania, and Poland. Most of these Member States, except for Slovakia, Croatia, and Lithuania, on average record a net migration balance in their regions, but this is insufficient to fill the gaps due to the cohort turnover effects. Poland records the highest deficit in working age population in terms of absolute size during the period observed: the 15-64 age group lost approximately 1 million potential workers.[24] On the positive side, the largest increases in working age population are recorded in Sweden and Germany with median contributions from positive net migration across their regions of 5% and 4% respectively.

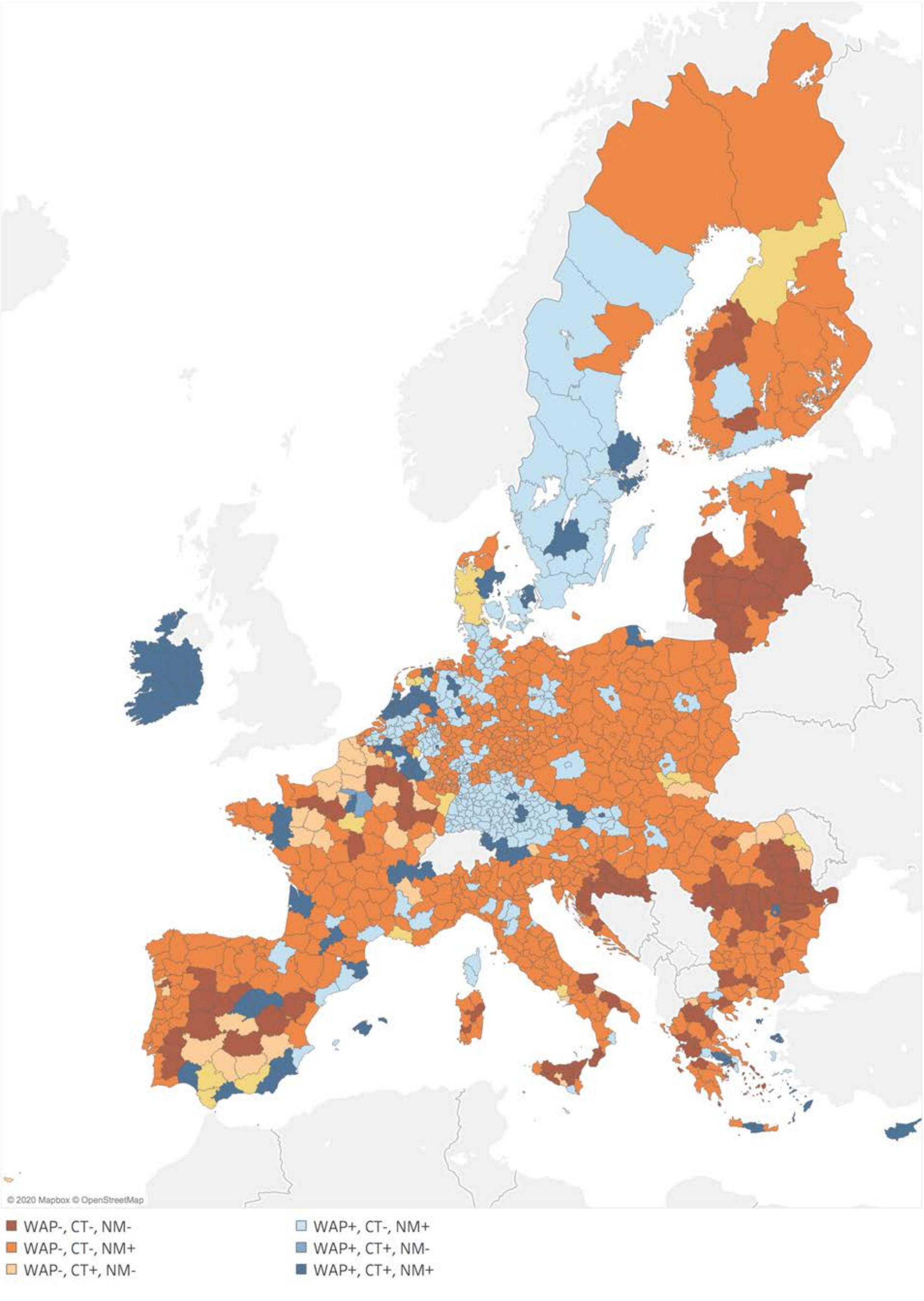
Complementing the analysis on the size of effects, the heterogeneity within each Member State was assessed by

23 As clarified in the Method and data section, net migration reflects both internal mobility and international migration.

24 This consists of approximately 730,000 people in the 65-69 age group plus a net migration balance of approximately 230,000.

FIGURE 18. Geographical distribution of changes in the working age population across the EU regions, driven by changes in cohort turnover and net migration in the period 2015-19

Note: WAP+ and WAP- correspond respectively to positive and negative changes in the size of the working age population between 2015 and 2019; CT+ and CT- correspond respectively to positive and negative changes in cohort turnover between 2015 and 2019; and NM+ and NM- correspond respectively to positive and negative changes in net migration between 2015 and 2019, at the level of EU regions.



measuring the standard deviation of the changes in the working age population. This conventional measure gives an indication of working population dynamics — which is a proxy for the dynamics in labour force supply — and their complexity when regional levels are not aligned with the national one. When sorting EU Member States by the estimated standard deviation of the changes in their regional working age populations, lower values were obtained in Slovenia, Bulgaria, and Belgium. This means that regional changes tend to be similar across regions (close to the mean value). On the other hand, Spain, Sweden, and Ireland register higher values and therefore more variation across regions.

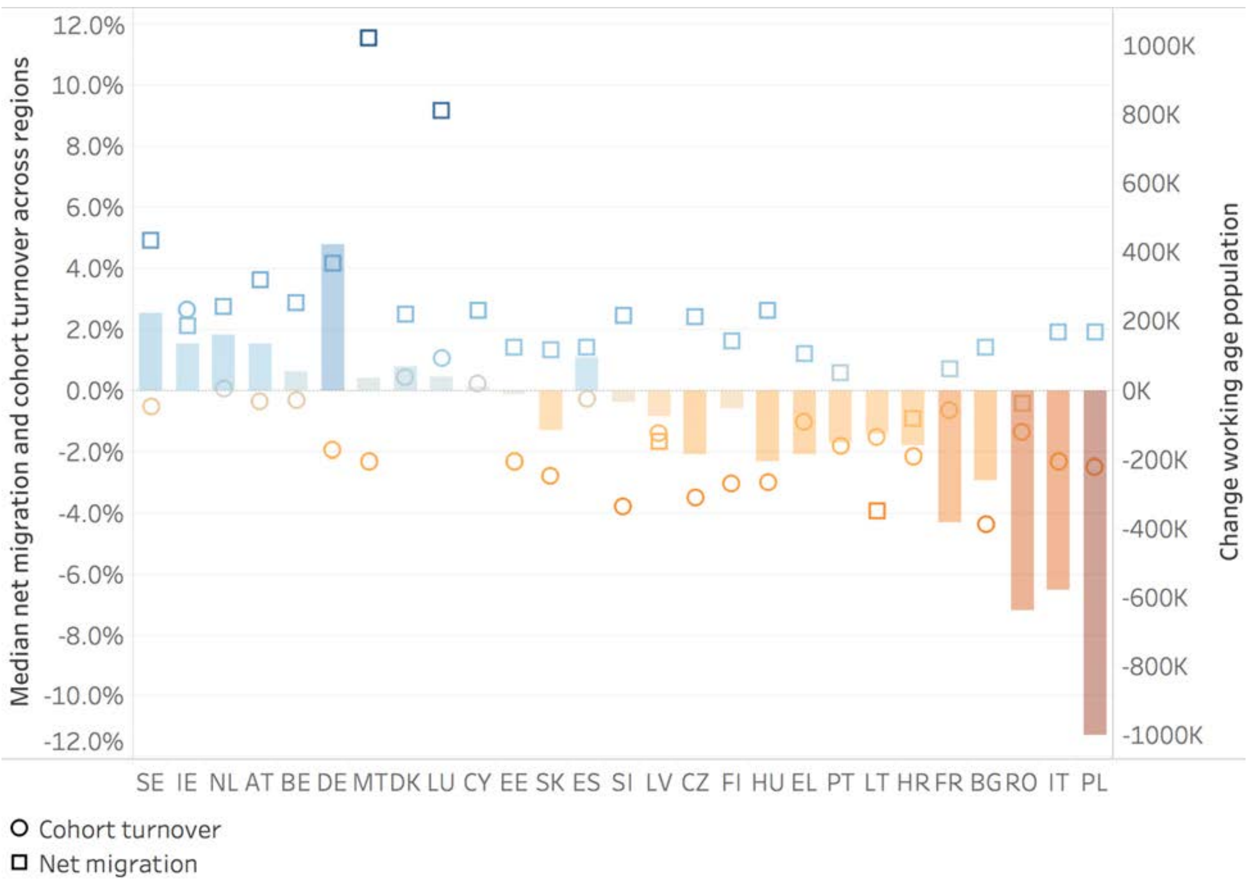
3.5 NET MIGRATION AND COHORT TURNOVER BY GENDER

According to the definition of Mason and Oppenheim (1997), a gender system is the set of socially constructed expectations used for describing the division of labour roles and household responsibilities between men and women. Cultural norms produce differences in female and male rights and obligations that may vary by region. A large body of research has discussed gender equality (i.e., availability of reliable contraceptive methods, increased participation of women in education and the labour force) as an essential factor in understanding low fertility regimes (McDonald, 2006; Caldwell and Schindlmayr, 2003) and consequently the ageing of populations. Here a demographic decomposition method distinguishing between female and male working age population by NUTS3 sub-region is adopted (Figures A2.1 and A2.2 in Appendix 2 display the changes in female and male working age populations across EU regions, and by Member State).

This comparison yields significant indications about demographic changes in the gender composition of the working age population at local level. There is a general weakness in many EU regions in being able to retain or attract female cohorts (attested to by the relative negative changes in female net migration balance) compared to male cohorts. In detail, during the period 2015-19, positive changes in net migration components are reported in 309 regions for women and in 347 regions for men. The

FIGURE 19. Cohort turnover and migration effects across EU Member States, 2015-19

Note: The y-axis on the left presents both the net migration and cohort turnover components during the period 2015-2019 as a proportion (percentage) of the national population in 2015. The y-axis on the right presents the change in absolute values in the national working age population. The national changes in the cohort turnover are displayed as circles, while the changes in the net migration are displayed as squares. Negative and positive changes in the working age population are reflected in the colour gradient (negative changes are in red, positive changes in blue).



female working age population decreases in two out of three regions; 237 regions (20% of the total) report both negative changes in female cohort turnover and net migration (Figure A2.1 in Appendix 2). In contrast, relative changes in male cohort turnover are positive in one out of four regions (294 regions). Furthermore, there are fewer regions (14% of the total) combining both negative changes in male cohort turnover and net migration than female ones, while there are 709 regions (corresponding to 60% of the total) where changes in male cohort effects are coupled with positive changes in male net migration balance.

The gender analysis carried out at national level provides evidence of regional analogies within the same Member State (Figure A2.2 in Appendix 2). In line with the hypothesis of the cultural incidence on the national gender systems, heterogeneity in the relative size of both components (cohort turnover and net migration effects) is higher across Member States than within regions of the same Member State. Although each Member State is characterised by a similar distribution between genders, disparities appear in some EU Member States such as Bulgaria, Hungary, Poland, and Romania, where negative changes in net migration effects are larger for women (Figure A2.2 in Appendix 2, bottom left-hand side of each Member State graph) while other Member States such as Germany and Sweden experience positive changes in their male net migration effects.

3.6 NET MIGRATION AND COHORT TURNOVER IN URBAN VERSUS RURAL EU REGIONS

This section examines how the demographic effects of net migration and cohort turnover differ between rural and urban regions. In the period 2015-19, on average the working age population decreased in rural and intermediate regions by -1.9% and -0.4% respectively, whereas it increased in urban regions (1.2%). Figure 20 displays the relative size of cohort turnover and net migration effects on the working age population in rural, urban, and intermediate regions. Negative cohort turnover affects all EU regions. As a relative proportion of the working age population in 2015, cohort effects are more important in rural EU regions compared to urban ones (-1.9% and -0.7% respectively). In contrast, all three types of region benefit from a positive relative contribution from net migration: the balance is more positive in urban and intermediate areas (3.7%, and 3.3% respectively) than in the rural areas (2.4%). Positive net migration effects contribute positively to mitigating ageing in all regions, but more effectively in the intermediate and urban regions, protecting these regions from further shrinkage of the labour force supply.

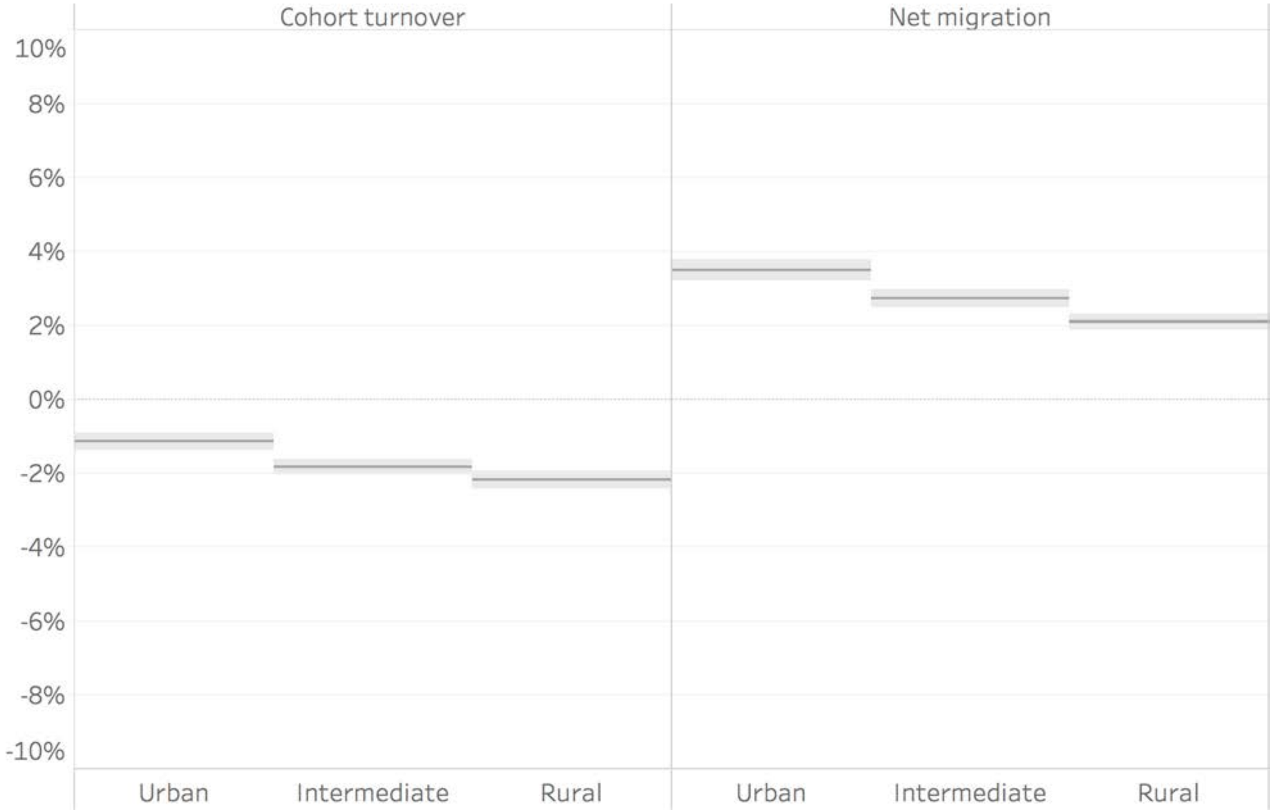
An overview of the relative changes in cohort turnover and net migration for selected EU Member States is provided in Figure A2.3 in Appendix 2. Cohort turnover has affected many regions but there are some exceptions such as Austria (urban regions), Belgium (rural regions), Denmark (urban and intermediate regions), the Netherlands (urban regions), Portugal (urban and intermediate regions) and Sweden (urban regions). This figure shows that negative changes in net migration are experienced in Spain (rural regions), Latvia (intermediate and rural regions), Portugal (intermediate and urban regions), and Romania (rural regions). In this sample of Member States, which are fairly representative of general trends across EU regions, positive changes in the working age population are limited to the urban regions of five countries (Austria, Denmark, the Netherlands, Portugal, and Sweden) and the intermediate regions of two countries (Denmark and Portugal). Belgian regions constitute the only case of rural areas with a surplus of their working age populations in the period 2015-19, a pattern that needs more analysis to understand how this Member State is able to retain population in rural areas. This confirms the tendency observed at general level: in urban regions, net migration effects partially mitigate the deficit due to negative cohort turnover effects, but this is not the case in the vast majority of EU rural regions.

3.7 MIGRANT VERSUS NATIVE POPULATIONS: THE CASES OF ITALY AND SWEDEN

It is essential to make the distinction between native and migration population when examining the impacts of international migration on ageing across EU regions. For this purpose, this section applies the decomposition method on Italy and Sweden, two Member States where spatial and age specific datasets are available for native and migrant populations.[25] Among the Italian-native population during the period 2015-19 for every 100 young people aged 15-19 years, there were 125 reaching retirement age (65-69 years) which meant an entry cohort of native Italians numbered approximately 700,000 people less than the exit cohort (3.5 million). The proportion is reversed in the migrant populations living in Italy, where for 100 young people aged 15-19 years, there were 56 elderly aged 65-69 years. In absolute values, the older migrant generation (134,000 people) was approximately half the size of the younger one (238,000 people). The surplus of migrant labour supply partially covers (18%) the deficit in the native

25 We are not able to distinguish between intra-EU mobility or the migration of third-country nationals.

FIGURE 20. Cohort turnover and migration effects across urban, intermediate, and rural EU regions 2015-19
Note: The y-axis displays cohort turnover and net migration effects as relative size (percentage) of the working age population in 2015. The grey area of the rectangle depends on the population size.

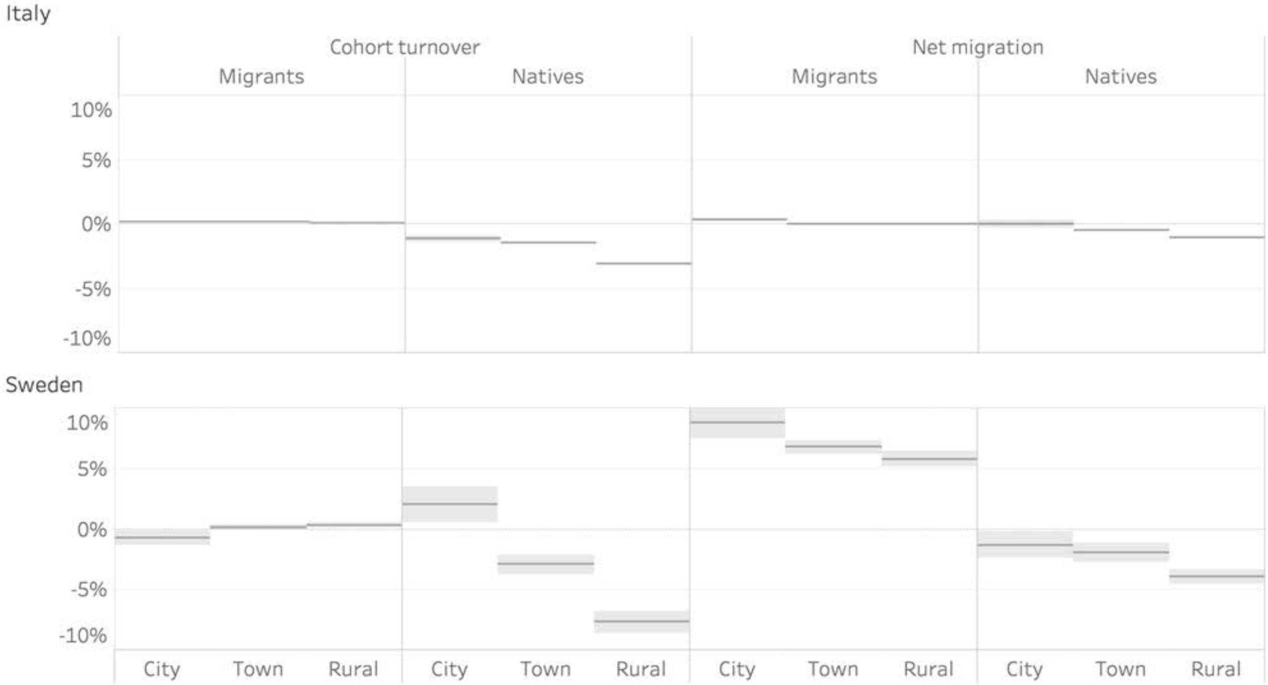


working age population. The relationship between native and migrant populations is different in Sweden, where the ratio between entry and exit cohorts is the same for both native and migrant populations: for 106 young people aged 15-19, there were 100 elderly reaching the age of retirement. Yet, the size of the migrant cohorts is approximately 17% of the native ones. In absolute values, exit native cohorts number 975,000 people against migrant cohorts of 168,000; entry native cohorts total 921,000 against migrant cohorts of 158,000.

Differences in demographic components are illustrated by place of residence in Figure 21. For the migrant population living in Italy, the relative median size of cohort turnover across regions is close to zero. Similar patterns are found for migrant population living in Sweden (Figure 21, first column). Some divergences become evident when Italian and Swedish native populations are compared (Figure 21, second column). In Italy, there is a drop in native populations across all areas but the Italian native population shows a larger deficit between entry and exit generations in rural regions (-3.8%) than in urban ones (-1%). In Sweden, the urban native population increases (1%) while Swedish native population living in rural regions falls (-9% in rural and -2% in intermediate areas). Italy also differs significantly from Sweden for net migration effects (Figure 21, third column). Across Italian regions, the effect of net migration for migrants does not vary and is close to zero in all areas, whereas in Sweden, changes in relative size of net migration are positive for migrants in all areas (around 10% in rural areas, 8% in intermediate, and 6% in rural areas). The two Member States experience similar net migration effect for native populations: close to zero in urban areas and becoming slightly negative for intermediate and rural areas (Figure 21, fourth column).

Italy is dealing with a more advanced stage of the demographic transition: younger generations are not able to replace older ones and migration is insufficient to counter the trend, exacerbating the already wide intergenerational gaps in all areas. In Sweden, patterns are specific to the area type, with an increase of the working age population in urban areas fueled by cohort and migration effects. The situation is more critical in both Member States in rural areas. In Italy, the effects of cohort turnover and migration for the migrant populations is balanced (both effects are approximately close to zero) while the deficit due to cohort turnover for Italian native populations is aggravated by negative net migration effects. In Sweden, positive net migration by immigrants is insufficient to counterbalance negative cohort turnover and net migration effects in the Swedish-native population.

FIGURE 21. Cohort turnover and migration effects across urban, intermediate, and rural EU regions by population in Italy and Sweden
Note: The y-axis displays cohort turnover and net migration effects as relative size (percentage) of the working age population. The grey area of the rectangle depends on the population size.



3.8 THE AGE AND SPATIAL PATTERNS OF NET MIGRATION

This section looks at the age patterns of net migration, in both absolute values and rates using 5-year age groups. The literature has shown that there are regularities in the age-specific patterns of migration between regions (Rogers, Willekens, and Raymer, 2001, 2002, 2003). Our indirect estimation of net migration has the advantage of integrating the age-specific and the spatial patterns of migration flows by comparing age-specific stock of populations residing in the areas at the beginning and the end of the period.[26]

Figure 22 captures urbanisation and counter urbanisation processes across EU regions during the period 2015-19, with clearly distinct patterns over the life course. In general, the age structure of EU inter-regional migration features two peaks: the first one at the age of entry onto the labour market (around age 20-25) and the second one at the ages close to retirement (around age 50-60). Migration-age specific patterns of rural regions only mirror the patterns in urban ones for intermediate ages. In the early phases of working age, young people exhibit negative net migration rates in rural regions (-5%) and intermediate regions (-3%) and a positive net migration rate in urban regions (+5%). After this peak net migration gradually decreases and adults (40-45 age groups) report large negative net migration (-2%) no matter where they live. Migration increases again after age 45 but contrarily to young people, in this case it is not characterised by the prevalent direction from rural to urban areas. Above age 60, net migration starts to show evidence of a counter urbanisation process with a larger propensity to move towards rural (3%) than intermediate and urban regions (2%).

At the national level (Figure A2.4 in Appendix 2), some Member States such as Germany present strong similarities with the EU migration profile. Migration flows in other Member States such as Spain reflect a sharper peak at the age of entry onto the labour force, compared Swedish flows, which are relatively flat across age, or the shifted labour force trends in Poland (with a peak occurring at older ages).

Figure 23 exemplifies how spatial patterns of age distribution may be quite dissimilar across Member States, by showing the net migration rates for the 20-24 cohort in Germany and in Italy. There are two parallel dynamics in Germany: emigration of young people from east to west, to the south and towards large cities. In contrast, in Italy, young people exhibit a clear and uniform pattern of south to north migration, but less intense than observed in

26 Statistics on stocks are generally more accurate and up-to-date than statistics on migration flows. A preliminary validation of the indirect estimates with the observed flows is presented in section A2.1 of the Appendix.

FIGURE 22. Net migration by age across European urban, intermediate, and rural EU regions, 2015-19
Note: The y-axis displays the median net migration rate across regions and the sum of net migration in absolute values according to the urban-rural regional typology. The x-axis displays the age-group by 5-year interval of the working age population.

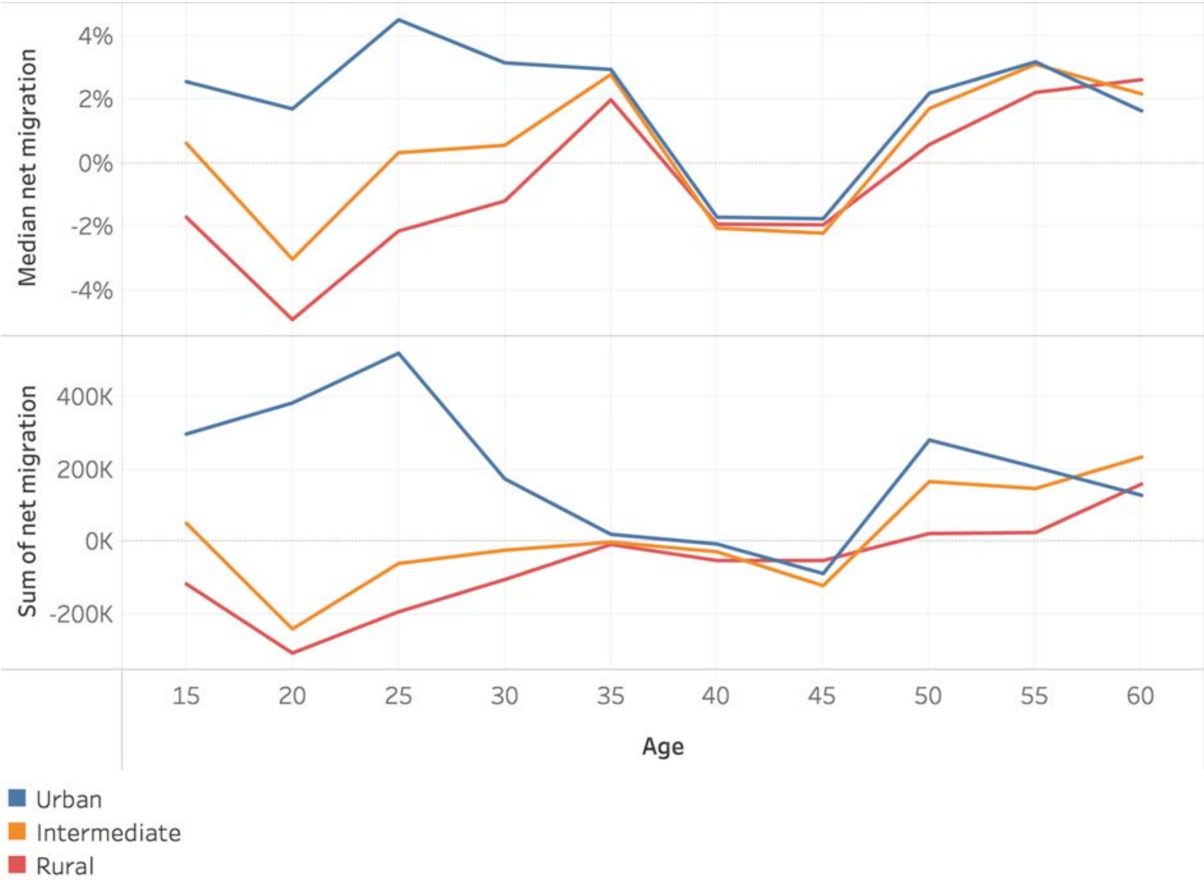
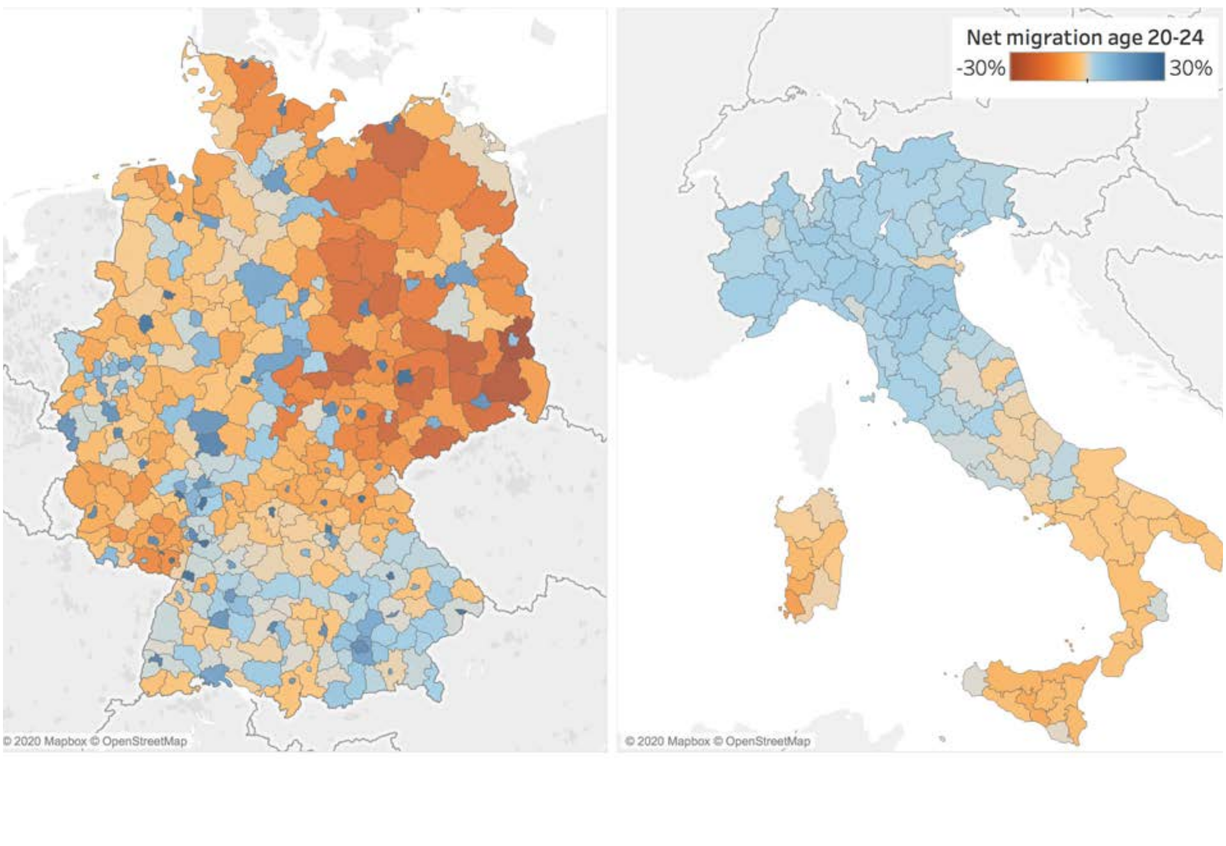


FIGURE 23. Net migration among the 20-24 cohort in Germany and Italy in the period 2015-19
Note: Negative and positive net migration rates are reflected in the colour gradient (negative rates are in red, positive rates in blue).



eastern Germany and without a clear attraction towards regions with large cities.[27]

3.9 CONCLUSIONS

Over the 2015-19 period, despite the shrinking of the working age population in most EU NUTS3-regions (64%), net migration effects in 324 regions (28%) are able to counterbalance the deficit due to cohort turnover, and generate an increase in the working age population. This is also evident at national level in five EU Member States (Malta, Belgium, Spain, Austria, the Netherlands, and Germany), where a surplus labour force supply mainly derives from a positive net migration balance. Nevertheless, differences in the ageing process remain marked at the territorial level. The shrinking of the working age population persists in rural areas: it decreases by -1.9% in rural EU regions and by -0.4% in intermediate ones whereas urban regions benefit from positive net migration. Comparing the age-specific migration profiles reveals that younger people (15-25 age group) exhibit the highest rates of net migration from rural (and intermediate) towards urban regions (1% and 3% respectively as relative size of the working age population in 2015) while older people (60+) report the highest propensity (4%) to move from urban to rural areas. As a result, migration is a factor accelerating the ageing process in rural regions in a reciprocal relationship with a decline in the labour force supply.

While ageing is visible across the entire European Union, some regions do benefit from migration (including internal and international migration, not distinguishing between intra-EU mobility and migration of third-country nationals). The analysis presented here has captured the heterogeneity of regional demographic dynamics (in terms of intensity and timing), setting the basis for the definition of targeted interventions at local the level to attract a labour force into areas such as rural ones that are currently challenged by depopulation.

27 The authors have argued that Italians start adult economic activities at a much later age than is common in other EU Member States. This is also reflected in the high share (66%) of Italian young adults that leave the family home only at a later age (Eurostat, 2020a). This gap in the transition of adulthood of young Italians (Billari and Liefbroer, 2010) may contribute to explain the lower migration effects here observed.

4. ACCESSIBILITY TO SERVICES AND URBAN AMENITIES

Mert Kompil, Patrizia Sulis, and Paola Proietti

Key findings

- Compared to rural areas, cities, towns, and suburbs provide better accessibility for all age groups to generic services, regardless of the geographical scope of the service provided.
- In mostly uninhabited and dispersed rural areas, where the resident population is sparsely distributed, service accessibility is lower and people need to travel longer distances to reach a generic facility, which could be problematic especially for the elderly.
- For the elderly population, average distances to services are slightly higher in rural areas and slightly lower in urban areas compared to the non-elderly population.
- Active transport modes – relying on human power for propulsion – can enhance and promote active and healthy ageing and play a significant role in accessing everyday services. Cities, towns, suburbs, and villages could provide more opportunities to access local services with active transport modes due to the higher proportion of population within walking and cycling distances.
- In the context of an ageing society, cities experience challenges in terms of affordability, in adapting infrastructures to promote equal access to generic services, and in counteracting segregation by age.

4.1 INTRODUCTION

Accessibility refers to the ease of reaching opportunities using appropriate means of transport. Fair and balanced accessibility to services is increasingly promoted as one of the key policy goals in EU cities and regions, and regards the well-being and quality of life of the elderly population. There are numerous factors that affect the service accessibility level of an area, such as the distribution of population and activities, the provision of services, and the supply and performance of transport infrastructure. It is also known that it is more difficult to provide the desired level of physical accessibility to services in some areas. A detailed understanding of the relationship between the distribution of amenities and the residential locations of the elderly in EU cities can be useful for targeting urban policies aimed at improving quality of life.

The first section in this chapter aims to answer whether accessibility to services in Europe varies for different age groups and by degree of urbanisation. This is done by exploring the spatial pattern of service accessibility in Europe for the elderly population, using modelled service location and population data at a fine spatial resolution. The second section investigates the quantitative relationship between the spatial patterns of urban amenities and the distribution of elderly population, using data collected specifically for the capital city of Paris.

4.2 ACCESSIBILITY TO SERVICES

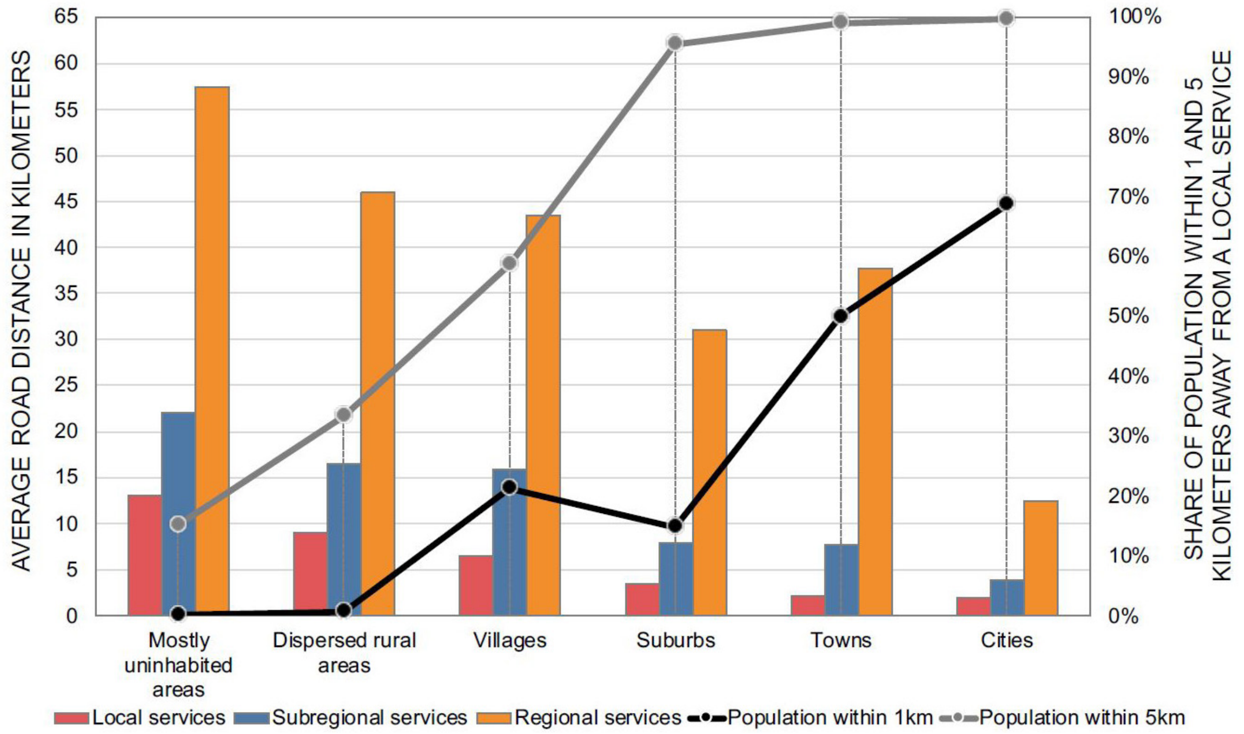
Urban areas in the EU, including cities, towns, and suburbs, provide better opportunities in terms of accessibility than rural areas (Kompil *et al.*, 2019). This holds true for all services analysed, regardless of whether they have a local, sub-regional or regional scope. In mostly uninhabited and dispersed rural areas, where the resident population is sparsely distributed, it is harder to provide the necessary conditions for economic viability of a service. Consequently, service accessibility in these areas is lower so that people need to travel longer distances to reach a generic facility. Table 1 describes the service areas/facilities modelled in this study.

However, these findings do not distinguish between ages. To find out whether there are differences in access to services for the elderly, the services modelled by Kompil *et al.* (2019) were matched with an age specific population grid, instead of a grid for the entire population. Then EU-wide accessibility to services was recomputed and reassessed for specific age groups including the elderly (over 65 years old) and non-elderly (under 65 years old). Figure 24, Figure 25, and Table 2 show the results of the accessibility analysis applied to the elderly and non-elderly population, summarized by degree of urbanisation. According to these results, average distances to services for the elderly population are slightly higher in rural areas, and slightly lower in urban areas, compared to the distances for the non-elderly population. The difference in average distances between the two age groups is not exceptionally large but is still significant, especially for accessibility to local and subregional services. This is more evident when the average distance to the nearest local service is considered – for instance, elderly populations have to travel 5% to 11% more on average to reach local services in rural areas compared to non-elderly populations. In contrast, elderly people have better accessibility to services in urban areas with a 3% to 6% shorter distance to the nearest local service in cities, towns, and suburbs, compared to the younger population (Table 2). This means that elderly people living in urban areas tend to choose more central neighbourhoods with higher accessibility to local services. Even a couple of hundred metres less to reach to the nearest local facility can be very important for an elderly person, particularly when they have deteriorating health conditions and/or mobility limitations.[28]

TABLE 1. Modelled service areas with the corresponding population and distance criteria
Source: Kompil et al. (2019, p. 4).

Type of services areas/facilities	Ideal service area population	Ideal service area distance
Local facilities (primary schools, small health facilities, childcare services, sport facilities, small markets etc.)	10,000 people	2.5 km
Subregional facilities (high schools, hospitals, theatres, cultural facilities, supermarkets etc.)	100,000 people	10 km
Regional facilities (specialized centres for education and health, large facilities for sports and cultural activities, other high-tech services etc.)	1,000,000 people	50 km

FIGURE 24. Average road distance (x-axis, bars) per person to services and share of population (y-axis, line) within a certain distance from a local service by degree of urbanisation for under 65 years olds



28 Accessibility pattern of people above 75 years old were also tested and no significant difference was found (∓ 1% difference only) compared to the accessibility pattern of people above 65 years old.

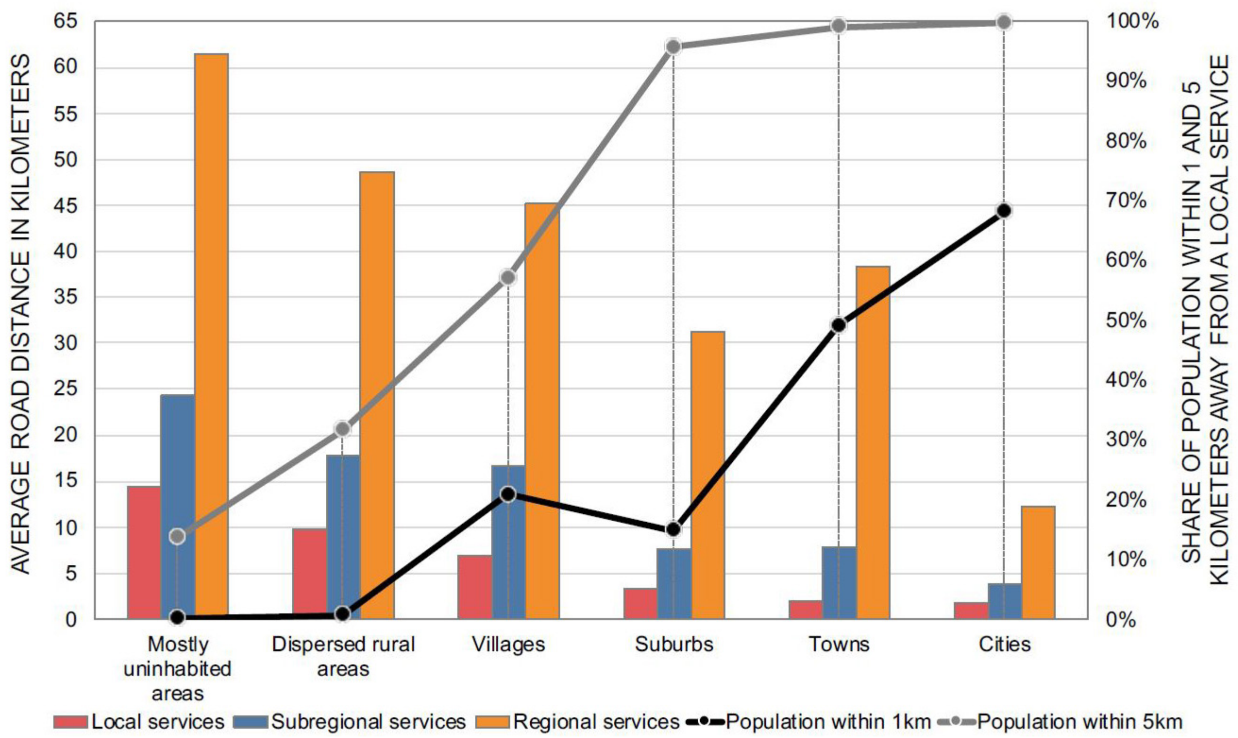
Mobility solutions for short to medium-short distances in many EU cities and towns have been moving towards policies that support active modes of transport such as walking and bicycling (Banister, 2008; Nieuwenhuijsen and Khreis, 2016), which are known for their desirable ecological characteristics, affordability and health benefits (Brown *et al.*, 2016; Mulley *et al.*, 2013; Rabl and Nazelle, 2012). Active mobility is also a fundamental option for the population of young seniors (65-74 years old) and a positive way of enhancing and promoting active and healthy ageing (Distefano, Pulvirenti, and Leonardi, 2020; Mateo-Babiano *et al.*, 2016). Especially with the currently increasing availability and affordability of electric bikes and scooters (Gössling, 2020), active transport modes might become an attractive alternative for young seniors when making short distance trips.

These recent developments are also important in service accessibility assessment. Villages, towns, suburbs, and cities provide more opportunities for accessing everyday services with active transport modes, due to the higher proportion of population within accessible distances – see Figures 23 and 24. For instance, it is estimated that more than 65% of the residents in cities have a local service within 1 km walking distance, and above 90% of them within 5 km cycling distance. These rates do not differ much among different age groups but point out that there is significant potential for access to services on foot or by bike for all age groups in compact residential developments. Obviously, making trips on foot and by bicycle are safer and more efficient, but may not only require investment in road infrastructure, but also changes in traffic regulations and education. Recent

TABLE 2. Average distance to the nearest generic facility at local, subregional, and regional levels - a comparison of under and over 65 years old in kilometres and by degree of urbanisation

Degree of urbanisation	Average distance per person to the nearest modelled (km)								
	Local service			Subregional service			Regional service		
	Below 65 years	Above 65 years	Diff. in%	Below 65 years	Above 65 years	Diff. in%	Diff. in%	Diff. in km	Diff. in%
Mostly uninhabited areas	13.0	14.4	10.9%	22.1	24.4	10.1%	57.4	61.5	7.2%
Dispersed rural areas	9.0	9.8	9.5%	16.5	17.8	8.0%	46.0	48.6	5.7%
Villages	6.5	6.9	5.7%	16.0	16.7	4.7%	43.4	45.2	4.2%
Suburbs	3.4	3.2	-6.1%	7.9	7.7	-2.0%	31.0	31.3	1.1%
Towns	2.1	2.0	-2.9%	7.7	7.8	1.5%	37.8	38.4	1.6%
Cities	1.8	1.8	-3.8%	3.9	3.8	-2.5%	12.4	12.4	-0.2%

FIGURE 25. Average road distance (x-axis, bars) per person to services and share of population (y-axis, line) within a certain distance from a local service by degree of urbanisation for over 65 years olds



studies showed that expansions of designated cycling network infrastructures are associated with increases in cycling (Mueller *et al*. 2018). In many cities, the way public spaces are designed must be rethought and reconsidered to make walking an attractive, efficient, and safe mode of transportation for the elderly (Distefano *et al*., 2020). However, outside cities, nearby destinations and proximity services are more sparsely distributed in dispersed rural and mostly uninhabited areas, which makes it more difficult to use active transport modes for the elderly population there. In a likely future environment with decreasing population, service provision and public transport delivery, accessibility to services is generally expected to worsen. In this case, cities, towns, and villages might play a significant role to ensure continued accessibility to services for the elderly, including the promotion of active transport modes. As a result, encouraging people to live in cities, towns, and villages can help to promote active mobility and ensure sustained and more sustainable service accessibility.

4.3 AGEING IN CITIES AND THE LOCATION OF AMENITIES: THE CASE STUDY OF PARIS

The geographical distribution of urban amenities across cities represents an important feature that can influence the quality of life of residents (Jacobs, 1961). Understanding the relative distribution of amenities in comparison to specific population groups is also crucial for cities to progress toward the Agenda 2030, in particular Sustainable Development Goal 11, which is focused on making cities and human settlements inclusive, safe, resilient, and sustainable, leaving no one behind (United Nations, 2015). By the same token, this is coherent with the Urban Agenda for the EU adopted in 2016 and representing a new multi-level working method promoting cooperation between the Member States, cities, the European Commission, and other stakeholders with the shared aim of stimulating growth, quality of life, and innovation in the EU cities, and to identify and successfully tackle social challenges (European Commission, 2016).
A quantitative evaluation of the current situation, and an understanding of the actual needs of cities in terms of general services (e.g., health, education) and specific amenities (e.g., parks, food shops) for selected users (such as elderly citizens) is essential in defining the right targets in policy and planning, and prioritising interventions to improve the condition of citizens. In addition, it is also important to create a balanced and accessible mix of amenities to support social, economic, and cultural encounters, gatherings, civic engagements, and to counteract segregation in cities (Sabater, Graham, and Finney, 2017).

This section presents an exploratory investigation into the relationship between the spatial location of urban amenities and the distribution of the elderly living in Paris. The importance in 2020 of a walkable city has gained momentum especially in the capital of France, where Mayor Anne Hidalgo has embraced this idea as an extension of her work to reduce the number of cars on the road. Paris qualifies as a particularly interesting case study, being a city that appears to experience several challenges in terms of both affordability and in adapting infrastructure to an ageing society. According to the "Quality of life in European Cities" report for 2020 (European Commission, 2020), 56% of people stated that, across EU cities, it is difficult to find "good housing at a reasonable price". Moreover, 78% of people mentioned that cities are a good place to live for the elderly, compared to a figure of 90% for the total population. In this context, 89% of people in Paris said that it is difficult to find "good housing at a reasonable price" and 64% of people said that Paris is a good place to live for the elderly compared to the 88% of the general population.

While investigating affordability is beyond the scope of this contribution, exploring the relationship between the distribution of amenities and the residential locations of the elderly is useful for targeting policies aimed at improving their quality of life in cities. The information presented in this work can be used to evaluate accessibility by walking to local services that meet essential needs of the elderly (e.g., health services, green areas, daily shopping). The method and results presented in this section are relevant as they offer a replicable, quantitative tool that can be applied to other cities and population groups (e.g., people with disabilities, families with young children) in supporting specific policies and planning developments. More in general, there is an increasing number of cities that are embracing the concept of a more local, healthy, and sustainable way of life, especially to support the recovery from COVID-19 and meet their citizens' demands. In a context of an ageing society, this concept can also promote active ageing (Eurostat, 2019).

4.3.1 DATA AND METHODS

Two data sets containing spatial information about urban amenities and population in the city of Paris were used in this work. A detailed description of the datasets is provided in Appendix 3.

The data set employed for urban amenities includes POIs (Points of Interest) containing several attributes for each amenity such as their name, address, type, and geographical coordinates. Data were collected in 2018 through the Google Maps API (Application Programming Interface) and gathered to cover the municipality of Paris.

The various amenity typologies were grouped into 12 macro-categories (accommodations, attractions, city services, culture, and entertainment, eating out, health and hospitals, parks, schools and education, shop food, shop goods, social services, and sports facilities), filtering the observations based on their relevance in terms of urban function, and associated to a 500 metres square grid covering Paris' entire functional urban area (FUA). To unveil the spatial patterns of amenity distribution, a machine learning technique was used that assigns each spatial unit to a class according to the variety of amenity typologies and the number of amenities for each typology located in the area (Sulis and Manley, 2019).

About the population data set, information regarding the distribution of elderly population in the city of Paris has been collected through the IRIS data source and spatial units[29] associated with the census values for 2015.[30]

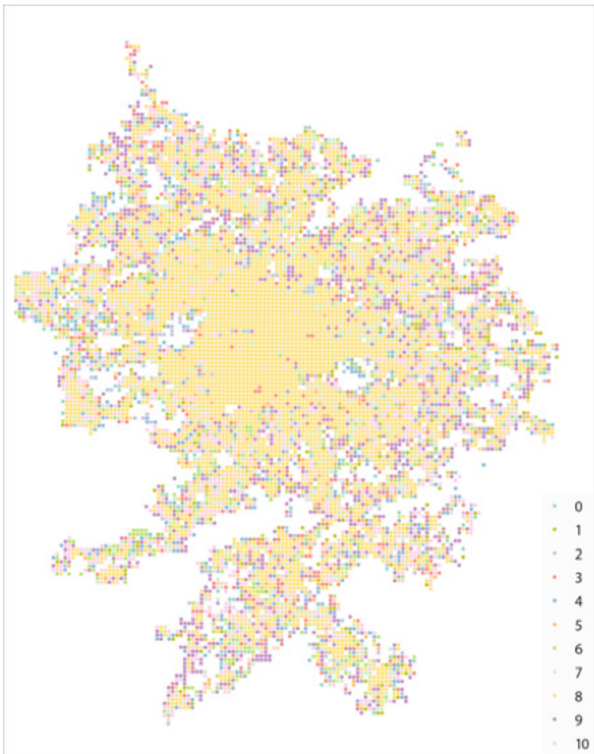
In order to have values on the spatial unit of the amenity data that are comparable, the population data were spatially associated with the grid and classified using Natural Breaks – a data clustering method designed to determine the best arrangement for placing values in 7 different classes characterised by the increasing proportion of people older than 65 years over the total population.

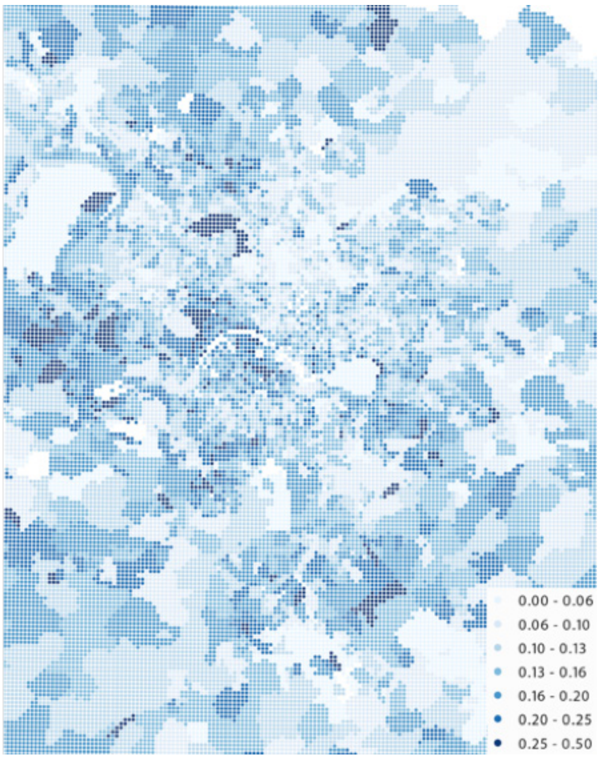
The focus of this specific analysis is to observe and compare the patterns of the spatial distribution of typologies of amenities and people over 65 years of age located in the same areas. The option adopted to make this comparison was to check the recurrent association between two sequences of classes in the same grid cell using a confusion matrix (for more details please see Appendix 3).

4.3.2 RESULTS

The results of the individual data sets are presented briefly and then the combination of these results is discussed. Regarding the amenity data, the cluster analysis unveils the similarity of amenity location patterns across the city of Paris (see Figure 26, more information available in Appendix 3). These results corroborate the empirical understanding of urban features: the central areas show the presence of a balanced variety of amenity typologies, with some areas also presenting a predominance of specific amenity typologies related to leisure such as historic and tourist attractions, or cultural amenities and entertainment venues. Observing the outer parts of the city, the analysis shows the occurrence of more specialised distribution profiles, with one or two amenity typologies distinctively characterising the places. The prevalence of green areas and parks, non-food shops, and sports facilities can be seen (see Appendix 3 for a full description of the various distribution profiles).

FIGURE 26. Patterns of amenity distribution (left) and over 65 population distribution (right)
Note: Each colour (and label) on the left represents the areas that have a similar distribution of amenity typologies. Each class on the right (and shade of blue) represents a higher share of elderly population living in the area.





29 IRIS (Ilots Regroupés pour Information Statistique) HYPERLINK "https://geocatalogue.apur.org/catalogue/srv/fre/catalog.search#/metadata/urn:apur:iris_od#/metadata/urn:apur:iris_od"https://geocatalogue.apur.org/catalogue/srv/fre/catalog.search#/metadata/urn:apur:iris_od

30 https://www.insee.fr/fr/statistiques/3627376

The distribution patterns of people over 65 years have quite low ratios in the centre of Paris, whereas the ratio can be middle to high outside the city centre, similar to the general spatial patterns of the elderly found in Chapter 2. Then the spatial patterns obtained from the analysis of amenities and population distribution were combined in order to identify any recurrence in the association of classes in the same area. By using a confusion matrix (Table 3), it can be seen that the majority of the recurrent associations are between the population classes ranging from class 2 (10% of people over 65 years of age living in the area) to class 5 (up to 20% of people over 65 years of age living in the area) and the amenity labels: 7 (predominance of health facilities), 8 (non-food shops, schools, hospitals and city services but also culture and accommodation), label 9 (non-food shops), and label 10 (predominance of school facilities and shopping). A concentration around these labels is expected as they represent the majority obtained from the cluster analysis.

Analysing the patterns of central Paris in detail, it can be observed that the most recurrent association occurs between classes 3 (with elderly up to 13% of the inhabitants) and 4 (with elderly up to 16% of the

TABLE 3. Confusion matrix, representing the association between population classes (rows) and amenity clusters (columns)
Note: Shaded cells are combinations where most associations occur.

	Amenity clusters										
Poulation classes	0	1	2	3	4	5	6	7	8	9	10
0	10	5	15	15	6	5	12	10	77	26	9
1	13	12	23	29	36	31	27	34	222	72	45
2	28	47	60	82	83	69	113	160	872	230	172
3	28	31	34	83	66	94	79	222	1005	195	143
4	40	48	47	82	94	110	107	296	1008	229	169
5	29	41	47	90	112	83	94	323	849	169	119
6	20	21	22	39	46	32	55	162	419	72	46
7	10	7	11	14	18	12	25	54	146	37	27

FIGURE 27. Distribution of amenity typologies for label 7 (left, predominance of health and hospital facilities) and label 8 (right, balanced variety of amenities)

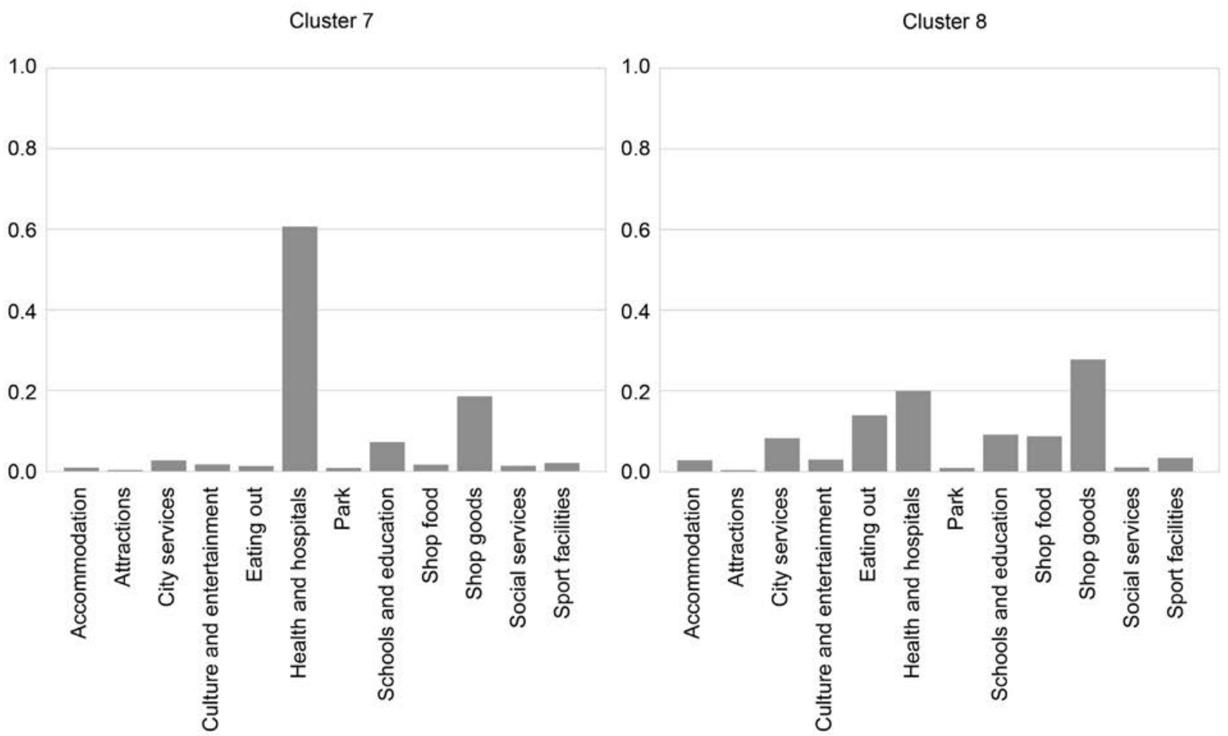
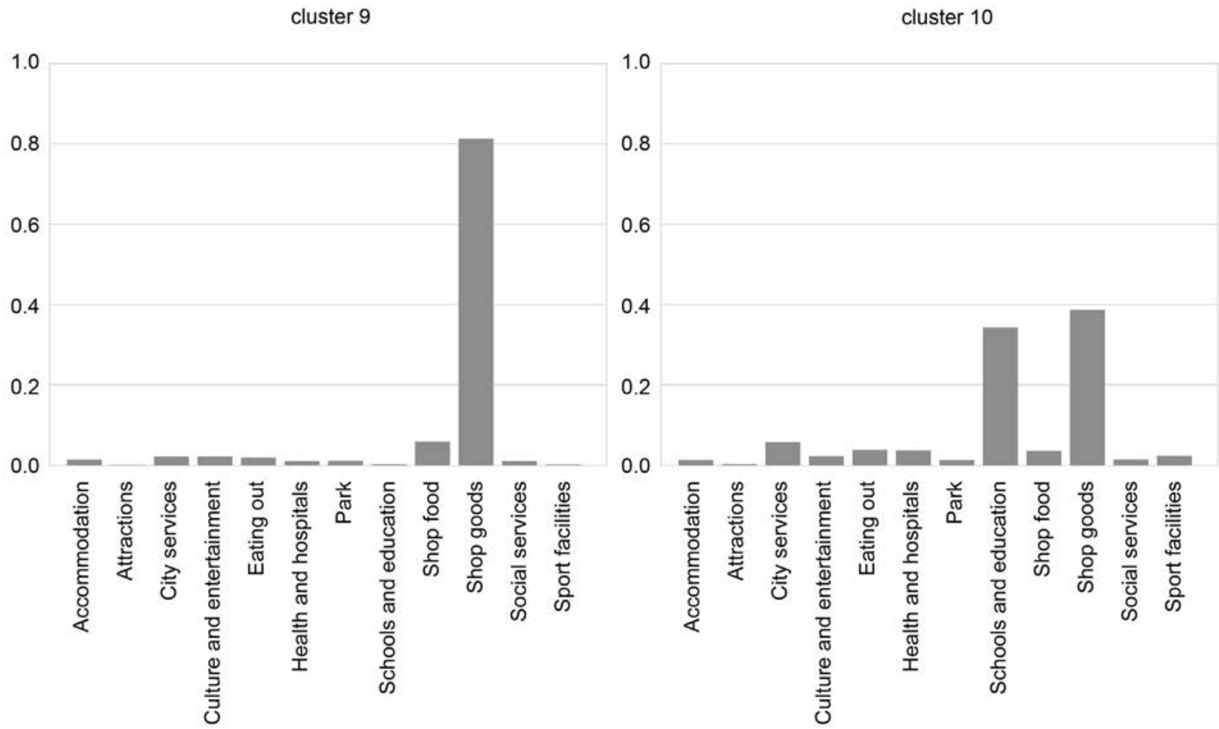


FIGURE 28. Distribution of amenity typologies for label 9 (left, predominance of non-food shops) and label 10 (right, predominance of education facilities and non-food shops)



inhabitants), and label 8 (see Figure 27), which shows quite a balanced variety of amenities located in the same area. This may be driven by the fact that this type of label includes most of the cells in the amenity classification (Brueckner, Thisse, and Zenou, 1999).

It is therefore interesting to look at the other labels where many associations occur such as between class 5, with elderly up to 20% of the inhabitants, and label 7 (see Figure 27), which shows a distinct predominance of health and hospital facilities located in the area. This may be explained by the fact that some people over the age of 65 years might have their residence address at retirement or nursing homes.

Moving to the outer city, a strong association between classes 2 and 4 for the elderly population (up to 16% of the inhabitants) and label 9 (see Figure 28) can be observed which shows a strong predominance of shopping facilities in the area: the location of these areas suggests they are shopping centres or high streets in the neighbourhoods. Another association is with label 10 (see Figure 28), which presents a distribution of amenities characterised by a relevant presence of schools and non-food shops and a fair variety of other activities such as city services, food shops, and eating-out amenities. Both these areas with a predominance of non-food shops are evenly distributed in the city, although they tend to be located out of the city centre.

It can also be observed that parks and other amenities related to urban green spaces are lacking in the areas frequently associated with the elderly classes. This might offer an interesting suggestion to the planning department of Paris since green spaces encourage physical activity, break social isolation, and help reduce vulnerability to heat, with the elderly being among the most vulnerable age groups to heat waves (Poelman, 2018; Siragusa *et al*, 2020).

4.3.3 LIMITATIONS AND FURTHER RESEARCH

The preliminary results presented in this section show which classes, corresponding to specific amenity typologies, are more frequently associated with the elderly living in the same area. In this work the association of classes at the level of every single spatial unit was analysed. It would be relevant in future work to consider the overall amenity distribution of surrounding spatial units as elderly people living in a specific area might easily reach and access urban services located nearby by walking (approximately up to 1 km), by cycling or by using public transport.
This analysis can be developed further by selecting fewer, more specific categories of urban amenities that are particularly relevant for the well-being and quality of life of the elderly in cities. The same methods can also be applied to other cities using similar data sets in order to obtain comparative evidence across EU cities and beyond.

In addition, it would be useful to integrate the information obtained from the quantitative distribution of amenities with information on access to services such as affordability, and with the real preferences of the elderly so that this information can be used to shape the features of the city they live in (Buffel and Phillipson, 2016; World Health Organization, 2015).

Finally, it is worth mentioning that information about amenities for this specific analysis is only available for the municipality of Paris. Unfortunately, this resulted in a partial lack of data for areas outside the municipality where many elderly people live (in some places, up to 50% of the local population). This is a limitation of the data set used in this analysis. Future work may require accessing additional data sources to collect the missing information in order to explore the distribution of existing amenities and the elderly population in the urban-rural continuum.

4.3.4 CONCLUSIONS

This work presents an exploratory analysis of the relationship between the spatial location of urban amenities and the distribution of the elderly living in Paris. Results show how the central areas of Paris, where the elderly population accounts for up to 16% of the inhabitants, are frequently associated with a balanced variety of amenities. On the other hand, the strongest association in the outer city occurs with areas that show a strong predominance of shopping facilities in the neighbourhoods. Finally, both in the centre and in the outer city, parks and urban green spaces are lacking most in areas inhabited by many elderly.A quantitative understanding of the actual need of cities in terms of general services (health, education) and specific amenities (parks, food shops, hospitals) for selected users, such as citizens over 65 years of age, is essential to define the right targets in policy and planning, and to prioritise interventions to improve the condition of the elderly living in cities. Examples of priorities include avoiding age segregation, promoting active ageing, equal access to services, and adapting urban infrastructure to walking and cycling mobility modes.

Finally, this exploratory analysis also suggests several paths for further research on spatial patterns of ageing in Paris, highlighting practical implications for policy and exploring the possibility of extending the same approach and methods to analyse more cities.

5. THE AGE STRUCTURE OF POPULATION AND MACROECONOMIC OUTPUTS: A TERRITORIAL PERSPECTIVE

Alessandra Conte, Sona Kalantaryan, and Fabrizio Natale

Key findings

- In line with the previous empirical evidence, the analyses presented in this chapter conducted at the NUTS3 regional level suggest that the relationship between the age structure of the working-age population and the GDP per capita and labour productivity per worker is not linear. The relationship is indeed characterized by a general pattern in which the young segments of the population are positively associated with the economic development of a region. This association reaches its peak when the working age population is mostly represented by middle-aged groups (35-44, 45-54) and then decreases as age increases further.
- There is a remarkable territorial heterogeneity in the results within this general pattern. Differences in the association between the age structure and per capita labour productivity clearly emerge in the case of rural, depopulated regions with negative net migration. In these cases, both the ageing and age groups of the working age population correlate negatively with the macroeconomic variables.
- In contrast, in more urbanised regions and in regions characterised by population growth and positive net migration balances, younger age groups contribute positively to macroeconomic outputs while ageing does not correlate significantly with the outcomes.
- Other important regional level factors (such as economic diversity in the employment structure, and total fertility rate) play an important role in the economic development of a region and potentially contribute to mitigating the economic consequences of an ageing population in the short-term.
- The findings presented in this chapter indicate a strong association between the recent demographic and economic dynamics observed in EU regions. In rural, depopulated regions with negative net migration, the negative association of the younger groups in the working age population with economic results seem to suggest that a large share of young people is not sufficient by itself to produce positive macroeconomic effects. From a policy perspective, these results indicate that the main challenge faced by regions with declining population is not merely ageing, but also the lack of employment opportunities for the younger generations.

5.1 INTRODUCTION

The process of population ageing that several EU Member States are going through is expected to have deep socio-economic implications at both national and regional levels (Eurostat, 2020b). It is widely recognised that population ageing has macroeconomic effects because it influences saving rates, physical capital accumulation, labour supply, interest rates, and international capital flows (Mason, 2005; Visco, 2005; Bloom, Canning and Graham, 2003). From a microeconomic perspective, a lower share of young workers may hamper productivity, as documented by Lallemand and Rycx (2009), and age-related changes in consumer behaviour can have important effects on the employment model in different sectors (Börsch-Supan, 2003). Finally, ageing is often associated with a redistribution of resources and revenues away from workers, and towards capital and company owners with a more limited effect of productivity improvements on wage growth (Daniele, Honiden, and Lembcke, 2019).

The early literature on the impact of labour force characteristics on aggregate output was largely focused on the role played by human capital and educational composition (Galor and Tsiddon, 1997; Mincer 1984; Becker, Murphy, and Tamura, 1990). With the shift in population distribution toward older ages in industrialised countries, scholars have turned their attention to the effect of population ageing and the age structure of the workforce on the output level and its growth. Recent studies documented a hump-shaped relationship between age structure and economic growth for the EU-15 Member States: an increase in the share of the retired age group (65+) is associated with decreasing GDP growth rates (Lindh and Malmberg, 1999; 2009). This pattern holds over time, suggesting that ageing is likely to be accompanied by stagnation in GDP growth in the future. A study by Denton and Spencer (2017) investigated the role of ageing in GDP in 20 OECD countries and found that 4.2% of growth per decade (or approximately 0.42% per year) would be necessary to offset the impact of population ageing through the period 2015-2045. In addition, if the goal were to achieve an overall increase of 1% in GDP per capita, that would require an average productivity growth rate of 15.1% per decade (or 1.4% per year). For most countries, this would be considerably higher than the productivity growth rates observed in recent decades (Denton and Spencer, 2017). Finally, using a demographic projection exercise, Crespo et al. (2016) show that the recently observed demographic trends may slow down the speed of income convergence in EU Member States in the coming decades.[31]

Empirical studies conducted at the sub-national level generally support the cross-country results. Changes in the workforce age structure are significantly correlated with changes in aggregate productivity and this estimated impact is generally larger than that documented for experience and wages in studies conducted at the micro-level. This suggests that the social (aggregate) return to a workforce with a particular experience profile is higher than the private (individual) return to experience. Furthermore, it should be noted (Feyrer, 2007)[32] that the magnitude of the age structure effect diminishes for lower levels of aggregations, suggesting that the work externalities driven by age structure changes are stronger at higher levels of aggregation (e.g., see Feyrer, 2007; 2008 for the case of US states versus metropolitan area levels).

Evidence from the OECD regions confirms the negative impact of population ageing on the GDP per capita growth rate (Daniele et al., 2019). This negative effect could be offset by increases in productivity but not everywhere. In fact, the productivity growth in many regions currently required to keep the output levels constant is higher than has been observed in many regions in the recent past. Moreover, ageing is negatively affecting productivity growth in urban more than in rural areas. The latter is mainly because urban areas are dominated by sectors - such as commercial services, finance and insurance - for which automation is more challenging, and business dynamism (adversely affected by an ageing workforce) is one of the keys to productivity growth.

Descriptive evidence of the relationship between the age structure of the population and aggregate output measures is provided in this section, which are the GDP per capita and labour productivity at the NUTS3 geographic level. Figure 29 shows a large variation in the GDP per capita and the old-age dependency ratio (OADR) – measured as the population over 65 on the population between 15 and 64 years old – across the NUTS3 regions in the EU. The regions with the highest GDP per capita are concentrated in Central and Northern Europe while those with a relatively low GDP per capita are in Eastern and Southern Europe. In some Member States such as Spain and Italy the regions with higher GDP are concentrated in the northeast, while in France they are equally distributed throughout the country. Looking at OADR, regions with a relatively low ratio are mainly concentrated in the eastern part of the EU, Ireland, and some regions of France and Spain.

31 While policies only targeting more active labour force participation to compensate ageing workforce will not be sufficient to counteract the negative effects of ageing on income convergence, efforts to reduce the educational attainment gap between the EU Member States can leverage the labour market policies and lead to an accelerated pace of income convergence (Crespo Cuaresma, Loichinger and Vincelette, 2016).

32 Göbel and Zwick (2012), Malmberg *et al.* (2008), Lallemand and Rycx (2009), Mahlberg *et al.* (2013) examine the link between age structure and productivity. For the relationship between experience and wages, see for instance, Bagger *et al.*, (2014) and Lagakos at al. (2018).

Figure 30 reports the distribution of GDP per capita and labour productivity (gross value added per worker) across the regions within each EU Member State. Although the two measures are closely connected, the high levels of labour productivity in some regions are linked to both labour market participation and to the efficient use of labour - reflecting the composition by age, skills and experience of the workforce- and the type of activity present in each regional economy (Eurostat, 2020b).[33] Bulgaria, Czechia, Lithuania, Poland, and Romania have both a relatively low level of GDP per capita and labour productivity. The largest differences in the two variables are observed in Germany, Ireland, Belgium, the Netherlands, Sweden, and Denmark. In some regions of these Member States, high labour productivity compensates for a large dependent population.

Figure 31 depicts the relationship between GDP per capita and the age structure of the working age population in EU regions. The figures show a positive relationship between economic output levels and younger age groups (15 to 24 years and 25 to 34 years) and those between 45 to 54 years. The association is negative for the share of the older age group (55 to 64 years) and those between 35 and 44 years.

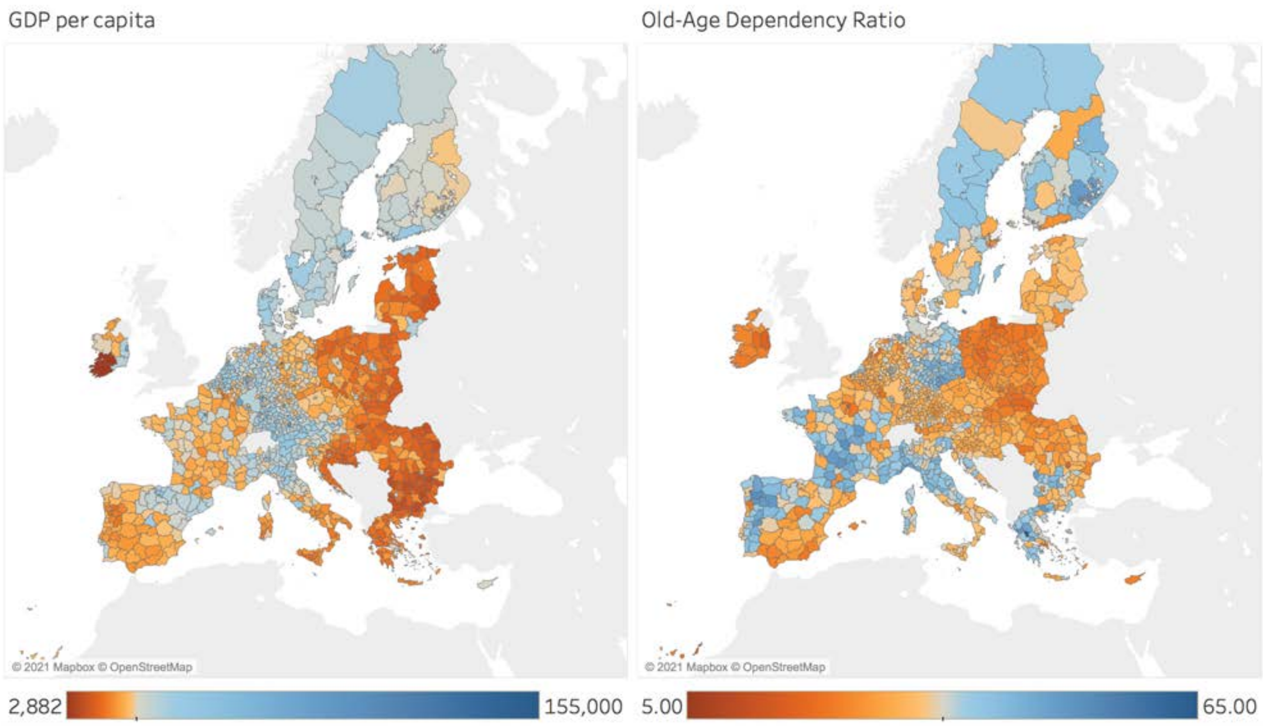
The next section presents the analysis of the simultaneous effects of the different age groups using a multivariate regression analysis, so that the relationship between the population age structure and macroeconomic outputs can be understood better.

5.2 EMPIRICAL STRATEGY AND DATA

This section outlines the data and methodology used to empirically examine the association between the age structure of the population and two aggregate economic output variables, which are (i) the per capita GDP and (ii) labour productivity measured in terms of the Gross Value Added produced per unit of labour (number of employed persons) at the regional level (see Appendix 4 for more details).

This empirical exercise relies on the demographic and aggregate economic output information provided by Eurostat regional statistics. The unit of analysis is the NUTS3 region which is the lowest-scale geographic unit for which both demographic and economic data are available. In terms of the methodology used, there is a growing empirical literature on the impact of the age structure of the population on economic performance at national and regional levels (Daniele, Honiden and Lembcke, 2019; Feyrer, 2007; Crespo Cuaresma, Lutz and Sanderson, 2016). A time series

FIGURE 29. GDP per capita (purchasing power standard) and Old-age Dependency Ratio (OADR) across EU NUTS3 regions, 2017
Source: own elaboration of Eurostat data, 2017. Note: The figures represent the distribution of the GDP per capita and the OADR for the NUTS3 regions of the 27 EU Member States. For France, the information on the GDP per capita refers to 2016 (information for 2017 is incomplete in many regions of France). The colour legend changes from orange to blue at the median value of GDP per capita (25,300 Euros) and OADR (31) at NUTS3 level.



33 Some activities such as business or financial services are characterised by higher levels of labour productivity (Eurostat, 2020b).

FIGURE 30. GDP per capita and labour productivity across EU Member States
Source: own elaboration of Eurostat data, 2017. Note: The figure represents the box-and-whisker plots for GDP per capita (red) and labour productivity (green) for EU Member States. The horizontal markers stand for the minimum, the maximum (excluding any outliers), the sample median, and the first and third quartiles. The information for GDP per capita for France refers to 2016 (many French regions have no information on employment for 2017).

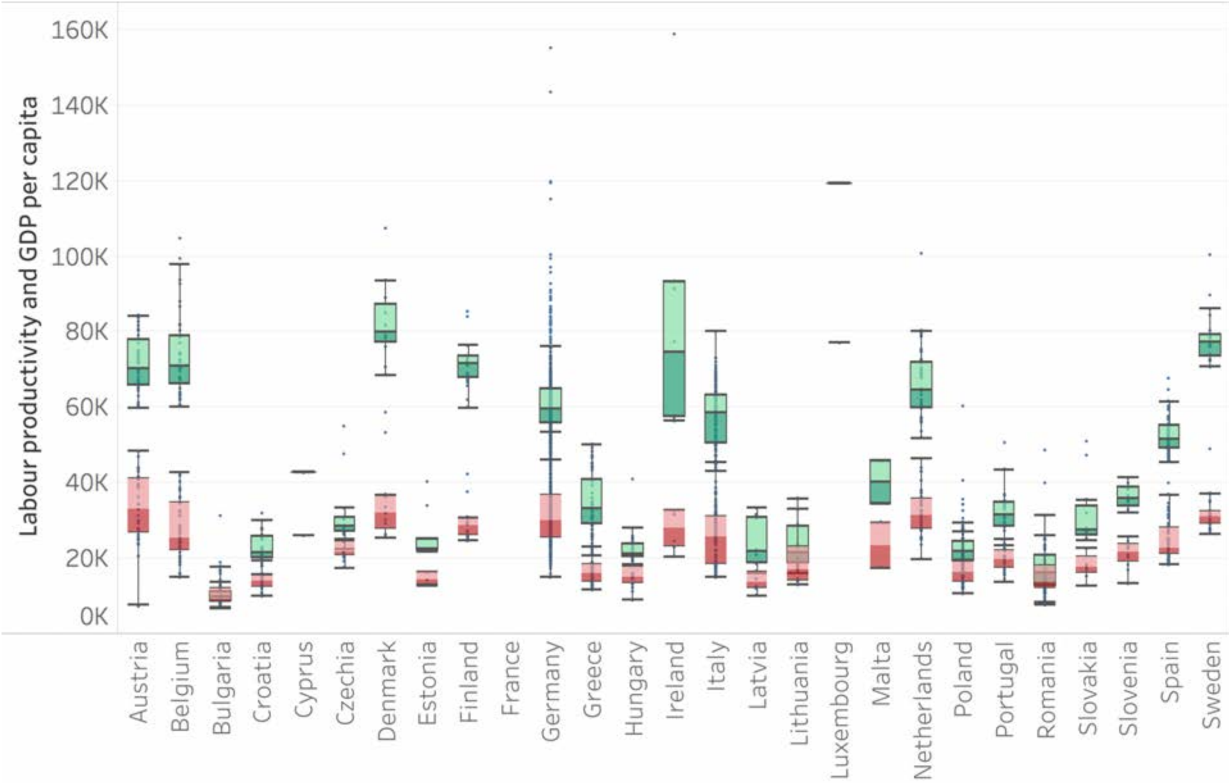
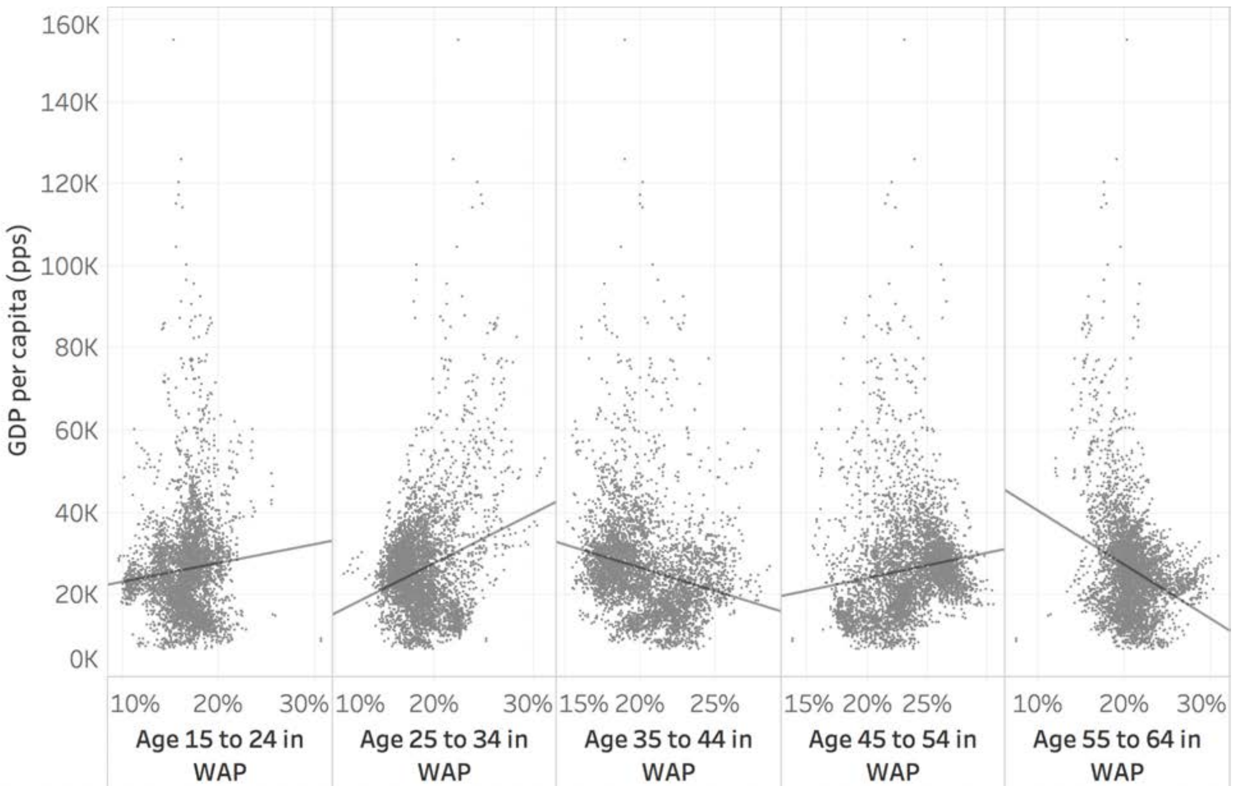


FIGURE 31. Relationship between the age structure of the working-age population and GDP per capita in EU NUTS3 regions, 2014-2017
Source: own elaboration of Eurostat data, 2014-2017.



of regional data covering the EU 27 Member States for the period 2014-2017 was used and OLS panel fixed-effects regression models were applied in order to examine the relationship between the age structure of the population and the GDP per capita as well as labour productivity. Our empirical model includes a set of year dummies to capture variation in the output due to the business cycle. The fixed effects specification controls for NUTS3 and country-specific unobserved and time-invariant factors.[34]

The main demographic variables representing the age structure of the population are the percentage of the population aged 25 to 34, 35 to 44, 45 to 54, and 55 to 64 years in the total working-age population (15 to 64 years of age).[35] The model also includes the old-age dependency ratio (OADR) defined as the number of people aged 65+ over the population aged 15-64 as well as its squared term to capture the potential non-linearity of the relationship with the dependent variables.[36] In addition to the main demographic variables, another control variable was added as an indicator capturing the employment structure of the territory and the total fertility rate (per woman) as an influential factor in the demographic structure of the region. The employment structure at regional level is approximated by a diversity index which measures the probability that two individuals randomly chosen from the pool of workers residing in the region are employed in different economic sectors.[37] In the literature, the empirical evidence suggests that areas with a more diverse employment structure are characterised by more stable economic growth (due to lower unemployment compared to more specialised areas) and are less vulnerable to sector-specific economic shocks (Milizia and Ke, 1993). It is therefore expected that th e diversity index will be positively associated with the economic performance of the geographical area. Regarding the impact of the total fertility rate on the output levels, the existing empirical evidence shows conflicting results (Cruz and Ahmed, 2018; Crespo Cuaresma, Lutz and Sanderson, 2014; Lee and Mason, 2010). However, some recent studies of economically developed countries and regions suggest that this relationship might be positive (Esping-Andersen and Billari, 2015; Goldscheider, Bernhardt and Lappegard, 2015, Essien, 2016).[38]

5.3 DATA DESCRIPTION

Table 4 presents the descriptive statistics of the variables employed in this empirical analysis for the period 2014-2017. The demographic indicators show large variations across regions. In 2017, the regions with the lowest share of individuals aged between 25 and 34 in the working-age population were Bornholm (12%) and Nordsjælland (13%) in Denmark, Serres, and Arta (14%) in Greece, Plön (14%) in Germany, and Ferrara and Biella (15%) in Italy. The highest values are observed in some provinces of Germany (more than 27% in Mainz, Dresden, Würzburg, Regensburg, Heidelberg, Leipzig, and Jena), and Byen København in Denmark (31%). Looking at the 55-64 age group in the total working-age population, the lowest percentages in 2017 were observed in France (Mayotte (7%) and Guyane (12%)) and Denmark (Byen København (12%)). In 2017, 72 out of 96 regions with more than a quarter of its working-age population above 55-year-old are in Germany, with the highest percentages observed in the provinces of Greiz and Spree-Neiße (approximately 31% in 2017).

The total fertility rate also varies considerably across regions. In 2017 the highest values were recorded in the French overseas territories (Guyane - 3.8 children, Mayotte - 4.9 children, la Reunion - 2.5 children), in Melilla (2.3 children) in Spain, and Vaslui (2.6 children) in Romania. The lowest values were recorded in several regions - outside the main conurbations - of Spain, Greece, Italy, and Portugal where there has been an increase in the percentage of women giving birth at an older age. In contrast to Spain, where the lowest total fertility rate seems to be concentrated in several provinces of the Canary Islands (Gomera, El Hierro, Gran Canaria, and Tenerife with a fertility rate equal to one child) and the Balearic Islands (where the rate in Las Palmas and Formentera slightly exceeds one child). Furthermore, in Italy the lowest fertility rates are distributed over the whole territory, thereby characterising the demographic structure of many provinces for example, of Sardinia (Carbonia-Iglesias - 0.8 child, Cagliari - 1.0 child), Puglia (Brindisi - 1.1 children and Lecce - 1.2 children), Lazio (Viterbo - 1.1 children), Umbria (Terni - 1.1 children), Piedmont (Biella - 1.2 children)).

34 Country effects are control for because the sub-national results could be driven by national economic structures and policies.

35 The younger age group (15 to 24 years) is excluded due to a collinearity issue.

36 The old-age dependency ratio used in this analysis refers to demographic dependency and not to economic dependency. In interpreting this indicator, it is important to consider that a country's retirement age may differ from 65, or that an increasing number of people over 65 are active in the labour market. These aspects are more closely reflected through an economic dependency ratio.

37 The diversity index is based on the Simpson index which is equal to the probability that two entities taken randomly represent the same type. Its transformation (1- Simpson index) is the probability that the two entities represent different types and is called the Gini-Simpson index, and is expressed as $\text{Diversity Index}_p = 1 - \sum_{n=1}^{s} \text{Share}^2_{sp}$, where Share_{sp} is the share of individuals employed in sector s among the total employed in province p. To build the sector of employment diversity index at the provincial level in this study, information on the number of employed individuals by economic sector was used (NACE Rev. 2). The main source of data for the number of people employed in specific sectors is Eurostat (nama_10r_3empers).

38 Some studies argue that gender equality is the driver of increased fertility levels in highly developed countries (for instance, see Myrskyla, Kohler, and Billari, 2011).

The EU old-age dependency ratio in 2017 was 30.2% of the working-age population. The highest values were reported in Evrytania in Greece, with 65 elderly people for every 100 persons of working-age in 2017. In this ranking, the Greek province is followed by Arr. Veurne (Belgium), Ourense (Spain), Suhl and Dessau-Roßlau (Germany), Creuse and Lot (France), and Arta and Preveza (Greece) with ratios over 50%. The lowest values are observed in French overseas territories (Mayotte - 5% and Guyane - 8.6%).

GDP in the EU amounted to an average of EUR 29,200 per inhabitant in 2017. Behind these aggregate figures, there are large differences across NUTS3 regions. In 2017, the highest levels of GDP were recorded in the main centres of economic activity in Europe. Several German provinces, including Munich, Ingolstadt and Wolfsburg, recorded the highest level of GDP per capita, followed by capital cities such as Dublin and Luxembourg. As also indicated in Figure 28, most regions with a per capita income below the 2017 EU average were concentrated in the eastern EU Member States such as Bulgaria, Romania, Hungary, Latvia, Poland and Croatia. In 2017, around 466 regions had labour productivity below the EU average, which amounted to about 55,000 EUR for the sample of NUTS3 regions included in the analysis. Furthermore, most of the regions in this case are in Bulgaria, Romania, and Poland. The lowest levels of labour productivity - below 8,000 EUR per worker - were recorded in Sliven and Silistra in Bulgaria, and Vaslui in Romania. On the other hand, Dublin (Ireland), Munich, Ingolstadt, Wolfsburg (Germany), Luxembourg (Luxembourg), Københavns omegn (Denmark), and Brussels (Belgium) reported labour productivity levels more than twice as high as the EU average for the same year. Finally, the lowest values of the diversity employment index were estimated for the provinces of Ceuta, Melilla, Fuerteventura, and Lanzarote (Spain), Vaslui (Romania), and Kerkyra and Kalymnos (Greece). The highest values were found in certain provinces in Estonia, Belgium, Poland, and Austria.

5.4 RESULTS

The relationship between the age structure of population and macroeconomic performance was empirically examined, providing a set of results for the whole sample of NUTS3 regions, and for various subgroups of regions, highlighting the existing heterogeneity in this relationship. Eight models have been estimated for each dependent variable: Model 1 using the total sample, Model 2 and 3 using the sub-samples of the regions with positive and negative population growth respectively,[39] Models 4 and 5 using the sub-samples of the regions with positive and negative migration including statistical adjustment,[40] and Models 6, 7, and 8 referring to the subsamples of regions with urban, intermediate, and rural characteristics.[41] When interpreting the findings, it is important to consider that

TABLE 4. Descriptive Statistics – 2014-2017
Source: own processing of Eurostat data.

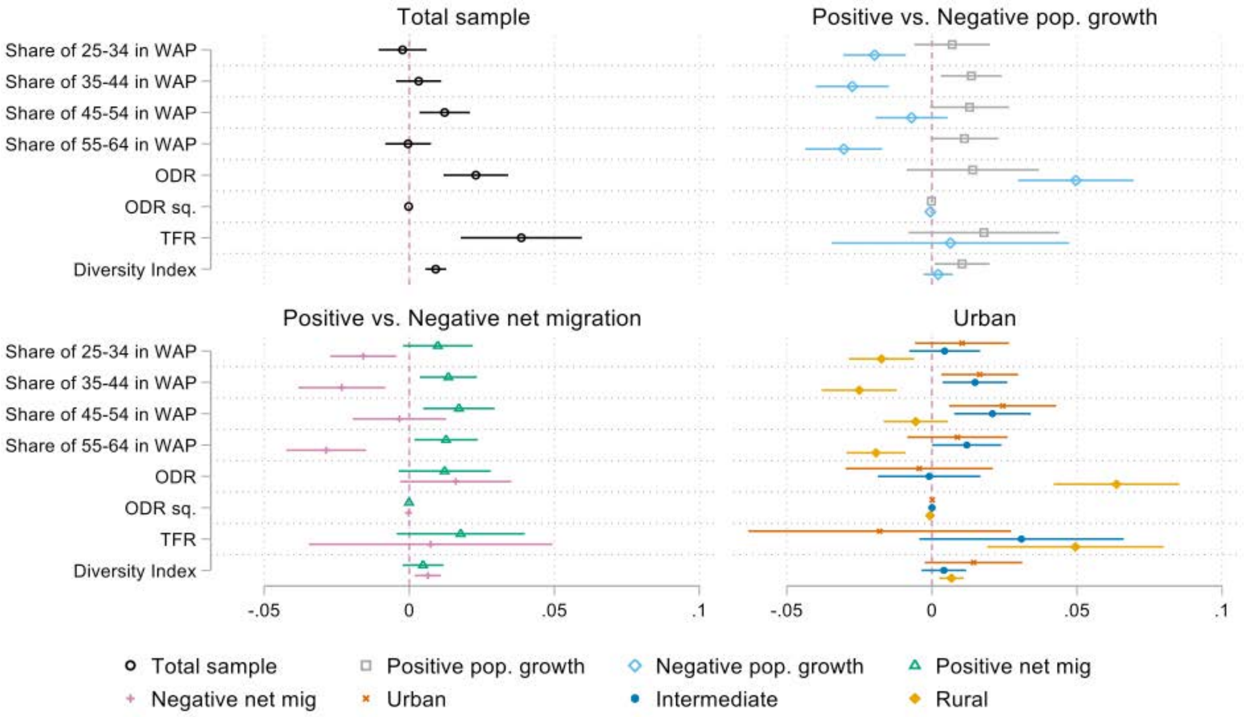
Variable	Mean	St. Dev.	Minimum	Maximum
GDP per capita pps (log)	10.07	0.43	8.73	12.00
Labour productivity (per employed person) (log)	10.73	0.53	8.61	11.97
Share of population 25-34/15-64 (%)	18.73	2.58	10.87	31.16
Share of population 35-44/15-64 (%)	20.36	2.41	15.12	28.63
Share of population 45-54/15-64 (%)	23.32	2.77	12.30	30.49
Share of population 55-64/15-64 (%)	20.94	2.63	7.15	30.94
Old age dependency ratio (OADR)	31.57	6.53	4.90	65.00
Old age dependency ratio (OADR)(sq. term)	1039.86	426.05	24.01	4225.00
Total fertility rate (TFR)	1.56	0.25	0.81	4.90
Sector of employment diversity index	75.92	2.89	53.42	84.92

39 The change in the population growth according to the Eurostat data (name of variable: demo_r_pjanaggr3) is the difference in the size of a population of the regions on 1 January of two consecutive years.

40 Net migration in Eurostat database (table demo_r_gind3) includes the statistical adjustments: it is a general estimation of the net migration based on the difference between population change and natural change between two dates (in the Eurostat database it is called net migration plus statistical adjustment). In different Member States net migration including statistical adjustment may, besides the difference between inward and outward migration, cover other changes in the population figures between 1 January for two consecutive years which cannot be attributed to births, deaths, immigration or emigration.

41 We follow the Eurostat classification of urban-rural regional typology to state the category of a region - urban, intermediate, or rural - based on the share of local population living there. Specifically, the urban-rural typology is a classification based on the following three categories: a) predominantly urban regions, NUTS3 regions where more than 80 % of the population lives in urban agglomerations; b) intermediate regions, regions where more than 50 % and up to 80 % of the population live in urban agglomerations; c) predominantly rural regions, regions where at least 50 % of the population live in rural grid cells (https://ec.europa.eu/eurostat/web/rural-development/methodology).

FIGURE 32. Regression results for GDP per capita
Note: The point estimates and corresponding confidence intervals are based on the results reported in Table A4.1 in Appendix 4.



these models do not quantify the causal relationship between the age structure of the population and the aggregate output indicators, but rather provide an analysis of this association and identify the prevailing pattern at the NUTS3 level.

Figure 32 illustrates the regression results of all models with GDP per capita as the dependent variable. Each marker represents the estimated coefficient of the independent variables while the associated horizontal lines are the corresponding confidence intervals.[42]

Tables A4.1 and A4.2 in Appendix 4 report the results of the OLS fixed-effect panel regressions, which separately measure the impact of the age structure of the population on the GDP per capita and on labour productivity. As shown in Table A4.1, regions with a higher share of the population aged 45-54 in the entire working-age population are characterised by a higher GDP per capita over the period considered. In general, most of the effect of the age structure on the level of economic development seems to be driven by this age group (Column 1). However, there is considerable heterogeneity of results among the regional subgroups. In the regions that experienced population growth either because of overall population growth (Column 2) or to a positive net (inward) migration (Column 4), the estimated association between the three age groups 35 to 44, 45 to 54, and 55 to 64 and the GDP per capita level are all significant and positive. Moreover, the regression coefficients of the age structure of the working age population in these regions follow a pattern in which the younger segments of the population are positively associated with dependent variables. This effect reaches its peak in the middle age groups and then gradually decreases with increasing age. In contrast, regions with negative population growth (Columns 3 and 5) show a negative association between the economic output level and the different age groups in the total working-age population for ages 25 to 34, 35 to 44, and 55 to 64. The characterisation of regions by degree of urbanisation shows similar differentiation of effects, as does grouping of regions according to population changes and net migration. In particular, the association is positive for urban and intermediate regions, and negative for rural EU regions. Higher effects are recorded for the age group 45-55 in both cases (Columns 6 and 7).

The old-age dependency ratio has not exerted downward pressure on the economic output level in all regions in the period considered. For regions with negative population growth as well as for rural regions, the analysis suggests that the old-age dependency ratio has a significant effect. In particular, there is an inverted U-shape relationship between the old-age dependency ratio and GDP confirming previous results (Crespo Cuaresma, Loichinger

42 If the line representing the confidence interval does not cross the line drawn at 0, then the coefficient is statistically significant at the 95 % confidence level.

and Vincelette, 2016).[43] The ageing process seems to be accompanied by an increase in the income per capita, as indicated by the positive sign of the OADR. However, a further increase in the old-age dependency ratio turns this association from positive to negative, as documented by the negative sign for the squared term of the OADR. Shifts towards advanced and extreme age are therefore possibly associated with a decline in the economic development of the regions in Columns 3, 5, and 8. The results also suggest that the threshold above which the relationship turns from positive to negative is when the OADR at NUTS3 level exceeds 0.5, or in other words, when more than half of the population exceeds 65 years of age. For regions experiencing population growth or positive net migration, as well as regions with prevalence of urban and intermediate settlements, no significant association was found between the old-age dependency ratio and GDP. This result further confirms that the (non-linear) effects of the age structure of economic performance mostly emerge in specific territorial contexts characterised by depopulation and/or negative net migration, and in rural areas.

Regarding the additional controls in the analysis, evidence of a positive association between the total fertility rate and GDP was only found in rural and intermediate areas. As for the role of diversity of employment across economic sectors within a region, it was found that the diversity index was positively associated with GDP per capita in several specifications. Economically diverse regions are potentially more resilient to the negative effects of population ageing and may therefore have better prospects for stable economic growth. These estimates suggest that the impact of population ageing on macroeconomic indicators could therefore be differential depending on the structure of the local economy, with population ageing (and possibly labour force) being less or more critical in some areas.

Table A4.2 in Appendix 4 shows the estimated coefficients of the regressions with labour productivity as the dependent variable. As with the specification of the GDP per capita, in this case the age group between 15 and 24 years is also excluded for collinearity reasons. In general, the groups of age between 25 to 34 and 35 to 44 years are positively and significantly associated with work productivity. The results reported in Column 1 therefore suggests a productivity model in which younger age groups are associated with an increase in productivity, whereas the 55-64 age group is negatively associated with labour productivity. The regression coefficients for the younger age groups are larger for the subsample of regions with increasing population or positive net migration (Columns 2 and 4). The results for regions characterised by a decrease in the resident population suggest a negative and statistically significant association only between productivity and the 55-64 age group. It was also found that there are significant differences in the relationship between the age structure of population and labour productivity across regions characterised by various degrees of urbanisation. Columns 6 to 8 show mixed results across urban, intermediate, and rural areas. In regions classified as urban and intermediate, the population aged between 25 and 54 has a significant and positive effect on productivity per worker. In rural areas, the effects of some age groups are significant and negative. The results presented in Table A4.2 are similar to those reported by Aiyar, Ebeke, and Shao (2019) as well as Feyrer (2007) in their cross-country studies, particularly for the older age groups.

The coefficients for the old-dependency ratio and its quadratic term are only significant for the total sample (Column 1), regions with declining population (Column 3), and rural regions (Column 8). Finally, regions with a high diversity employment index on average have higher labour productivity across several specifications. The total fertility rate also appears to be significant and positively associated with regional productivity.

Labour productivity at the regional level is therefore influenced in the short-term by changes in the relative size of different age groups and by economic factors. Although the age groups analysed represent the age structure of the total working-age population (and not the age structure of the active or employed population[44]), the potential shift in population composition from young workers to older workers is evident through its negative effects on labour productivity. The channels through which this effect may occur are multiple. Beyond the effect on individual productivity, influenced by the deterioration of some skills (mainly physical) through time, an increasing number of adult workers in the workforce may have negative externalities and influence certain business dynamics (Karabarbounis and Neiman, 2014; Hopenhayn, Neira, and Singhania, 2018).

5.5 CONCLUSIONS

The relationship between the age structure of the population and the per capita GDP and labour productivity

43 Several studies suggest a non-linear relationship between the old-age dependency ratio and economic performances (Crespo Cuaresma, Loichinger, and Vincelette, 2016). According to Zhang and Zhang (2005) and Emerson, Knabb, and Sirbu, (2019), individuals respond rationally to increased longevity by saving more money to cope with a long period of retirement. However, the institutional response to population ageing - and the resulting redistribution of resources across sectors - will determine whether or not future economic growth will be slowed down by ageing. This will depend on how much is allocated to the elderly rather than to children, education, or infrastructure.

44 As documented in Yihan Liu and Niklas Westelius (2016), the use of the age structure of the working age population (instead of the age of the workforce) may have the benefit of avoiding the bias in estimates resulting from the reaction of the workforce participation rates across different age groups to different productivity models.

at the EU NUTS3 regional scale for the period from 2014 to 2017 has been analysed in this chapter. The results indicate that the age structure of the population is an important factor in shaping the economic development of each region.

Our results are in line with previous empirical evidence (Feyrer, 2007; Crespo Cuaresma, Loichinger, and Vincelette, 2016), and suggest that the shift in the age structure towards older segments of the population, as well as the increase in old-age dependency on the working-age population have a significant and negative impact on both the level of per capita income and labour productivity at regional level. In particular, it was found that the younger segments of the working-age population are positively associated with the dependent macroeconomic variables whereas the association with the share of the older working-age population (50-64 years) is negative in several specifications of labour productivity.

These results show a clear territorial heterogeneity. The impact of the age structure on economic development and productivity differs according to the characteristics of the regions analysed. Regions with a growing population that are prevalently characterised by urban settlements, which generally exert a considerable pull effect on migrants and younger segments of the population, benefit from the positive economic effects of a younger population structure. Regions with a declining population that are classified as rural face the more negative economic consequences of an ageing population. Moreover, in regions with an increasing population, the regression coefficients present a distribution where the younger segments of the population are positively associated with the dependent variables. This effect reaches its peak in the middle-aged groups and then gradually decreases with increasing age. In addition, it was found that in rural and depopulated regions, the increase observed in the older age group (compared to the working-age population) exert a negative effect on economic growth, especially if its share exceeds 50% of the total population.

Beyond the significant effect of the age structure of the population, we have provided evidence that high rates of fertility and economic diversification of the territory are positively associated with economic output and higher labour productivity in several regions. The latter results indicate that several factors at the regional level may therefore influence and alleviate the negative consequences of an ageing workforce and population, at least in the short-term. These results complement the findings of a recent OECD study that concludes that an ageing population does not necessarily mean a shrinking economy: older adults have specific needs in terms of housing, mobility, care and more, and hence, support to the silver economy sector could contribute to economic and employment growth (OECD, 2020).

From the perspective of policy implications, it is important to support effective strategies that integrate both demographic dynamics and the economic development of the region, addressing also the opportunities that may arise from the silver economy. While migration patterns are long lasting and difficult to influence by public policy, addressing the push factors may help stem the outflow in some regions, possibly providing an effective mean of alleviating regional demographic challenges, especially in territories most affected by depopulation and ageing. The general decline of the population is leading to serious changes in the demographic structure and generates constraints on the labour market linked to the outflow of mostly young and skilled human resources. Economic growth and macroeconomic stability can sustain the accumulation of capital in the region to promote its development. The creation of opportunities for older people to actively return to the labour market as well as the generation of opportunities to attract and retain young, more qualified workers are some of the actions that need to be considered.

6. POLITICAL ATTITUDES AND BEHAVIOURS: DO AGE AND TERRITORY COUNT?

Marco Scipioni and Guido Tintori

Key findings

- Survey data show that age divides emerge when it comes to both the salience of and attitudes towards different key political issues whereas rural-urban divides are rarely observed.
- There are large and persistent divides in political interest between both self-reported levels of urbanisation and age groups, with higher levels of interest recorded among self-described urban respondents and older cohorts. Data on political behaviour tends to align with this, as turnout tends to be higher in predominantly urban NUTS3 compared to both intermediate and rural regions, and tends to increase with age.
- Aggregated election data at NUTS3 level shows that political divides depending on both age and place of residence emerge when analysing votes for political parties along two dimensions, namely stances regarding the EU and immigration.

6.1 INTRODUCTION

The previous sections described how the reshaping of the age composition of territories across Europe has affected a series of socio-economic facets in the lives of Europeans. This chapter moves from a similar set of considerations – i.e., concerning the multi-faceted complexity of the demographic transformations Europe is undergoing - to offering an empirical overview of their possible interactions with the political attitudes and behaviours of Europeans.

A territorial distribution of population patterns tending towards an unbalanced mixing of generations could lead to residential segregation in urban areas, and loss of active population in small towns and rural areas (Iammarino, Rodriguez-Pose, and Storper, 2019). If the social networks of individuals become increasingly homogenous along age lines, then the chances, especially for the elderly, of intergenerational interactions taking place disappear as well as contacts reflecting the diversity in the population. It also increases their tendency to form opinions and beliefs by drawing mostly from in-group information sources, a process known as 'social homophily' (McPherson, Smith-Lovin and Cook, 2001). By the same token, these dynamics may negatively impact on social cohesion at large, nurturing a tension in the contract between generations.

The implications of these place-based processes have critical consequences for the political domain in two respects in particular. On the demand side, they breed growing intergenerational distrust and create divides in the definition of political issues that parties and governments should prioritise – e.g., the fight against climate change and resource depletion, employment, fair globalisation versus health and pension systems, security, local communities (Galasso *et al.*, 2004). On the supply side, an increasingly isolated ageing population may exacerbate the competition between political parties for this cohort of citizens in certain constituencies, polarising the debate, in some cases territorially, concerning the resources and actions that should be devoted to their needs (Choe, 2003; Karvonen and Kuhnle, 2001; Kriesi, 2010; Super, 2020; van der Brug, 2010).

The recent rise of anti-establishment and challenger parties in several EU electoral events, the increasing fragmentation of party systems across Europe, and the results of the Brexit referendum are linked to profound transformations currently affecting European societies (de Vries and Hobolt, 2020; Hobolt, 2016). Both media reports and academic studies investigated the role of a range of socio-demographic developments as possible reasons, from growing inequality and the divide between winners and losers of globalisation, to the effects of migration and increasing ethnic diversity. Social scientists have relied on the concept of cleavage to analyse the relationship between the individuals' political attitudes and behaviours, on the one hand, and the underlying socio-demographic and economic structure of the society they live in on the other hand. Under the overarching assumption that the political debate and party competition reflect different collective interests and identities in society, this approach divides the members of a political community (polity) into groups according to a series of characteristics (age, gender, class, religion, values, etc.) in order to understand the extent to which each of these structural determinants can explain or predict the attitudes and political behaviour of individuals (Lipset and Rokkan, 1967; Choe, 2003; Colomer and Puglisi, 2005; Goldberg, 2020; Casal Bértoa, 2014).

The rest of the chapter moves from the theoretical inputs of several studies that adopt the cleavage theory and pay particular attention to age and ageing society in order to consider their role in recent developments of European politics (O'Grady, 2019; Hooghe and Marks, 2018; Tilley and Evans, 2014; van der Brug, 2010; Whiteley, 2016). The empirical work builds on Scipioni, Tintori et al. (2020), and further expands the analysis of the attitudes and political behaviour of Europeans with a specific focus on the ageing of societies, the geographical distribution of populations along generational divides, and the part played by urban/rural place of living.

A widespread assumption in both the academic literature (O'Grady, 2019; Sears and Funk, 1999; Peterson, Smith and Hibbing, 2020) and media reports (The Economist, 2020) is that ageing is associated with a hardening of attitudes, less tolerance, and growing conservative preferences (Foner, 1974). In parallel, similar patterns emerged in individual attitudes and in the context of residence, especially when shifts in population dynamics have been observed whereby young people tend to gravitate towards or remain in economically and culturally vibrant cities while elderly individuals show a propensity to stay put even in depopulating areas (see chapter 2) or move towards less densely populated and rural settings (Ford and Jennings, 2020; Maxwell, 2019; Rokkan and Urwin, 1983; 1982). To the extent that the trends are occurring, one implication would be to record growing divides in attitudes between both urban and rural areas, and according to age divides.

In electoral terms, political matters are decided by the number of votes in a constituency. It is therefore useful to investigate more systematically whether and to what extent attitudes and political preferences diverge among Europeans as a function of age and place of residence. The importance of capturing recurrent place and age-based patterns and divergences is relevant especially in relation to hot issues currently being debated, their salience as well as the degree of participation in politics (electoral turnout, political activism).

In this vein, the empirical analysis in this study used three different datasets and described differences in geographical units according to age and population density. With regard to attitudes, Standard Eurobarometer data from 2003 to 2019 was collected, harmonised, and analysed in the light of the age and self-reported place of living of respondents (i.e., 'Rural area or village', 'Small or middle-sized town', 'Large town'). For the political behaviour, turnouts in elections or the national and European Parliaments were examined using the data assembled in the context of the Geography of Discontent work (Dijkstra, Poelman, and Rodríguez-Pose, 2019) coordinated by DG (Directorate General) REGIO. In addition, the dataset used in the report 'Immigration and trust in the EU', with votes in the elections to the European Parliament 2019 for parties coded according to their positions towards the EU and immigration as provided for in the Chapel Hill Expert Survey (CHES).

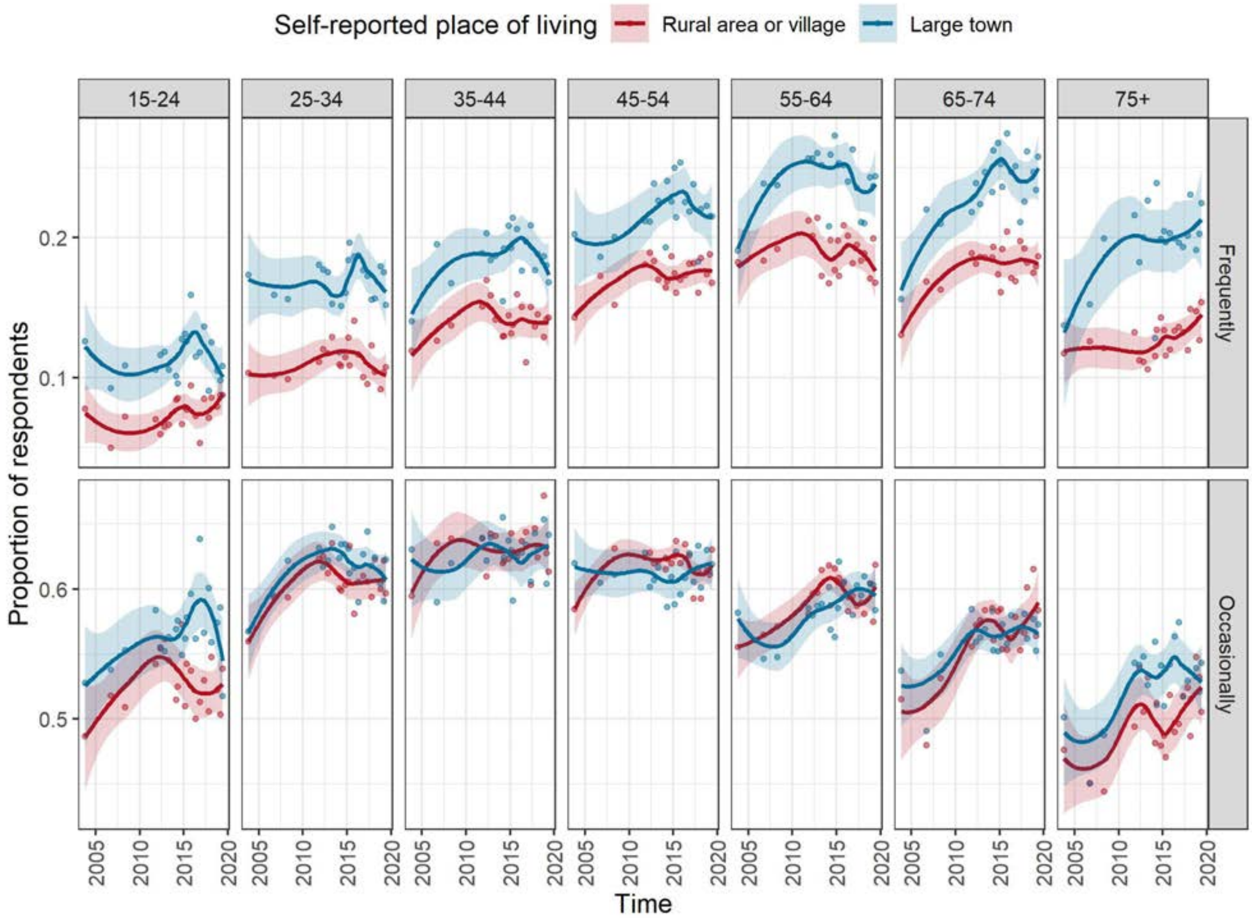
6.2 INTEREST IN POLITICS

Figure 33 illustrates the various levels of interest in politics of Eurobarometer respondents by age and self-reported level of urbanisation.[45] These survey-recorded outcomes report a more broadly defined interest in political affairs as opposed to actual political participation as recorded in election turnout.

There are several noteworthy features in the graph below. First, those who self-report that they live in urban areas say they are more interested in political matters compared to those self-reporting that they live in rural places. For those who discuss political matters 'frequently', the peak of declared interest in politics is in the age cohort between 55 and 64 years of age. The differences in political interest depending on place of residence only seem to relate to those engaging 'frequently' in politics and not so much to those who 'occasionally' do so. For this latter group, age differences persist, with the age group with the highest proportion of those occasionally discussing politics being between 35 and 44 years old, and the lowest above 75 years of age.

45 The original Eurobarometer question reads: 'Would you say you live in a...?' 'Rural area or village'; 'Small or middle-sized town'; 'Large town'; 'DK'. In this chapter, the authors often abbreviate the first response in rural areas, and drop the second to simplify the comparison, shorten the third response into urban areas ('Large town'). For consistency reasons, the don't know answers (DK) were systematically dropped as they are not reported in older Eurobarometer datasets.

FIGURE 33. Political interest by age and place of living
Source: Standard Eurobarometer, 2003-2019. Notes: Proportion of those who answered ‘Frequently’ and ‘Occasionally’ to the question: ‘When you get together with friends or relatives, would you say you discuss frequently, occasionally or never about…?’ ‘Political matters’”. Due to uneven coding in the original data, ‘don’t know’ replies were discarded. After November 2011, ‘Political matters’ is a rounded average of three different variables, namely national, European, and local. Weighted observations.



6.3 ATTITUDES TOWARDS NATIONAL AND EU INSTITUTIONS

Figure 34[46] shows the differences by self-reported place of residence and age brackets in several attitudinal questions. Two main trends emerge in the case of trust in the EU (first row). First, there is a divide between those living in rural versus those living in urban areas (blue lines and dots, standing for ‘Large town’). In general, those self-reporting that they live in urban areas tend to trust the EU more than those who live in rural areas. However, this urban/rural divide in levels of trust in the EU widely varies through time and across age brackets. Second, the share of respondents declaring that they trust the EU declines as age increases (markedly, until the age bracket 55-64 years old, and then it flattens). This also emerges in the study presented in this paper when different attitudinal questions regarding the EU such as whether one is satisfied with how democracy is functioning in the Union (second row) were examined.

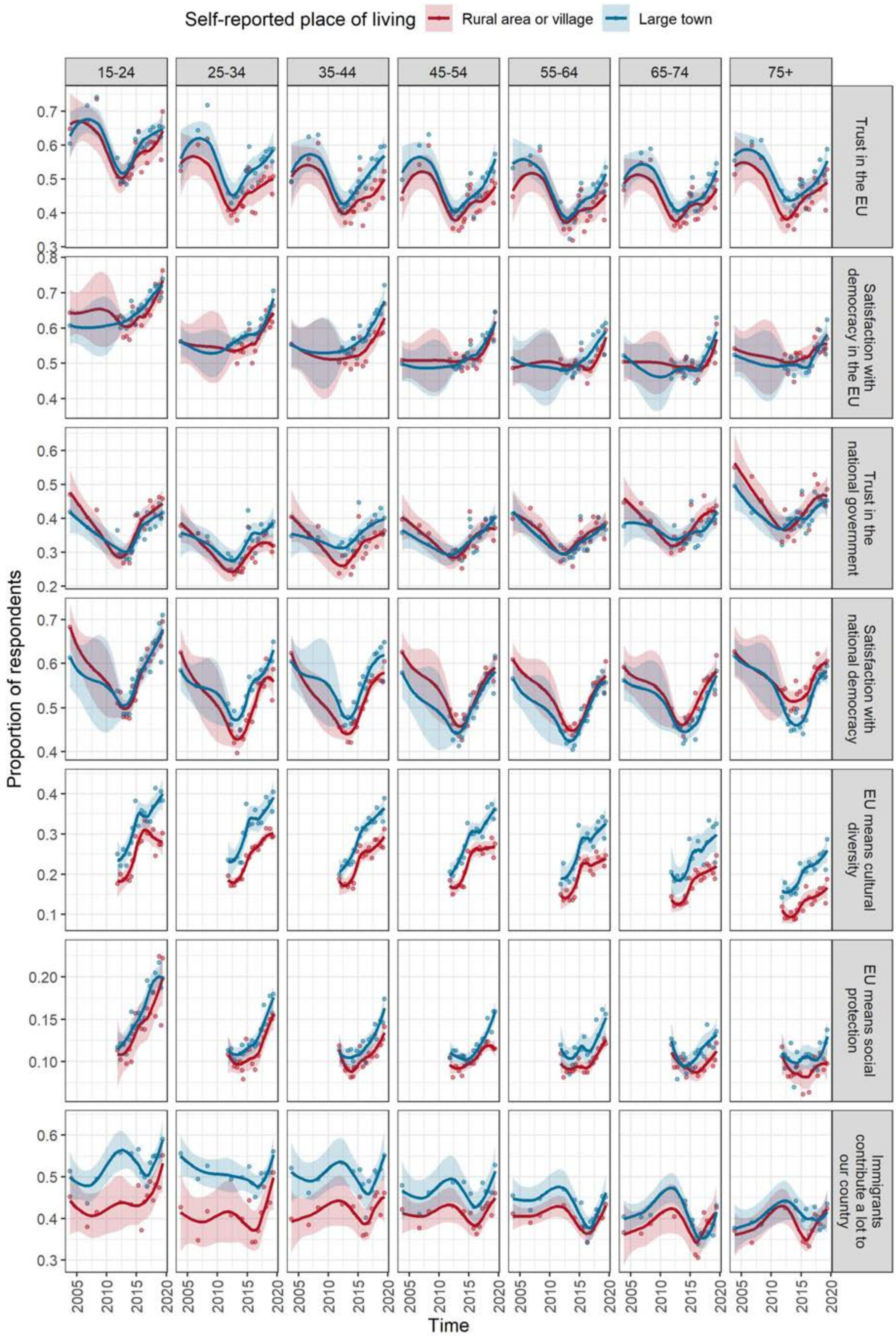
In the case of trust in the national government (third row), the patterns are somewhat harder to decipher than in the previous case. First, the rural/urban divide is less evident and systematic across time and age brackets. In addition, at several points in time those self-reporting that they live in rural areas tend to trust the national government more than those who live in urban areas – in other words, the opposite pattern compared to the trust in the EU. Second, the share of respondents trusting the national government peaks at the extremes of the age brackets (15-24 and above 75 years old). Again, this is confirmed by satisfaction with democracy at the national level (fourth row). These descriptive figures suggest the presence of age and territorial cleavages when trust in both European and national institutions is considered.

However, the fact that a young/old cleavage emerges more clearly in the case of attitudes towards the EU suggests that this divide is issue dependent. In other words, it is likely that respondents identify the EU

46 A noteworthy feature of Figure 34 is the clear dip in first four rows around 2010, which is mainly related to the Euro-zone crisis. In the bottom row, the dip is around 2015, this time mainly related with the so-called asylum and migration crisis of 2015/16.

FIGURE 34. Differences in attitudes by age and place of living

Source: Standard Eurobarometer, 2003-2019. Notes: Proportion of those responding in the positive. Due to uneven coding in the original data, 'don't know' replies have been discarded. Weighted observations.



with issues that have been connected with openness, globalisation, and communitarian identity versus diversity as a result of immigration. Evidence-based work that addresses whether and when these cleavages are more pronounced in relation to specific issues can contribute to understanding the ways the impact of demographic change coupled with territorial diversity in Europe might shape its political debates and landscapes. Furthermore, this was explored by looking at responses to the question on what the EU means to interviewees, focusing on cultural diversity and social protection. In these two cases a pattern similar to that recorded in the case of trust in the EU, was observed. The EU is decreasingly associated with cultural diversity as age increases. In addition, we witness a persistent urban/rural gap between respondents. Furthermore, while over time more respondents in each age group have tended to answer the question on cultural diversity positively, the older cohorts have not witnessed the same steep increase as the younger ones. This last trend is even more apparent if we move to the other possible meaning of the EU analysed here,[47] namely whether the EU means social protection. Here, because of a slump in the early 2010s, the starting point for the oldest cohort is almost the same as the last data point in 2019. Notably, the same slump is almost absent for age groups below 35 years old. Finally, when it comes to immigration, there seems to be an intermittent rural/urban divide for age cohorts below 35 years old, but this decreases as age increases. This suggests that the relationship between age and immigration attitudes may be modulated by place of residence, something that is explored further in the rest of this section. In parallel, attitudes towards immigration tend to become more negative as age increases.

WHAT MATTERS MOST: DIFFERENCES IN ISSUE SALIENCE

An important aspect to consider is what matters most for whom and where. This is a critical issue as there may be attitudinal differences between the groups analysed here (young/old, respondents self-declaring to live in urban versus rural areas), but those differences may be of little actual salience for respondents within those groups. Figure 35 illustrates the salience[48] respondents attribute to a series of political issues disaggregated by age and place of living. A territorial divide - i.e., urban versus rural areas– seems to be less evident here except in very few cases such as housing.[49] On the other hand, age divides appear to be much more pronounced, particularly in the case of taxation, housing, and crime.

6.4 COMBINING AGE AND PLACE OF LIVING

To further elaborate the relationship between attitudes towards political institutions and immigration, on the one hand, and age and place of residence, on the other, an interaction between age and place of residence was included in a linear probability model while holding some socio-demographics of the respondents constant (namely, gender, education, occupation, marital status). The expectation in using this simple linear probability model is to observe significant differences in the levels of trust (towards the EU and the national government) and attitudes towards immigration depending on the combination of age and self-reported place of residence. Figure 36 shows the results for the entire EU[50] Eurobarometer dataset.

In the left-hand facet (trust in the EU), one piece of key evidence is that once the above-mentioned individual characteristics have been controlled for, the differences connected with place of residence and age are confirmed as shown above in the descriptive analysis. Among respondents self-reporting to live in rural areas, statistically significant differences are particularly notable between the youngest and oldest cohorts (respectively, 15-24 and 75+ years old). In contrast, the only statistically significant difference between those declaring that they live in urban areas is between those aged 15-24 and those over 75 years old on the one hand, and those aged 55-64 years old on the other. In other words, age divides tend to emerge between fewer age groups in urban areas compared to rural areas.

Turning to trust in national government, once other characteristics have been controlled for, the descriptive differences connected with place of residence and age reported in Figure 34 tend to disappear. The only statistically significant difference is between those aged above 75 years old and all age groups from 15 to 64 years old in both rural and urban areas.

Finally, one of the aspects where divides were descriptively observed in Figure 34 was in terms of both respondents' self-reported location and age, namely attitudes towards immigration. Here again no statistically significant differences were found based on self-reported place of residence in the predicted probabilities of believing that immigrants contribute to the country of respondent residence. Furthermore, no statistically significant difference by age was found.

47 The reader should be aware that there are a number of other meanings that can be investigated, namely: 'Peace', 'Freedom to travel, study and work anywhere in the EU', 'Economic prosperity', 'Democracy', 'Stronger say in the world', 'Euro', 'Unemployment', 'Bureaucracy', 'Waste of money', 'Loss of our cultural identity', 'More crime', 'Not enough control at external borders'.

48 The original Eurobarometer question reads 'What do you think are the two most important issues facing (OUR COUNTRY) at the moment?'.

49 And even here only for those aged below 45 years old.

50 It should be noted, therefore, that the picture would look different for individual Member States or specific points in time. Furthermore, the Eurobarometer surveys analysed here were fielded when the UK was still an EU Member State.

FIGURE 35. Differences in issue salience by age and place of living
Source: Standard Eurobarometer, 2003-2019. Notes: Proportion of those mentioning the issue. Due to uneven coding in the original data, 'don't know' replies have been discarded. Weighted observations.

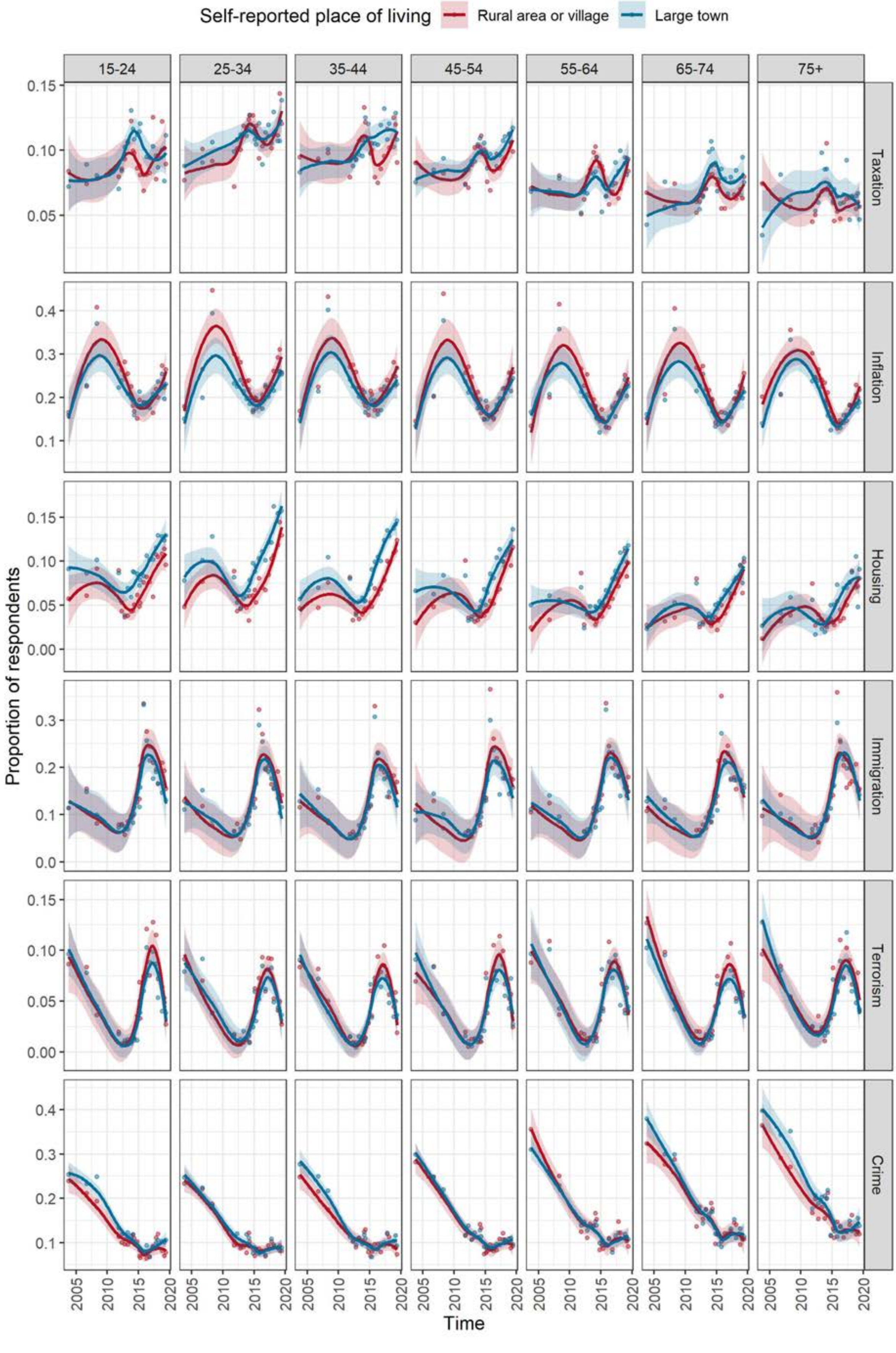
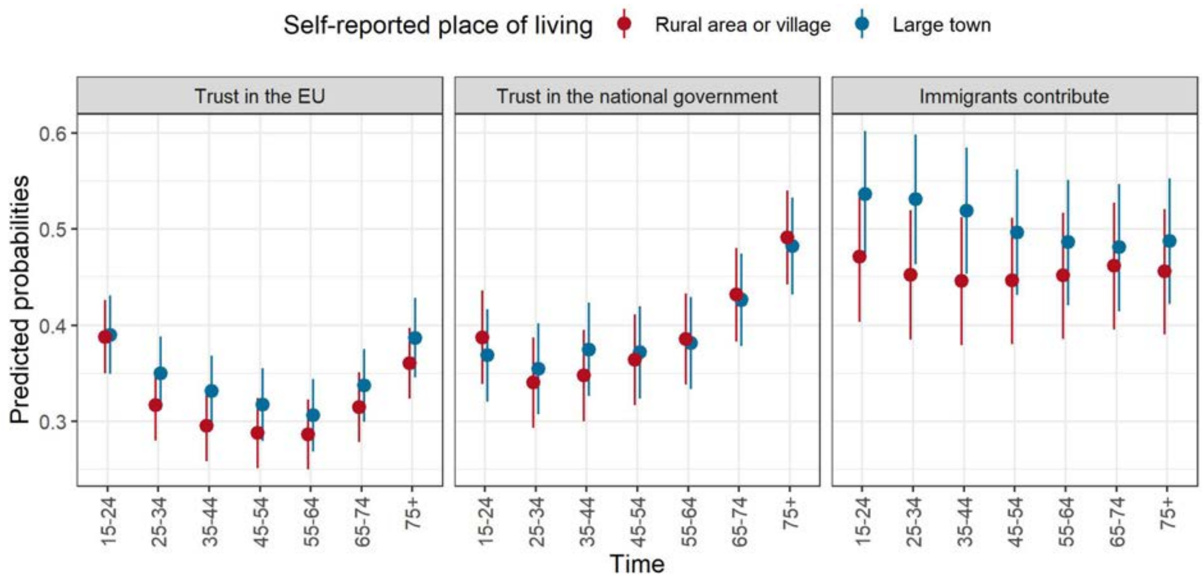


FIGURE 36. Predicted probabilities of trusting the EU, trusting the national government, and thinking that immigrants contributed to the country, associated with age and place of living

Source: Standard Eurobarometer, 2003-2019. Notes: Due to uneven coding in the original data, 'don't know' replies have been discarded. Weighted observations. Country and period dummies. Bars represent 95% confidence intervals with robust standard errors, clustered at NUTS level. Controls: education, gender, occupation, marital status.



6.5 AGEING AND TERRITORIAL ASPECTS IN POLITICAL OUTCOMES

Observing systematic differences in attitudes represents only one part of the picture. It is important to understand whether any age- and place-based divide may also inform people's political behaviours. In this respect, the data assembled for the DG REGIO work on Geography of Discontent concerning national parliamentary elections across the EU between 2013 and 2018 is examined first. When focusing on aspects connected with ageing and territorial features such as population density, net migration, or population growth, the rural-urban classification from Eurostat[51] of 2013 and 2016 was adopted. Furthermore, the median age at NUTS3 level,[52] which has been available since 2014, was used.

6.5.1 VOTER TURNOUT

Provided that voting is not compulsory in most EU Member States, voter turnout is one of the main indicators for measuring the level of political engagement of citizens in a democracy. The dataset of Geography of Discontent collected electoral data on national parliamentary elections between 2013 and 2018, and on several covariates of interest, at different geographical levels.[53] In fact, the NUTS3 level was the lowest geographical level that allowed for harmonisation of the turnout rates across all Member States. This also entailed attributing the degree of urbanisation of the NUTS3 level to smaller geographical units where the turnout was registered, even when classified differently.

In Figure 37, turnout rates show a decreasing trend moving from urban regions to rural ones. In the plot, the middle bar in each 'violin-shaped' figure displays the median. The data shows a decreasing trend as urbanisation decreases, from approximately 65% to approximately 56%. The larger the width of the violins, the more concentrated geographical units were at that point on the turnout rate scale. This means that the largest cluster of urban geographical units had a turnout rate close to 75%, whereas in most of the rural geographical units, the turnout rate concentrated around values between 50% and 56%.

The relationship between turnout and population density (which is at the basis of the rural-urban typology for NUTS3 regions[54]) is not linear. The graph below (Figure

51 The urban-rural typology is available at https://ec.europa.eu/eurostat/web/rural-development/methodology (accessed on 10/09/2020).

52 Population: Structure indicators by NUTS3 regions (demo_r_pjanind3); available at https://ec.europa.eu/eurostat/databrowser/view/demo_r_pjanind3/default/table?lang=en (accessed on 10/09/2020).

53 Data on political outcomes is mostly at NUTS3 level or below, except for Germany and Greece (where the geographical unit is larger). The level of disaggregation of the covariates is more uneven, with some at LAU, some at NUTS3, some at NUTS2 level. For instance, the average annual real growth of GDP/capita is at NUTS3 level, the share of people born outside the EU at NUTS2 level, and the share of people (aged 25-64) with a tertiary education at NUTS2 level.

54 Territorial typologies manual - urban-rural typology; https://ec.europa.eu/eurostat/statistics-explained/index.php/Territorial_typologies_manual_-_urban-rural_typology#Classes_for_the_typology_and_their_conditions (accessed on 16/12/2020).

FIGURE 37. Turnout rate by urban-rural typology at NUTS3 level
Source: Eurostat; DG REGIO. Notes: Lines within violins represent quartiles of distribution, the second being the median.

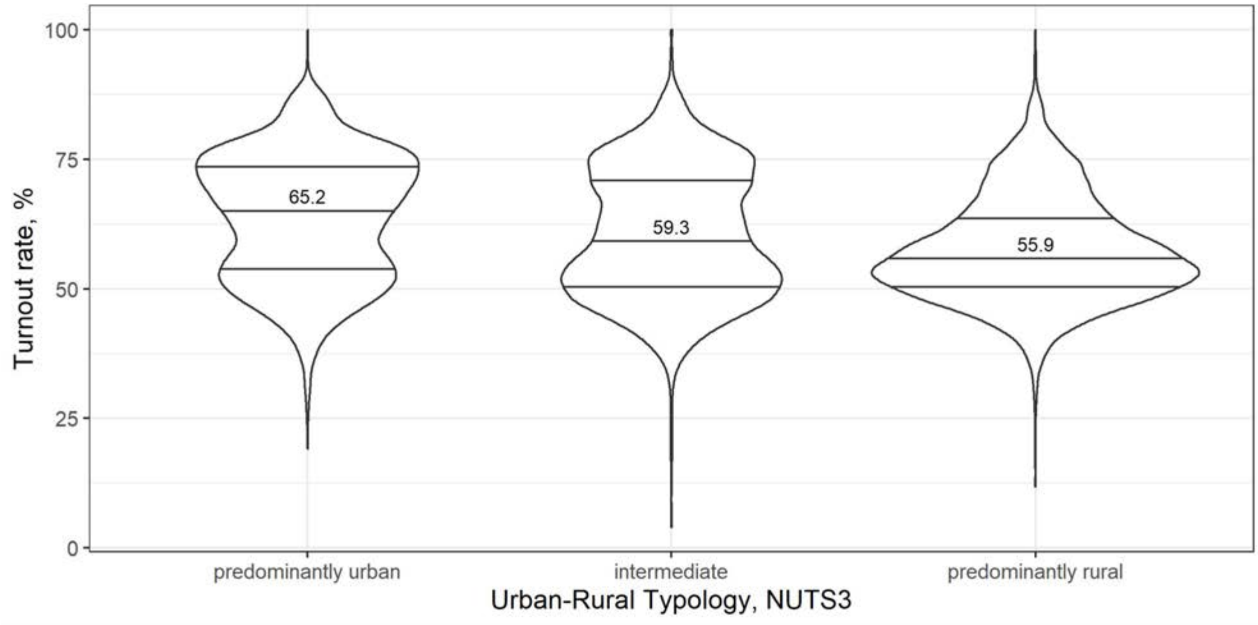
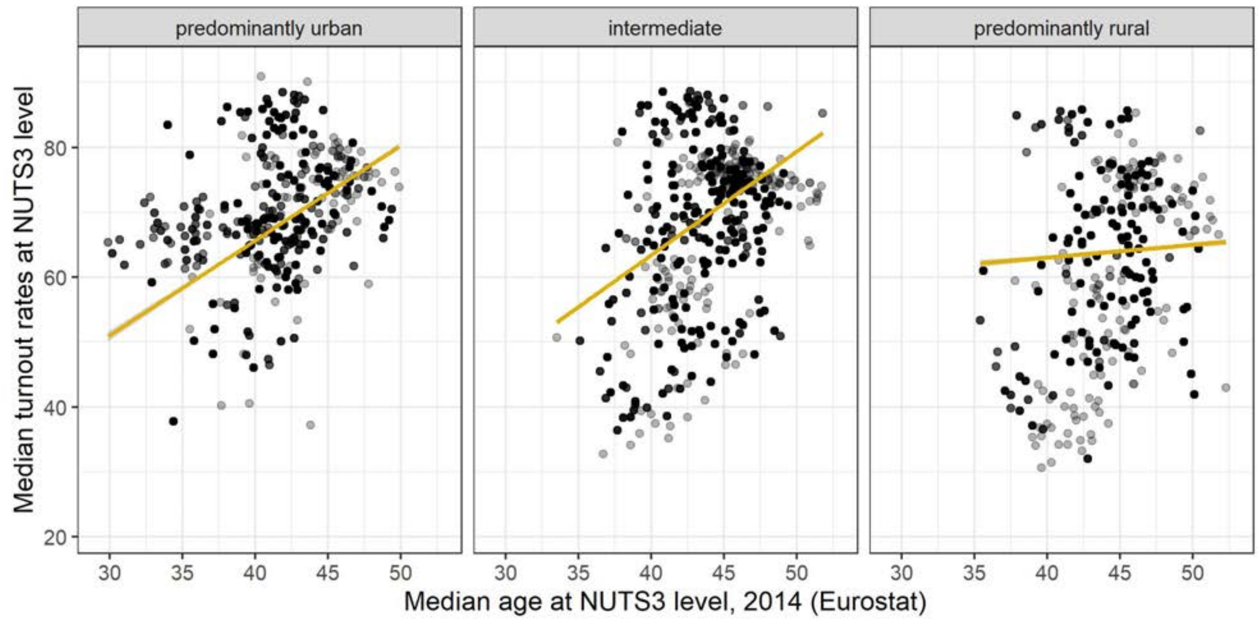


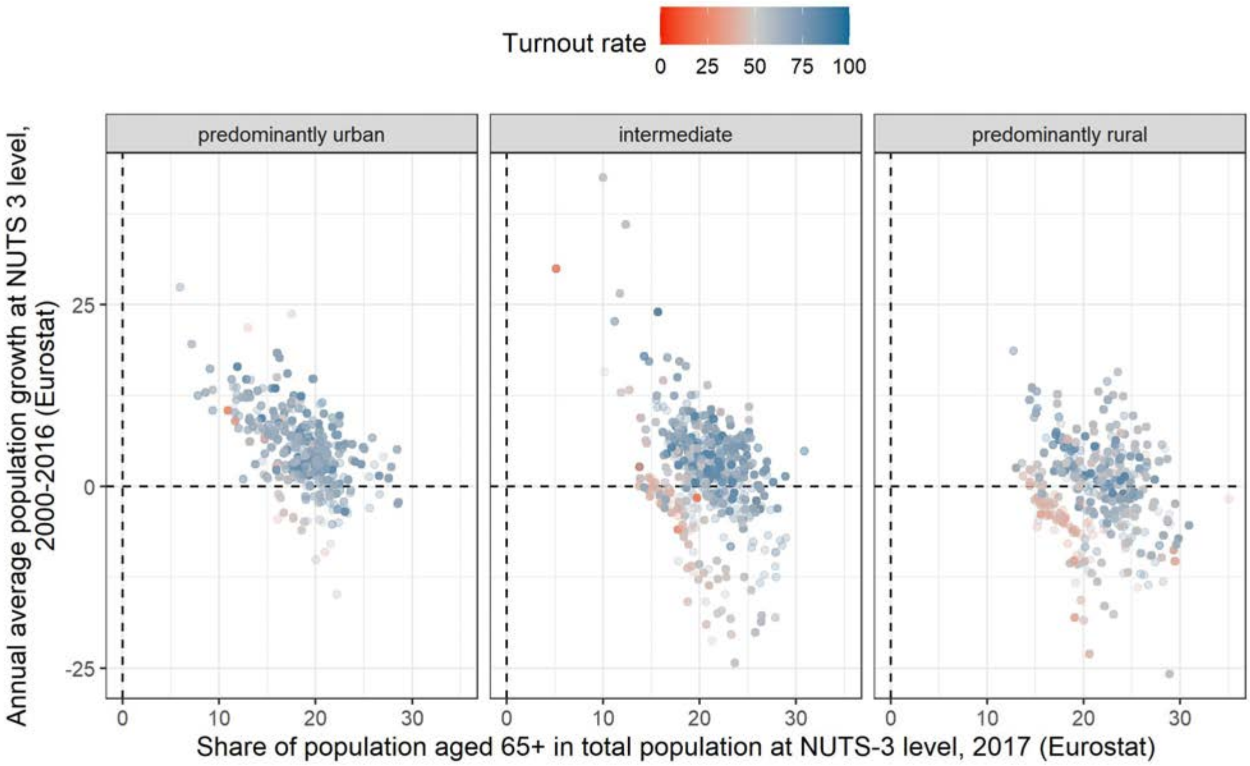
FIGURE 38. Median turnout rate at NUTS3 level, median age at NUTS3 level in 2014, by urban-rural typology
Source: Eurostat; DG REGIO.



38) shows that such a relationship is indeed likely to be mediated by age. In other words, while turnout rates overall tend to steeply increase with median age in predominantly urban and intermediate regions, they are nearly flat in predominantly rural regions.

Figure 39 examines the relationship of turnout with both age (share of elderly) and population growth. In this case, it was possible to keep the information on turnouts at the territorial level where it was originally recorded, thereby varying from the electoral district or LAU levels to NUTS3. The colour of the dots – each dot representing a single territorial unit – range from full red (0% turnout) to full blue (100% turnout), with grey colour capturing the middle of the distribution (i.e., around 50%). It is firstly worth noticing that turnout tends to be around 50% or lower in areas that experienced population decline (i.e., in the lower quadrant of the plot). In addition, most red dots concentrate in the lower quadrant, i.e., in areas that lost population. Conversely, it can also be seen that the blue dots prevail in both urban and intermediate areas but less so in rural areas.

FIGURE 39. Turnout rate by share of population aged over 65 and population growth
Source: Eurostat; DG REGIO. Notes: in the graph, we group observations by the NUTS3 rural-urban typology as that is the level where covariates are recorded (plotted on the x and y axes). However, the observations relative to turnout rates are measured at different geographical levels (some at LAU level, some at electoral districts, other at NUTS3). Table A5.1 in Appendix 5 specifies whether data on turnout rates were recorded at NUTS3 or at LAU/other levels.



Put differently, urban areas, which have experienced the bulk of population growth and tend on average to be younger, have also recorded higher levels of turnout compared to intermediate and rural NUTS3.

6.5.2 VOTING BEHAVIOUR ALONG TWO DIMENSIONS: EU AND IMMIGRATION

In this last part, we look at actual votes for parties that participated in the elections of the European Parliament of 2019. We ranked the parties according to their positions towards the EU and immigration, building on the coding by the Chapel Hill Expert Survey (CHES[55]).

We selected all parties that were ranked as more critical towards the EU (the bottom 20% of the dimension[56]) and then counted the votes these groups gathered. The analysis was carried out at NUTS3 level. Figure 40 shows that the share of votes for parties with critical views on the EU also increases as the median age of residents increases. This relationship – captured by the yellow trendline - is particularly high in intermediate and rural areas whereas in urban areas it is almost flat.

The same analysis was repeated at NUTS3 level with parties ranked according to their positions towards immigration, as coded by the CHES. All parties that were ranked as more critical towards immigration (again the top 20% of the dimension) were selected. Figure 41 shows two divergent trends depending on the level of urbanisation. In rural areas, as median age within NUTS3 increases, the proportions of votes for parties with critical stances towards immigration also increases slightly. However, this relationship clearly emerges only in rural areas. For the other two levels of urbanisation, the distribution of dots is very sparse, and in urban areas the trendline is indeed slightly negative.

6.6 CONCLUSIONS

The analysis of Eurobarometer data series shows that age divides emerge when it comes to the salience of

55 See Chapter 2 in Scipioni, Tintori et al. (2020) for a full description of the parties' coding along the selected political dimensions coded in CHES.

56 This exercise was repeated using 2 different thresholds, at 25% and 33%, to check whether the results changed substantially. The most conservative threshold was selected as these proportions are not calculated out of the total votes casted in the NUTS3 of references, but out of the total votes that were classified according to CHES. Considering that this is a lower figure, the net result is likely to inflate these proportions. Consequently, a more stringent threshold was selected.

FIGURE 40. Proportion of votes for political parties with critical stances regarding the EU by NUTS3
Source: ZEIT ONLINE dataset on 2019 EP (European Parliament) election and CHES. Notes: Higher proportions mean more votes for parties with critical stances regarding the EU.

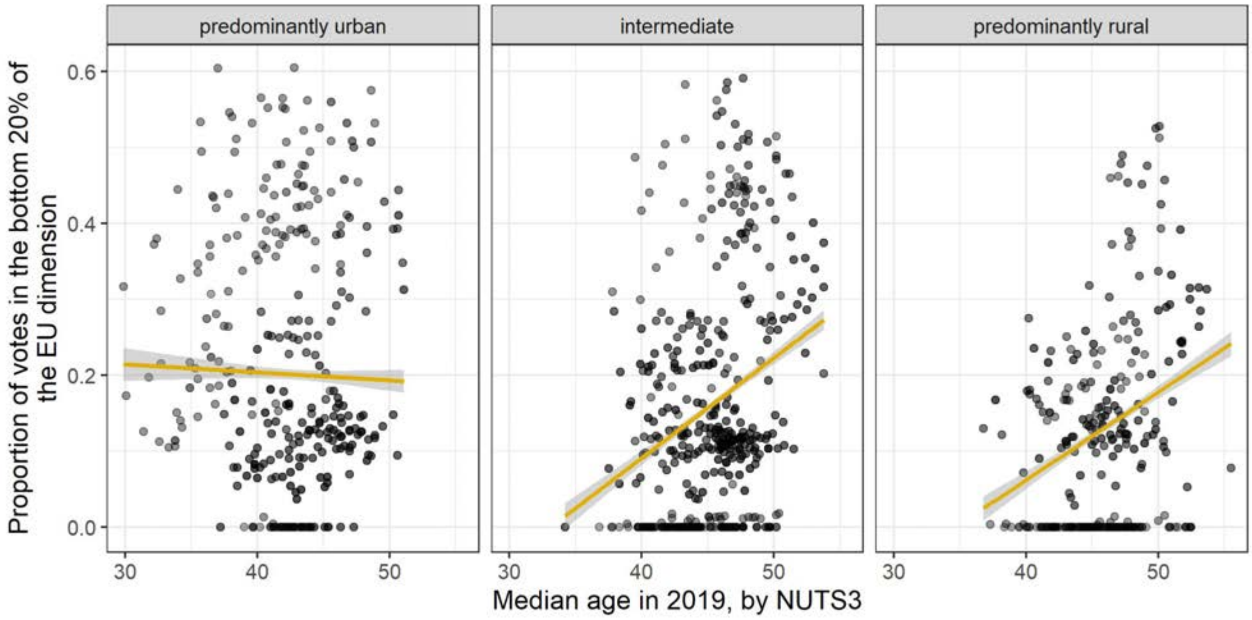
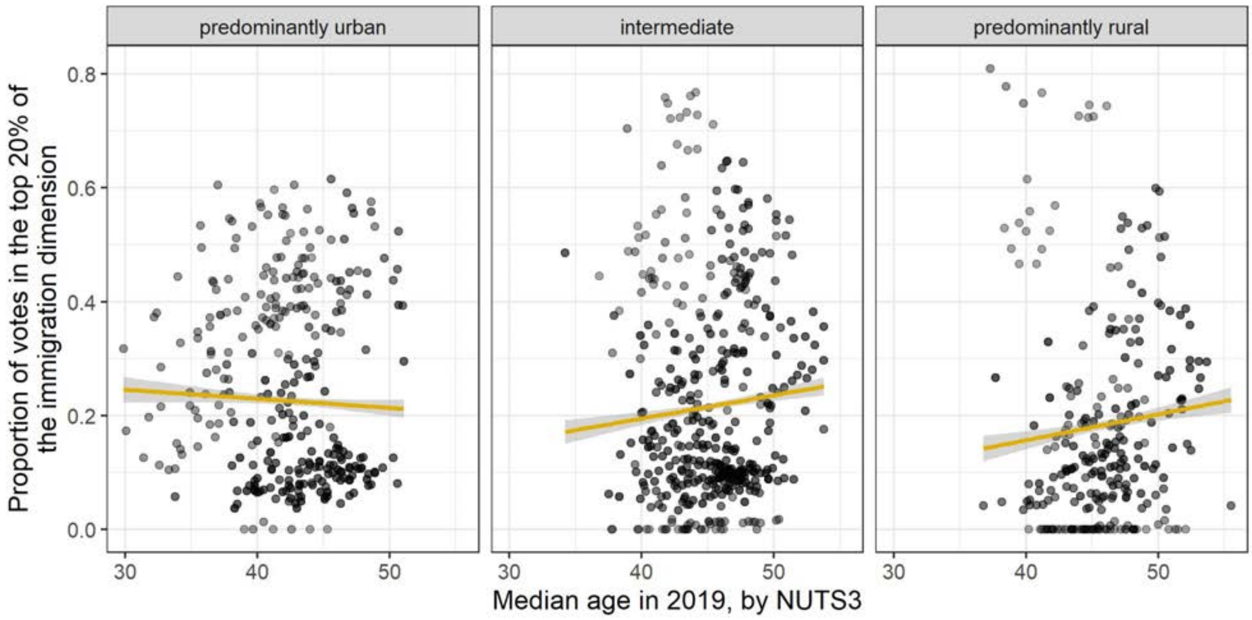


FIGURE 41. Proportion of votes for political parties with critical stances regarding immigration by NUTS3
Source: ZEIT ONLINE dataset on 2019 EP election and CHES. Notes: Higher proportions mean more votes for parties with critical stances regarding immigration.

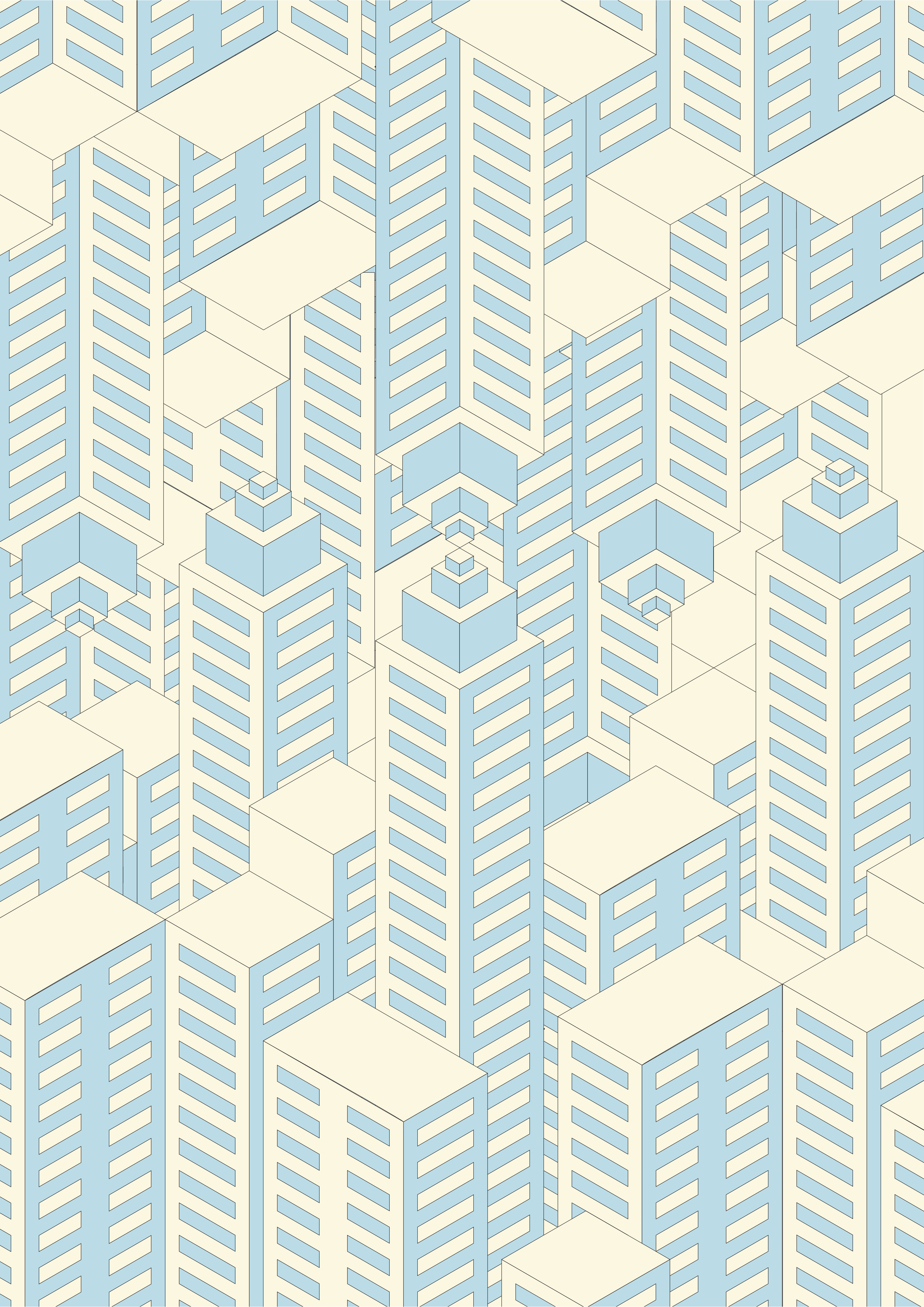


different key political issues. However, at the descriptive level, there are large differences in attitudes between different age groups over several but not all issues - in other words, age divides appear to be issue dependent. On the other hand, rural-urban differences seldom emerge.

Concerning political interest, the analysis highlights persistent and evident divides along the lines of self-reported level of urbanisation and age groups, with higher levels of interest recorded by self-described urban respondents and older cohorts.

Turning to political behaviour, data on actual participation tends to agree with the survey findings on political interest as turnout tends to be higher in predominantly urban NUTS3 compared to both intermediate and rural regions. Similarly, turnout tends to increase with age. Aggregated election data at NUTS3 level shows that political divides depend on both age and place of residence emerge when analysing votes for political parties sorted according to their positioning towards two political dimensions, namely stances regarding the EU and immigration.

This section has focused on an aggregated EU perspective. It is likely that future work could benefit and produce more articulated insights by concentrating on both individual Member States and specific changes over time.



CONCLUSIONS

One of the main conclusions of the unique research conducted in the framework of this report is that **the process of ageing varies considerably at territorial level** within a general trend of convergence across all EU macro-regions, pointing to the **need to assess ageing and its implications in the EU at a more granular level, looking at territorial characteristics**. This research points out that ageing is not necessarily linked to the traditional units of analysis such as administrative units and/or rurality, but is constructed from multiple processes such as depopulation, remoteness, accessibility to services, and lack of economic opportunities.

The processes underlining ageing at territorial level are of demographic nature and linked to three phenomena, low birth rates and mortality rates, and migration rates. While the first two are related to natural population increase and are mostly spatially uniform within Member States as the demographic transition runs its course, migration, and **in particular internal migration, is a big game changer for territories**, depending on their attractiveness, regarding job opportunities and access to infrastructure and services.. The research presented in this report shows how internal migration alters the spatial distribution of territories in relation to multiple factors that are highly related to the life cycle of individuals, so with age and hence ageing. This will be addressed in the Green Paper on Ageing.[57] Here it is shown that migration is a factor accelerating the ageing process in rural EU regions in correlation with a decline in the labour force supply. On the other hand, migration in many regions can offset the loss of working-age population due to cohort turnover. More analysis should be devoted to exploring the drivers and dynamics of internal migration in the EU. This will be important for the issue of depopulation in rural areas in terms of developing the Long-Term Visions for Rural Areas.[58]

In terms of policies, the findings indicate the need for policies that affect the local level, where they also matter most for EU citizens, because this is where decisions might have a more direct impact on their living conditions, and so be more visible to them.[59] This is evident when discussing services and amenities at the local level in terms of availability, but also in terms of access which is of great importance to the elderly population, especially those with disabilities and health conditions preventing mobility.[60] Regarding access to services and amenities, the policy and planning should not only tackle rural areas, but also cities, and this could become quite challenging with an ageing population.

The local-level approach is also crucial when thinking about social cohesion as the report shows that political divides depending on both age and place of residence emerge regarding stances about the EU and immigration. This link with ageing will be important for the development of the work on economic, social and territorial cohesion[61] and for the European Committee of the Regions, which represents local and regional authorities in the EU.[62]

The report also demonstrates that the economic vitality of territories is linked with the pace of ageing. This is challenging for policy makers: first, preventing territories entering a cycle of negative economic growth, loss of employment, negative net migration, reduction in available services and amenities, depopulation, which have been shown to lead to a higher prevalence of ageing with its associated challenges. When this has already occurred, there should obviously be an effort to reverse the cycle (revive the economy) and support the population that still lives there, which is potentially more elderly than the population in other regions. This is considered to lie in the territorial dimensions of the Europe 2020 Strategy,[63] which is the EU's growth and jobs strategy aimed at providing financial support to help regions overcoming obstacles to their development. The opportunities offered by the silver economy might be considered as well.

57 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12722-Green-Paper-on-Ageing

58 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12525-Long-term-vision-for-rural-areas

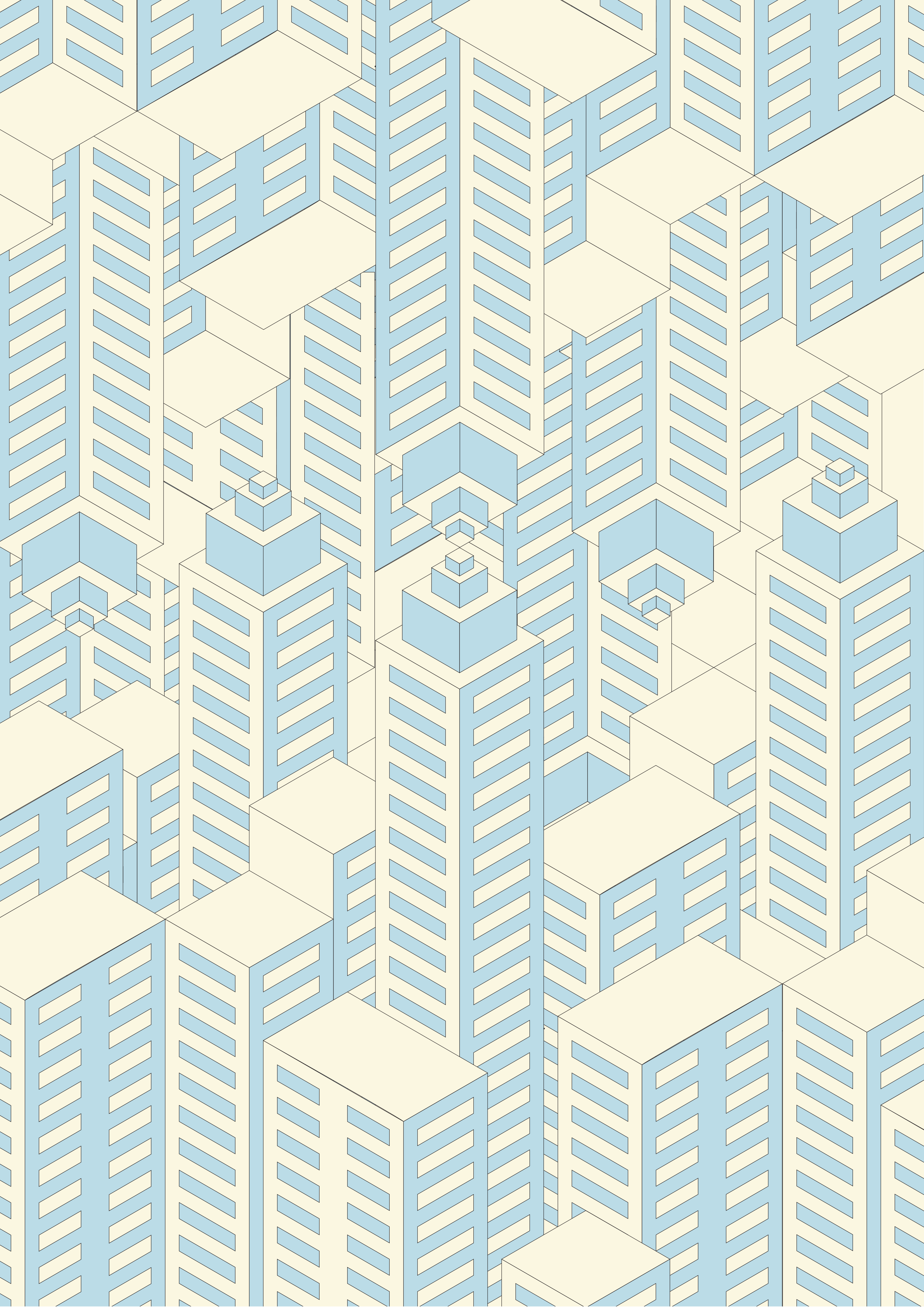
59 https://ec.europa.eu/commfrontoffice/publicopinion/index.cfm

60 Forthcoming Science for Policy Report on "Health care and long-term care workforce: Demographic challenges and potential contribution of migration and digital technology", https://publications.jrc.ec.europa.eu/repository/handle/ JRC121698.

61 https://www.europarl.europa.eu/factsheets/en/sheet/93/economic-social-and-territorial-cohesion (accessed on 30/11/2020).

62 https://cor.europa.eu/en/about/Pages/default.aspx

63 https://knowledge4policy.ec.europa.eu/territorial/topic/regional_en#Eu2020



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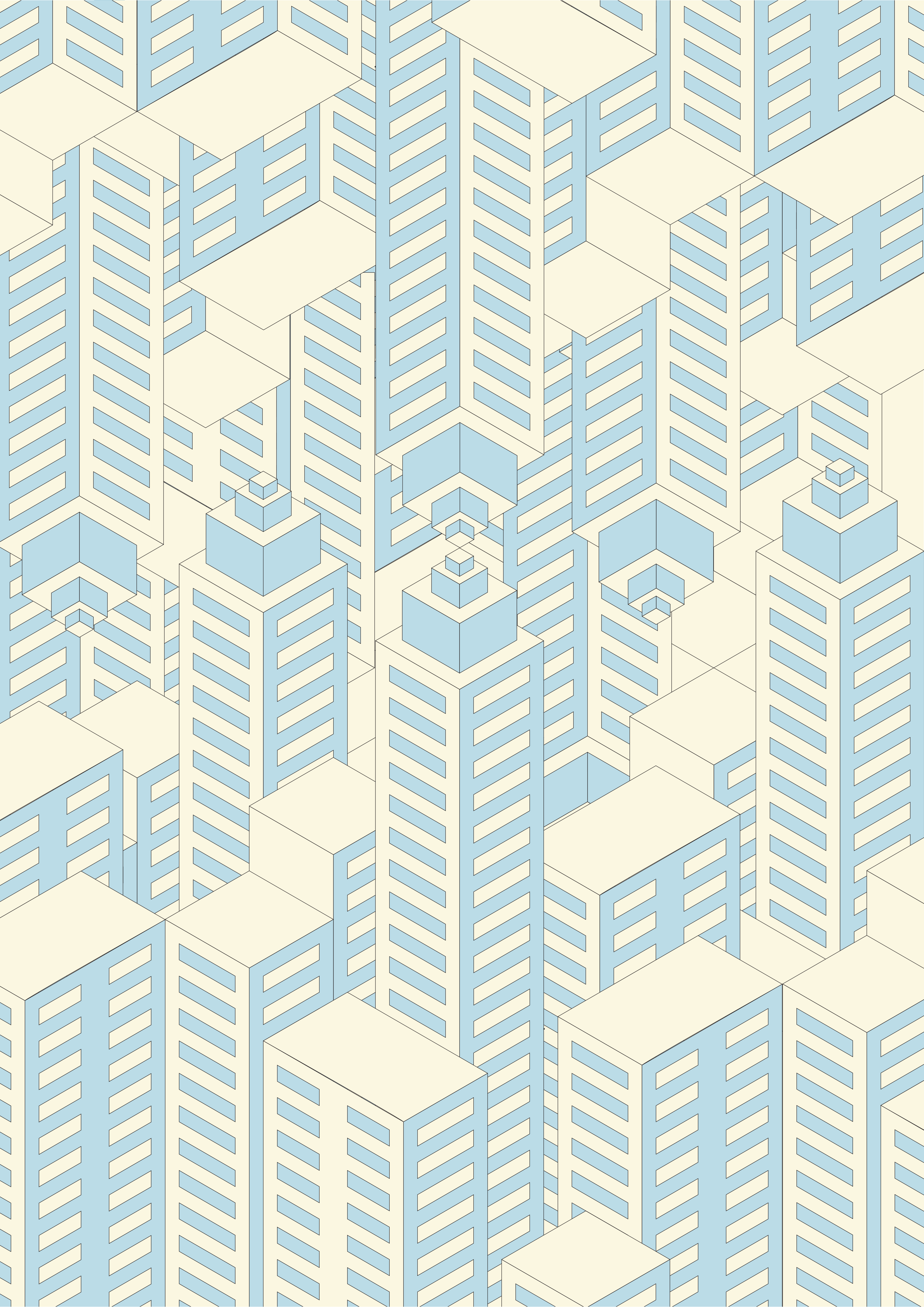


APPENDIX 1

A1.1 DOWNSCALING AND PROJECTION OF THE POPULATION BY AGE AT HIGH SPATIAL RESOLUTION

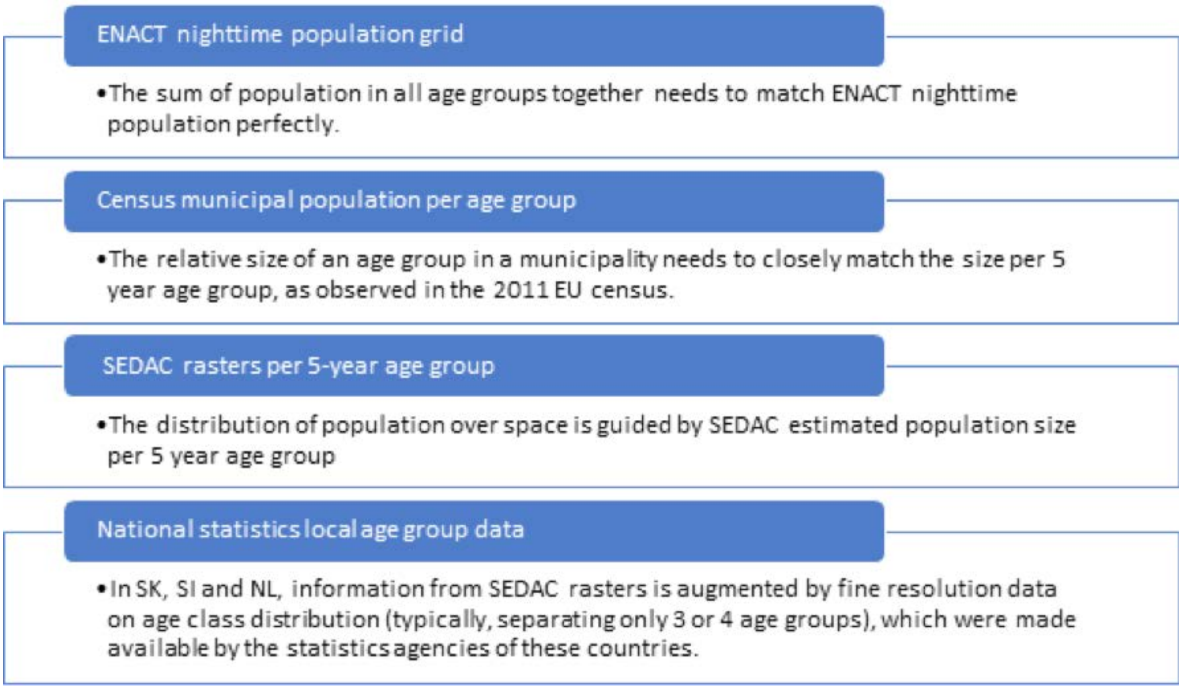
Most of the results presented in Chapter 2 are based on grid maps that indicate, for every square kilometre of land across the EU, the number of people in 5-year age groups that are expected to live there. These grid maps have been produced to describe the 2011 population distribution. The year 2011 is used here as a description of the 'current' state because it is the most recent year for which EU-wide census data are readily available. Based on the 2011 reference map, similar maps have been produced to describe the expected population distribution per five age group for the period 2012-2050.

An extensive modelling chain has been setup in order to obtain the reference and projected population grid maps. This modelling chain, its assumptions and characteristics are described in detail in Jacobs-Crisioni *et al*. (forthcoming). Relevant previous works regard prior experiments with local age-specific projections (Jacobs-Crisioni *et al*., 2020a) and the development of LUISA model population projections (Jacobs-Crisioni *et al*., 2017). Territorial population projections are based on regional population projections that EUROSTAT derived from the EUROPOP13 national population projections. The EUROPOP13 population projections were prepared for the 2015 ageing report (European Commission, 2015).[64] This section outlines the main assumptions behind the production of the 2011 baseline and the future maps of population by age group.

ESTIMATING CURRENT LOCAL POPULATION SIZE BY AGE GROUP

An extensive model has been developed to get realistic estimates of current local population size by age group. The goal of this estimating process was to get the most accurate possible estimates of EU population sizes that could be used in conjunction with LUISA in- and outputs. A number of sources were used to obtain these estimates (see Figure A1.1). As a first step, population was distributed across the EU's geography using as ancillary information 2010 gridded population of the world estimates (GPW) per 5-year age group produced

FIGURE A1.1 Sources used to generate grid maps of estimated population size per 5-year age group, and the role of each source in the generation process



64 The EUROPOP13 population projections are no longer being disseminated. In January 2021, Eurostat released population projections at NUTS3 level corresponding to EUROPOP2019, the latest baseline Eurostat population projections produced at national level and covering the time horizon from 2019 to 2100.

by ('GPW', see Doxsey-Whitfield *et al.*, 2015). Those 2010 grid data were considered the most accurate available representation of the 2011 population distribution in Europe. However, for the Netherlands, Slovakia and Slovenia, finer resolution data on population distribution per age group were available and used to augment the GPW data.

The GPW data provide a useful starting point for describing age-specific population distribution per age group but, unfortunately, are not consistent with other LUISA model inputs in terms of values and spatial characteristics. To be used in conjunction with other LUISA in and outputs, the estimates needed to be consistent with the ENACT night-time population grid map (Batista e Silva *et al.*, 2020) that is used by the population projection module in LUISA. Those ENACT maps are at a finer spatial resolution (1-hectare grid cells instead of 1 square kilometre grid cells) and, summed up, do not yield values consistent with GPW totals. To ensure harmonized LUISA inputs, grid map estimates from GPW were modified to reflect ENACT night-time grid spatial resolution and totals accurately. In addition, the grid maps need to yield an accurate description of the relative size of age groups in a local area. Relative sizes of age groups in a municipality, as recorded in the 2011 EU-wide census, were used to control the population distribution over age classes. Thus, in a second step, iterative proportional fitting routines were used to generate grid maps that would meet two conditions; 1) in terms of resolution and aggregated population, the grid maps are consistent with the ENACT night-time grids; and 2) in terms of sizes of each age group in a municipal population, the summed size of every age group in the grid maps is as consistent as possible with municipal population sizes from the EU census. Where both conditions could not be satisfied, preference was given to meet the first condition. When comparing summed population groups with ENACT population estimates, the EU wide mean absolute percentage error (MAPE) is 0.004%; the Meurthe-et-Moselle region in France (FR411) yields the highest deviations between summed population groups and ENACT estimates, with a MAPE of 0.4%. When comparing modelled and observed municipal age group sizes, errors are larger, with an overall MAPE of 2%, and MAPEs over 10% in 2 regions in Malta (namely MT001 & MT002). Further controls have shown that these sizeable MAPEs are mostly caused by aggregation errors from the 100m grid to the municipality level.

ESTIMATING FUTURE LOCAL POPULATION SIZE BY AGE GROUP

Starting from the 2011 population grids per age group, projections of local population per age five group were generated on the basis of LUISA local population projections from the Reference 2020 scenario (Jacobs-Crisioni *et al.*, 2017) and Eurostat EUROPOP13 regional population projections (European Commission, 2015). As in the generation process for the 2011 population distribution maps, these two inputs were used as mathematical constraints in an iterative fitting procedure. Additionally, averages of net migration per age group per degree of urbanisation were used to assist in modelling intraregional population movements. A full list of the sources used and the role they play in these estimates is given in Figure A1.1.

The local population projections per age group are held consistent with general local population projections from the LUISA Reference scenario 2020, so that the sum of people in all age classes should be equal to the population projections from that scenario. As a consequence, the age group projections inherit many of the assumptions behind the LUISA Reference scenario. LUISA is a complex model that is set up to measure the impacts and external effects of trend changes and EU policies through local changes in the distribution of land functions, e.g., recreational, transport, agricultural, etc. It assumes that land functions compete for most profitable locations, while those functions are related with the distribution of the residential population. LUISA's 2020 Reference scenario is based on many assumptions, of which the most noteworthy are input expectations on population size, economic growth, and the amount of space needed for specific land functions. Most assumptions in the Reference scenario 2020 follow those from the 2017 Reference scenario (Jacobs-Crisioni *et al.*, 2017), with limited updates done to the population distribution functions presented there. However, expectations regarding the future amount of land needed in a region for agricultural activities has been updated and are now based on 2019 baseline CAPRI results (for more information on the CAPRI model, see Britz and Witzke (2008)).

The process to obtain local population projections, broken down by age group, consisted of several steps that were repeated recursively for every year for which LUISA produced general population projections, i.e., 2012, 2015, 2020, up to 2050, with five-year intervals. The procedure is similar to the process outlined in Jacobs-Crisioni *et al.* (2020), with some differences that will be marked here. The procedure executed here works with 5-year age groups, rather than broad age classes as was done in the previous application. For this application, the female and male population sizes were estimated separately. Age-specific fertility rates were applied to the female population of reproductive age to obtain local births estimates; and age and gender specific mortality rates were applied to get a more accurate estimate of local number of deaths. Lastly, the attractiveness function that governs the initial distribution of population per age class was revised, now being the multiplicative result of two factors. The relative prior (i.e., in the previous timestep) size of an age class in a grid cell is a factor. That factor is modified by multiplying the relative pull of the environment in which a grid cell resides, which in turn depends on a grid cell's urbanisation level, and age class specific preferences. The pull that specific degrees of urbanisation exerts on specific age classes is proxied by regional net migration statistics, as presented in chapter 3 of this report. For the sake of the attractiveness functions described here, net migration numbers have been rescaled to values between 1 and 2. This implies for instance that areas that are considered urban, which according to net migration values exert a substantial pull on 20 to 25 year olds, have a much larger attractiveness on that age class than a rural area, even in the hypothetical case that both the urban and rural area the same percentage of the population consists of 20 to 25 year olds.

LIMITATIONS

There are a number of noteworthy limitations to the adapted methodology. Most importantly, while the used modules do model migration within a region, the destination of migrants depends only on prior population distributions and present-day net migration patterns. This implies that the mechanism is set up to reproduce current preferences into the future, and no trends breaks are assumed. In addition, the generated projections are by design consistent with regional population projections provided by Eurostat. The regional distribution of migration in those projections is mostly driven by an extrapolation of present-day net migration numbers. In the current LUISA setup, population is not allowed to spill-over (i.e., migrate) to neighbouring regions, even if due to e.g., high pressure on space, such spill overs are plausible. Thus, the produced maps need to be understood as reflecting what would happen if present-day patterns of ageing and net migration remain.

A1.2 REGRESSION RESULTS AND STATISTICAL TESTS ON CONVERGENCE AND DIVERGENCE IN THE SHARE OF ELDERLY AT LAU LEVEL

Table A1.1 Regression model for the share of elderly in LAU shows the results of a series of regression models testing the association between the share of elderly in LAU and their classification according to the urban-rural regional typology (model 1), if they are in areas experiencing a decrease population (model 2) and in mountain areas (model 3). The data include the 2011 population statistics from the Census and our projections for 2015, 2020, 2030 and 2050. The three independent variables are also tested in interaction with time (models 4-6) to see if their effects on the share of elderly are expected to expand in the future.

The results of the regression model 1-3 indicate that after controlling for country characteristics, the overall population size, and year, the share of elderly is higher in rural areas (4.2 pp greater than in cities), in areas experiencing depopulation (2.0 pp greater than in areas with population increase) and in mountain areas (2.0 pp greater in respect of other areas).

TABLE A1.1 Regression model for the share of elderly in LAU

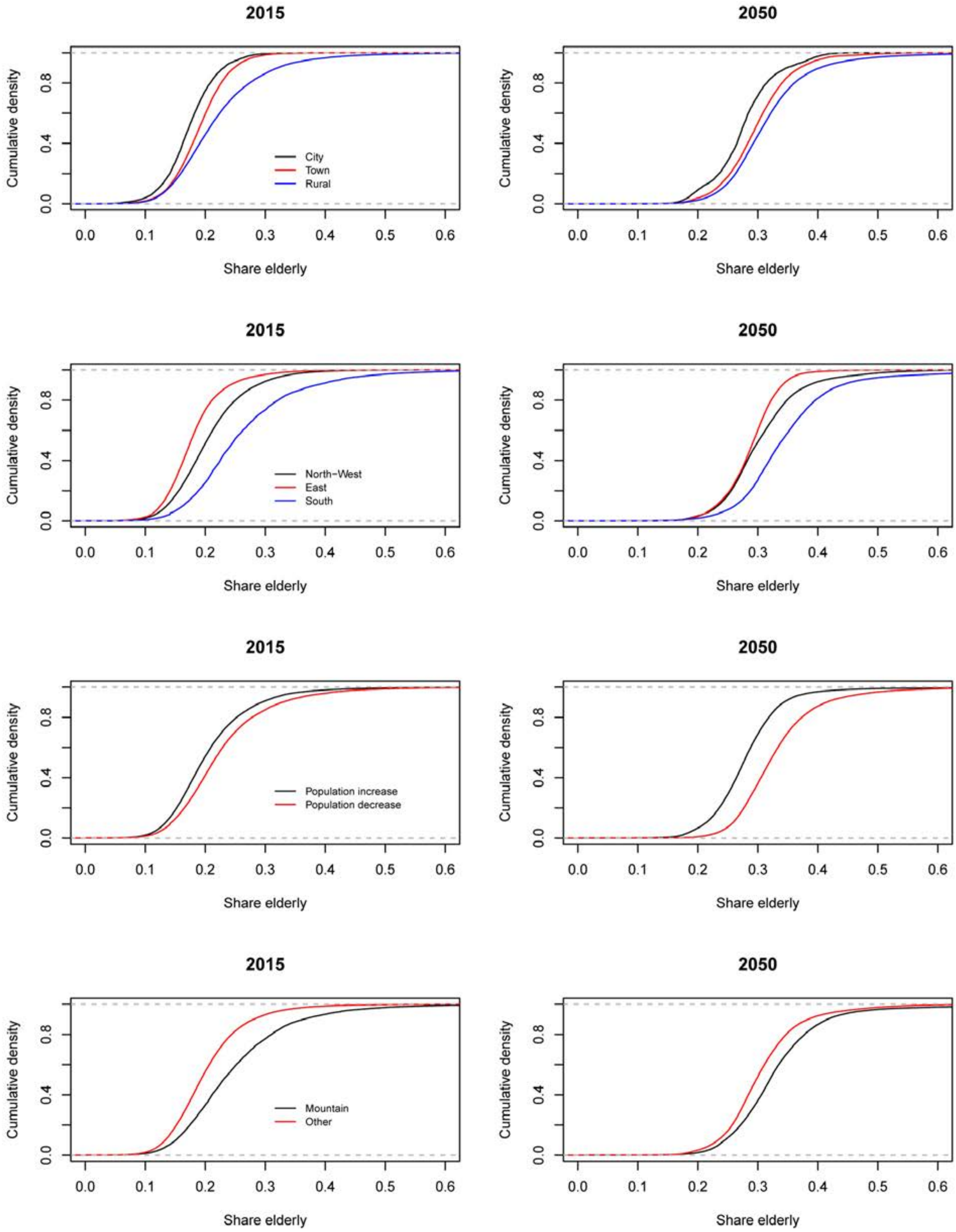
	Share of elderly in LAUs 2011-2050					
	(1)	(2)	(3)	(4)	(5)	(6)
Town	0.008***	0.007***	0.006***	−0.120	0.006***	0.006***
	(0.001)	(0.001)	(0.001)	(0.088)	(0.001)	(0.001)
Rural	0.042***	0.039***	0.038***	0.434***	0.037***	0.038***
	(0.001)	(0.001)	(0.001)	(0.079)	(0.001)	(0.001)
Year	0.003***	0.003***	0.003***	0.003***	0.002***	0.003***
	(0.00001)	(0.00001)	(0.00001)	(0.00004)	(0.00001)	(0.00001)
Population	−0.00000***	−0.00000***	−0.00000***	−0.00000***	−0.00000***	−0.00000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Depopulation		0.019***			−2.231***	
		(0.0002)			(0.033)	
Mountain			0.021***			1.138***
			(0.0003)			(0.034)
Town by year				0.0001		
				(0.00004)		
Rural by year				−0.0002***		
				(0.00004)		
Depopulation by year					0.001***	
					(0.00002)	
Mountain by year						−0.001***
						(0.00002)
Observations	387,905	387,905	387,905	387,905	387,905	387,905
R^2	0.404	0.415	0.413	0.404	0.422	0.415
Adjusted R^2	0.404	0.414	0.413	0.404	0.422	0.415

Note: *p<0.1; **p<0.05; ***p<0.01

The interactions with time in the models 4-6 show that the gaps are expanding over time for depopulating areas (0.1 pp every year) more than for rural areas (0.02 pp every year) and narrowing in the case of mountain areas (-0.1 pp every year).

Figure A1.2 shows the distributions of the share of elderly in LAU in 2015 and 2050 according to their categorisation by the following four criteria: the belonging to the three classes of the urban-rural regional typology, the belonging to three EU macro-regions of North-West, East and South Europe, the change in overall population in respect of previous year and if they are in mountain areas. This representation of the data gives a more comprehensive view in respect of the simple comparison of median values.

FIGURE A1.2 Empirical Cumulative Distribution Functions (ECDF) of the share of elderly in LAU (2015, 2050) by three classes of the urban-rural regional typology, EU macro regions, and changes in population



In particular, it allows to appreciate differences not only for intermediate values of the share of elderly, but also for the lower and higher values, along the entire distribution. From the comparison of the distance between the lines in 2015 and 2050, it is possible to assess whether distributions are diverging or converging. This visual comparison of distributions across groups and years is confirmed by statistical tests (Kolmogorov-Smirnov Tests) which allow reaching the following conclusions:

- the share of elderly in rural LAU are greater than in cities and this difference would be shrinking between 2015 (0.29, $p < 0.01$) and 2050 (0.26, $p < 0.01$) (convergence);
- the share of elderly in LAU in southern Europe are greater than in eastern Europe and this gap would be shrinking between 2015 (0.48, $p < 0.01$) and 2050 (0.37, $p < 0.01$) (convergence);
- the share of elderly in LAU with decreasing population is greater than with in those with increasing population and this gap would be expanding between 2015 (0.12, $p < 0.01$) and 2050 (0.32, $p < 0.01$) (divergence);
- in the case of mountain areas, differences in the distribution in respect of other areas are small and not statistically significant for both years.

A1.3 AGEING AND DISTANCE TO FUNCTIONAL AREAS AND POPULATION DENSITY – ADDITIONAL MATERIAL

FIGURE A1.3 Changes in the share of elderly, (in red) and in the share of children and adolescents (in blue) with the distance from the centre of functional areas in Sweden, Denmark, Spain, the Netherlands, Lithuania, Estonia, Austria, Ireland, Finland, Slovenia, Latvia, Hungary

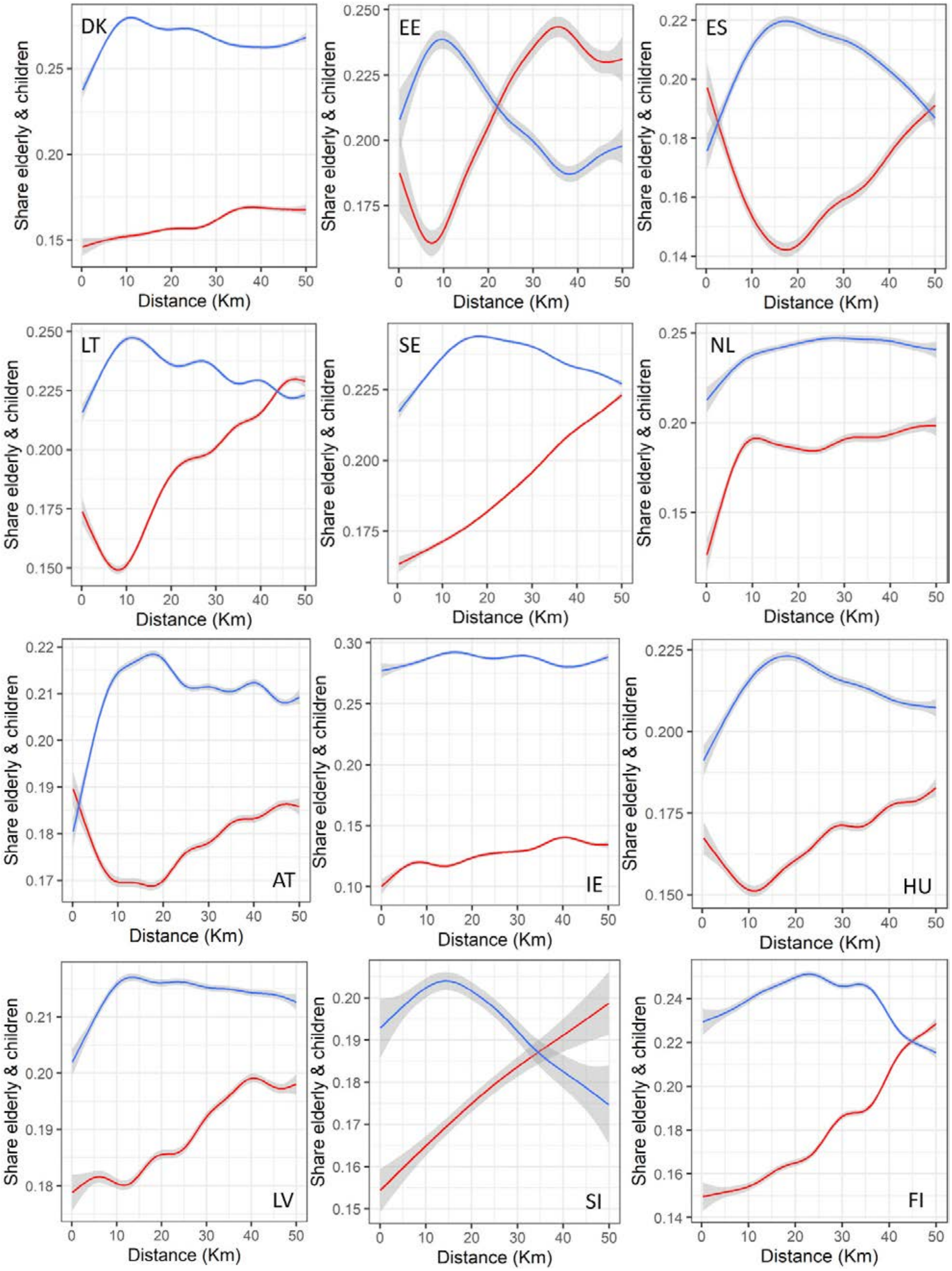
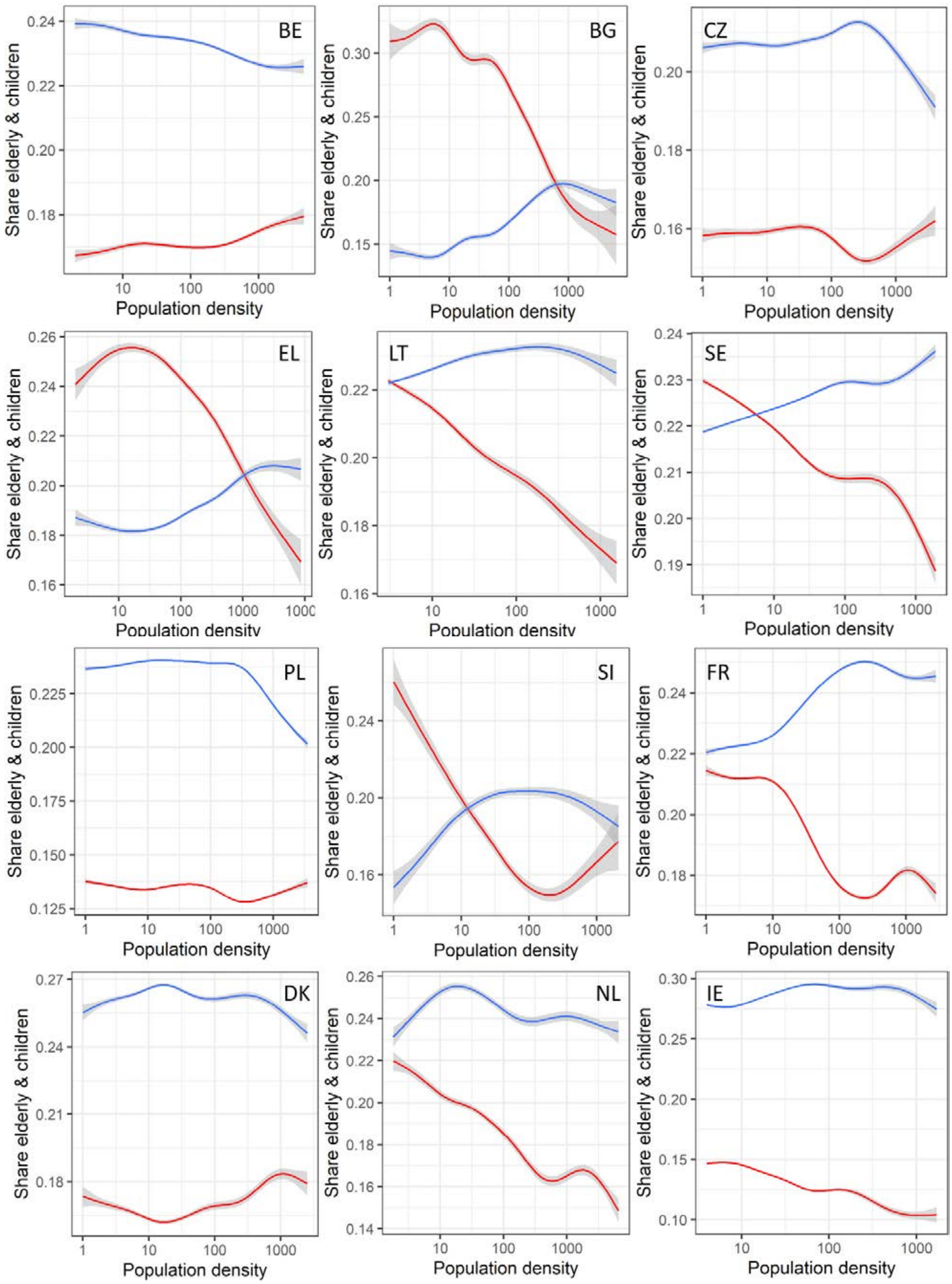


FIGURE A1.4 Changes in the share of elderly (in red) and in the share of children and adolescents (in blue) with the increase of population density in Belgium, Bulgaria, Czechia, Lithuania, Greece and Sweden, Poland, Slovenia, France, Denmark, Ireland and the Netherlands



A1.4 ADDITIONAL MATERIAL ON MOUNTAIN AREAS

FIGURE A1.5 Population living in mountain areas by age group and Member State (2015), and change of the population in mountain areas by age group and Member State between 2015 and 2050

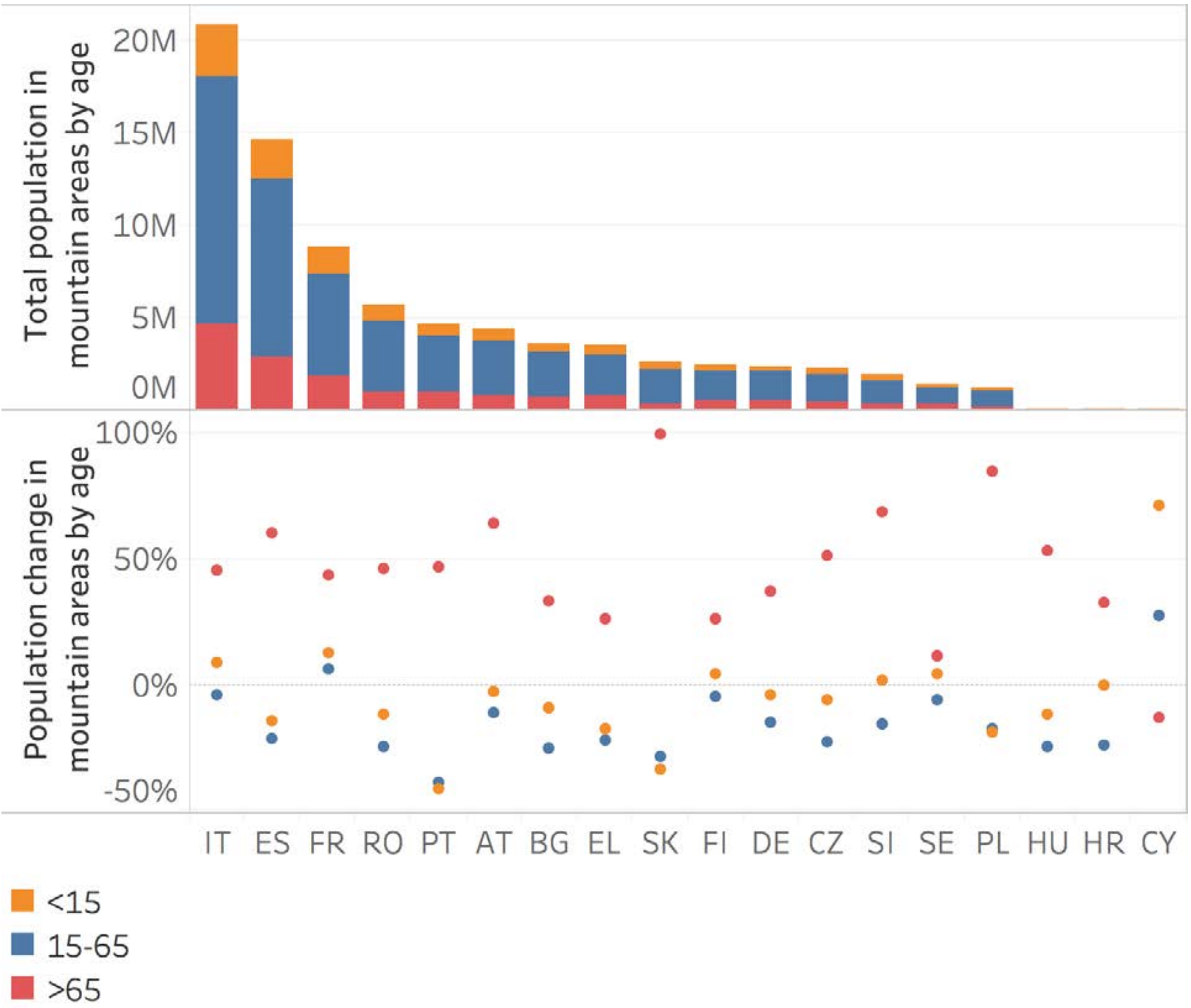


Figure A1.5 presents the population living in mountain areas by Member State differentiated between the three age cohorts in 2015. The picture is highly variable across EU Member States with Italy, Spain and France in the top of the ranking accounting, all together, for more than half of the total EU mountain population, opposite to the particularly low population in Hungary, Croatia and Cyprus. Between 2015 and 2050, the elderly population is projected to increase slower in Sweden, Finland and Greece, staying below 30%. Looking at the working age population, France is the only Member State with a positive trend with an increase about 6% (more than 805 thousand people) by 2050. All the other EU Member States would see an important decrease in this essential group in terms of economic growth. Portugal is expected to lose more than 1.2 million people in working age population (39%), followed by Slovakia (28.2%), Bulgaria (25%), Hungary (24.8%) and Romania (24.7%). For the children, the largest growth in mountain areas is projected for France (200 thousand people, equal to 13%) and Italy (252 thousand people, equal to 9%), followed by Sweden and Finland.

APPENDIX 2

FIGURE A2.1 Cohort turnover and net migration changes across EU regions by gender
Note: red circles represent female working age population, blue circles represent male working age population; on x-axis, the relative change (%) of the net migration in the specific NUTS3 subregion; on y-axis, the relative change (%) of cohort turnover

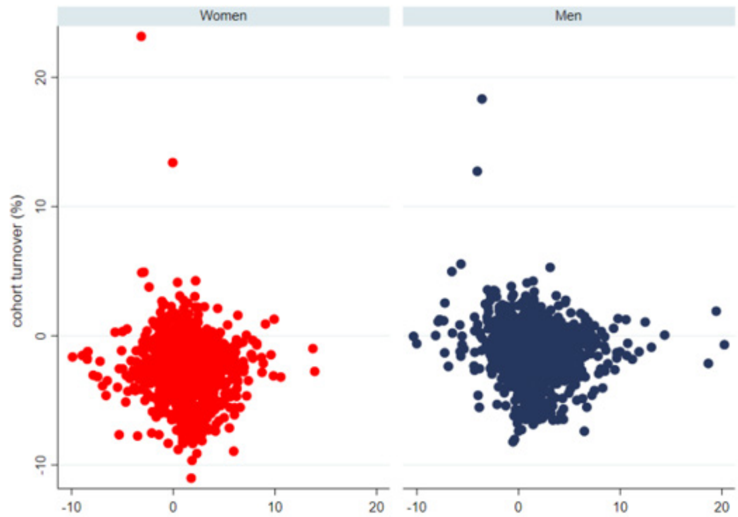


FIGURE A2.2 Cohort turnover and net migration changes across EU regions by Member State and gender
Note: blue circles represent male relative changes and red circles represent female relative changes; on x-axis, the relative changes of the net migration on the working age population in the specific Member State; on y-axis the correlated relative changes of the cohort turnover on the working age population in the specific Member State. Each circle corresponds to a NUTS3 sub-region within the Member State.

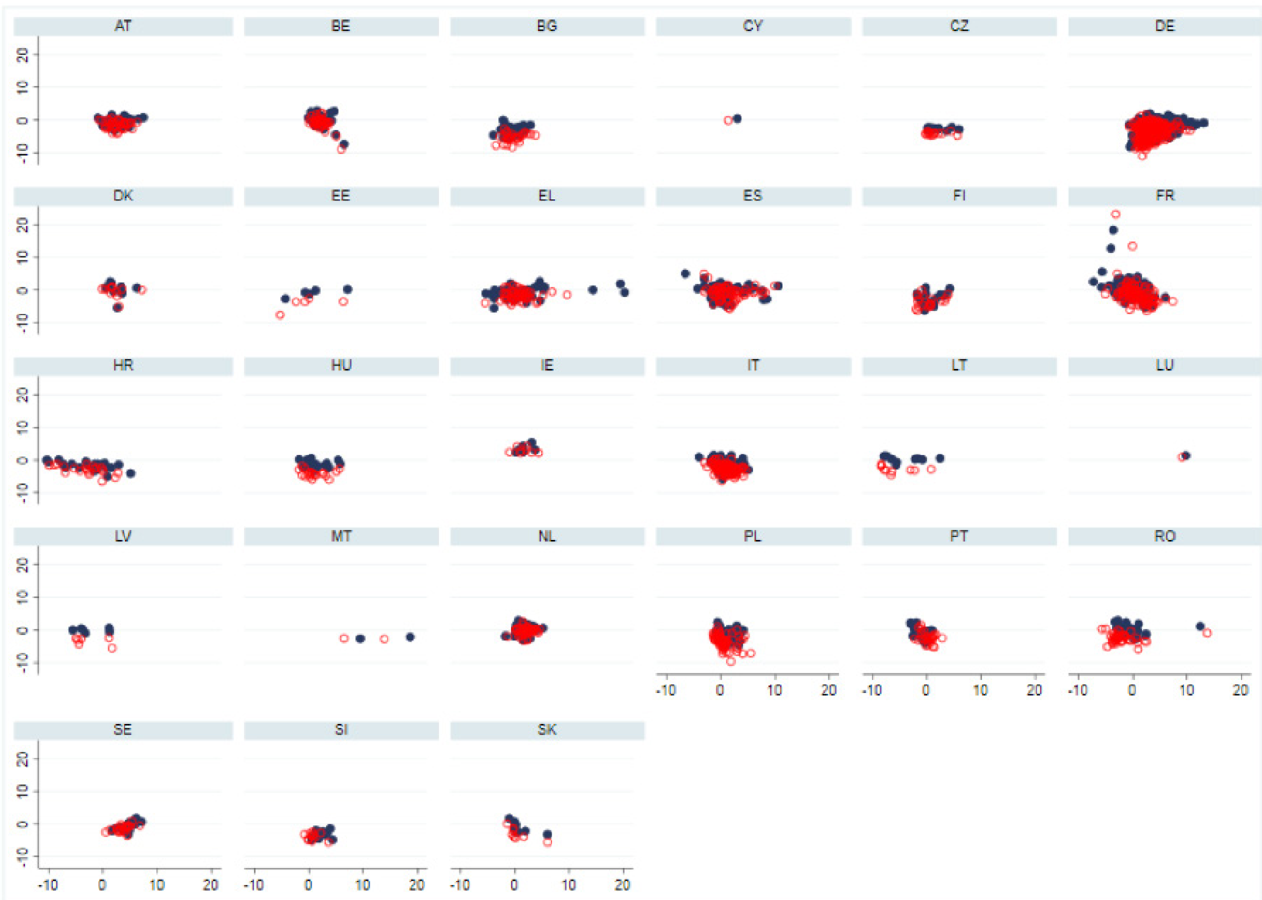


FIGURE A2.3 Cohort turnover and migration effects across urban, intermediate and rural EU regions in selected EU Member States
Note: blue bars represent urban regions, red bars represent rural EU regions and grey bars represent intermediate regions; on x-axis, the relative changes of the net migration in the specific region (urban, rural and intermediate); on y-axis the correlated relative changes of the cohort turnover. For example, in Sweden, rural regions (red bar) report the following changes: -1.7% as cohort turnover, +4% as net migration component.

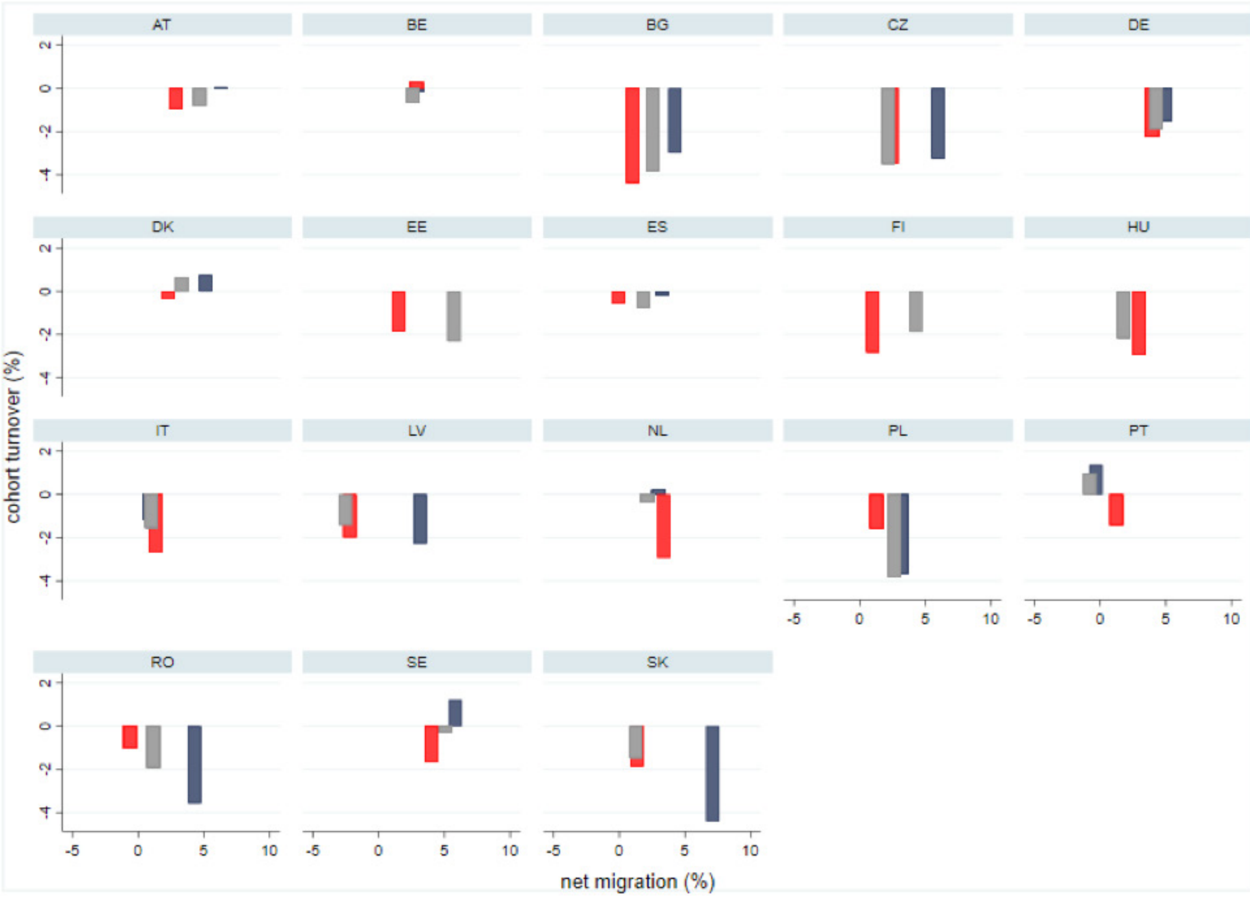
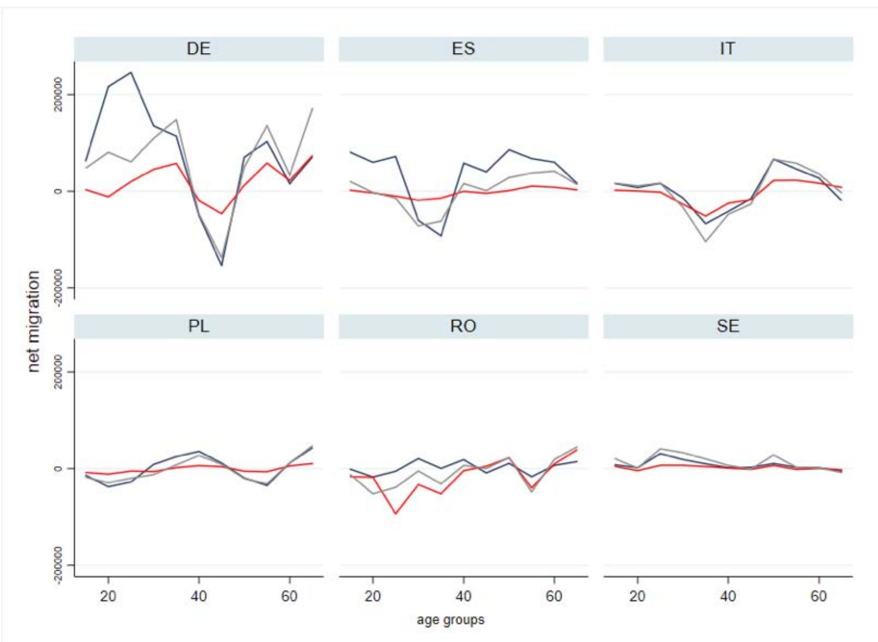


FIGURE A2.4 Net migration across urban, intermediate and rural EU regions in selected EU Member States, 2015-19
Note: blue lines represent urban regions, red lines represent rural regions and grey lines represent intermediate regions; on x-axis, 5-year age groups (15 to 64 years).



A2.1 PRELIMINARY VALIDATION ANALYSIS OF ESTIMATED NET MIGRATION TRENDS

The analysis is conducted using official statistics by Eurostat on immigration and emigration flows by Member State and age group (data sources: migr_emi1ctz and migr_imi1ctz). We extract annual data for 15-64 age groups from 2015 to 2018; for 2019, estimated value is derived as 2017-18 average. The example below refers to Belgian and German datasets.

Out-flows (emigration) are subtraced from in-flows (immigrantion) to obtain the net migration balance which is compared with our estimated value using the indirect method. In the case of Belgium, the estimated value is 2% higher than the Eurostat value, while for Gemany the divergence rises to 10%. However, it should be noted that, for both cases, estimated net migration balance, which is derived from the aggregation of the NUTS3 values, is within the 95% confidential interval range.

TABLE A2.1 Comparison between Eurostat and estimated data for migration, Belgium and Germany

		Eurostat data				Estimated	Period
		2015	2016	2017	2018	2019	2015-19
Belgium	Emigration	20213	20026	15989	15830	15909	87968
	Immigration	52814	36446	38259	44119	41189	212827
	Net migration	32601	16420	22270	28289	25280	124860
	Indirect method 95% CI						126854 84560 169147
Germany	Emigration	80247	116829	128521	111288	119904	556790
	Immigration	770369	388184	308941	301161	305051	2073706
	Net migration	690122	271355	180420	189873	185147	1516917
	Indirect method 95% CI						1693694 1484119 1903270

APPENDIX 3

A3.1 PARIS CASE-STUDY: DATA DESCRIPTION AND METHODS

AMENITIES

Regarding the information about urban amenities, the data set employed in this work contains records about their spatial location in Paris. Each record is a Point of Interest (POI) representing an urban amenity and containing several attributes associated with it, such as the name and address, the type of amenity, the geographical coordinates (lat/long). Data have been collected in 2018 through the Google Maps API and have been gathered to cover the entire municipality of Paris (see Figure 26 in section 4.3.2).

In this work, we employed a selection of these attributes to perform the analysis:

- a unique ID identifying the amenity;
- the classification of the amenity (typology), assigned by the provider and common amongst all the cities (i.e., bar','restaurant', 'shop', or more specific as 'football field')
- the geographical location (geographic coordinates identified by latitude and longitude)

Amenities are consistently categorised by the provider. We grouped the different amenity typologies into 12 macro-categories (accommodation, attraction, city services, culture and entertainment, eating-out, health and hospitals, parks, schools and education, shop for food, shop for goods, social services, and sport facilities) filtering the observations based on their relevance in terms of urban function, that might be particularly relevant for unveiling spatial patterns of human mobility in cities. To obtain results at a spatial unit comparable with previous work and data, we used a 500 metres square grid covering the city, and we associated the amenities contained within each cell with a spatial join.

To unveil the similarity of spatial patterns of amenity distribution within the city, we employed an unsupervised learning technique applied to the grid cells, analysing how similar they are about the variety of amenities. For spatial pattern similarity, the cluster algorithm assigns each spatial unit of the grid to a specific class according to the similarity of amenities within each unit in terms of the variety of amenity typologies and the number of amenities for each typology (see Figure A3.1).

POPULATION

Information regarding the distribution of elderly population for the city of Paris has been collected through the IRIS data source and spatial units (https://geocatalogue.apur.org/catalogue/srv/fre/catalog.search#/metadata/urn:apur:iris_od) associated to the Census values for 2015: https://www.insee.fr/fr/statistiques/3627376

Data are selected for the total population and for the elderly population in each spatial unit. Values were joined to the correspondent IRIS spatial area. In order to have values comparable to the spatial unit of the amenity data set, the population data were spatially associated to the grid transforming each cell in a centroid and associating the population value for that point on the IRIS area to each centroid. If the centroid was intersecting more IRIS areas, the mean was calculated. At the end of the spatial analysis, each centroid corresponding to the grid cells was carrying a number of attributes useful for spatial comparison to amenity distribution (see Figure 26 in section 4.3.2):

- the ID of the cell;
- the label of each cell from the unsupervised learning of amenity distribution;
- the number of people aged 65 years and over located in the cell;
- the share of people aged 65 years and over in the cell;
- the Jenks natural breaks class associated with the number of people aged 65 years and over in the cell;
- the Jenks natural breaks class associated with the share of people aged 65 years and over in the cell.

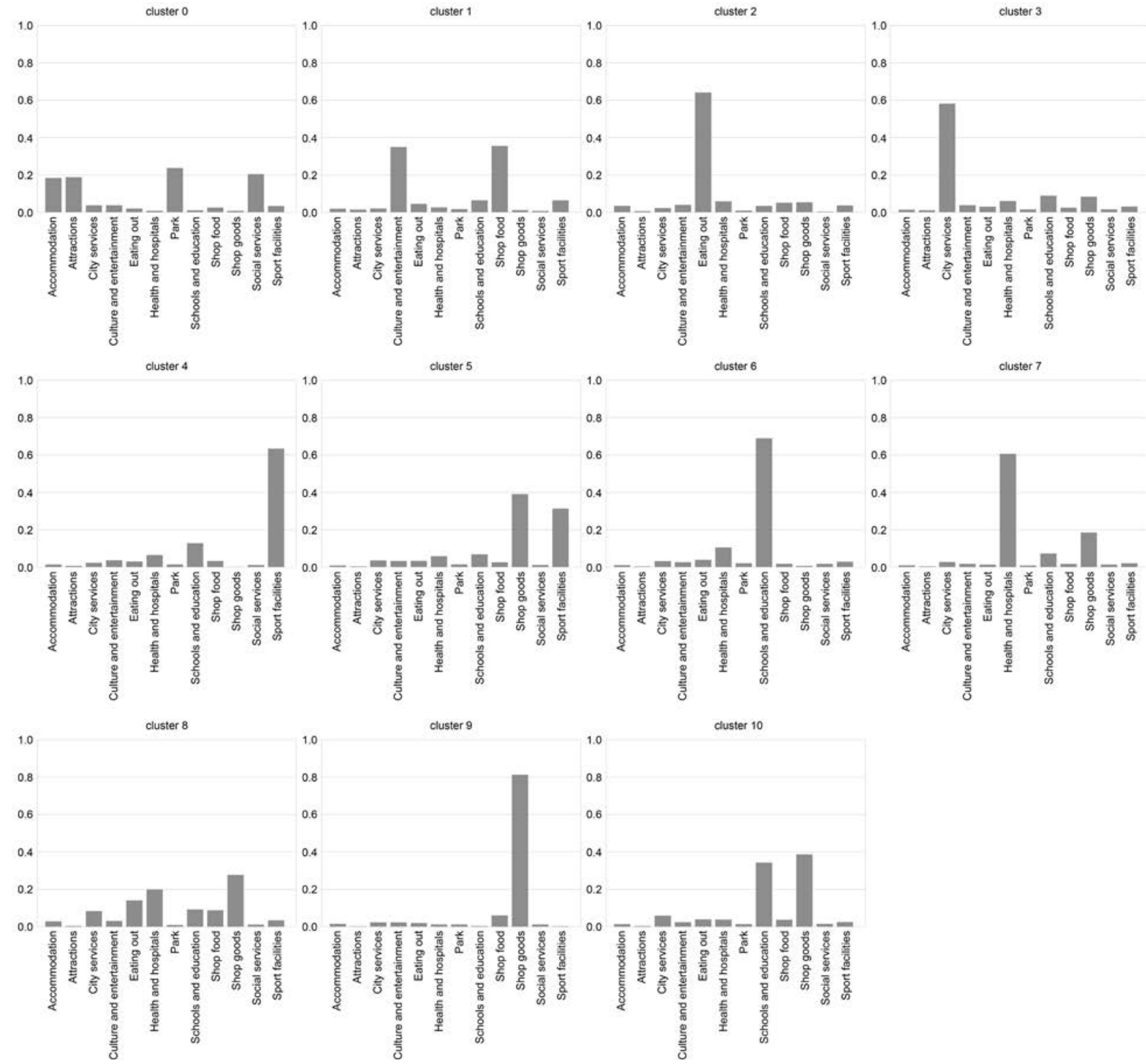
For this preliminary analysis, we employed two sets of classes, for the number and share of elderly. Both the classes are used in the analysis to observe significant differences in comparison to the labels of amenity distribution. Furthermore, Jenks natural breaks classification methodology is preferred to other methods as it highlights the differences between classes and minimises those within the same class (to obtain more homogeneous classes, as this is also the aim of unsupervised learning applied to the amenity dataset).

COMPARISON OF SPATIAL CLASSIFICATIONS

The focus of this specific analysis is not to evaluate the dependence between the population and a specific amenity (which can be explored in the following phase), but to observe and compare the patterns of the spatial distribution of elderly and typologies of amenities located in the same areas.

To make this comparison, one option is to check the recurrent association of two classes/categories in the same grid cell. In this way, it is possible to spatially compare the distribution of elderly (number and share) and the distribution of amenity typologies in each cell. This

FIGURE A3.1 Distribution of amenity typologies for label 0 to 10 (different areas in the city are classified into different groups according to the predominance of specific amenity typologies)



allows obtaining a descriptive understanding of the spatial characteristics of areas, for example of the amenities available at a short distance to the elderly population living in Paris. This analysis may be extended also taking into consideration the surrounding cells.

To compare two sequences of classes, we employ a confusion matrix (also called matching matrix in the case of unsupervised learning), often used to visualise the performance of the algorithm comparing actual and predicted classes at the end of the classification process. In this case, we apply it to compare the association between categories assigned to the same grid cell: the algorithm counts each time the same pair of classes are associated, to observe the relationship between the distribution of elderly in the city and the variety of amenities. The confusion matrix is calculated for different combinations of classes:

- classes for people aged 65 years and over and the labels of amenity distribution;
- classes for the share of people aged 65 years and over and the labels of amenity distribution.

APPENDIX 4

BOX A4.1 Gross Domestic Product and Labour Productivity

To estimate the local economic outputs, we use the Gross Domestic Product (GDP) and Labour Productivity

The main data source is Eurostat and for the GDP we employ the variable *nama_10r_3gdp*, while for the labour productivity we use the gross value added (*nama_10r_3gva*) and total employment (head count) (*nama_10r_3empers*).

The GDP is the main aggregate to measure the economic output of a region. It is presented per inhabitant and is therefore a proxy of the average standard of living. GDP per inhabitant is expressed in purchasing power standards (PPS) compared to the EU average. PPS series have a levelling effect for the price level, as provinces with high GDP per inhabitant tend to have relatively high price levels (the cost of living in Luxembourg is generally higher than in Sofia).

Labour productivity is measured by the gross value added divided by a measure of labour input, i.e. the number of persons employed. It is an indicator of local competitiveness and efficiency models. GVA is defined as output (at basic prices by NUTS3 regions) minus intermediate consumption (at purchaser prices); GVA can be broken down by industry and institutional sector. The sum of GVA over all industries or sectors plus taxes on products minus subsidies on products gives the gross domestic product. In the labour productivity analysis, France is excluded because it lacks employment information at NUTS3 level.

For both dependent variables, we use their logarithmic transformation in the regressions.

TABLE A4.1 The relationship between demographic structure and GDP per capita in the EU at NUTS3 level
Note: The reported results are based on panel fixed effects model. The dependent variable is log GDP per capita pps. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1; FE stands for fixed effects.

VARIABLES	Total Sample	Pop growth		Net migration		Prevailing type of settlement		
		Positive	Negative	Positive	Negative	Urban	Intermediate	Rural
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WAP2534	-0.002	0.007	-0.020***	0.010	-0.016***	0.010	0.004	-0.017***
	(0.004)	(0.007)	(0.006)	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)
WAP3544	0.003	0.014**	-0.027***	0.013***	-0.023***	0.016**	0.015***	-0.025***
	(0.004)	(0.005)	(0.006)	(0.005)	(0.008)	(0.007)	(0.006)	(0.007)
WAP4554	0.012***	0.013*	-0.007	0.017***	-0.003	0.024***	0.021***	-0.006
	(0.004)	(0.007)	(0.006)	(0.006)	(0.008)	(0.009)	(0.007)	(0.006)
WAP5564	-0.000	0.011*	-0.030***	0.013**	-0.029***	0.009	0.012**	-0.019***
	(0.004)	(0.006)	(0.007)	(0.006)	(0.007)	(0.009)	(0.006)	(0.005)
OADR	0.023***	0.014	0.050***	0.012	0.016	-0.004	-0.001	0.064***
	(0.006)	(0.012)	(0.010)	(0.008)	(0.010)	(0.013)	(0.009)	(0.011)
OADR sq	-0.000***	-0.000	-0.001***	-0.000	-0.000**	0.000	0.000	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
TFR	0.039***	0.018	0.006	0.018	0.007	-0.018	0.031*	0.049***
	(0.011)	(0.013)	(0.021)	(0.011)	(0.021)	(0.023)	(0.018)	(0.015)
Diversity Index	0.009***	0.010**	0.002	0.005	0.006***	0.014*	0.004	0.007***
	(0.002)	(0.005)	(0.003)	(0.004)	(0.002)	(0.009)	(0.004)	(0.002)
2015.year	0.019***	0.019***		0.015***	0.035***	0.022***	0.020***	0.013***
	(0.002)	(0.003)		(0.002)	(0.005)	(0.003)	(0.003)	(0.004)
2016.year	0.041***	0.040***	0.024***	0.036***	0.071***	0.046***	0.049***	0.028***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.010)	(0.006)	(0.005)	(0.007)
2017.year	0.078***	0.070***	0.065***	0.068***	0.129***	0.080***	0.087***	0.060***
	(0.004)	(0.006)	(0.009)	(0.006)	(0.014)	(0.008)	(0.007)	(0.010)
Constant	8.511***	8.135***	10.369***	8.398***	10.428***	8.003***	8.564***	9.316***
	(0.338)	(0.676)	(0.507)	(0.546)	(0.594)	(0.884)	(0.550)	(0.443)
Observations	4,132	2,722	1,408	2,799	1,330	868	1,886	1,366
R-squared	0.661	0.592	0.716	0.641	0.717	0.675	0.652	0.707
NUTS3 groups	1,071	1,025	609	837	522	224	485	359
NUTS3 FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

TABLE A4.2 The relationship between demographic structure and Labour productivity in the EU at NUTS3 level
Note: The reported results are based on panel fixed effects model. The dependent variable is log Labour productivity. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

VARIABLES	Total Sample	Pop growth		Net migration		Prevailing type of settlement		
		Positive	Negative	Positive	Negative	Urban	Intermediate	Rural
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WAP2534	0.008*	0.018***	-0.005	0.017***	-0.002	0.016**	0.016***	-0.007
	(0.004)	(0.006)	(0.007)	(0.006)	(0.007)	(0.008)	(0.006)	(0.007)
WAP3544	0.009**	0.021***	-0.012	0.023***	-0.016*	0.015**	0.019***	-0.014**
	(0.004)	(0.005)	(0.008)	(0.005)	(0.009)	(0.006)	(0.006)	(0.007)
WAP4554	0.005	0.009	-0.009	0.010*	-0.006	0.007	0.014**	-0.009
	(0.005)	(0.007)	(0.008)	(0.006)	(0.009)	(0.009)	(0.006)	(0.006)
WAP5564	-0.013***	0.008	-0.038***	0.007	-0.042***	-0.011	-0.001	-0.026***
	(0.004)	(0.006)	(0.009)	(0.006)	(0.009)	(0.009)	(0.006)	(0.006)
OADR	0.024***	0.007	0.060***	0.014*	0.019	0.006	0.002	0.063***
	(0.006)	(0.012)	(0.014)	(0.008)	(0.012)	(0.014)	(0.009)	(0.014)
OADR sq	-0.000**	-0.000	-0.001***	-0.000	-0.000	-0.000	0.000	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
TFR	0.089***	0.042***	0.046*	0.051***	0.080***	0.017	0.080***	0.089***
	(0.012)	(0.014)	(0.025)	(0.011)	(0.026)	(0.025)	(0.021)	(0.017)
Diversity Index	0.021***	0.010**	0.012***	0.010**	0.021***	0.011	0.008	0.023***
	(0.003)	(0.005)	(0.004)	(0.005)	(0.003)	(0.009)	(0.006)	(0.002)
2015.year	0.021***	0.022***		0.022***	0.027***	0.026***	0.021***	0.017***
	(0.002)	(0.003)		(0.003)	(0.006)	(0.004)	(0.003)	(0.004)
2016.year	0.038***	0.039***	0.018***	0.039***	0.055***	0.042***	0.041***	0.030***
	(0.003)	(0.004)	(0.005)	(0.004)	(0.012)	(0.007)	(0.005)	(0.006)
2017.year	0.071***	0.062***	0.055***	0.065***	0.106***	0.071***	0.075***	0.059***
	(0.005)	(0.006)	(0.011)	(0.006)	(0.017)	(0.009)	(0.007)	(0.009)
Constant	8.249***	8.694***	9.535***	8.602***	9.507***	9.452***	8.876***	8.479***
	(0.360)	(0.609)	(0.660)	(0.557)	(0.715)	(0.856)	(0.592)	(0.522)
Observations	4,114	2,715	1,397	2,791	1,320	866	1,880	1,356
R-squared	0.559	0.540	0.579	0.577	0.619	0.534	0.529	0.656
NUTS3 groups	1,062	1,021	603	833	517	223	482	354
NUTS3 FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

APPENDIX 5

TABLE A5.1 Geographical entity used for Figure 37 on turnout rates
Note: for most states, geographical entities are LAUs, but in some cases they are other type of entities (e.g., Germany). For a fuller description of the data, please visit https://ec.europa.eu/regional_policy/en/information/publications/working-papers/2018/the-geography-of-eu-discontent.

Country	Geographical entity
AT	LAU/Other
BE	LAU/Other
BG	LAU/Other
CY	LAU/Other
CZ	NUTS3
DE	LAU/Other
DK	LAU/Other
EE	LAU/Other
EL	NUTS3
ES	LAU/Other
FI	LAU/Other
FR	LAU/Other
HR	LAU/Other
HU	NUTS3
IE	LAU/Other
IT	LAU/Other
LT	LAU/Other
LU	LAU/Other
LV	LAU/Other
MT	NUTS3
NL	LAU/Other
PL	LAU/Other
PT	LAU/Other
RO	NUTS3
SE	LAU/Other
SI	LAU/Other
SK	LAU/Other
UK	LAU/Other

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