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Age patterns of net migration and urbanisation dynamics across European municipalities

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Abstract

Across the European Union (EU) Local Administrative Units (LAUs), populations are experiencing persisting differences in their age structures that can only be interpreted accounting for migration and mobility components. Yet, in the absence of census data, migration patterns of local populations are not available from EU-official statistics. To fill the gaps, we firstly combine census data with statistics available from the National Statistical Institutes of the EU-Member Sates in a harmonised database on age-specific population structures, covering all EU-LAUs for the period 2011–2019. Secondly, we apply model life tables to assess changes by cohort over the intercensal period and provide estimates of age-specific net migration rates at LAU levels. The analysis reveals how migration dynamics vary along demographic patterns and to what extent differences are related to the degree of urbanisation and territorial characteristics (distance from city centres, remoteness, population change, GDP per-capita and poverty level) across the EU municipalities.

KEYWORDS

degree of urbanisation, Local Administrative Units, municipalities, net-migration

1 | INTRODUCTION

The assumption that the European Union (EU) countries are converging from a demographic perspective is one of the main underlying hypotheses of the demographic projections released by EUROSTAT (2020a). However, when looking at a finer territorial classification, persisting territorial and demographic differences become evident across EU regions (Goujon et al., 2021; Kashnitsky et al., 2020). Beside the impacts of increased longevity and lesser fertility, the key-role of international migration and internal mobility in demographic changes has been assessed both in theoretical and empirical analyses. Authors have argued that the earlier stages of urban transition were driven by internal rural to urban mobility (Davis, 1965; De Vries, 2013; Dyson, 2011; Rowe et al., 2019), while more recent counter-urbanisation trends have been characterised by urban to rural reverse movements. Although van den Berg et al. (1982) have described three consecutive stages of urbanisation, suburbanisation and counter-urbanisation and a hypothetical fourth stage of reurbanisation strictly following a sequential order, recent dynamics of urbanisation outline a more stratified picture of the EU, with the coexistence of shrinking and expanding cities due to suburbanisation and reurbanisation processes (Kabisch & Haase, 2011).

Studies have revealed the plurality of net migration age-specific profiles across subregions, which are mostly explained by the economic attractiveness of places and the availability of services and amenities (Goujon et al., 2021). As confirmed by the recent EU initiatives, like the Long-Term Vision for Rural Areas (EC, 2020), these dynamics have important implications, not only for the depopulation trends of rural areas and economic development of urban places, but also for political and social cohesion at the local level.

To explore the role played by territorial characteristics, empirical analyses should consider differences in age structure at municipality or finer local levels (Gutiérrez Posada et al., 2018; Sabater et al., 2017). For instance, Gutiérrez Posada et al. (2018) have measured the spatial heterogeneity of population ageing in Spanish Local Administrative Units (LAUs): several cities are ageing at a slower pace than rural LAUs, but opposite effects are also detected, particularly in more economically active areas (such as the North-eastern regions on the Ebro). Nevertheless, gaps in data availability have limited the analyses to given spatial and temporal coverages. Furthermore, when looking at future scenarios, municipalities are projected to become more and more relevant: the share of population living in urban areas is expected to increase from 55% in 2018 to 68% by 2050 (United Nations, 2019).

The projected growth of populations living in urban settlements amplifies the current role played by local authorities, in particular performing policy key-functions related to EU climate adaptation strategies and land-use regulations, or as implementing actors of national emergency planning (EEA, 2020). As the recent COVID-19 pandemic has dramatically demonstrated, climate change and globalisation have altered ecological systems and increased inequalities in urban life (Benton, 2020). To make EU municipalities more resilient in the future, the integration of policy areas[1] has been suggested for a sustainable and well-managed development of territories.

By adopting LAUs as the territorial level of analysis, we seek to complement previous studies that have recognised (subnational) regional governance as key to addressing EU cohesion policies (de Beer et al., 2012, Groenewold and de Beer, 2014). In view of the lack of official statistics at local level, we estimate age-specific net migration rates across EU municipalities for the intercensal period between 2011 and 2019, to explore how migration dynamics have shaped local populations, along with their degree of urbanisation and related spatial patterns (i.e., distance from city centres, remoteness, population change, GDP per capita and poverty, definitions are provided in Section 4.3).

The paper is structured as follows: Firstly, we set the context for the analysis examining the role played by mobility and migration in the urbanisation process (Section 2). Secondly, we set-up a harmonised data set on population by age covering 101,409 EU LAUs, over the 27 EU Member States (MS). Due to heterogeneous practices in data collections by EU national statistical systems, we combine data from the latest population census (2011) with statistics collected by the National Statistical Institutes (NSIs). To deal with missing or incomplete figures, we make use of the high-resolution population values provided by Batista e Silva et al. (forthcoming) to derive the number of populations at LAU levels (details are provided in Section 3). Thirdly, using the harmonised data set of EU LAUs' population, we adopt the period-cohort model life tables to estimate age-specific net migration rates for all EU municipalities from 2011 to 2019 (details are provided in Section 4). Then, these new data sets allow us to explore the dynamics of net migration along demographic and spatial patterns by EU municipality. We classify LAUs by their degree of urbanisation and spatial characteristics to capture similarities and divergences across EU territories (Section 5). Lastly, we develop how findings would contribute to the mapping of the migration and mobility challenges over EU municipalities.

2 | THE RELATION BETWEEN MIGRATION AND URBANISATION DYNAMICS

Research efforts to identify the role of migration in changing population distribution find their first conceptualisation in Ravenstein's work (Ravenstein, 1889). Based on a cross-sectional comparison of population censuses in Great Britain and Ireland, Ravenstein outlined the Laws of Migration and detected the dominance of rural towards urban mobility due to the rapid industrialisation in the 19th century. Nevertheless, counter urban to rural movements started being evident in 1970s across several Western European regions (Champion, 1989; Fielding, 1989).

Regularities in age patterns of migration have been recognised by Rogers and Castro (1983). Accounting for heterogeneous area definitions and limitations in reliability of local data, authors have calculated regional variations in age-specific internal migration rates for a large sample of countries and modelled the age profile of migration (Rogers & Castro, 1983). Pursuing a similar approach, Rowe et al. (2019) defined the index of net migration impacts. Aiming to assess the role of internal mobility on population distribution, authors concluded that cross-national differences were driven by interactions between the intensity of migration and its effectiveness on spatial settlements, which varied systematically with urbanisation (following Ravenstein's classic conceptualisation of rural vs. urban mobility) to more recent counter urbanisation trends. Rees and Kupiszewski (1999) disentangled demographic patterns of regional net migration from urbanisation using population density as a proxy to differentiate urban from rural areas. They defined three main systems of population redistribution in Europe: (i) the system of classic urbanisation, exemplified by the vast majority of Estonian, Romanian, Norwegian and Polish regions; (ii) the intermediate system, in which urbanisation and counter urbanisation trends coexist, such as in some regions of Italy, Germany, Portugal and the Czech Republic; (iii) the system with a majority of counter urbanising regions, mostly located in the Netherlands and United Kingdom. Similar findings have been reached by Bell et al. (2015) and Sánchez and Andrews (2011), stressing the lower mobility in the regions of Southern and Eastern Europe compared to those of Northern and Western Europe. In

[1]Several EU programmes (e.g., EU Next Generations, European Green Deal, Horizon 2020, LIFE and Interreg) offer the possibility for local populations to benefit from EU funding resources.

addition to studies highlighting the role of migration as one of the determinants of population redistribution, the authors focused on economic development to understand the age-specific characteristics of rural and urban populations. For instance, Lewis (1954) provided the first conceptual framework of population-development interactions through the modelling of two closed economic sectors, the industrial sector with unlimited labour supply and the agricultural sector based on family labour, which explained the mobility from rural to urban areas. Scholars have argued the incompleteness of Lewis' model to interpret the general equilibrium of modern societies, which is restricted to the supply side of structural changes and sectoral compositions (Chenery, 1960, 1979). For instance, the so-called structural change paradigm (Islam, 2014) described how urbanisation could be originated from the changes of fertility and mortality in rural areas, without a substantial contribution from migration as suggested by Lewis' classic conceptualisation of development.

Currently, European countries experience the advanced phases of the demographic and migration transition (de Haas, 2010), but relative differences in the speed of the process remain across regions (de Beer et al., 2012). In European countries where ageing is one of the main demographic trends, the dynamics of urbanisation in the short and medium term are shaped by age differences in net migration: a higher proportion of older age groups tends to move from urban to rural areas, whereas urban areas retain their attractiveness mainly to younger populations (Goujon et al., 2021).

The limited number of cross-country studies exploring the link between urbanisation and demographic change at local level can be partly explained by the gap in the availability of sufficiently disaggregated data, combining the breakdown by age with high geographical resolution for the entire EU. For this reason, we have gathered population data at LAU levels in the EU and harmonised national statistics to create a new database covering all EU municipalities.

3 | DATA

With the exception of population censuses, there is no official systematic and regular European data collection on age-specific population and demographic components at LAU levels. Moreover, Eurostat collects age-specific population data at NUTS-3 level, while figures at lower geographical level are only available from NSIs.[2] This should change with the 2021 census round[3] but for the scope of this analysis, focusing on the available data between 2011 and 2019, we collected and harmonised the latest data on the population for all EU municipalities.

Table 1 summarises the territorial and temporal coverage of LAU age-specific population data by EU MS. Specifically, figures on age-specific population at LAU level were fully available for the majority of EU municipalities (58%), corresponding to 38% of EU population settled in 8 EU MS (Czechia, Denmark, France, Hungary, Lithuania, Slovakia, Spain and Sweden). For additional 5 EU MS (Italy, Poland, Portugal, Finland and Germany), data availability at LAU level approximated 99% of the population residing in the country. In The Netherlands and Belgium, the population coverage ranged around 96%, while in Bulgaria and Austria, the proportion fell to 74% and 79%, respectively. For all countries, data at LAU level were downloaded from NSI websites using the Application Programming Interfaces or manually when not available.

To fill the gaps in NSI data, in particular for the remaining countries, namely Croatia, Cyprus, Estonia, Greece, Ireland, Latvia, Luxembourg, Malta, Romania and Slovenia, where no data on age-specific population at LAU levels were available, we relied on the estimates of population at high spatial resolution (1 km^2) by Batista e Silva et al. (forthcoming), based on the ETRS89/LAEA coordinate reference system. Following the GISCO classification (2018), we upgraded the gridded population from the polygon/raster to LAU levels. In the absence of a correspondence with the LAU-GISCO classification, we employed the OpenStreetMap Nominatim webtool to mark LAUs' borders according to the national definition. The LAU population thus obtained was disaggregated by age using the age structure of NUTS-3 regions in 2019 (EUROSTAT, 2021c). The sensitivity of the results to these imputations are discussed in Section 5.

The resulting data set contains yearly information on the population size at LAU level according to the following variables: *Country*, *year*, *NUTS-3 code*, *LAU code*, *age* (in single years) for the period 2011–2019.

To measure the accuracy of our estimates and to check for potential anomalies in the age structure, we conducted a data validation using the mean absolute percent error. LAU data by age were aggregated to the NUTS-3 level and compared to the official data (EUROSTAT, 2021c) for the same reference year (Supporting Information: Figure A1 in the Appendix). In the majority of EU MS, the index varies in the acceptable range from 0% to +4%, except for Greece Latvia and Ireland, where it reaches +6%.

4 | EMPIRICAL STRATEGY

We adopt model life tables[4] by single-year of age period-cohort in order to derive net-migration. Due to heterogeneity in the dates of the 2011 population census across EU MS (for instance, Germany

[2] When available, they may not be comparable because disaggregated by age-group or territorial level not aligned with the EU definitions.

[3] 2021 population census round should become available from 2023 at a spatial resolution of a 1 km grid in accordance with the Inspire Directive.

[4] According to Keyfitz (1984), the life table is a theoretical model, which describes variations in mortality patterns of populations across age-groups. Defining a cohort as a group of people living in the same territory and sharing the same year of birth, the period life table provides the probability of dying at each annual age over the course of the cohort lifetime.

TABLE 1 Availability of age-specific population data at LAU level from 2011 to 2019 by EU MS

		LAUs		Availabillity of LAUs data		Missing data (%)		Missing data		Period	
		Number	Population	Number	Population	Number	Population	Number	Population	From	To
1	Czechia	6243	10,630,790	100	100	-	-	-	-	3/26/2011	12/31/2018
2	Denmark	99	5,827,463	100	100	-	-	-	-	1/1/2011	12/31/2019
3	France	38,195	66,523,607	100	100	-	-	-	-	1/1/2011	1/1/2017
4	Hungary	3155	9,778,371	100	100	-	-	-	-	10/1/2011	1/1/2018
5	Lithuania	60	2,794,090	100	100	-	-	-	-	3/1/2011	1/1/2020
6	Slovakia	2928	5,457,873	100	100	-	-	-	-	5/21/2011	1/1/2020
7	Spain	8135	47,433,487	100	100	-	-	-	-	11/1/2011	1/1/2020
8	Sweden	290	10,327,589	100	100	-	-	-	-	12/31/2011	12/31/2019
	Total	59,105	158,773,270								
	% of EU	0.58	0.36								
1	Austria	2117	8,899,871	100	79	0%	21%	8	1,896,349	10/31/2011	1/1/2020
2	Belgium	581	11,431,396	96	96	4%	4%	26	484,426	1/1/2011	12/31/2019
3	Bulgaria	259	5,630,472	98	74	2%	26%	6	1,442,169	2/1/2011	12/31/2019
4	Finland	309	5,489,494	99	99	1%	1%	2	31,486	12/31/2010	12/31/2019
5	Germany	10,731	83,105,365	96	99	4%	1%	399	915,033	5/9/2011	12/31/2019
6	Italy	7907	60,313,506	99	100	1%	0%	53	274,535	10/9/2011	1/1/2019
7	Netherlands	355	17,282,163	90	97	10%	3%	34	518,809	1/1/2011	1/1/2019
8	Poland	2467	38,324,561	100	100	0%	0%	11	61,566	3/31/2011	12/31/2019
9	Portugal	3072	10,166,953	99	100	1%	0%	20	29,504	3/21/2011	12/31/2019
	Total	27,798	240,643,781								
	% of EU	0.27	0.54								
1	Croatia	0	0			-	-	556	4,019,723	3/31/2011	1/1/2018
2	Cyprus	0	0			-	-	615	857,834	10/1/2011	1/1/2018
3	Estonia	0	0			-	-	79	1,327,276	12/31/2011	1/1/2018
4	Greece	0	0			-	-	6133	10,583,359	5/9/2011	1/1/2018
5	Ireland	0	0			-	-	3441	4,696,304	4/10/2011	6/24/2016
6	Latvia	0	0			-	-	119	1,922,035	3/1/2011	1/1/2019
7	Luxembourg	0	0			-	-	102	601,423	2/1/2011	1/1/2018
8	Malta	0	0			-	-	68	460,092	11/20/2011	1/1/2018
9	Romania	0	0			-	-	3181	19,524,382	10/20/2011	1/1/2018
10	Slovenia	0	0			-	-	212	2,056,972	1/1/2011	12/31/2019
	Total	0	0					14,506	46,049,400		
	% of EU	0.14	0.10								
	EU	101,409	445,466,451								

Note: Source: Authors' compilation based on Eurostat and NSI data.

Abbreviations: EU, European Union; LAU, Local Administrative Units; MS, Member States.

reports May 9th, Estonia December 31st and Bulgaria February 2nd), the initial interval of the analysis has been calibrated weighting the annual period (2011) into monthly fractions.[5]

We assume that the probability of dying during one year of ageing corresponds to the probability of dying within one calendar-year. Thus, individuals become systematically one year older at the beginning of each calendar period.[6] From the probability of dying, the following functions are derived:

(i) the probability of survival, as the complement to the probability of dying for the selected age-groups/cohorts during the reference period.

(ii) the numbers of years lived collectively by survivors within the age/period interval. From an actuarial point of view, these indicate the numbers of years that are lived collectively—and within the age-period interval—by a cohort of 100,000 births that experience the age specific mortality conditions observed during the reference period. The effects of mortality are reflected in the decline of the numbers of person-years between consecutive ages.[7]

(iii) the survival ratio, describing the average mortality conditions during the reference period, as the proportion of people, among those who survive to a given age/period, who live on and attain the next age level (UNDESA, 1970). The life table survival is also known as the projective ability of survival, because of its application in demographic projection methods (Livi Bacci, 2006). Modelling a life table stationary population stands for the probability that individuals of the same birth *theoretical* cohort will still attain older ages (or be alive one or several years later).

Due to the lack of mortality data at LAU level, we used the information about mortality at NUTS-3 level. We therefore assume that people living in neighbouring LAUs, within the same NUTS-3 territory, are exposed to similar mortality regimes. We use the model life tables developed by Coale and Demeny (1966) based on the average mortality level detected by sex at NUTS-3 level in 2019 (EUROSTAT, 2021b). The choice of 2019 as reference year is justified by the small differences in age-specific mortality behaviours between 2011 and 2019.[8] Then, we use the life table for modelling the *theoretical* cohorts at the end of period, under the hypothesis of closed populations or no migration during the whole reference interval. Since life tables have an open-ended age group,[9] the computation of net migration is limited to the age-groups below life expectancy at birth.

We adopt the survival ratio method (UNDESA, 1970) to formalise the computation of *theoretical* cohorts as follows:

$$p\_t_{t+a}^{x+a,i} = p\_o_t^{x,i} * \frac{L_{t+a}^{x+a,i}}{L_{t+a}^{x,i}} +.$$

where,

i represents the LAU unit.

a corresponds to the age and period interval.

x corresponds to the age group in 2011.

$x + a$ corresponds to the age group in 2019, with $(x+a) \ll e_t^i$ life expectancy.

$p\_o_t^{x,i}$ represents the observed cohort p^i living in LAU at age^x at the beginning of period.

$L_{t+a}^{x+a,i}$ represents the number of person-years lived by the stationary population in the NUTS-3 where the LAU is located, at age $x+a$.

$L_{t+a}^{x,i}$ represents the number of person-years lived by the stationary population in the NUTS-3 where the LAU is located, at age x.

$p\_t_{t+a}^{x+a,i}$ is the *theoretical cohort* that would be expected in 2019 at age $^{x+a}$living in LAU^i under the hypothesis it has been closed to migration during the interval a.

$\frac{L_{t+a}^{x+a,i}}{L_{t+a}^{x,i}}$ is the prospective survival probability of individuals belonging to the cohorts aged x of a stationary population closed to migration to attain the age $x + a$.

The difference between the *theoretical cohorts* and observed cohorts in $t + a$ is the estimated net migration during the period t to $t + a$:

$$nm_{t+a,t}^{x+a,i} = p\_t_{t+a}^{x+a,i} - p\_ob_{t+a}^{x+a,i}.$$

where,

$nm_{t+a,t}^{x+a,i}$ represents the net migration by cohort over the reference period obtained as residual value from the comparison between the *theoretical* and observed cohorts at the end of the reference period.

$p\_t_{t+a}^{x+a,i}$ represents the *theoretical cohort* in 2019 as derived using the prospective survival probability method.

$p\_ob_{t+a}^{x+a,i}$ represents the observed cohorts as recorded by official statistics.

[5]It should be noted that the reference period of analysis consists of 8-year interval, which differs from the conventional age-group interval (or its multiple) commonly applied to aggregate population structures. This constraint motivates our methodological choice to stratify population data by annual age groups.

[6]We apply a synthetic indication of 1-year age/period as whole, rather than notations of exact age and specific point in time.

[7]In model life tables, the function reflects the age composition of a population which experiences a constant replacement by 100,000 births and a mortality regime as observed during the reference period. This population is described as stationary, with a zero growth rate for all age groups.

[8]This is because the in terms of mortality periods from 2011 to 2019 are relatively similar. On the contrary, whether the analysis would be extended to 2020, the exceptional effects of COVID-19 pandemic and the different impacts at local level should be taken into account.

[9]This would cause the twisted interpretation that nobody survives after the achievement of the life expectancy.

We compute the *annual theoretical cohort* net migration rate as the proportion of the estimated *annual theoretical cohort* net migration in people exposed to the risk of migration, meaning the average cohorts between age x and $x + a$. Doing so, we provide the crude annual period-cohort net migration rate of the $(x + a/2)$ age *theoretical cohorts* of surviving individuals during the mid-period $(t + a/2)$. The model algorithms were implemented in R language within the GNU R computing environment (R Core Team, 2020).

The estimated net migration suffers from some limitations. We have no information about immigration and emigration flows, and evidently about the origin and destination of the net migration, whether it is dominantly composed of internal, or intra-EU mobility or international migration. The residual method would produce good measurements of net migration when homogeneous mortality regimes are applicable to populations over time. This implies the adoption of Markovian hypotheses on immigrants' assimilation with native demographic behaviours at their arrival in the destination territories. Furthermore, net migration estimates may be affected by inaccuracy in existing population statistics: being errors in the population changes reflected in the estimated net migration, under-representations of cohorts at the end of the period may drive overestimates of population changes during the reference period.

4.1 | Method validation

To control and when possible, partially reduce the bias, an adjustment strategy is designed based on the alternative method of reverse survival ratios, which consists in the use of the reciprocals of the survival ratios to calculate the expected cohorts that would have been x years old at the beginning of the reference period. The rationale is that the cohorts at the time t are composed by the survivors at the end of the reference period (time $t + a$), plus the migrants and deaths that occurred during the interval. The application of two methods provides different estimates of the cohort-period net migration, following opposed timing of migration and mortality events (concentrated at the beginning and at the end of the period). To compensate errors in the scheduling of cohort events, that should be rather distributed over the interval, we calculate the adjusted cohort-period net migration rates, as the average of two different estimates, referring to migration events that occurred in the middle of the interval for the mean age $(x + a/2)$ cohorts of survivals. To assess the appropriateness of our model specifications, we compare adjusted net migration rates (net migration rates obtained from survival ratios and reverse survival ratios) with the population growth. This check gives an indication of the coherence and consistency of the demographic components across age groups. Theoretically, when appropriate life tables are available and cohort population data sets are accurate, the estimated net migration rates should approximate migration tendencies by cohort along the population lifetime.

We verify the consistency of estimated net migration rates with the rates derived from the official demographic projection (baseline scenario) data sets provided by Eurostat at NUTS-3 level (EUROSTAT, 2021d) for the period from 2019 to 2027 (8-year interval). In the Supporting Information: Figure A2 in appendix, we show an example of a validation for the municipality of Torino in Italy (the results for all EU NUTS-3 are available upon request). We compare the Eurostat annual period-cohort net migration rates with:—estimates of annual period-cohort net migration rates derived from the application of the prospective survival probability method;—estimates of annual period-cohort net migration rates derived from the application of the reverse prospective survival probability method;—estimates of the adjusted annual period-cohort net migration rates;—the annual exponential population growth.

In general, estimated and projected migration trends are similar; estimated net migration diverges from the population growth from age 40+, mirroring the increase of mortality along age-groups. Likely, mortality regimes at older ages motivate deviations when the reverse survival probability method is applied (Supporting Information: Figure A2 in the Appendix, light blue line). As expected, the method generates results in line with the demographic projection trends.

We extend our method operability by its generalisation at NUTS-1 levels using Eurostat statistics on immigration and emigration from 2011 to 2019 (EUROSTAT, 2021e). Supporting Information: Figure A3 in the Appendix exemplifies the validation for Austria. The method fits well the generalisation at NUTS-1 for all cohorts, with some few exceptions for young adults and older cohorts. Specifically, higher estimated rates derive from under-enumeration of mortality levels for cohorts aged 18–24, whereas lower ones are a consequence of over-representation of mortality severity among cohorts aged 66–72.

As additional implementation, we apply the method to LAU data sets on populations and internal and international migration made available by the Austrian Institute of Statistics' data sets (2021) from 2011 to 2019. Supporting Information: Figure A4 in the Appendix compares population growth rates and estimated annual migration rates across pooled Austrian LAUs for the 2011–2019 period. When comparing estimates of annual migration rates with annual period-cohort rates derived from official statistics, discrepancies are not higher than standard error levels (4%). Thus, we can conclude that the method seems to be satisfactory in profiling age-specific migration rates at LAU levels. Nevertheless, it remains clear that the method's goodness-of-fit depends on the accuracy of population data sets and life table applied in the method.

4.2 | Territorial characteristics

We apply the estimated age-specific net-migration rates to investigate differences by degree of urbanisation, using the Eurostat categorisation of LAUs into cities, towns and rural areas (EUROSTAT, 2020b, 2021a), which distinguishes three categories or degrees of urbanisation: (a) urban, areas where more than 80% of the population lives in urban agglomerations; (b) rural, areas where at least 50% of the population lives in rural agglomerations; (c) intermediate, areas where more than 50% and up to 80% of the population lives in urban agglomerations. Furthermore, we select five variables corresponding to the most frequently used criteria in EU regional strategies:

distance from city centres, remoteness, population change, GDP per capita and poverty level. Even though the distance from city centres partly overlaps the degree of urbanisation, each category gives a slightly different perspective in terms of territorial characteristics. These different perspectives have a fundamental role in highlighting some features in the dynamics of urbanisation and counter-urbanisation which could be unnoticed, when referring to the simpler dichotomy between rural and urban areas and conducting analyses at higher levels of geographical units.

1. *Distance from city centres* was calculated for each LAU considering the Euclidean distance of its centroid in respect of the centroid of the closest among the 20 largest cities in each country. The continuous values were clustered in the following three groups of distance: (i) below 5 km; (ii) between 5 and 20 km; (iii) above 20 km. The threshold of 20 largest cities was based on our preliminary analysis of population distribution by LAU carried out to identify municipalities which would represent on average 40% of the EU population as a whole.
2. *Indicators of remoteness* at LAU level were obtained from a data set considering travelling time to the closest town or city above 45 min (Perpiña Castillo et al., 2021). Overall, in Europe, a limited number of LAUs are defined as remote. They are mainly located in France (29%), Spain (21%), Romania (11%), Ireland (9%) and Italy (7%). The restrictive threshold of travelling time above 45 min for remoteness may explain the relatively lower differences in age structure and net migration emerging when considering this criterion.
3. *Population changes* which occurred at LAU level were defined as follow: *depopulation* for LAUs experiencing an average crude annual change during the reference period lower than −10 per 1000 residents; *shrinking* for values of average annual change between −10 per 1000 and 0 and *growing* in the case of a positive average annual change. The threshold for depopulation has been used in the Long-Term Vision for Rural Areas (EC, 2020).
4. Economic variables, the *GDP per capita* and *share of population at risk of poverty*, have been used by the European Commission's Directorate General for Regional and Urban Policy.[10] Both indicators have been discretized in three classes using *k*-means and clustered independently in each country.

Supporting Information: Figure A5 in the Appendix visualises the application of criteria by the mapping of German municipalities.

5 | RESULTS

We divide EU municipalities into discrete classes reflecting the above-described territorial characteristics to present differences in population structure and age-specific net migration.

[10]Ardeco, https://knowledge4policy.ec.europa.eu/territorial/ardeco-online_en#demography

5.1 | Age-specific populations by spatial pattern

The age-specific populations in 2011 (the starting year for the analysis) are displayed in Figure 1 by single year of age and according to the territorial characteristics of the LAUs.

5.1.1 | Degrees of urbanisation/distance from cities/remoteness

The share of population up to 45 years tend to be under-represented in rural areas and towns, in LAUs more distant from city centres, in remote areas and in LAUs experiencing moderate or severe depopulation. Older people, on the contrary, become increasingly overrepresented in towns and rural areas, distant places and depopulating areas. The largest gap between rural areas and cities is recorded for ages from 60 to 64 years, whose share is 0.2 percentage points higher in rural areas than in cities. The share of the population between the age of 15 and 35 years is 0.2 percentage points lower in LAUs that are *more than 20 km far from city centres* than in city centres. Consistent with the classification by degree of urbanisation, the share of middle-aged adults (with ages between 40 and 44 years) is higher in cities and in suburban centres *at a distance between 5 and 20 km from city centres*. The same pattern is visible for those between 10 and 19 years of age, which correspond most-likely to the children of those middle-aged adults.

5.1.2 | Population change/economic dimensions

We observe that youth aged between 20 and 24 years are not necessarily underrepresented in areas experiencing population decline. Similarly, differences in the share of age-groups below 35 years seem not to be influenced by the two economic dimensions, the level of GPD per capita of the region and the poverty level. By contrast, these dimensions are related to positive differentials among adults aged between 40 and 55 years, and negative for those between 55 and 65 years. Youths are overrepresented in poor regions while ages from 50 to 55 years are underrepresented.

In 2011, the largest rural-urban differentials were recorded for youth aged from 20 to 24 and from 75 to 79 years. For the former, the gap is −0.24 percentage points between the share of urban versus rural, and for the latter it is +0.26 percentage points. Figure 2 displays the age-specific rural-urban differentials by single year of age and over time, comparing 2011 with 2019.

In 2019, while the proportion of youth population remained higher in urban than in rural areas, the gaps between the proportion of rural and urban population narrowed, becoming more evenly distributed across ages. More specifically, the rural-urban differential was less marked for ages from 20 to 24 years (narrowing to −0.14 percentage points from −0.24 percentage points in 2011) and for ages from 75 to 79 years (0.15 percentage points in 2019 from 0.26

FIGURE 1 Share of population by single year of age (%) across EU municipalities by territorial characteristics, 2011. EU, European Union.

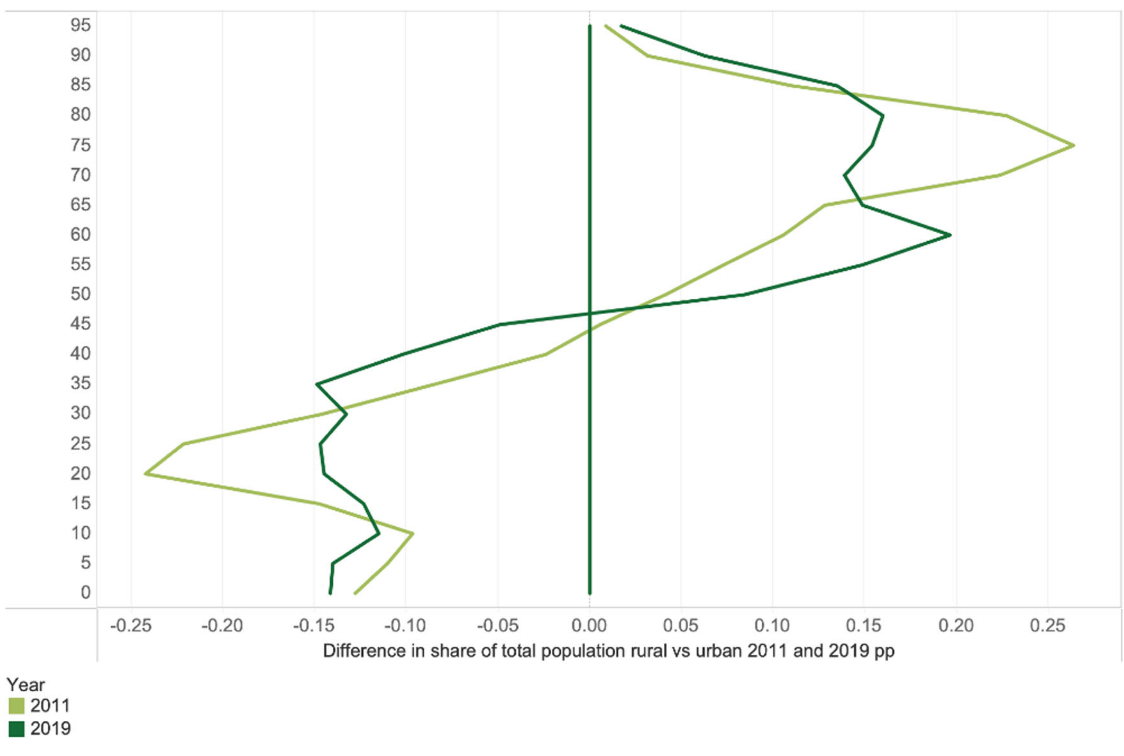

FIGURE 2 Age-specific differentials in the share of populations in rural versus urban areas over the period 2011–2019.

percentage points in 2011), whereas it increased for the ages from 50 to 64 years. This reveals a potential trend in resettlement between urban and rural areas: in 2019, a greater proportion of the adult population preferred rural municipalities than in 2011. If this counter-urbanisation trend was to continue in the future, it might be able to mitigate or slow down the speed of ageing, which mainly affects rural municipalities in the EU (Goujon et al., 2021).

5.2 | Age-specific net-migration by spatial pattern

We present the smoothed age profiles of net migration for the selected territorial characteristics, obtained by averaging the estimated net migration at LAU level (Figure 3).

5.2.1 | Degree of urbanisation

There is a positive net migration (more in-flows than out-flows) of youths in cities, which corresponds to a negative net migration in rural areas and towns. Positive patterns are also observed among people aged from 35 to 39 years in rural areas and towns. This trend is associated with similar positive flows among children (aged 0–4 years): whereas rural areas are losing young people, families with children and older adults who tend to move from urban to rural and intermediate areas. Finally, older populations (60+ years) tend to leave cities and move to cities and towns.

5.2.2 | Distance from cities

We observe a tendency of adults aged between 35 and 39 years to move far away from urban municipalities (both classes of distance, *5–20 km and 20+ km*). As expected, this propensity is reflected in the youngest age-groups, while older population (65+ years) are more likely to move close to city centres (reporting a negative net migration for all three classes of distance). Consistently with previous findings, youths are likely to move towards cities.

5.2.3 | Remoteness

These profiles do not provide additional insights in terms of net migration, besides a slightly higher tendency of young people to leave more remotely located areas in comparison with other areas.

5.2.4 | Population change

This classification reveals migration patterns for ages 35 to 39 years that are apparently inconsistent with the previous ones: young adults would move towards growing areas in terms of population (that experienced positive net migration rates), while rural municipalities are expected to be the most affected by depopulation. Yet, the trends could capture the positive effects of migration in mitigating ageing. For instance, Ghio et al. (2022) outlined that in 2015–2019,

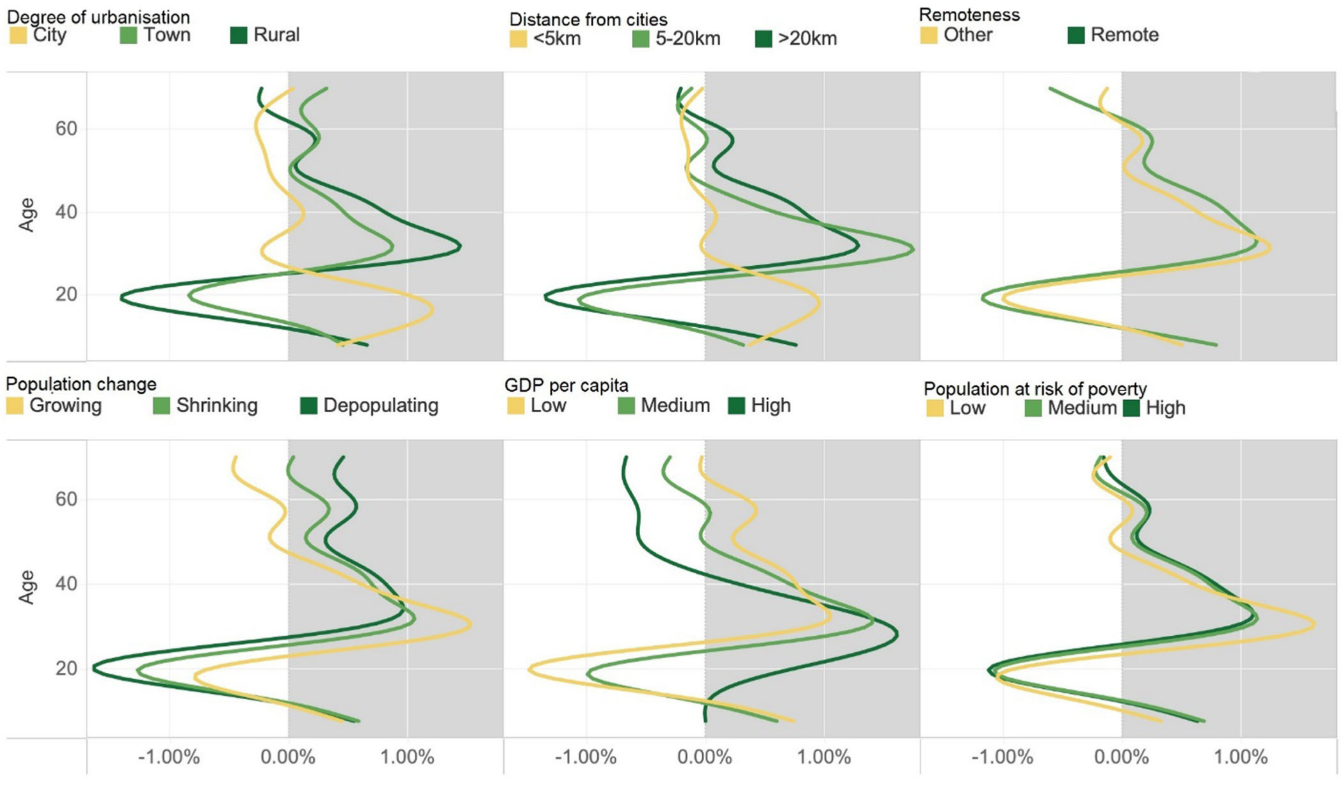

FIGURE 3 Age-profiles of net migration by single year of age by territorial characteristic over the period 2011–2019.

27% of EU territories benefitted from positive net migration to counterbalance the deficit in the working-age population due to cohort turnover.

5.2.5 | Economic dimensions

Three main patterns become evident when looking at GDP per capita: a negative net migration for ages between 20 and 24 years in low and medium GDP per-capita municipalities, a positive net migration for ages from 35 to 39 years in all municipalities, and a negative net migration for population above 40 years of age in high GDP per capita municipalities. Whether the low income operates as a push factor for younger population, it becomes a pull factor for older population. High GDP per capita seems to be an additional pull factor for ages from 35 to 39 years, doubling up the rates recorded in low-income areas. The poverty dimension does not reveal relevant differences in terms of net migration across territories. As for GDP per capita, low poverty areas show relatively higher positive net migration rates among those aged between 35 and 39 years.

The age-patterns of net migration exhibit strong variations across EU municipalities. Figure 4 illustrates the case of the 20–24 cohorts.

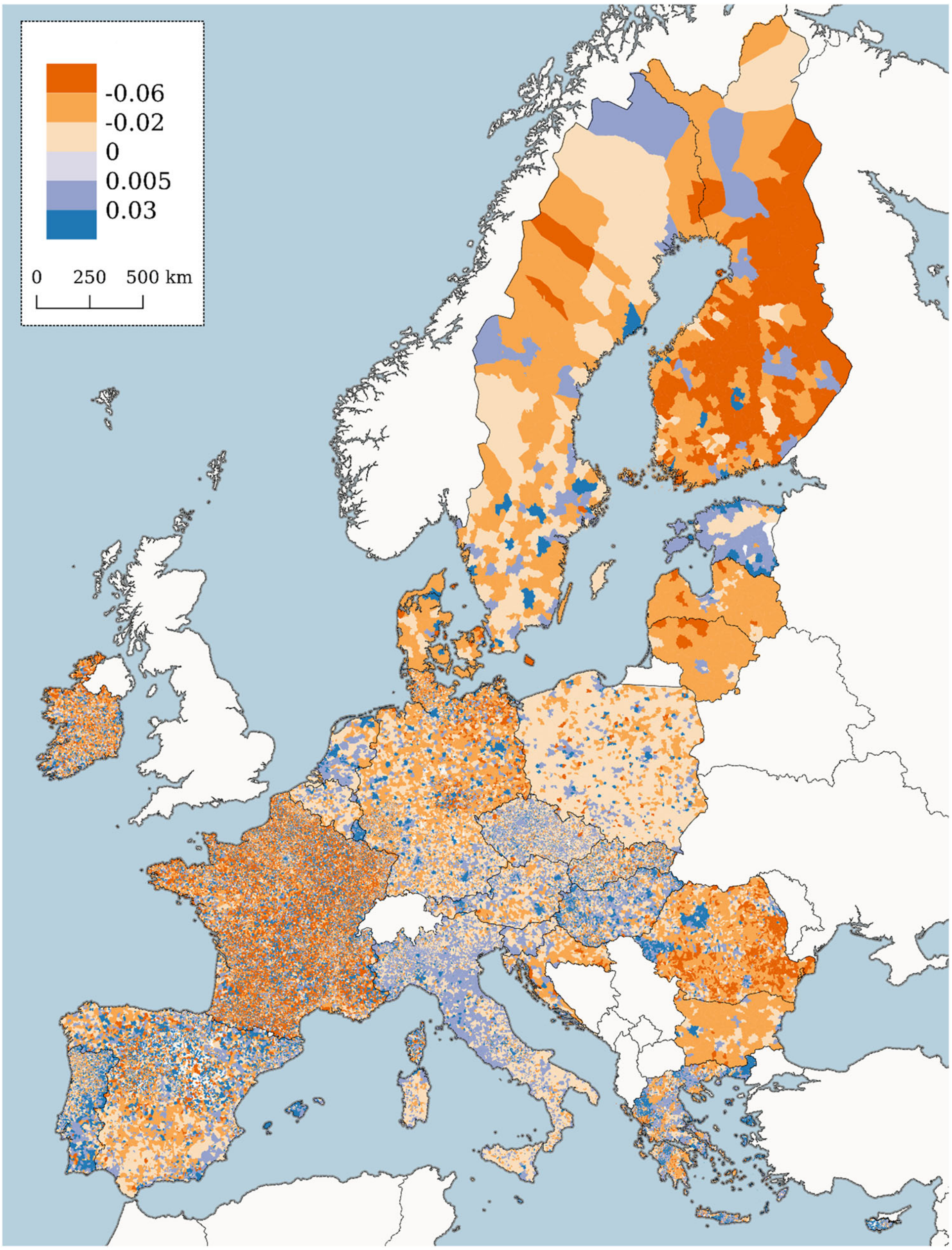

FIGURE 4 Net migration rates of the 20–24 age-groups across EU municipalities. EU, European Union.

The majority of EU municipalities (53%) experience net negative migration rates for these young cohorts, while only 36% exhibit positive net migration rates among the 20–24 cohorts[11]. As expected, the vast majority (85%) of EU municipalities recording a negative net migration are classified as rural.

Yet, spatial patterns are dissimilar across countries. For instance, in Germany, two parallel dynamics are evident: immigration (positive net migration) of young people towards large cities; emigration (negative net migration) of young people from Eastern to Western and Southern municipalities. By contrast, in Southern EU countries like Italy, the net migration of the 20–24 age-group exhibit a more uniformed pattern, negative in the South and positive in the North municipalities, pointing at internal mobility. The intensity is lesser[12] than what was observed in Germany and with a larger spread across territories. Similar tendencies are observable in France, where, beside a vast majority of Eastern and Southern municipalities exhibiting negative net migration rates, a few municipalities in the same regions seem to be attracting these youth cohorts. In Bulgaria, the dominance of negative net migration rates may be an indication that young people are moving outside of the country. These dynamics are less evident in the EU Northern countries, where there seems to be a (in-out movement) compensation within the countries.

With the aim to reduce the uncertainties in the net migration outcomes, we measure the impact of our empirical strategy by excluding LAUs with imputed population values from the analysis. Supporting Information: Figure A6 in the Appendix shows the net-migration rates for the 20–24 cohorts limited to the countries where input data were derived from official data available through the NSIs. The proportion of EU municipalities reporting a negative net migration rate for the young cohorts remains around 52%, with a prevalence (82%) of rural municipalities. This implies that our findings are robust and not impacted by the imputed values.

6 | DISCUSSION AND CONCLUSIONS

There have been multiple conceptualisations of the role of rural to urban dynamics in shaping population structures at territorial levels. (Davis, 1965; Rees & Kupiszewski, 1999; Rees et al., 2017). However, we lack knowledge about the nuances and changes in migration at local level due to missing data. In this study, we undertook two major efforts. Firstly, we created a data set of population by age at LAU levels for the entire EU, handling the large coverage and variations in the data coming from different national sources. Doing so, we complement the figures available from the 2011 population census with the latest statistics available from NSIs, anticipating the release of the 2021 gridded population census statistics foreseen for 2023. Secondly, we use these data sets to derive age-specific net migration rates at LAU level using the survival method. Finally, we explore how territorial characteristics interplay with net migration by age-group, across EU municipalities. Results by different categorisation of LAUs show heterogeneity over the EU that cannot simply stem from the rural-urban dichotomy. The combination of spatial and demographic factors plays a more central role in explaining these territorial divergences. As main outputs, we assess age-specific net migration differentials across the selected geographical and economic characteristics. Although young people (aged from 20 to 24 years) tend to move towards urban areas to reside close to city centres, their mobility seems less affected by the contextual level of GDP per capita and poverty levels. A tentative explanation is that the movements towards cities at these ages may be mostly associated with the undertaking of tertiary education and career development. Because these migrations are linked to the transition to adulthood, they may translate in (un)stable settlements. Young adults (of ages from 30 to 34 years) exhibit a preference toward rural areas rather than cities, but they also live at intermediate distances from city centres. The mobility behaviours among this age group, clearly mirrored by similar patterns in children, are likely linked to family formation. The need for bigger housing arrangements and access to green spaces may be among the fundamental drivers for these movements. Finally, elderly would be less discouraged by low economic conditions and tend to move more toward rural areas in respect to younger generations. In this case, adding distance from the city centres to the rural-urban characteristics provides additional insights by showing that, in parallel to a preference for rural areas, some population groups prefer living in city centres.

Although further analyses would be needed, especially along a longer time horizon and disaggregating in- and out-flows, we outline a stratified picture by age over the EU. Youths experience high rates of rural to urban mobility, happening at national level (internal migration) or intra-EU level (international migration) affecting particularly Eastern EU territories. By contrast and overall, young parents and children are more likely to be attracted by towns and rural areas contributing to and potentially leading the counter-urbanisation tendencies. Those have been further fuelled by the COVID-19 pandemic that has led to the increase of remote work practices (Stawarz et al., 2022). By revealing how the age structure and net migration patterns vary greatly across EU municipalities, findings confirm the relevance of the link between urbanisation and demographic dynamics. These patterns are evident not only through the rural-urban dichotomy, but also accounting for changes in the attractiveness of places over the life course. Consequently, the deepening of territorial differences in the EU should not be merely analysed using the simplistic paradigm of rural-urban migration. Large movements across EU municipalities respond to residential preferences which change over the lifetime of individuals. The presence of services, like universities and health-care structures, should be considered essential in policy planning to contrast territorial economic and demographic divergences within the EU. By targeting territorial patterns, our analysis would serve the planning of these

[11] The remaining share of municipalities experiences net migration rates closed to zero.

[12] Migration behaviours of young cohorts may reflect and be also a consequence of their transition to adulthood. For instance, the observed lower migration effects may result from the fact that Italian young adults used to leave the family home only at a later age (Billari and Liefbroer, 2010).

social cohesion initiatives, aimed at improving the accessibility of services, the revamping of local economies and the attractiveness of depopulated areas. Yet, the successful implementation of these policy actions requires better structural coordination among the EU and local stakeholders.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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